EMIT Total Solution

Installation Manual
AFRC

March 2018

Contents

CONVENTIONS USED

Within an instructional section:

Bold text refers to required tools.

Underlined text refers to EMIT item numbers, kit components, or assembly components.

Italicized text refers to items or parts already existing on the engine, compressor, or panel.

	Important notes or warnings

	Tips, examples, and suggested practices

POWER, COMMUNICATION, AND WIRING,

POWER SUPPLY

The EIM and the associated ETS modules are designed to use either 12 or 24 Volt systems. Nothing is required from the user to switch between these two settings. An engine with an alternator and battery is generally preferred, and power is supplied by simply connecting the positive battery terminal on the modules.

	Use a fuse on the positive side of the power supply (5 Amp for an EIM and EMD configuration, 10 Amp an EIM/EMD/AFRC configuration). Use a 10 Amp fuse for the ignition system itself.

	Automotive type battery chargers are NOT recommended.

	If powering from one 12V battery within a 24V configuration, it is critical that the 12V battery used has the negative terminal connected to skid, or the location, ground.

If an AC to DC power supply is required, a 24 Volt 10 Amp version with 100 mV peak to peak maximum ripple, such as the Sola model #SDN 10-24-100P power supply, is recommended.

INSTALLATIONS WITH MULTIPLE MODULES – CAN COMMUNICATION

Installations that include two or more ETS modules require that switch settings on the individual modules be set appropriately. Failing to set the switches may result in faulty communication between the modules and may potentially display erroneous data on the EIM screen.

The communication protocol between the EIM and the individual modules operates on a daisy chain topology. The protocol requires that the modules on both ends of the communication network be terminated (switched up), while the modules in between remain unterminated (switched down).

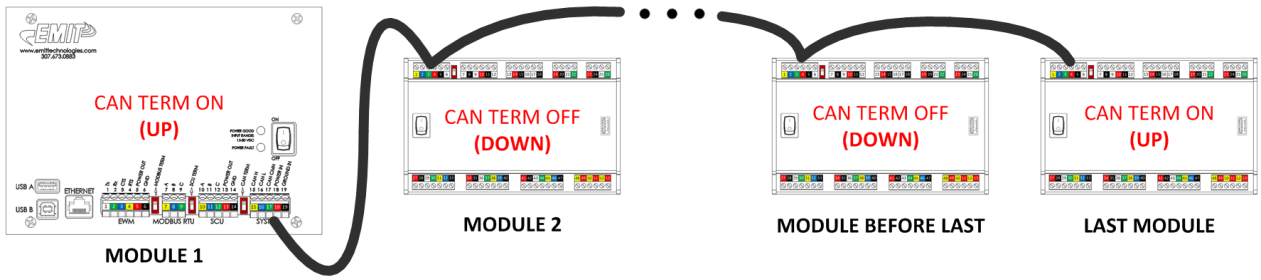


Figure 1. Network Switch Position Example

Termination of the module is selectable by sliding the red switch next to the module's power and communication connecter in the up position. The up, or terminated, position is defined by the arrow displayed on the cover next to the switch.

WIRING

Standard wiring harnesses are constructed with FEP insulation and a FEP jacket rated at 200ºC. This product has excellent resistance to oils, aliphatic hydrocarbons, heat, weather, acids, alkalis as well as oxidation. This product also has superior abrasion and flame resistance. Harnesses are also available with an armored jacket. The EIM enclosure has five 1/2 inch conduit ports located on the underside of the enclosure back. The wiring diagram is shown on the quick start guide (available separately). The wiring

connections to the EIM and ETS modules are connected to removable plugs via screw terminals. Each plug is labeled with the appropriate pin numbers and corresponding colors to ease installation. The following are important guidelines for wiring the EIM and ETS modules to the engine:

- Do not install the system with power applied.
- If not enclosed in conduit, the wiring harness should be securely attached to the supporting structure using tie wraps or mounting brackets.
- Long, unsupported wire runs should be avoided.
- Keep all wiring away from hot or moving parts and all ignition wires.
- All wiring splice connections should be soldered and protected with heat shrink tubing, with the exception of thermocouples.
- Thermocouple wires should be spliced only when necessary, using approved procedures.
- Properly connect all wires before energizing the power connection.
- Care should be taken when making connections to the terminal blocks to allow for excess wire for the front cover to be folded back up and secured in place. This prevents strain on the connections.
- Shielding wire must be grounded to the available lugs inside the back of the enclosure using ring terminals and 10-32x1/4” screws.
- Insulate the exposed shielding with heat shrink tubing or other approved protection.
- Any unused wires should be de-energized and connected to a ground lug.
- Ensure terminal (19) of the EIM is also grounded to the enclosure
- All electrical components must share a common ground.

