EMDEC

Operating & Troubleshooting Guide

Electro-Motive
Diesel Engine
Control

N00012EP

ELECTRO-MOTIVE

Third Edition - May 2005

Acknowledgments

The EMDEC Operating & Troubleshooting Guide has been prepared for use by qualified personnel engaged in the maintenance and repair of electronic fuel injection systems on Electro-Motive diesel engines.

Always refer to the correct electrical schematic for the specific application.

NOTE:
To ensure compliance with emission standards and warranty conditions, use only by O.E.M. certified replacement pads. Consult the appropriate Service Parts Catalogue for the application.

This publication was produced and illustrated for Electro-Motive Diesel Inc. by International Technical Services, 400 Queens Avenue., London ON Canada N6B 1X9. Tel. (519) 439-2362 Fax. (519) 675-1868.

Table of Contents

Chapter 1 Introduction and System Development

Chapter 2 EUI Fuel Delivery System

Chapter 3 Electronic Injection Equipment - Fuel Components

Chapter 4 EMDEC Electronic Components & Operation

Chapter 5 Load Control

Chapter 6 Diagnostic Tools

Chapter 6
cont.

Chapter 6 cont.

Chapter 7 Maintenance Procedures

Chapter 7
cont.

Chapter 8 Troubleshooting

Chapter 8
cont.

Chapter 8 cont.

Introduction & System Overview

1

1.1 INTRODUCTION

This manual has been prepared for personnel involved in the maintenance and repair of the General Motors EMDEC (Electro-Motive Diesel Engine Control) fuel injection system. This electronically-controlled fuel delivery system is currently available for the 710 series, and 265H series diesel engines, and as a retrofit to appropriate older engines. EMDEC is applicable to rail, power, marine, and industrial applications.

This text is intended to provide a solid workable knowledge of the basic EMDEC system, its components, operation, and troubleshooting.

Due to the significant variations between equipment applications, the system used in this presentation reflects a basic configuration. Always refer to the correct Engine Maintenance Manual (EMM), and wiring schematic for specific service data.

EMDEC system diagnostics may be performed using a laptop computer with a diagnostic program called "WIN-EMMON", and in some locomotive applications, by using the EM2000 control computer. This text will illustrate diagnostic techniques for both situations.

1.2 REASONS FOR DEVELOPMENT OF EMDEC

The EMDEC system was developed to allow for a number of improvements in engine performance. Electronic control of a fuel injection system aids in improved fuel economy, and a reduction in certain types of exhaust emissions. This is made possible by the system's ability to sense changes in engine or ambient conditions, and adjust fuel delivery rates and injection timing to compensate.

An additional benefit is the ease with which the system can be modified. By altering the programming within the control modules, the same physical components can be used on different engines, or for different performance ratings.

1.3 EMDEC COMPONENTS

The EMDEC system consists of several main components that are common between most engine applications. These components will be examined in detail later in the text. A brief description follows.

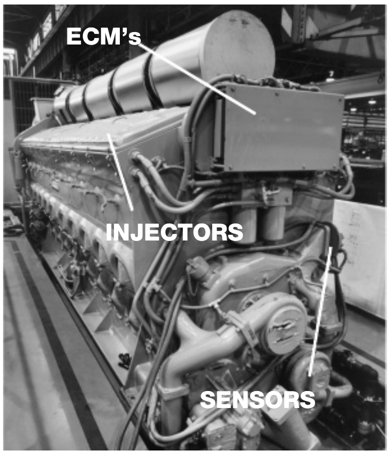


Figure 1.1 *EMDEC Main Components*.

1.3.1 Engine Control Modules (ECM's)

The Engine Control Modules perform all the functions of the Woodward governor such as injection control and engine protection. They are self-contained microprocessors, individually programmed for a specific application. Through internal wiring harnesses they are connected to the injectors and various sensors. "Cold Plates" (if applied) use return fuel to stabilize the temperature of the units and are attached to the front face of the ECM's

1.3.2 Electronic Unit Injectors (Two-Stroke)

EMDEC equipped two-stroke EMD engines use electronically-controlled unit injectors. The injectors are fitted to the cylinder heads in a similar manner to the mechanical style. However, instead of a mechanical linkage, a wiring harness connects each injector to its controlling ECM.

Figure 1.2 *EUI Injector.*

1.3.3 Electronic Fuel Pumps & Injectors (Four-Stroke)

Unlike the unitized injector on the 710 series of engines, the 16V265H engines are currently equipped with separate fuel pump and injector (nozzle) assemblies for each cylinder. Although separate components, they function in a manner identical to the unitized assembly. Bosch manufactures the four-stroke injection equipment to EMD specifications. Like other EMDEC applications, all fuel pumps are connected to the controlling ECM by an electrical harness.

