

Combustion Air System

Screen 1:

Welcome Screen:

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

Screen 2:

Introduction to Combustion Air System:

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

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

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

Screen 3:

Disclaimer:

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

Screen 4:

Overview of the Combustion Air System:

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

Screen 5:

Major Components of the Combustion Air System:

Major components of the combustion air system include the following:

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

Screen 6:**V-Screens:**

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

Screen 7:**Plastic Air Cleaner Panels:**

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

Screen 8:**Baggy Air Filters:**

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

Screen 9:**Turbocharger:**

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

Screen 10:**Major Components of the Combustion Air System (Cont'd):**

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

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

Screen 11:**Water-Based Intercooler:**

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

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

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

Screen 13:**Exhauster Blower:**

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

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

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

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

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

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

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

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

Screen 17:**Turbo Discharge Ducts:**

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

Screen 18:**Return Air Ducts:**

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

Screen 19:**Intermediate Ducts:**

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

Screen 20:**Instrumentation Devices of the Combustion Air System:**

The sensors of the combustion air system include the following:

- Manifold Air Temperature (MAT) Sensor
- Ambient True Temperature (ATT) Sensor
- Pre-Turbine Right Temperature (PTRT) and Pre-Turbine Left Temperature (PTLT) Sensors
- Turbocharger Right Speed (TRS) Sensor

Screen 21:**Manifold Air Temperature (MAT) Sensor:**

Located at the end of the engine's intake air manifold, the MAT sensor provides manifold air temperature information to the Engine Control Unit (ECU).

Screen 22:**Ambient True Temperature (ATT) Sensor:**

Located in the combustion air filter compartment wall, the ATT sensor measures the temperature of the air entering the turbocharger and provides the information to the ECU.

Screen 23:**Pre-Turbine Right Temperature (PTRT) and Pre-Turbine Left Temperature (PTLT) Sensors:**

Located in each exhaust manifold at the connection points to the turbocharger, the PTRT and PTLT sensors measure the temperature of the exhaust air going into the turbocharger and provide the information to the ECU.

Screen 24:**Turbocharger Right Speed (TRS) Sensor:**

Located in the turbocharger, the TRS sensor measures the rotational speed of the turbocharger and provides the information to the ECU.

Screen 25:**Instrumentation Devices of the Combustion Air System (Cont'd):**

Additional sensors of the combustion air system include the following:

- Barometric Air Pressure (BAP) Sensor
- Manifold Air Pressure (MAP) Sensor
- Engine Air Filter Pressure (EAFP) Sensor

Screen 26:**Barometric Air Pressure (BAP) Sensor:**

Located on the wall of Control Area 4 (CA4) in the Auxiliary Cab, the BAP sensor measures the atmospheric pressure and provides the information to the ECU.

Screen 27:**Manifold Air Pressure (MAP) Sensor:**

Located at the end of the engine's intake air manifold, the MAP sensor measures the air pressure in the intake manifold and provides the information to the ECU.

Screen 28:**Engine Air Filter Pressure (EAFP) Sensor:**

Located in the combustion air filter compartment just above the fuel filter tanks, the EAFP sensor measures the pressure of the air at the outlet of the filters and before entering the turbocharger. This information is provided to the ECU, where the BAP sensor pressure is compared to the EAFP sensor pressure to determine if the engine air filters need to be replaced.

Screen 33:**Operation of the Combustion Air System:**

The combustion air system, in conjunction with the split cooling water system, provides a regulated manifold intake temperature to the engine to meet strict government emissions requirements. At high load and/or high ambient conditions, a lower intake temperature decreases the amount of harmful emissions from the exhaust stack and decreases fuel consumption. At low load and/or low ambient conditions, a warmer intake temperature decreases other regulated emissions, such as carbon monoxide (CO) and white smoke. A two-stage hybrid intercooler design regulates the manifold air temperature. The intake manifold air is cooled or heated through an air-to-water (or water-based) intercooler, where water cools or heats the intake air. When additional cooling is required, the manifold air is cooled through a V-shaped air-to-air (or air-based) intercooler configuration. Two separate fans provide cooling air for the air-to-air intercooler. Shutters on the air-to-air intercooler provide additional control of the amount of cooling air flow, thus allowing a more controlled manifold air temperature.

Screen 34:**Air Flow Through the Combustion Air System:**

The turbocharger creates a vacuum that draws air into the combustion air system through V-screens. The air flows through eight plastic air cleaner panels. An exhaust blower, connected to the bleed air duct, provides a drawing force to discharge the dirty air from the air cleaner panels into the radiator cab. The clean air from the air cleaner panels fills the combustion air filter compartment. Five baggy filters provide the final filtration of the air entering the turbocharger. The turbocharger compresses the filtered air and sends it to the water-based intercooler. The compressed air from the turbocharger is very hot, and the water-based intercooler provides the first stage of cooling. At Notch 8, full load, the compressed air from the turbocharger can exceed 425°F. The water-based intercooler brings the compressed air temperature down below 210°F.

Screen 35:**Air Flow Through the Combustion Air System (Cont'd):**

When further cooling of the air is necessary, the air-based intercooler provides the second stage of cooling. If additional cooling is not required, the air just passes through the air-based intercooler to the intake air manifold on the engine. The air-based intercooler contains two fans and two shutters to regulate the outlet air temperature below 125°F. The intake air manifold distributes the cooled, compressed air to each power assembly on the engine. The exhaust air from the power assemblies spins the turbine blades in the turbocharger before exiting the exhaust stack.

Screen 38:**Air-Based Intercooler Fan and Shutter Control:**

The Engine Management System (EMS) software monitors the intake manifold air temperature on the engine by means of the MAT sensor. Based on this information, the EMS controls each shutter and fan separately to regulate the temperature. There are eight possible cooling configurations. To avoid over-cycling of a single fan or shutter, each device is cycled ON/OFF or OPEN/CLOSED in an alternating manner. As manifold air temperature increases, each shutter position (both closed, one open, or both open) is commanded sequentially with both fans OFF until the shutters are completely open. Note that there is a minimum holding time between each change of shutter position. If the manifold air temperature exceeds the set point with the shutters fully open, one intercooler fan is turned ON and both shutters are closed to limit the increase in intercooler air flow. If additional air flow is required, the first shutter is opened. If the temperature continues to rise, the second shutter is opened. If the temperature again exceeds the set point, the second intercooler fan is turned ON and one shutter is closed. If additional air flow is required, the second shutter is opened, resulting in both fans in service and both shutters in the fully open position to provide maximum cooling.