	Armored harnesses include a stainless steel overbraid. Use appropriate tools for cutting harness to length or removing excess overbraid material.

EIM INSTALLATION

MOUNTING THE EIM

The EIM enclosure is designed to be weatherproof, but care should be taken when mounting the controller to minimize the impacts of the environment. The following guidelines should be followed when selecting a mounting location:

- Do not mount the controller in locations where excessive vibration, heat, and/or moisture exist (refer to EIM specifications).
- Avoid mounting the controller within eight (8) feet of high energy electrical sources such as ignition coils, sparkplug wires, or "G" leads.
- Do not mount with the front screen facing direct sunlight as the UV will degrade the touch screen material.
    - If mounting external to a panel, the EIM Mount Outdoor Kit (14202) includes a cover for UV protection.
    - If mounting within a panel using EIM Panel Mount Kit (14200), the panel should include a shroud or dark window tint to protect from UV.
- Do not mount with the front screen of the controller facing ignition systems or magnetos. RF noise from these components may interfere with the operation of the controller.
- Engine must have resistor spark plugs.
- Do not mount either internally or externally on a "tattle tale" panel.

Figure 2. Assembly Exploded View

The EIM is designed to be both panel or externally mountable. To externally mount the EIM to a structure, use the mounting holes on the reverse side of the EIM. Drill a four-hole pattern in the mounting surface using dimensions in Figure 3. Base Mount Drill Dimensions and screw the enclosure back to the structure using 1/4-20 screws (included with the indoor or outdoor mounting kits).

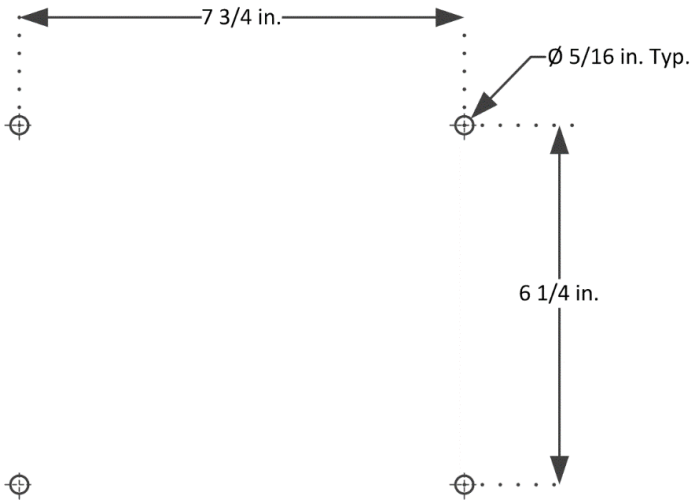


Figure 3. Base Mount Drill Dimensions

The EIM Mount Indoor Kit (14201) and the EIM Mount Outdoor Kit (14202) both include brackets for mounting on the end of a structure including the side an instrumentation panel.

⚠	Do not drill holes in the enclosure or the warranty will be voided.

For panel mounting, cut the panel and drill using the dimensions shown in Figure 4, and mount the EIM face. The EIM Panel Mount Kit (14200) includes a gasket and four (4) 10-32 nylon locking nuts to secure the EIM.

⚠	If the controller face is not mounted in a weatherproof enclosure, use of the EIM Panel Mount Gasket (14007) is required to maintain warranty coverage. This item is included in the EIM Panel Mount Kit (14200).