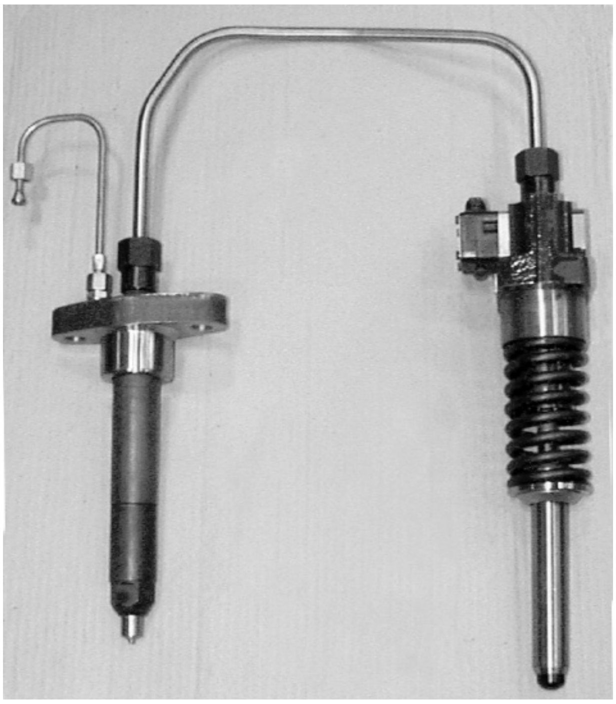


Figure 1.3 *Injection Pump & Nozzle for H-Engine*.

1.3.4 Sensors

EMDEC uses various sensors to determine crankshaft speed and position, system pressures, andtemperatures. The sensors are connected to the ECM's by means of external wiring harnesses .

1.3.5 Power Supply & Interface Module

The 24 volt power supply and interface module converts control system voltage into a stable 24 volts, as required by the EMDEC components.

In addition, the interface module allows for communication between the injection system and the control system. Speed inputs forexample, are converted from the solenoid commands found on a Woodward governor, into RPM requests that are understood by the EMDEC system.

1.3.6 Conclusion

EMDEC is by no means a ***finished*** system. As system and performance requirements change, the components and programming are being refined to better meet the needs of our customers. Older applications are upgraded to reflect the changes and maintain commonality of components.

1.3.7 EMDEC Glossary Of Terms

ECM	Engine Control Module.
EM2000	Locomotive control computer.
EMDEC	Electro-Motive Diesel Engine Control.
Engine Ratio	Expression of amount of fuel being consumed as a percentage of total available fuel at a given engine speed.
Engine_R	Engine ratio as seen on the EM2000 computer.
EUI	Electronic Unit Injector
MUI	Mechanical Unit Injector
Pulse Width	Duration of an injection sequence, measured in degrees of crankshaft rotation.
SRS	Synchronous Reference Sensor, used for timing and speed signal.
TRS	Timing Reference Sensor, used for timing and speed signal.
PID	Parameter ID.
SID	System ID.
MID	Message ID.
EHC	Engine Harness Connector.

Notes:

1

Notes:

EUI Fuel Supply System

2.1 INTRODUCTION

In operation, the basic fuel supply systems usedwith EMDEC-equipped engines function similar to MUI equipped systems. Major differences include filtration, fuel pressures, and fuel volume. This section of the text will trace the fuel flow through twotypical systems, those applied to typical 710 applications, and as applied to the 6000 HP 265H application. Due to the differences between equipment, always refer to the specific service publications foryour applications.

2

2.2 THE 710 TYPE FUEL SUPPLY SYSTEM

The function of the fuel supply system is to provide the injectors with a supply of filtered fuel in quantity, and at pressures adequate to ensureproper performance. Figure 2.1 on the following page shows the basic system as configured for a typical 710 engine locomotive application.

NOTE:

Before performing maintenance or diagnostics on the fuel system, ensure that the proper system schematic is available for reference.