Screen 39:**Air-Based Intercooler Fan and Shutter Control (Cont'd):**

The sequence of shutter positions and fan speeds is based on the resulting air flow through the air-to-air intercooler and the subsequent manifold air temperature. With the shutters both open and the fans both off, some energy transfer occurs due to natural convection. Significantly more air flow and thus energy transfer occurs when one of the fans is on and both shutters are open. To limit the magnitude of the air flow change, the shutters are both closed when the first fan is turned on. The sequence explained above works in reverse for decreasing manifold air temperature. With both fans in service and both shutters initially open, as the temperature decreases, the first shutter is commanded closed. If the temperature is less than the lower set-point with the shutters at a minimum position (one shutter open, one shutter closed), the first fan to start is turned OFF, and both shutters are opened. If less cooling air flow is required, both shutters are then closed. When the temperature again drops below the lower set-point, the second fan is turned OFF and both shutters are commanded to the fully open position. The shutter position is then reduced from both open to one open, or to both closed or until manifold air temperature is no longer below the lower set point. To minimize the probability of fan motor bearing deformation and pitting on either fan due to inactivity, a condition referred to as brinelling, a fan is commanded to run for 10 seconds if the fan has been off for 30 minutes and the locomotive is not in the self-test mode. The table displays the air-based intercooler shutter and fan configuration.

Screen 40:**Protection Strategies:**

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

Screen 41:**Hot Pre-Turbine Protection:**

When either pre-turbine temperature signal, as read by the PTRT or PTLT sensor, is hot, the available horsepower from the engine is reduced to protect the turbocharger from damage. When either pre-turbine temperature signal exceeds 1325°F, the available horsepower is modulated to hold the pre-turbine temperature at a maximum of 1325°F. If the available horsepower is reduced to 80% because of a high pre-turbine temperature for one minute, a Hot Pre-turbine Deration incident is logged. If the pre-turbine temperature cannot be controlled, and the available horsepower has been reduced to zero for five minutes, the engine shuts down and logs a Hot Pre-turbine Shutdown incident.

Screen 42:**Turbo Overspeed Protection:**

When the turbo speed signal, as read by the TRS sensor, is high, the available horsepower is reduced to prevent damage to the turbocharger bearings. If the TRS signal exceeds

23,500 RPM for five seconds, the available horsepower is reduced to 3660 and an Engine Turbocharger Overspeed Incident is logged. The restriction clears after 60 minutes.

Screen 43:

Turbo Surge Protection:

A turbo surge is defined as a 6 psi drop followed by a 3 psi rise in manifold air pressure in one second. When a turbo surge is detected, the engine speed is raised or the available horsepower is lowered to prevent damage to the turbocharger. If three surge events are detected in one minute, the available horsepower is limited to 3660, the engine speed is set to 1050 RPM, and a Notch 7 Surge Incident is logged. Additional turbo surge events are ignored for one minute while the engine is in transition. If no more surge events are detected in one hour, the restriction is cleared. If three more surge events are detected in a one minute interval before the hour has expired, the available horsepower is limited to 2940, and engine speed is set to 1050 RPM. The one hour timer is then restarted. If surge events are detected, no further action is taken until the one hour timer has expired and all restrictions are cleared. The High Air Filter Differential Pressure Protection function protects the turbocharger from excessive speed caused by clogged baggy filters.

Screen 44:

High Air Filter Differential Pressure Protection:

The High Air Filter Differential Pressure Protection function protects the turbocharger from excessive speed caused by clogged baggy filters. The EAFP sensor measures the pressure in the combustion air filter compartment in units of psia. The EAFP sensor value is compared with the BAP sensor value to determine the difference. When the EAFP sensor value is lower than the BAP sensor value, air flow through the baggy filters is being restricted, indicating dirty filters. The EMS software converts the measurement to inches of water using the following formula and sensor readings: $\text{Air Filter Pressure} = 27.7 \times (\text{BAP sensor} - \text{EAFP sensor})$. If the pressure in the combustion air filter compartment is greater than 14 inches of water at Notch 8, the engine horsepower is derated to a maximum of Notch 7 horsepower.

Screen 46:

Operational Details:

Recognizing and understanding operational data, pertinent self-tests, and normal operating temperatures and pressures is important when diagnosing problems.

Screen 47:

Monitor Parameters:

The table displays a list of monitor parameters. To help maintenance personnel monitor the combustion air system, these parameters are available on the Smart Display, in Level 3 access.

Screen 48:**Self-Tests:**

Self-Tests 325 and 326 are used to test the air-based intercooler fan contactors. These self-tests pick up or drop out the contactors that apply AC power to the fans and are used to test the contactor feedback circuits. Self-Tests 407 and 408 are used to test the operation of the air-based intercooler fans. These self-tests apply AC power to the fans. Self-Tests 327 and 328 are used to test the air-based intercooler shutters. These self-tests energize or de-energize the magnet valves that apply compressed air to open or close the shutters. All of these self-tests are initiated through the Smart Displays.

Screen 49:**Normal Operating Temperatures and Pressures:**

The table provides normal expected operating temperatures and pressures for air flowing in the system.

Screen 50:**Running Maintenance Schedule:**

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

Screen 51:**Plastic Air Cleaner Panels:**

The plastic air cleaner panels provide the primary stage of air filtration for the combustion air system. After going through the V-screens, the air is drawn into the plastic air cleaner panels. The combustion air system uses eight air cleaner panels. The air cleaner panels require no routine running maintenance other than a visual inspection to see if they are intact and free of debris. If they are cracked or broken, they must be replaced. If panels are plugged with debris, remove and clean them and return them to service.

Screen 53:**Winter-Summer Door:**

The winter-summer door provides a means to mix warm air from the engine cab with cold outside air to prevent ice crystals from clogging the baggy air filters as well as to maintain warmer engine manifold air temperatures during cold ambient temperatures. The winter-summer door is located in the floor area of the combustion air filter compartment. In warm weather conditions, the door is in the down position and closed to block the air passage that leads to the engine cab area. This allows full flow of air through the plastic air cleaner panels. In cold weather conditions, the door is in the raised position to partially block the incoming air from the plastic air cleaner panels while opening the path for the warm air to travel from the engine cab area. The winter-summer door requires no routine running maintenance. However, if the door is not in the correct position for the climate, locomotive performance may suffer.

Screen 54:**Baggy Air Filters:**

The baggy air filters clean fine particles from the intake air as it comes from the air cleaner panels. The five baggy filters are located in the combustion air filter compartment, which is located in the radiator cab. Access to the compartment and filters is through doors located on both sides of the locomotive.