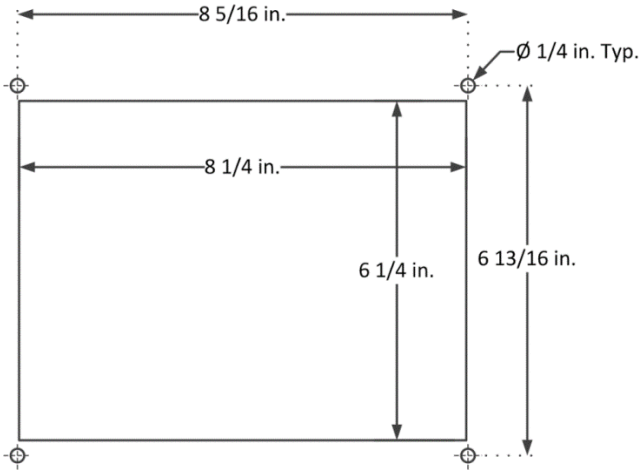


Figure 4. Cutout Dimensions for Panel Mounting

AFRC AND EMD INSTALLATION

MOUNTING THE AFRC MODULE

Any module can be mounted either within the base of the EIM enclosure or on any standard 35mm DIN rail within a separate enclosure.

The Module EIM Mount Kit (14206) includes triangular-shaped flanges, or ears, that can be inserted into the end caps of the modules and then secured within the EIM base using the provided 6-32 screws.

The Module Panel Mount Kit (14205) includes a section of 35mm DIN rail and feet that slide into the channels on the bottom of the module. To install the feet, one end cap of the module must be removed and then re-attached once the feet on in position. DIN rail stops are included and can be used on each end of the module to keep it from moving or sliding on the DIN rail.

If additional space is required to mount a module, the Module External Enclosure Mount Kit (14207) provides an additional enclosure and hardware to mount the module within the enclosure.

THERMOCOUPLES

The ETS system uses Type-K thermocouples as inputs. The thermocouples should be placed very close to the catalyst element in a pre (upstream) and post (downstream) configuration. Once the thermocouples are inserted into the sample port, tighten the fittings to secure the thermocouples in place.

	If at all possible, avoid splices in thermocouple wires. If a thermocouple wire must be spliced, use ceramic wire nuts.

OXYGEN SENSORS

Following are the requirements for proper installation of the oxygen sensor:

- The oxygen sensor should be installed in the exhaust system between the engine and the catalytic converter and/or muffler.
- The mounting location should be as close to the engine exhaust manifold as possible.
- The sensor should be exposed to the unobstructed flow of the exhaust gases from all cylinders to be controlled by that sensor. Do not locate the sensor in a coupling or in a location where the exhaust gas flow is uneven due to obstructions or sharp bends.
- The sensor location chosen should allow for easy access.
- The location chosen should not subject the exterior shell of the sensor to an ambient air temperature greater than 350ºF.
- For optimum resistance to water intrusion, mount sensors so the exposed end of sensor is oriented at or above horizontal to prevent moisture accumulation.
- Do not mount vertical/above exhaust as the heat rise may damage harness.
- Do not mount directly below exhaust as condensation may damage sensor element.

If installing a post-catalyst oxygen sensor, it should be installed in a “necked” or “throttled” flow region after the catalyst to ensure proximity to well mixed exhaust gas with minimal interference from a flow boundary layer. Welding an 18 mm port to receive the oxygen sensor on the catalyst housing/silencer outlet neck (narrowest flow region of the post-catalyst exhaust system) is the preferred placement. However, installing a ½” NPT to 18 mm adaptor on an available port in the exhaust tailpipe is an acceptable alternative.

⚠	Drain wires are required to be secured to the shield terminal block of the AFRC Advanced or AFRC Lite if using the six-wire wideband sensor.

💡	Sensor replacement is recommended every 2,200 hours or as performance of sensor dictates.

A weld-on adapter may be required for sensor installation in exhaust systems with no available O2 port. To mount the adapter, drill and spot face a hole in the exhaust pipe at the selected location then weld on the 18mm adapter. A flat, smooth sealing surface is required to assure accurate readings. Air or exhaust leaks will impact sensor operation. After the adapter is installed, an 18mm x 1.5 tap should be run through to ensure proper thread contact on O2 sensor.