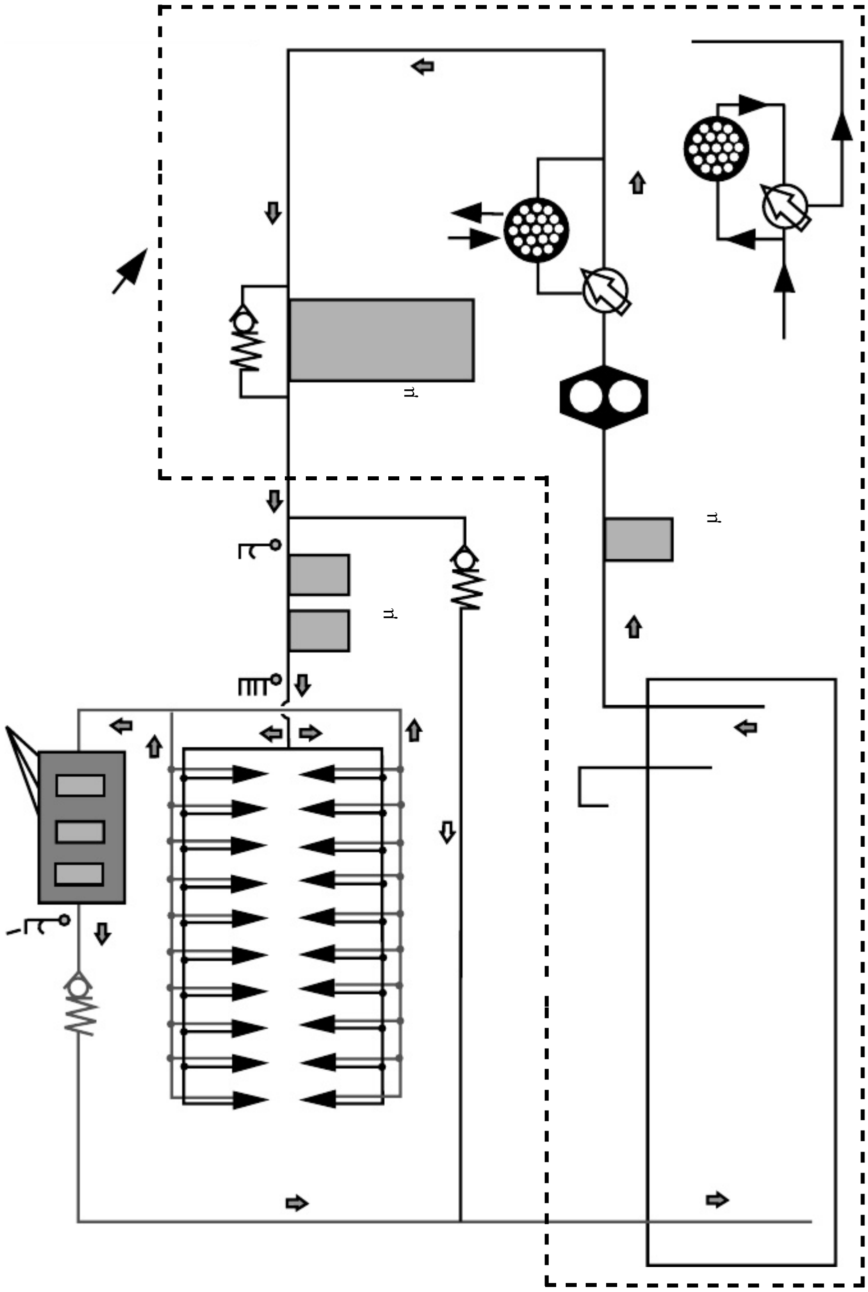


Figure 2.1 *Typical 710 Type EUI Fuel System.*

2.2.1
Suction Strainer

As in the MUI system, fuel is pulled from the fuel tank through a suction strainer by the fuel pump. This strainer, mounted on the equipment rack *(figure 2.2)* protects the fuel pump from any large debris contained in the tank.

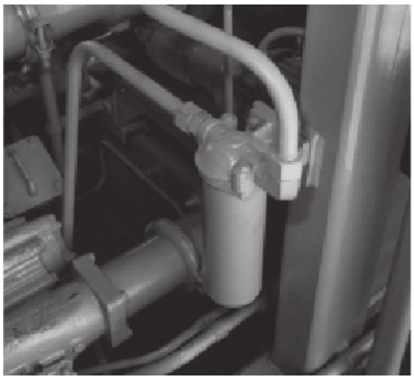


Figure 2.2 *Suction Strainer.*

2.2.2
Fuel Pump

The fuel pump *(figure 2.3)* is typically mounted on the equipment rack. The pump has been increased in capacity over MUI systems, with output between 5.5 and 8 GPM depending on the application. While still supplied with 74 VDC from the control system, the motor carries its own inverter pack, and operates on AC to eliminate brush and commutator maintenance.

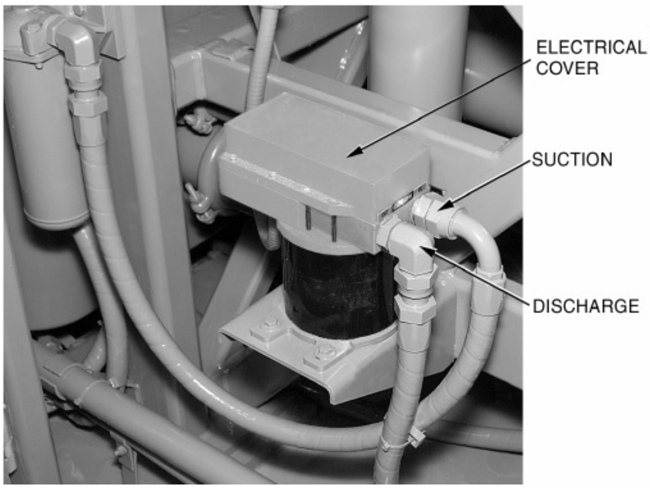


Figure 2.3 *Fuel Pump.*

2.2.3

Fuel Preheater & Primary Fuel Filters

Most EUI systems are equipped with a fuel preheater and thermostatic modulating or AMOT valve *(figure 2.4)*. Inlet fuel temperature is monitored by this valve, which has a setting of 75° F(96° F on previous locomotive models). Should fuel temperature drop below the nominal setting, fuel will be directed through the fuel preheater where it is warmed by engine cooling water.

Fuel next flows to the 13 micron primary fuel filters *(figure 2.4)*. These filters are equipped with a bypass valve that will allow fuel to flow around the filters to the engine, if the filters plug. Should the filters begin to plug, the pressure will increase in the line between the primary filters and the fuel pump.