Screen 55:**Baggy Air Filters Removal and Installation:**

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

Typical steps to remove and install new baggy air filters are as follows:

1. Shut down the diesel engine.
2. Open the door to access the combustion air filter compartment from the engineer's side (A-side) of the radiator cab.
3. Remove the bar clamp and the wire cages that are accessible from this side.
4. Remove and replace the used air filters with new approved baggy air filters.
5. Install the wire cages.

Screen 56:**Baggy Air Filters Removal and Installation (Cont'd):**

6. Open the door to access the combustion air filter compartment from the helper's side (B-side) of the radiator cab.
7. Remove the wire cages that are accessible from this side and replace the used air filters with new approved baggy air filters.
8. Install the wire cages.
9. Close and secure the door to the combustion air filter compartment.
10. On the engineer's side (A-side), install the bar clamp to hold the air filters in place.
11. Close and secure the door to the combustion air filter compartment.

Screen 57:**Turbocharger:**

The turbocharger compresses air for use by the engine during the combustion process. Driven by engine exhaust gases, the turbocharger compresses the clean filtered air and feeds it to the engine by way of intercoolers. The turbocharger has no mechanical driving gear. Engine exhaust gases drive the turbocharger's turbine, which in turn rotates the turbocharger's compressor attached to the same shaft. Perform the removal and installation steps as discussed in the Turbocharger Removal and Installation module of the GEVO Diesel Engine Advanced course.

Screen 58:**Water-Based Intercooler:**

As part of a two-stage manifold air-cooling process, the Water-Based Intercooler (WBIC) provides the first stage of this cooling. The WBIC cools the air discharged from the turbocharger. At Notch 8 engine speed, the outlet air temperature from the WBIC is typically around 200°F.

Note: Engine load, altitude, and ambient air temperature can significantly affect this value.

The WBIC consists of a core and an outer shell. The core is a mechanically bonded tube and fin design. The cooling water flows inside the tubes and makes two passes through the shell before exiting. The turbocharger discharge air flows over the tubes and fins in one pass. Perform the removal and installation steps as discussed in the Split Cooling Water System module of this course.

Screen 59:**Air-Based Intercooler:**

The air-based intercooler provides the second stage of the manifold air-cooling process. The turbocharged air (or combustion air) leaving the water-based intercooler flows through two symmetrical air-to-air heat exchangers, which are mounted in a "V"-shaped configuration. Two 16 HP, suction-type fans are turned on or off individually to control the cooling air that flows across the heat exchangers. Two shutters, located at the inlet side of the cooling air paths, can also be opened or closed to provide additional cooling control. Four shutter control magnet valves are used to open and close the shutters. The magnet valves are located in the combustion air filter compartment on the helper's side (B-side). When cooling is not required, both fans are turned off and both shutters are closed. At Notch 8 engine speed, the outlet air temperature from the air-based intercooler is typically below 122°F.

Note: Engine load, altitude, and ambient air temperature can significantly affect this value.

The air-based intercooler is located in the upper section on the radiator cab adjacent to the univalve assembly.

Screen 60:**Air-Based Intercooler Package Removal:**

Typical steps to remove the air-based intercooler package are as follows:

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

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

Warning: All lifting fixtures and support stands referenced have been individually manufactured, tested, and certified. Lifting devices manufactured by other facilities per these recommended numbers should be individually tested and certified by an appropriate outside testing agency before use. Follow all Railroad Operating/Shop Procedures concerning lifting devices.

1. Shut down the diesel engine.
2. Depressurize the locomotive cooling system as discussed in the Split Cooling Water System module of this course.
3. Disconnect the battery switch.
4. Unbolt and remove all top covers over the air-based intercooler package.
5. Unbolt and remove the side screens on both sides of the locomotive.

Screen 61:

Air-Based Intercooler Package Removal (Cont'd):

Note: The intermediate ducts connect the water-based intercooler and the air-to-air heat exchangers. Access the ducts through the top and inside the combustion air filter compartment.

6. Unbolt the intermediate ducts at the lower "V" area of the air-based intercooler.

Note: The return ducts connect the air-to-air heat exchangers and the engine.

7. Unbolt the return ducts at the 8-inch Victaulic couplings on the top outboard connections of the air-based intercooler package.
8. Remove and retain the fasteners from the clamp of the return duct bracket on both the A-side and B-side of the locomotive.
9. Remove the return ducts from the IFE cover of the engine.
10. Attach the lifting hook and strap at each pipe assembly and lift the return ducts from the locomotive.
11. Disconnect the wiring at the six "red apple" insulators on the helper's side (B-side) of the locomotive at the rear end of the inlet screen.
12. Cut the fasteners holding these wires to the tape rail on the radiator cab structure.
13. Disconnect the grease fittings at the connection points through the side screen at the front end on the engineer's side (A-side) of the locomotive.

Screen 62:**Air-Based Intercooler Package Removal (Cont'd):**

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

14. For a top-mounted shutter assembly, remove the shutter actuator cover to allow access to the air lines, then disconnect the air lines on the shutter cylinders.
15. For side-mounted shutter assemblies, disconnect the air lines from the two shutter cylinders.

Note: Not all Evolution Series locomotives are equipped with an air-to-air shutter assembly. Some locomotives have a covering grate in place of the air-to-air shutter assembly.

16. Unbolt the four vertical mounting bolts on the radiator cab support wings on each side of the locomotive by accessing the bolts through the side screen openings.

Warning: The air-based intercooler weighs approximately 3375 lbs. (1530 kg). Ensure the lifting device is adequate. Failure to do so may result in personal injury or death.

17. Attach a four-hook lifting device at the lifting points and lift the air-based intercooler package from the locomotive.
18. Align and place the air-based intercooler package in the support stand on the shop floor.

Screen 63:**Air-Based Intercooler Package Installation:**

Typical steps to install an air-based intercooler package are as follows:

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

Warning: The air-based intercooler weighs approximately 3375 lbs. (1531 kg). Use a crane or appropriate lifting device to avoid personal injury.

Note: Comply with all railroad safety procedures before proceeding to the top of the radiator cab. The radiator rock guards were not designed to be walked on by more than one person. Use the supplied walkway covers.

Warning: If the locomotive is equipped with AESS, the diesel engine may start without operator action. Exercise caution when working around the radiator cab. Ensure that

AESS is disabled before performing any maintenance procedures on the locomotive. Failure to do so may result in death or serious personal injury.