Figure 5. Oxygen Sensor Standoff

Item #13020

💡	For turbo-charged engines, a "standoff" is available to keep the sensor out of the direct exhaust stream because of the extreme heat (see Figure 5). Contact EMIT Technologies for more information.

⚠	Use only a moly-graphite based anti-seize (Loctite 51605) on the sensor threads. Any other anti-seize compound may poison the oxygen sensor or catalyst!

DIGITAL POWER VALVES

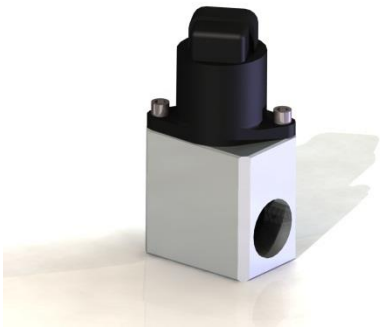
The digital power valve must be installed in the fuel delivery system of the engine. It will control the fuel flow rate to the carburetor when properly installed.

Follow these guidelines for proper valve installation:

- The valve should be mounted as close to the gas mixer inlet as possible.
- The digital power valve plug connection should NOT be positioned below the valve body.
- The valve size should match piping size of the mixer gas inlet. Exceptions are lightly loaded engines. Contact EMIT Technologies for recommendations.

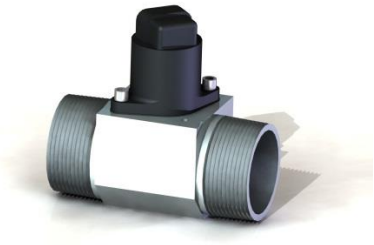
⚠	Do not over tighten the threads on female threaded 1/2" and 3/4" valves. The pipe could interfere with the actuating device of the valve.

1/2" NPT Inline Valve
Item #12013

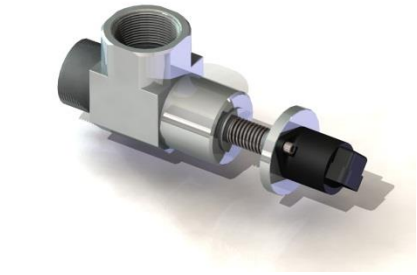


3/4" NPT Inline Valve
Item #12014

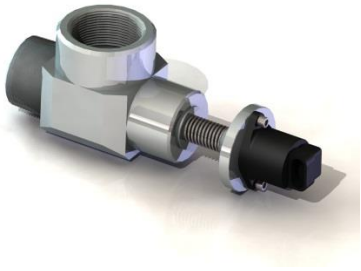
1-1/4” NPT Inline Valve
Item #12015



1-1/2” NPT Inline Valve
Item #12016



1-1/4” External Dynamic Valve
Item #12017



1-1/2” External Dynamic Valve
Item# 12018

Modified 600
Item #12022

Modified 600D
Item #12023 Standard
Item #12025 Large Bore VF
Item #12025 Small Bore VF

Figure 6. Types of Digital Power Valves

MANIFOLD PRESSURE SENSOR

The manifold pressure sensors are installed directly to the intake manifold of each bank of the engine. Take care not to obstruct any linkage or moving assemblies during the installation. Use adaptors, manifolds, or fittings as necessary. The pressure port threads of the sensor are $^1/_4$" NPT male.

CATALYST DIFFERENTIAL PRESSURE SENSOR

The catalyst differential pressure sensor is installed by running stainless tubing from each side of the catalyst to the respective ports of the sensor.

Follow the requirements below for proper catalyst differential pressure installation:

- Secure the assembly to a nearby structure, such as a handrail or optional EMIT flange-mount arm
  - Do not leave the assembly supported only by the stainless tubing
- The mounting location of the sensor should be placed in an elevated position above the catalyst access ports to allow any condensation to drain out of the tubing and away from the sensor
- The sensor should be oriented with the pressure ports horizontally level
  - The body, or center portion, of the sensor can be installed vertically in any orientation
- The mounting location chosen should not subject to an ambient air temperature greater than 185ºF
  - Do not mount directly vertical/above catalyst housing as the heat will likely exceed the temperature range of the sensor
- 3/8", or larger, stainless tubing is recommended to avoid excessive condensation buildup or freezing