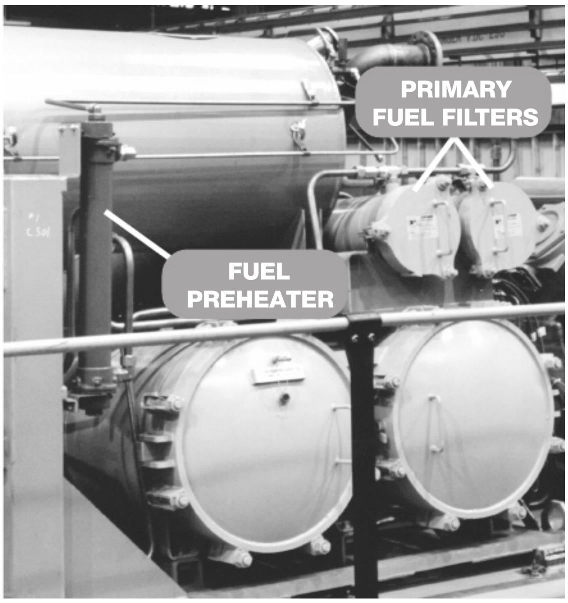


Figure 2.4 *Fuel Preheater and Primary Fuel Filters.*

The bypass begins to open *(crack)* at 25 psi, and is fully open at 30 psi. Any impurities in the fuel will be trapped by the secondary filters which will quickly plug.

On certain EUI applications, pressure transducers have been added to the filter inlet and outlet lines, connected to the control system. Should the pressure differential across the primary filters exceed 25 psi, the control system will indicate a plugged filter condition.

On later models without spin-on secondary fuel filters, primary filters are 5 microns and the bypass valve is located between the fuel pump and the thermostatic valve to direct fuel to the tank in the event of plugged filters.

2

2.2.4 Fuel Block

From the primary filters, fuel now travels to a fuel block at the bottom right front of the engine from which 3 steel tubes *(or flexible hoses on some applications)* run vertically up to the Secondary Spinon Fuel Filter Manifold. This fuel block feeds fuel to the Spin-on Fuel Filter Manifold and receives return fuel from the engine. The 3 fuel lines coming from the block are:

- the return to the fuel tank (closest to the engine),
- the fuel supply (middle line), and
- the filter bypass fuel return to fuel tank (third line).

2.2.5

Secondary Fuel Filter Manifolds

In early models the fuel enters the Spin-on Secondary Fuel Filter Manifold. Depending on the application, this manifold may be:

- mounted on the right front corner of the engine *(figure 2.5a)*,
- mounted on the front center of the engine *(figure 2.5b)*,

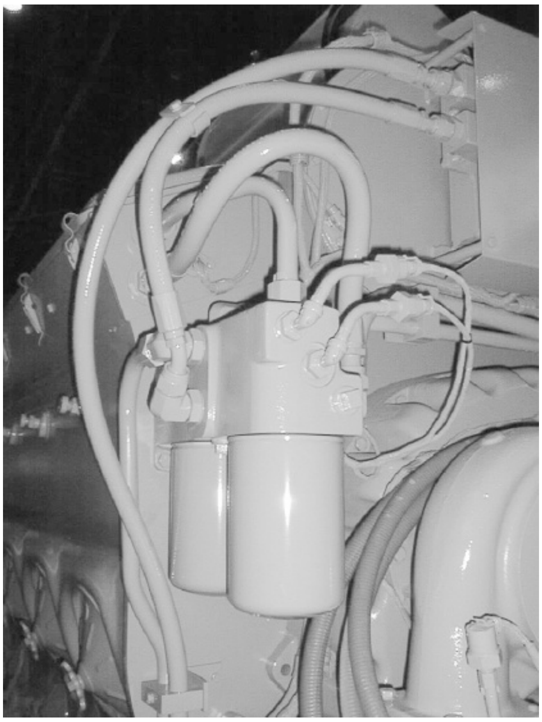


Figure 2.5a *Fuel Filters Mounted On Right Front Corner Of The Engine..*

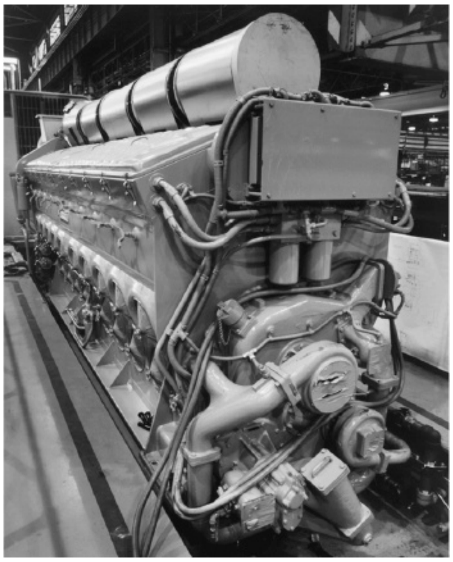


Figure 2.5b *Front Mounted Filters.*

NOTE:

Due to the increased fuel pressure and risk of fuel leaks at this location, the sight glasses have been eliminated on later EMDEC applications.