1. Attach a four-hook lifting device at the lifting points and lift the air-based intercooler package into place on the radiator cab.
2. Align the mounting holes and install the four vertical mounting bolts on the radiator cab support wings on each side of the locomotive by accessing the bolts through the side screen openings.
3. For side-mounted shutter assemblies, connect the air lines to the two shutter cylinders.
4. For a top-mounted shutter assembly, connect the air lines to the shutter cylinders and install the shutter actuator cover.
5. Connect the grease fittings at the connection points through the side screen at the front end on the engineer's side (A-side) of the locomotive.
6. Connect the six wires to the correct "red apple" insulators on the helper's side (B-side) of the locomotive at the rear end of the inlet screen.
7. Secure the wires to the tape rail on the radiator cab structure with fasteners.

Screen 64:

Air-Based Intercooler Package Installation (Cont'd):

8. Using an appropriate lifting device, lift and install the return ducts to the IFE cover of the engine.
9. Place the return ducts in the air-to-air frame and attach the return pipe brackets with fasteners that were removed during removal.

Note: Ensure that the B-side of the return duct flange is installed as far to the center of the cab as possible (towards the A-side) to avoid interference with the B-side turbo discharge duct during operation.

10. Connect the return ducts to the top outboard connections of the air-based intercooler package.

Note: Access the ducts through the top and inside the combustion air filter compartment.

11. Connect the intermediate ducts at the lower "V" area of the air-based intercooler.
12. Install the side screens on both sides of the locomotive.
13. Install the top covers over the air-based intercooler package.
14. With the air-based intercooler package installed, re-fill the locomotive cooling water system as discussed in the Split Cooling Water System module of this course in preparation for returning the locomotive to service.

Screen 65:**Air-to-Air Heat Exchanger Removal:**

Typical steps to remove one of the air-to-air heat exchangers from the air-based intercooler are as follows:

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

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

Note: The following steps are performed with the air-based intercooler removed from the locomotive and sitting on the ground on an appropriate support stand.

Warning: All lifting fixtures and support stands referenced have been individually manufactured, tested, and certified. Lifting devices manufactured by other facilities per these recommended numbers should be individually tested and certified by an appropriate outside testing agency before use. Follow all Railroad Operating/Shop Procedures concerning lifting devices.

1. Unbolt and remove the close off angles that secure the top of the air-to-air heat exchanger in place.
2. Unbolt the air-to-air heat exchanger shoulder and lower mounting bolts at all four corners of each heat exchanger.

Note: It is not necessary to unbolt the shutter mounting bolts.

Warning: Each individual air-to-air heat exchanger weighs approximately 620 lbs. (281 kg). Use a crane or appropriate lifting device to avoid personal injury or death.

3. Attach the lifting fixture (TESCO T65420) to the top of the air-to-air heat exchanger using all four tapped holes in the side rails of the heat exchanger.
4. Using the lifting fixture, lift and slide the old air-to-air heat exchanger out of the sheet metal pocket support frame.

Screen 66:**Air-to-Air Heat Exchanger Installation:**

Typical steps to install one of the air-to-air heat exchangers to the air-based intercooler are as follows:

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

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

Note: The following steps are performed with the air-based intercooler removed from the locomotive and sitting on the ground on an appropriate support stand.

Warning: All lifting fixtures and support stands referenced have been individually manufactured, tested, and certified. Lifting devices manufactured by other facilities per these recommended numbers should be individually tested and certified by an appropriate outside testing agency before use. Follow all Railroad Operating/Shop Procedures concerning lifting devices.

1. Attach the lifting fixture (TESCO T65420) to the top of the air-to-air heat exchanger using all four tapped holes in the side rails of the heat exchanger.
2. Using the lifting fixture, lift and slide the air-to-air heat exchanger into the sheet metal pocket support frame.
3. Install the air-to-air heat exchanger shoulder and lower mounting bolts at all four corners of each heat exchanger.
4. When re-installing the air-to-air heat exchanger on the air-based intercooler frame, only replace the two mounting bolts at the lower inlet air corner and leave out the mounting bolts at the other three remaining corners.

Note: Replacing the two bolts at the lower inlet air corner only and leaving out the other three pairs of bolts allows for thermal growth of the intercooler cores.

5. Install the close off angles that secure the top of the air-to-air heat exchanger in place.

Screen 67:

Shutter Removal – Side-Mounted Shutter Assembly:

There are two different generations of the air-to-air shutter assembly designs; a top-mounted design and a side-mounted design. The removal of a side-mounted shutter assembly is explained in this section.

Typical steps to remove a side-mounted shutter assembly from the air-based intercooler are as follows:

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

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

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

Note: The following steps are performed with the air-based intercooler removed from the locomotive and sitting on a support stand.

Warning: All lifting fixtures and support stands referenced have been individually manufactured, tested, and certified. Lifting devices manufactured by other facilities per these recommended numbers should be individually tested and certified by an appropriate outside testing agency before use. Follow all Railroad Operating Procedures concerning lifting devices.

1. If required, disconnect the air lines attached to the shutter cylinders on both shutter assemblies.
2. Loosen the ten ½-13 x 1.50-inch hex bolts that secure the air-to-air shutter assembly to the air-based intercooler frame.
3. Loosen the four ½-13 x 1.25-inch hex bolts that secure the air-to-air shutter assembly to the air-based intercooler heat exchanger.
4. Remove and save the top two ½-13 x 1.50-inch hex bolts, split lockwashers, and flatwashers, then attach swivel clevis lifting lugs in the bolt holes.

Warning: The air-to-air shutter assembly weighs approximately 225 lbs. (102 kg). With the lifting device connected to the swivel clevis lifting lugs, ensure the lifting device is adequately supporting the assembly weight before removing the remaining hardware. Failure to do so may result in personal injury or death.

5. With the air-to-air shutter assembly properly supported, remove and save all previously loosened hex bolts, split lockwashers, and flatwashers.
6. Once all the bolts have been removed and the shutter assembly is supported by the lifting lugs, support the bottom of the shutter so it does not swing out as the support stand is removed.

Note: The shutter assembly may also be supported by sitting on the forks of a fork lift as well to ensure it is secure.

7. Remove the shutter assembly from the air-based intercooler frame.

Screen 68:

Shutter Installation – Side-Mounted Shutter Assembly:

There are two different generations of the air-to-air shutter assembly designs; a top-mounted design and a side-mounted design. The installation of a side-mounted shutter assembly is explained in this section.

Typical steps to install a side-mounted shutter assembly to the air-based intercooler are as follows:

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

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

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

Note: The following steps are performed with the air-based intercooler removed from the locomotive and sitting on a support stand.