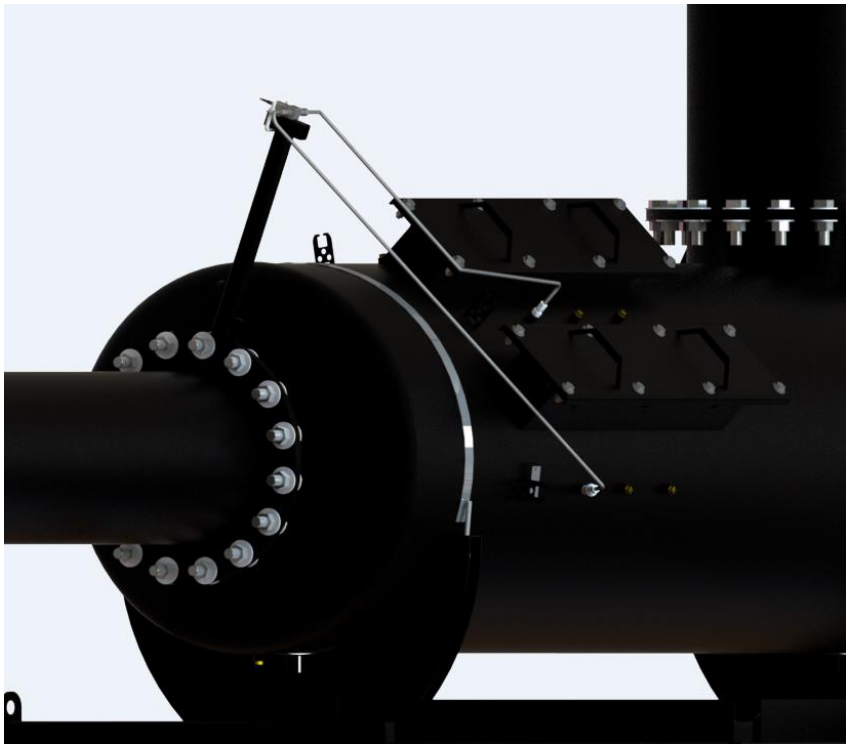


Figure 7. Proper Differential Pressure Sensor Mounting (Angled View)

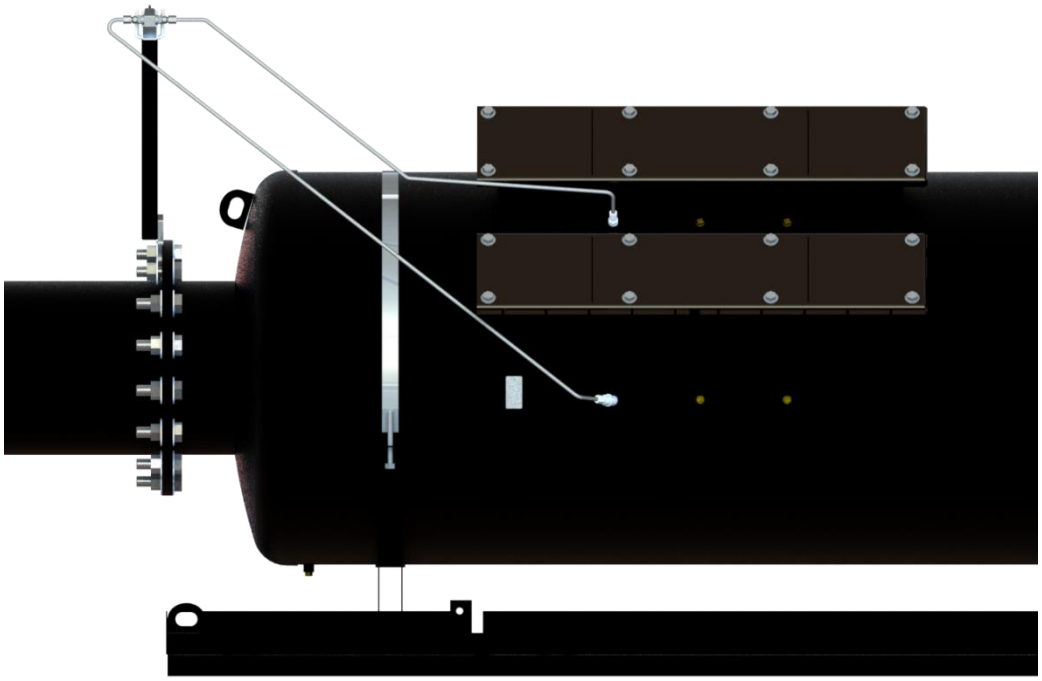


Figure 8. Proper Differential Pressure Sensor Mounting (Side View)