Figure 2.5c *Engine Without Front Mounted Filters.*

Regardless of the mounting application, internal porting within the manifold allows the fuel to flow to the cracking side of the high pressure filter bypass valve, and both spin on secondary filters. Bypass valve is located internally in the housings without sight glasses. On EUI applications, these filters have a 5 micron rating. The element size has been increased from previous systems to allow a greater fuel flow rate. Fuel pressure is monitored by EMDEC at this point, by means of a pressure transducer located in the upper left-hand portion of the manifold, when facing the front of the engine.

NOTE:

In previous models, if the primary fuel filters are bypassing, the Secondary Spin-ons will quickly plug up. Back pressure between the secondary filters and the fuel pump will rise, causing the high pressure bypass valve to open. Fuel will flow through the high pressure bypass valve and from there back to the fuel tank. Unlike the primary bypass, when the secondary filters plug, the engine will starve for fuel causing major performance problems. Changing of both primary and secondary fuel filters is mandatory on all EMD engines.

Under normal conditions, fuel flows from both secondary filters into a common line inside the fuel filter manifold. At this point, a temperature sensor has been installed to allow EMDEC to monitor fuel temperature.

For applications with the filter mount on the front right corner of the engine, fuel leaves the manifold and enters a ported fuel distribution block mounted on the front center of the engine. From this fuel block, supply lines connect to the right and left bank fuel manifolds to supply the fuel injectors. On engines with the filter manifold mounted in the center of the engine, fuel is routed directly to the fuel manifolds in the top decks of the engine.

Fuel travels down the upper line of the manifold, down each bank of the engine, terminating at the last cylinder on each side. Note that the fuel manifolds have been increased in size to 7/8" diameter.

2

2.2.6 Fuel Injectors

Each injector is supplied with fuel through fuel jumpers as on MUI systems. The jumpers however, are now a flexible line with a larger diameter *(figure 2.6)*. The fuel enters the fuel injectors through a small in-line filter element, then circulates through the injector's internal passages. A portion of the fuel is used for injection, the remainder is returned to the fuel tank. Note that lubrication and cooling of the fuel injector is done with this excess fuel flow as in previous systems. For a more detailed operation of the injector, refer to Chapter 4.

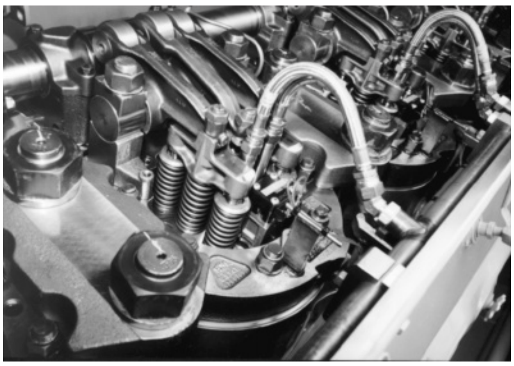


Figure 2.6 *Electronic Fuel Injectors.*

2.2.7 Return Flow

Fuel now leaves the injector through the jumper line to the lower line of the fuel manifold. In previous models, the return fuel flow from the manifolds is routed through cold plates (if applied) attached to the front face of the ECM's. The cold plates consist of a block with milled fuel passages covered with a thin plate. As return fuel temperature is nominally 120 - 140° F and does not change quickly, this fuel is used to stabilize the temperature of the ECM's.

2.2.8 Check Valve

From the cold plates, the return fuel is directed to the return fuel check valve.

> **NOTE:**
> This check valve may have a rating between 30 and 60 psi, depending on application. Ensure that you consult the Engine Maintenance Manual for the correct check valve application.

On previous systems equipped with sight glasses, this valve is located under the return fuel sight glass *(closest glass to the engine)*. On most EMDEC systems, the valve is mounted inside the filter manifold block. The check valve ensures that the system maintains back pressure for proper injector operation. Note that system pressures have been increased on EMDEC engines. Always refer to the appropriate Engine Maintenance Manual for correct system pressures.

After passing through the return fuel check valve, the fuel is directed down through the fuel block on the lower right front corner of the engine, then back to the fuel tank.

2.3 265H TYPE FUEL SUPPLY SYSTEM

While the basic fuel supply system applied to H engines performs the function as the 710 type systems, there have been several major changes to the operation.

2.3.1 Fuel Tank

The fuel supply system (*figure* 2.7) begins with the fuel tank (a).

The tank is equipped with drains for the fuel side and the retention tank portion.

2

2.3.2 Suction Strainer

Fuel is drawn up to the engine through the suction strainer (b) that serves to protect the fuel pumps. Certain 265H engine applications are equipped with two fuel pumps, one electrically-driven (c), and one mechanically-driven (d).

2.3.3 Fuel Pump

The electric fuel pump is used for priming the engine prior to startup; normal engine operation is with the mechanical pump only.

The electric fuel pump is a diaphragm-type pump controlled by the EM2000, and is mounted below the equipment rack. During fuel prime, the pump draws fuel from the tank through the suction strainer and supplies the system through the fuel filter.