Warning: All lifting fixtures and support stands referenced have been individually manufactured, tested, and certified. Lifting devices manufactured by other facilities per these recommended numbers should be individually tested and certified by an appropriate outside testing agency before use. Follow all Railroad Operating Procedures concerning lifting devices.

Warning: The air-to-air shutter assembly weighs approximately 225 lbs. (102 kg). With the lifting device connected to the swivel clevis lifting lugs, ensure the lifting device is adequately supporting the assembly weight before removing the remaining hardware. Failure to do so may result in personal injury or death.

1. Attach the lifting lugs to the shutter assembly and place the shutter assembly on the air-based intercooler frame.
2. Install the four ½-13 x 1.25 inch hex bolts, ½ split lockwashers, and ½ flatwashers retained during removal.
3. Install the ten ½-13 x 1.50 inch hex bolts, ½ split lockwashers, and ½ flatwashers retained during removal securing the air-to-air shutter assembly to the top of the air-based intercooler frame.
4. If required, connect the air lines attached to the shutter cylinders on both shutter assemblies.

Screen 69:

Shutter Removal – Top-Mounted Shutter Assembly:

There are two different generations of the air-to-air shutter assembly designs; a top-mounted design and a side-mounted design. The removal of the top-mounted shutter assembly is explained in this section.

Typical steps to remove the top-mounted shutter assembly from the air-based intercooler are as follows:

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

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

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

Note: The following steps are performed with the air-based intercooler removed from the locomotive and sitting on a support stand.

Warning: All lifting fixtures and support stands referenced have been individually manufactured, tested, and certified. Lifting devices manufactured by other facilities per these recommended numbers should be individually tested and certified by an appropriate outside testing agency before use. Follow all Railroad Operating Procedures concerning lifting devices.

1. Remove and save the four bolts, washers, and lockwashers securing the actuator cover to the shutter assembly.
2. Remove the shutter actuator cover to allow access to the air lines.
3. Disconnect the air lines attached to the shutter cylinders.
4. Remove and save the hex bolts, washers, and lockwashers securing the air-to-air shutter assembly to the top of the air-based intercooler frame.

Warning: The air-to-air shutter assembly weighs approximately 273 lbs. (124 kg). Ensure the lifting device is adequate. Failure to do so may result in personal injury or death.

5. Attach lifting lugs to the holes in all four corner gussets of the shutter assembly.
6. Lift the shutter assembly from the top of the air-based intercooler frame.

Screen 70:

Shutter Installation – Top-Mounted Shutter Assembly:

There are two different generations of the air-to-air shutter assembly designs; a top-mounted design and a side-mounted design. The installation of the top-mounted shutter assembly is explained in this section.

Typical steps to install the top-mounted shutter assembly from the air-based intercooler are as follows:

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

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

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

Note: The following steps are performed with the air-based intercooler removed from the locomotive and sitting on a support stand.

Warning: All lifting fixtures and support stands referenced have been individually manufactured, tested, and certified. Lifting devices manufactured by other facilities per these recommended numbers should be individually tested and certified by an

appropriate outside testing agency before use. Follow all Railroad Operating Procedures concerning lifting devices.

1. Attach the lifting lugs to the holes in all four corner gussets of the shutter assembly.
2. Place the air-to-air shutter assembly on the top of the air-to-air frame.
3. Install the hex bolts, washers, and lockwashers retained during its removal.
4. Connect the air lines to the shutter cylinders.
5. Place the shutter actuator cover on the air-to-air frame.
6. Install the four bolts, washers, and lockwashers to secure the shutter actuator cover.

Screen 71:

Air-to-Air Fan Assembly Removal:

Typical steps to remove an air-to-air fan assembly for locomotives with a top-mounted air-to-air shutter assembly from the locomotive cooling system are as follows:

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

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

Note: This process can be performed while the air-based intercooler is installed in or removed from the locomotive.

1. Remove the air-to-air shutter assembly as discussed in the Shutter Removal – Top-Mounted Shutter Assembly section of this module.
2. Disconnect the grease fittings from the fan to be removed.

Screen 72:

Air-to-Air Fan Assembly Removal (Cont'd):

3. Disconnect all fan motor leads.
4. Remove and save all bolts and washers that secure the air-to-air fan assembly to the air-based intercooler frame.

Note: Save all hardware for reuse.

Warning: The air-to-air fan assembly weighs approximately 300 lbs. (136 kg). Ensure the lifting device is adequate. Failure to do so may result in personal injury or death.

5. Attach a crane or lifting device to the lifting hooks on the fan assembly.
6. Remove the air-to-air fan assembly from the locomotive.

Screen 73:

Air-to-Air Fan Assembly Installation:

Typical steps to install an air-to-air fan assembly for locomotives with a top-mounted air-to-air shutter assembly to the locomotive cooling system are as follows:

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

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

Note: This process can be performed while the air-based intercooler is installed in the locomotive.

Warning: The air-to-air fan assembly weighs approximately 300 lbs. (136 kg). Ensure the lifting device is adequate. Failure to do so may result in personal injury or death.

1. Attach a crane or lifting device to the lifting hooks on the air-to-air fan assembly.
2. Install the air-to-air fan assembly in position on the air-to-air intercooler.
3. Install all bolts and washers retained during removal to secure the air-to-air fan assembly to the air-to-air intercooler.
4. Connect all fan motor leads.
5. Connect the grease fittings.
6. Install the air-to-air shutter assembly as discussed in the Shutter Installation – Top-Mounted Shutter Assembly section of this module.

Screen 74:

Exhauster Blower:

The exhauster blower is an 8.5 horsepower, AC motor-driven exhauster that removes dirty air (or bleed air) from the spin cleaners and discharges it into the radiator cab. The AC motor is electrically connected through an Exhauster Motor Breaker (EMB) to the auxiliary alternator. As long as the auxiliary alternator is functioning, the exhauster blower will also function. The exhauster blower runs at engine speed. The EMB provides overload protection for the AC source (auxiliary alternator) to the exhauster motor.

Screen 75:

Exhauster Blower Removal:

Typical steps to remove the exhauster blower are as follows:

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

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

1. Open the connection box cover located on the blower motor and disconnect the three motor leads from the terminal block located on the blower motor. Note the identification of each lead on each terminal for subsequent reconnection.
2. Disconnect the flexible conduit at the exhauster blower motor connection box and save all hardware.
3. Remove the section of handrail opposite the exhauster blower on the engineer's side (A-side) of the locomotive and save all hardware.
4. Remove and save all exhauster blower mounting bolts and hardened washers.
5. Remove and save the bolt, washer, lockwasher, and nut fastening the blower duct assembly to the blower assembly.
6. Place a steel pry bar between the blower duct assembly and the exhauster blower base, and carefully pry the blower toward the short-hood end of the locomotive until the blower clears the duct assembly.