⚠	Stainless tubing less than 3/8” may result in false readings due to condensation build up

⚠	It is the installer’s responsibility to ensure the continuous ambient temperature the sensor is exposed to is less than 185°F. Exceeding this value will damage the sensor.

OIL PRESSURE SWITCH

The oil pressure switch is installed directly to the engine. Use adaptors or fittings as necessary. The pressure port threads of the sensor are $^{1}/_{8}$” NPT male.

AFRC SETUP AND CONFIGURATION

ENGINE CONDITION

For proper AFRC operation, it is critical that the engine be in good operational status. Verify the following before running the AFRC:

- Valves are adjusted to factory specification
- Spark plugs are properly gapped and in good condition
- Cylinders have good compression
- Mixers are in good condition and regulator fuel pressure is set to factory specification
- Fuel connections are secure and leak-free
- Ignition system functioning correctly and timing set appropriately for fuel composition

If the controller is operating at near the valve limit, or is at the valve limit and still not controlling well, the fuel pressure likely needs to be adjusted.

CONTROLLER SETUP

While the engine is not running, perform the following steps to prepare the controller for operation:

- AFRC module is installed and wired
- Digital power valve(s) are installed
- Secure the front panel of the EIM to the enclosure by re-tightening the four (4) front panel screws
- Run signal source is properly connected
- Run signal source is properly selected on the **Run Signal Trigger** screen (Pg. 10)
- Fuel connections are secure and leak-free
- Load valve manual adjustments on external dynamic valves are fully open (full rich, or seven turns from fully closed) for startup only
- Enter *Setup* or *Engineering* mode on the controller by entering the appropriate password
- Set the “Control” toggle button on the **AFRC Home** screen (Lite Pg. 300, Adv. Pg. 200) to “Manual”

The engine can now be started.

VALVE SETUP

No valve setup required unless an External Dynamic or 600 Series valve is being used. For information on these valve types, their setup, and operation refer to Appendix D of the main user manual.

SENSOR SETUP

The AFRC Advanced has the following optional sensor inputs available for process monitoring, run signal, and mapping:

- Manifold Pressure Sensors (two available)
  - “Manifold Press Left” and “Manifold Press Right”
    - Single bank configurations utilize the “Manifold Pressure Left” input
  - Sensors are pre-configured for the system and can only be enabled or disabled
- Analog (one available)
  - “ANALOG”
  - Configurable to 0-5V, 1-5V, or 4-20mA
- Oil Pressure Switch (one available)

    - "Oil Press Switch"
    - Pre-configured as normally open (N/O) and can only be enabled or disabled
- Thermistor (one available)
    - "Ambient"
- Thermocouple (one available)
    - "Manifold"
    - Type-K thermocouple only
- Magnetic Pickup (one available)
    - "RPM"
    - 1-100 Volts

The AFRC Lite has the following optional sensor available for process monitoring and mapping:

- Manifold Pressure Sensor (one available)
    - "Manifold Press"
    - Sensors is pre-configured for the system and can only be enabled or disabled

The different sensor types are available for setup by selecting their respected buttons on the top of the screen.

Configuring the Analog and Discrete Inputs

To setup the manifold pressure sensors or the oil pressure switch, simply select the "Enable" toggle box next to the sensor label. Darker colored toggle buttons indicate the sensor is actively enabled.

For the general purpose "ANALOG" input, the following fields are required:

- Name – Label of the sensor that will be displayed within the AFRC's user interface
- Enabled – Activates sensor input
- Output – 4-20mA, 0-5 Volt, or 1-5V sensor output type
- Low Scale – Lowest output value of the sensor
- Full Scale – Highest output value of the sensor
- Units – Units of the sensor

Figure 9. AI/DI Sensor Setup Screen

Configuring the Temperature Inputs

The thermocouple and thermistor inputs only require their respected “Enable” toggle buttons to be selected in order to be operational.