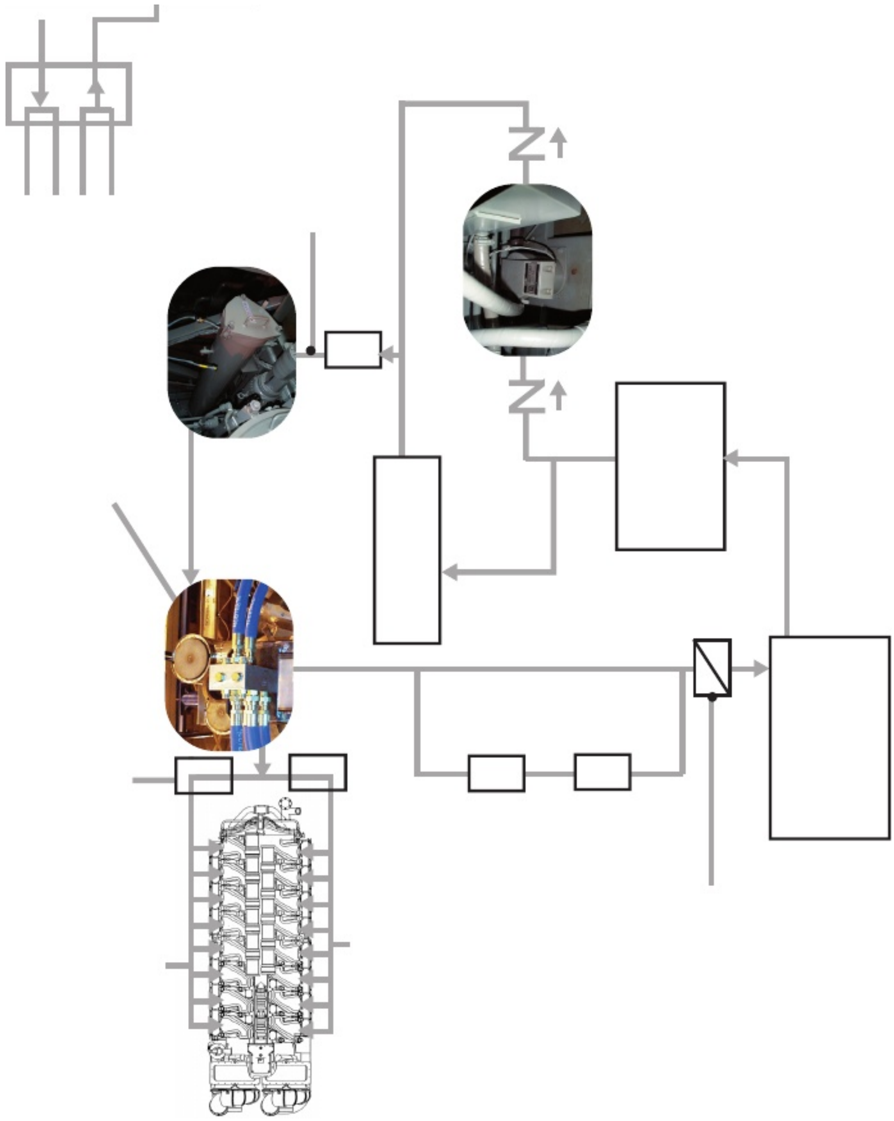


Figure 2.7 *Fuel Supply System.*

2.3.4 Fuel Filter

The fuel filter (e) is a paper element type rated at 13 microns and is equipped with a 25 psi bypass valve. Note the increased size of the filter to handle the greater flow rate of the new system.

2.3.5 Fuel Distribution Block

From the filter, fuel is transferred to the fuel distribution block (f) mounted on the front of the engine. Flow is divided at this point and directed to the supply rails (g) running down each bank of the engine.

2

At each cylinder location, flexible jumpers carry a supply of fuel to the rocker box housing, then with internal jumpers, across to the pump body.

2.3.6 Injection Pumps

The injection pumps use a portion of the fuel supply for engine operation, the remainder carries excess heat from the pumps back to the return side of the system. Through another set of flexible jumpers, return fuel is routed into left and right bank return fuel rails (h). At the front of the engine, fuel is directed from each return rail to a cold plate mounted to that bank's ECM to stabilize temperatures within the unit. From the cold plates, fuel then travels to the fuel distribution block where a return check valve ensures proper system back pressure. Excess fuel now is sent back to the tank.

Notes:

Electronic Injection Equipment - Fuel Components

3.1 INTRODUCTION

The two-stroke EMD engine has used a unitized fuel injector design throughout its history. While this feature has been retained for the 710 series of EMDEC-equipped engines, the Electronic Unit Injectors (EUI) are of a slightly different design and use a different control system. Electronic engine control is now installed on all new production engines.

3.2 710 SERIES ELECTRONIC UNIT INJECTOR

The EUI's *(figure 3.1)* still perform the same functions as the previous system's mechanical unit injectors (MUI's). They meter, time, pressurize and atomize the fuel. However, the functions performed by the Woodward governor have been taken over by the Engine Control Modules (ECM's). The lay shaft and injector racks have been replaced by a wiring harness. The helix and barrel assembly of the MUI has been replaced by a solenoid, and hollow poppet valve located on the new injector.

Currently there is one type of EUI available for all 710 engine applications.