Warning: The exhauster blower weighs approximately 530 lbs. (240 kg). Ensure that the lifting device is adequate. Failure to do so may result in personal injury or death.

7. Using a crane lifting hook attached to the single lifting lug, carefully lift the blower from the base and remove the blower assembly from the locomotive.
8. Carefully set the blower assembly on a skid in a level position.

Screen 76:

Exhauster Blower Installation:

Typical steps to install the exhauster blower are as follows:

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

Warning: The exhauster blower weighs approximately 530 lbs. (240 kg). Ensure that the lifting device is adequate. Failure to do so may result in personal injury or death.

Note: When installing the exhauster blower, inspect and remove any loose hardware or objects that may have fallen into the exhauster blower upward-pointing discharge opening.

1. Carefully position the blower assembly onto the mounting base with a crane, then slide the blower into position, aligning the blower with the duct assembly and the mounting holes.
2. Install the blower mounting hardware and torque the bolts to 155 to 170 lb.-ft. (210 to 231 Nm).
3. Carefully pull the three exhauster blower motor leads back into the connection box.

Caution: When the power leads to the exhauster blower motor have been disconnected at either end for any reason, it is possible to incorrectly connect the leads at reinstallation. If any two power leads are swapped at either end, the blower may still operate; but it will rotate backwards. Backward running of the equipment blower will greatly decrease the air filtering of the equipment blower and engine air filters. This reduced ventilation can shorten the life and/or do serious damage to the traction motors and diesel engine. To check rotation, with the engine at IDLE, place a tie wrap on top of the motor shaft exposed between the motor end bell and the drive-end shaft guard. If the tie wrap moves outward, the motor rotation is correct.

4. Connect the motor lead wires to the terminals in the box, ensuring that each lead is on the correct terminal.
5. Connect the flexible conduit to the connection box.
6. Install the bolt, washer, lockwasher, and nut to secure the blower to the blower duct assembly.
7. Install the section of handrail previously removed.

Screen 79:

Summary:

You have reached the end of this module!

In this module, you learned to:

- State the purpose and location of the combustion air system.
 - The combustion air system provides sufficient air to the engine during the combustion process and maintains the temperature of that air.
 - The components of the combustion air system are located in the engine cab and radiator cab.

- State the purpose and location of the major components of the combustion air system.
 - V-Screens: Located on both sides of the radiator cab, the V-screens block large items from entering the combustion air system.
 - Plastic Air Cleaner Panels: Located behind the V-screens, the panels provide the primary stage of air filtration for the combustion air system.
 - Baggy Air Filters: Located in the combustion air filter compartment, these filters clean the fine particles from the intake air as it comes from the air cleaner panels.
 - Turbocharger: Located on the Integrated Front End (IFE) cover of the diesel engine, the turbocharger compresses the air for use by the engine during the combustion process.
 - Water-Based Intercooler: Located in the upper section of the radiator cab adjacent to the turbocharger, the water-based intercooler provides the first stage of cooling for the air discharged from the turbocharger.
 - Air-Based Intercooler: Located in the upper section of the radiator cab adjacent to the water-based intercooler, the air-based intercooler provides the second stage of cooling for the turbocharged air.
 - Exhauster Blower: Located in the radiator cab on the engineer's side (A-side) of the locomotive, the exhauster blower removes the dirty air from the spin cleaner panel bleed air duct, continuously discharging the bleed air and dirt out the top of the unit and into the radiator cab. From the radiator cab, the radiator fans pull the air out, discharging the dirty air through the top of the locomotive.
 - Winter-Summer Door: Located in the combustion air filter compartment, the winter-summer door prevents ice crystals from clogging the baggy air filters.
 - Shutter Control Magnet Valves: Located in the combustion air filter compartment on the helper's side (B-side) of the locomotive, these magnet valves control the air-flow for opening and closing the shutters on the air-based intercooler.
 - Turbo Discharge Ducts: These ducts transport the combustion air from the turbocharger to the water-based intercooler.
 - Return Air Ducts: These ducts transport the cooled combustion air from the air-based intercooler to the engine intake manifold.
 - Intermediate Ducts: These ducts transport the combustion air from the water-based intercooler to the air-based intercooler.

- State the purpose and location of the instrumentation devices of the combustion air system.
 - Manifold Air Temperature (MAT) Sensor: Located at the end of the engine's intake air manifold, the MAT sensor measures the manifold air temperature and provides the information to the ECU.
 - Ambient True Temperature (ATT) Sensor: Located in the combustion air filter compartment wall, the ATT sensor measures the temperature of the air entering the turbocharger and provides the information to the ECU.

- Pre-Turbine Right Temperature (PTRT) and Pre-Turbine Left Temperature (PTLT) Sensors: Located in each exhaust manifold at the connection points to the turbocharger, these sensors measure the temperature of the exhaust air going into the turbocharger and provide the information to the ECU.
- Turbocharger Right Speed (TRS) Sensor: Located in the turbocharger, the TRS sensor measures the rotational speed of the turbocharger and provides the information to the ECU.
- Manifold Air Pressure (MAP) Sensor: Located at the end of the engine's intake air manifold, the MAP sensor measures the air pressure in the intake manifold and provides the information to the ECU.
- Barometric Air Pressure (BAP) Sensor: Located on the wall of Control Area 4 in the Auxiliary Cab, the BAP sensor measures the atmospheric pressure and provides the information to the ECU.
- Engine Air Filter Pressure (EAFP) Sensor: Located in the combustion air filter compartment just above the fuel filter tanks, the EAFP sensor measures the pressure of the air at the outlet of the filters and before entering the turbocharger and provides the information to the ECU.

Screen 80:

Summary (Cont'd):

- Describe how the combustion air system operates.
 - The turbocharger draws air into the combustion air system through V-screens.
 - The air flows through eight plastic air cleaner panels.
 - An exhauster blower discharges the dirty air from the air cleaner panels into the radiator cab.
 - The clean air from the air cleaner panels fills the combustion air filter compartment.
 - Five baggy filters provide the final filtration of the air entering the turbocharger.
 - The turbocharger compresses the filtered air and sends it to the water-based intercooler which provides the first stage of cooling.
 - If necessary, the air-based intercooler provides the second stage of cooling. If not, the air passes through the air-based intercooler to the intake air manifold on the engine.
 - The intake air manifold distributes the cooled, compressed air to each power assembly on the engine.
 - The exhaust air from the power assemblies spins the turbine blades in the turbocharger before exiting the exhaust stack.
- Describe the protection strategies used with the combustion air system.
 - Hot Pre-Turbine Protection: When either pre-turbine temperature signal as read by the PTRT or PTLT sensor is hot, the available horsepower from the engine is reduced to protect the turbocharger from damage.