Figure 10. Temperature Sensor Setup Screen

Configuring RPM

The RPM input is configured by providing the pulses per revolution and selecting the “Enable” toggle button. This option is only available on the AFRC Advanced.

Figure 11. RPM Sensor Setup Screen

⚠	Modifying an existing sensor configuration requires the “Enable” toggle box to be toggled off and back on to take effect.

RUN SIGNAL

By default, the run signal selection is set to “Auto-Detect”, which scans enabled sensors for each module. The AFRC Advanced has three applicable inputs:

- Pre-catalyst thermocouple (terminals 24 and 25)
- Oil pressure switch (terminals 39 and 40)
- RPM (terminals 17 and 18)

If an AFRC Lite is installed, the only available run signal trigger sensor available is the pre-catalyst thermocouple (terminals 21 and 22).

Additionally, the run signal can be generated from a connected EMD, if equipped, using the following inputs:

- Pre-catalyst thermocouple
  - EMD terminals 24 and 25
- Oil pressure switch
  - EMD terminals 39 and 40

Finally, the Ignition state can be used to determine run signal, if the ignition is in a running state the signal is set to Run.

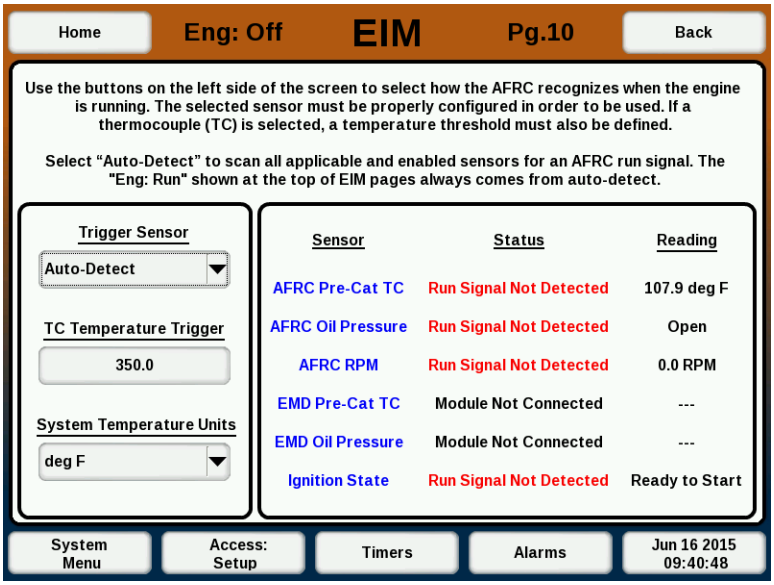


Figure 12. Run Signal Trigger Screen

	The oil pressure switch will provide a more accurate uptime and cumulative run time recording and is recommended for the EMD, if equipped.

ALARM SETUP

Up to eight (8) custom alarms can be configured on the AFRC to display within the **Alarms** screen (Pg. 40) or to trigger an external alarm though the error relay (terminal 6).

Configuring alarms is done on the **Alarm Setup** screen (Lite Pg. 305, Adv. Pg. 206) through the following parameters:

- Sensor – Input or condition to be monitored
  - Only enabled sensors are available for selection
- Min – Minimum trigger value (optional)
- Max – Maximum trigger value (optional)
- Duration – Time, in seconds, for the sensor reading to either be below the minimum trigger value or above the maximum trigger value to become active
- Action – Action to take when alarm becomes active
  - Warning – Displays the alarm within the **Alarms** screen (Pg. 40) and flashes the "Alarms" button on the footer of the display
  - Shutdown – Closes the error relay (terminal 6), displays the alarm within the **Alarms** screen (Pg. 40), and flashes the "Alarms" button on the footer of the display

It is optional to select both "Min" and "Max" values, but at least one must be selected for sensor monitoring alarms. Selecting both values is available for monitoring a condition within a window, if desired.

Figure 13. Alarm Setup Screen

Upon selecting the necessary information, the alarm is enabled by toggling the "Enable" toggle box next to the sensor's name.