Figure 3.1 *Electronic (EUI) and Mechanical (MUI) Injectors.*

The EUI may be broken down into three basic sections - control, high pressure pump, and injector *(figure 3.2)*.

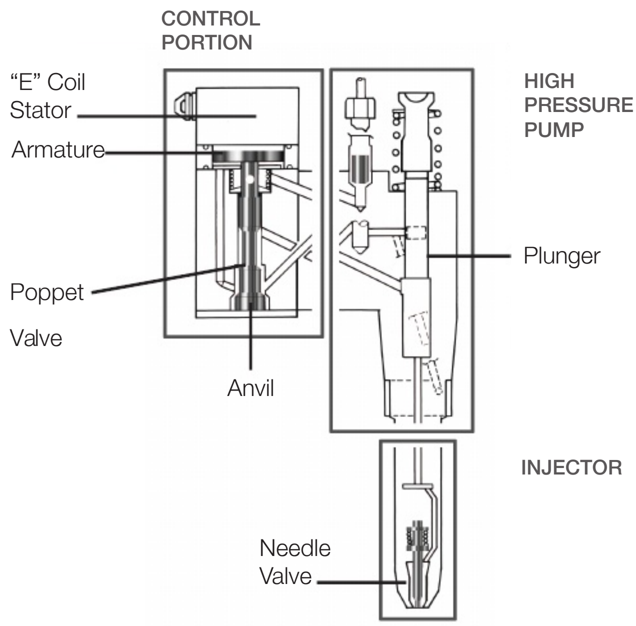


Figure 3.2 *Breakdown of EUI.*

3.2.1
Control Portion Solenoid

The control section consists of a solenoid, armature, return spring, hollow poppet valve, and body portion. The solenoid mounted to the top of the body portion is an “E” coil stator connected to its controlling ECM by a wiring harness. The solenoid is nothing more than a precision wound coil that magnetizes when power is applied by the ECM. As a note, the stator is not polarity sensitive, it does not matter how the wires are connected to the terminal screws.

3.2.2
Armature

Below the stator is a spring-loaded armature assembly. The armature consists of a flat plate that is drawn upwards towards the coil when it is energized. When the coil is de-energized, the return spring moves the armature downwards.

3.2.3
Hollow Poppet Valve

Connected to the armature is the hollow poppet valve. This valve controls the flow of fuel through a passage formed by the poppet, and by the seat area of the body portion. Controlling the flow of fuel at this point is what actually controls the injection pulse. This will be discussed in detail in the next section - Operation. To reduce the risk of poppet damage due to the high pressures involved in injection, the poppet has been plated with a thin layer of titanium. Note also that a bench, or rest has been installed below the poppet valve to limit the downwards motion of the poppet.

3.2.4 High Pressure Pump Portion

The high pressure pump portion is made up of the plunger assembly and the injector body portion. The plunger is operated by the camshaft through the injector rocker mechanism, similar to a mechanical injector. Downwards motion of the plunger is used to generate the high pressures required for injection. Note that the diameter of the plunger is slightly smaller than the diameter of the cylinder. The fill passage for the pump chamber is located at the upper left corner in the illustration. At no time is this passage blocked by the plunger, which simply acts to displace a volume of fuel in the chamber.

3.2.5 Injector Portion

The actual injector forms the lower portion of the assembly, and protrudes into the combustion chamber. The injector is comprised of a check valve, needle valve, needle valve spring, and spray tip. The spray tip has orifices that atomize the fuel as it is forced through the tip into the combustion chamber.

3.2.6 Fuel Flow Through The EUI

Fuel flows from the flexible jumper line to the EUI, entering through its inlet filter located in the body of the injector. Refer to figure 3.3 which shows the fuel flow in the EUI in the de-energized state *(no injection)*.

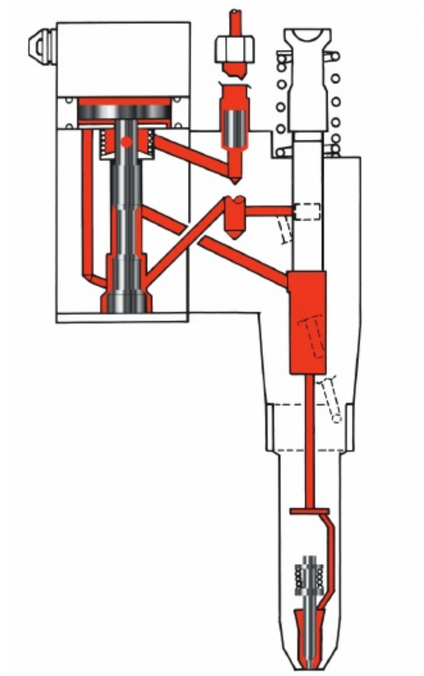


Figure 3.3 *Flow of Fuel Through EUI (no injection).*

An internal passage directs fuel to the control portion of the injector, filling the armature chamber below the "E" coil stator. The flow of fuel through the armature chamber cools the stator and armature, also providing lubrication for components. From this chamber, fuel is allowed to flow through a passage in the body of the injector to the lower fuel chamber.