- Turbo Overspeed Protection: When the turbo speed signal as read by TRS sensor is high, the available horsepower is reduced to prevent damage to the turbocharger bearings.
- Turbo Surge Protection: When a turbo surge is detected, the engine speed is raised or the available horsepower is lowered to prevent damage to the turbocharger.
- High Air Filter Differential Pressure Protection: The EAFP sensor measures the pressure in the combustion air filter compartment. When the EAFP sensor value falls below the BAP sensor value, air flow through the baggy filters is being restricted, indicating dirty filters.
- Describe how to perform running maintenance related to the combustion air system.
 - The recommended running maintenance schedule associated with the combustion air system and its major components are as follows:
 - Inspect the combustion air system and the diesel engine daily or after every trip. While the engine is idling, make a visual inspection of all system piping, the water-based intercooler, and the air-based intercooler for air leaks. Make corrections as necessary. Then, check the exhaust manifolds for leaks, cracks, and broken welds. Visually inspect the turbocharger discharge ducts for tears or holes in the silicone layer. Replace if any damage is found.
 - Inspect the air-based intercooler every 184 days. Inspect the intercooler for any air leakage. Check for any debris or dirt on the heat exchangers. Run Self-Test 407 and 408 to verify that the fans operate properly. Inspect the shutter mechanism for looseness or wear. Run Self-Test 327 and 328 to verify that the shutters operate properly.
 - Replace the engine baggy filters every 184 days.
 - Every year, lubricate the air-based intercooler fan bearings, following the specifications.
 - Lubricate the bearings of the exhaust blower every three years.

Screen 81:

Summary (Cont'd):

- V-Screens
 - The V-screens require no routine running maintenance other than a visual inspection to see if they are intact and free of debris. If the V-screens are covered with debris, remove the debris before dispatching the locomotive.
- Plastic Air Cleaner Panels
 - The air cleaner panels require no routine running maintenance other than a visual inspection to see if they are intact and free of debris.
 - If a panel is cracked or broken, it must be replaced. If plugged with debris, remove the panel, clean it, and return it to the locomotive.

- Winter-Summer Door
 - The winter-summer door requires no routine running maintenance. If the door is not in the correct position for the climate, locomotive performance may suffer.
- Baggy Air Filters Removal and Installation
 1. Shut down the diesel engine.
 2. Open the door to access the combustion air filter compartment from the engineer's side (A-side) of the radiator cab.
 3. Remove the bar clamp and the wire cages that are accessible from this side.
 4. Remove and replace the used air filters with new approved baggy air filters.
 5. Install the wire cages.
 6. Open the door to access the combustion air filter compartment from the helper's side (B-side) of the radiator cab.
 7. Remove the wire cages that are accessible from this side and replace the used air filters with new approved baggy air filters.
 8. Install the wire cages.
 9. Close and secure the door to the combustion air filter compartment.
 10. On the engineer's side (A-side), install the bar clamp to hold the air filters in place.
 11. Close and secure the door to the combustion air filter compartment.
- Turbocharger Removal and Installation
 - Perform the removal and installation steps as discussed in the Turbocharger Removal and Installation module of the GEVO Diesel Engine Advanced course.
- Water-Based Intercooler Removal and Installation
 - Perform the removal and installation steps as discussed in the Split Cooling Water System module of this course.
- Air-Based Intercooler Package Removal
 1. Shut down the diesel engine.
 2. Depressurize the locomotive cooling system.
 3. Disconnect the battery switch.
 4. Unbolt and remove all top covers over the air-based intercooler package.
 5. Unbolt and remove the side screens on both sides of the locomotive.
 6. Unbolt the intermediate ducts at the lower "V" area of the air-based intercooler.
 7. Unbolt the return ducts at the 8-inch Victaulic couplings on the top outboard connections of the air-based intercooler package.
 8. Remove and retain the fasteners from the clamp of the return duct bracket on both the A-side and B-side of the locomotive.
 9. Remove the return ducts from the IFE cover of the engine.
 10. Attach the lifting hook and strap at each pipe assembly and lift the return ducts from the locomotive.

11. Disconnect the wiring at the six “red apple” insulators on the helper's side (B-side) of the locomotive at the rear end of the inlet screen.
12. Cut the fasteners holding these wires to the tape rail on the radiator cab structure.
13. Disconnect the grease fittings at the connection points through the side screen at the front end on the engineer's side (A-side) of the locomotive.
14. For a top-mounted shutter assembly, remove the shutter actuator cover to allow access to the air lines, then disconnect the air lines on the shutter cylinders.
15. For side-mounted shutter assemblies, disconnect the air lines from the two shutter cylinders.
16. Unbolt the four vertical mounting bolts on the radiator cab support wings on each side of the locomotive by accessing the bolts through the side screen openings.
17. Attach a four-hook lifting device at the lifting points and lift the air-based intercooler package from the locomotive.
18. Align and place the air-based intercooler package in the support stand on the shop floor.

Screen 82:

Summary (Cont'd):

- Air-Based Intercooler Package Installation
 1. Attach a four-hook lifting device at the lifting points and lift the air-based intercooler package into place on the radiator cab.
 2. Align the mounting holes and install the four vertical mounting bolts on the radiator cab support wings on each side of the locomotive by accessing the bolts through the side screen openings.
 3. For side-mounted shutter assemblies, connect the air lines to the two shutter cylinders.
 4. For a top-mounted shutter assembly, connect the air lines to the shutter cylinders and install the shutter actuator cover.
 5. Connect the grease fittings at the connection points through the side screen at the front end on the engineer's side (A-side) of the locomotive.
 6. Connect the six wires to the correct “red apple” insulators on the helper's side (B-side) of the locomotive at the rear end of the inlet screen.
 7. Secure the wires to the tape rail on the radiator cab structure with fasteners.
 8. Using an appropriate lifting device, lift and install the return ducts to the IFE cover of the engine.
 9. Place the return ducts in the air-to-air frame and attach the return pipe brackets with fasteners that were removed during removal.
 10. Connect the return ducts to the top outboard connections of the air-based intercooler package.