	Modifying an existing alarm requires the "Enable" toggle box to be toggled off and back on to take effect.

	A sensor can be placed in two alarm rows. For example, a PostCat TC alarm could be configured to shutdown at 1250, and generate a warning at 1000.

AutoControl Range Alarm

If AutoControl is used on the AFRC Advanced, the final alarm in the **Alarms Setup** screen (Pg. 206) is the "AutoControl Range" alarm. This alarm can be used to fall back from "AutoControl" to "Setpoint" mode in the event the Post Catalyst O2 sensor milliVolt reading is pushed outside the set range, which can indicate the sensor is failing.

On a trigger of the alarm condition, the AFRC will go into "Setpoint" mode with a target setpoint valve defined by the alarm. The default is "777". To change the fallback setpoint value, select the "Setpoint: 777" button within the alarm row.

This event will trigger an alarm, AFR062 (min trigger) or AFR063 (max trigger), on the **Alarms** screen (Pg. 40). This alarm must be reset in order to switch back from "Setpoint" mode to "AutoControl" mode. A security access level of *Setup* or *Engineering* is required to reset the alarm.

CONTROLLING THE ENGINE

RUNNING THE ENGINE

Detecting the Run Signal

With the engine running, the AFRC will detect the engine operation through the sensor trigger defined within the **Run Signal Trigger** screen (Pg. 10). If a valid run signal is recognized, the black text in the header next to the "Home" button will display "Eng: Run".

Sensor Warm Up

Upon detecting the system run signal, the bank status within the control box will display "Heater Warmup" indicating the sensors have been started. After the sensor heaters are warmed, the AFRC will be ready to control. When the AFRC is ready, and in "Manual" control mode, the bank status will display "Ready" and will wait until the control mode is transitioned from "Manual" to "Auto". A security level of *Setup* or *Engineering* is required to toggle the control mode.

If the AFRC is already in "Auto" mode, it will start the process for initializing control.

Load Delay

Once the sensor is warm and in "Auto" mode, the AFRC will go into a load delay. By default, the load delay waits 30 seconds before the controller starts to move the valve.

If an AFRC Advanced is used and "Auto Control" is enabled, the controller not transition to delay mode until the pre-catalyst or post-catalyst thermocouple read a light off temperature of 550 degrees F.

The load delay time is used to allow the engine to properly warm and load. This time can be increased by adjusting the "Load Delay" value within the **Engineering Setup** screen (Lite Pg. 304, Adv. Pg. 207). *Engineering* security access is required.

Starting Control

When starting control, the bank status will update to "Attempting To Control". The valve will automatically adjust to try and match the actual O2 reading with the desired target setpoint. As the valve finds the position that's meets the target and is stable, the status will update to "Controlling".

Optimizing the Target Setpoint

The oxygen target setpoint "Target" should be set to optimize catalyst performance. This should be conducted while the engine is at a normal operating temperature and under normal loading. An exhaust gas analyzer should be used to reach optimum performance.

If an AFRC Advanced is used and "Auto Control" is enabled, no target setpoint adjustment is necessary.

External Dynamic and "600" Series Manual Valve Adjustment

If an external dynamic or 600 series valve is in use and the desired oxygen sensor target setpoint cannot be reached, then the valve will need manual adjustments. These valves contain an external "load" screw, which must be rotated to make adjustments (for more information, refer to Appendix D of the main user manual).

STOPPING THE ENGINE

The engine may be stopped at any time. The AFRC will detect the engine has stopped based on the trigger selected on the **Run Signal Trigger** screen (Pg. 10). When using thermocouples as the run indicator ("AFRC Pre-Cat TC" or "EMD Pre-Cat TC"), the controller will detect the engine has stopped after the pre-

catalyst thermocouple drops below the trigger point (450°F by default). When using an oil pressure switch (“AFRC Oil Pressure” or “EMD Oil Pressure”), AFRC RPM, or Ignition State, the controller will immediately detect the engine has been shut down.

After the controller detects a shutdown, the digital power valve will fully open and then move to the startup position. This digital power valve cycle is repeated once after each engine shutdown to maintain calibration of the digital power valve position.