11. Connect the intermediate ducts at the lower "V" area of the air-based intercooler.
12. Install the side screens on both sides of the locomotive.
13. Install the top covers over the air-based intercooler package.
14. With the air-based intercooler package installed, re-fill the locomotive cooling water system in preparation for returning the locomotive to service.
- Air-to-Air Heat Exchanger Removal
 1. Unbolt and remove the close off angles that secure the top of the air-to-air heat exchanger in place.
 2. Unbolt the air-to-air heat exchanger shoulder and lower mounting bolts at all four corners of each heat exchanger.
 3. Attach the lifting fixture (TESCO T65420) to the top of the air-to-air heat exchanger using all four tapped holes in the side rails of the heat exchanger.
 4. Using the lifting fixture, lift and slide the old air-to-air heat exchanger out of the sheet metal pocket support frame.
- Air-to-Air Heat Exchanger Installation
 1. Attach the lifting fixture (TESCO T65420) to the top of the air-to-air heat exchanger using all four tapped holes in the side rails of the heat exchanger.
 2. Using the lifting fixture, lift and slide the air-to-air heat exchanger into the sheet metal pocket support frame.
 3. Install the air-to-air heat exchanger shoulder and lower mounting bolts at all four corners of each heat exchanger.
 4. When re-installing the air-to-air heat exchanger on the air-based intercooler frame, only replace the two mounting bolts at the lower inlet air corner and leave out the mounting bolts at the other three remaining corners.
 5. Install the close off angles that secure the top of the air-to-air heat exchanger in place.
- Shutter Removal – Side-Mounted Shutter Assembly
 1. If required, disconnect the air lines attached to the shutter cylinders on both shutter assemblies.
 2. Loosen the ten ½-13 x 1.50-inch hex bolts that secure the air-to-air shutter assembly to the air-based intercooler frame.
 3. Loosen the four ½-13 x 1.25-inch hex bolts that secure the air-to-air shutter assembly to the air-based intercooler heat exchanger.
 4. Remove and save the top two ½-13 x 1.50-inch hex bolts, split lockwashers, and flatwashers, then attach swivel clevis lifting lugs in the bolt holes.
 5. With the air-to-air shutter assembly properly supported, remove and save all previously loosened hex bolts, split lockwashers, and flatwashers.
 6. Once all the bolts have been removed and the shutter assembly is supported by the lifting lugs, support the bottom of the shutter so it does not swing out as the support stand is removed.
 7. Remove the shutter assembly from the air-based intercooler frame.

- Shutter Installation – Side-Mounted Shutter Assembly
 1. Attach the lifting lugs to the shutter assembly and place the shutter assembly on the air-based intercooler frame.
 2. Install the four ½-13 x 1.25 inch hex bolts, ½ split lockwashers , and ½ flatwashers retained during removal.
 3. Install the ten ½-13 x 1.50 inch hex bolts, ½ split lockwashers , and ½ flatwashers retained during removal securing the air-to-air shutter assembly to the top of the air- based intercooler frame.
 4. If required, connect the air lines attached to the shutter cylinders on both shutter assemblies.

Screen 83:

Summary (Cont'd):

- Shutter Removal– Top-Mounted Shutter Assembly
 1. Remove and save the four bolts, washers, and lockwashers securing the actuator cover to the shutter assembly.
 2. Remove the shutter actuator cover to allow access to the air lines.
 3. Disconnect the air lines attached to the shutter cylinders.
 4. Remove and save the hex bolts, washers, and lockwashers securing the air-to-air shutter assembly to the top of the air-based intercooler frame.
 5. Attach lifting lugs to the holes in all four corner gussets of the shutter assembly.
 6. Lift the shutter assembly from the top of the air-based intercooler frame.
- Shutter Installation – Top-Mounted Shutter Assembly
 1. Attach the lifting lugs to the holes in all four corner gussets of the shutter assembly.
 2. Place the air-to-air shutter assembly on the top of the air-to-air frame.
 3. Install the hex bolts, washers, and lockwashers retained during its removal.
 4. Connect the air lines to the shutter cylinders.
 5. Place the shutter actuator cover on the air-to-air frame.
 6. Install the four bolts, washers, and lockwashers to secure the shutter actuator cover.
- Air-to-Air Fan Assembly Removal
 1. Remove the air-to-air shutter assembly.
 2. Disconnect the grease fittings from the fan to be removed.
 3. Disconnect all fan motor leads.
 4. Remove and save all bolts and washers that secure the air-to-air fan assembly to the air-based intercooler frame.
 5. Attach a crane or lifting device to the lifting hooks on the fan assembly.
 6. Remove the air-to-air fan assembly from the locomotive.
- Air-to-Air Fan Assembly Installation
 1. Attach a crane or lifting device to the lifting hooks on the air-to-air fan assembly.
 2. Install the air-to-air fan assembly in position on the air-to-air intercooler.

3. Install all bolts and washers retained during removal to secure the air-to-air fan assembly to the air-to-air intercooler.
4. Connect all fan motor leads.
5. Connect the grease fittings.
6. Install the air-to-air shutter assembly.
- Exhauster Blower Removal
 1. Open the connection box cover located on the blower motor and disconnect the three motor leads from the terminal block located on the blower motor. Note the identification of each lead on each terminal for subsequent reconnection.
 2. Disconnect the flexible conduit at the exhauster blower motor connection box and save all hardware.
 3. Remove the section of handrail opposite the exhauster blower on the engineer's side (A-side) of the locomotive and save all hardware.
 4. Remove and save all blower mounting bolts and hardened washers.
 5. Remove and save the bolt, washer, lockwasher, and nut fastening the blower duct assembly to the blower assembly.
 6. Place a steel pry bar between the blower duct assembly and the exhauster blower base, and carefully pry the blower toward the short-hood end of the locomotive until the blower clears the duct assembly.
 7. Using a crane lifting hook attached to the single lifting lug, carefully lift the blower from the base and remove the blower assembly from the locomotive.
 8. Carefully set the blower assembly on a skid in a level position.
- Exhauster Blower Installation
 1. Carefully position the blower assembly onto the mounting base with a crane, then slide the blower into position, aligning the blower with the duct assembly and the mounting holes.
 2. Install the blower mounting hardware and torque the bolts to 155 to 170 lb.-ft. (210 to 231 Nm).
 3. Carefully pull the three exhauster blower motor leads back into the connection box.
 4. Connect the motor lead wires to the terminals in the box, ensuring that each lead is on the correct terminal.
 5. Connect the flexible conduit to the connection box.
 6. Close the connection box.
 7. Install the bolt, washer, lockwasher, and nut to secure the blower to the blower duct assembly.
 8. Install the section of handrail previously removed.