An additional flow of fuel to the lower chamber is through a passage to the hollow center of the poppet valve. Fuel flows through the valve into the lower fuel chamber to provide cooling of the valve. As the fuel enters the lower chamber, the flow splits, with most of the fuel leaving the injector through the return passage to the return fuel jumper line. From there it travels through the return system to the fuel tank.

If the injector is de-energized, the poppet valve is open allowing fuel to flow upwards around it. This fuel travels into a drilled passageway to fill the high pressure pump chamber below the plunger. As in the previous systems, it is important to note that most of the fuel sent through the injector is used for cooling and lubrication; only a small amount is actually used for injection.

3.2.7 Operation Of The EUI

The EMDEC electronic unit injector is both electrical and mechanical in operation. It performs the functions of metering and timing electronically, while the functions of pressurizing and atomizing are still done mechanically.

The metering and timing functions are controlled by the ECM's, which "fire" each individual EUI at a precise point in time for a specific duration.

This action is based on the software program contained in the ECM's and "inputs" into the ECM's such as:

- speed requests from the control system via the interface module,
- timing and speed data from the timing pick-ups,
- engine and ambient conditions from the various EMDEC sensors.

3.2.7.1 Start Of Injection

The easiest way to understand the operation of the EUI is to follow it through a typical injection sequence. Refer to figure 3.4 for the flow of fuel through the injector during an injection sequence.

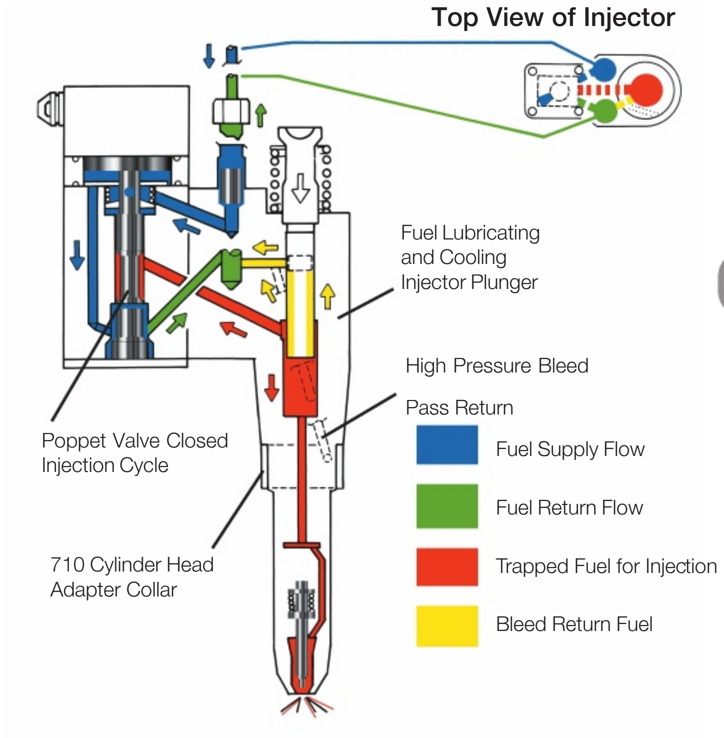


Figure 3.4 *Flow of Fuel Through EUI (during injection).*

3

3.2.7.2

Piston Rises In Cylinder

As the piston rises in the cylinder, the fresh air charge is compressed, raising the temperature to a level that will ignite atomized fuel. At the same time, the camshaft and rocker mechanism begin to drive the injector plunger downward. Note that although the plunger is moving into the chamber, no pressure is generated. Because the fill passage is not blocked and the poppet valve is open at this point, the fuel that is displaced by the plunger simply travels back through the poppet valve into the lower fuel chamber.

3.2.7.3

Fueling Decisions

Based on the software in the ECM's, and timing, speed and performance inputs into the ECM, these devices will make a fueling decision. They will decide at what point to energize the injector solenoid, and what duration the injector is to remain energized. At the precise point in time the respective injector is to fire, the ECM generates a control signal to the solenoid through the wiring harness.

3.2.7.4

Injection

When the solenoid is energized, the armature and poppet valve move upwards until the poppet contacts the seat in the body portion, closing the passage around the poppet. Remember that the plunger is moving downwards in the pump chamber, displacing the fuel contained in the chamber. With the poppet closed, this fuel is now trapped with no outlet. The pressure of the fuel in the chamber instantly begins to rise. Note that the shape of the poppet valve prevents pressure in the pump chamber passage from pushing the poppet open. Since the fuel pressure pushes outwards in all directions, the force exerted on the poppet balance is not affected by fuel pressure.

The high pressure generated in the pump chamber is also transmitted downwards to the spray tip through the column of fuel and the check valve. As the pressure increases, it pushes outwards in all directions in the tip area, including backwards against the tapered surface of the needle valve. When the pressure in the tip area has reached between 2000 psi and 2400 psi, the needle valve will be lifted off its seat against the needle valve spring. This allows fuel to flow through the needle valve and the orifice holes in the spray tip, into the cylinder.

3

The continued downwards motion of the plunger causes the pressure in the injector to rise to the final working pressure of between 16,000 psi and 18,000 psi. Note that once injection has begun and the injector has reached the final working pressure, the flow rate of the tip cannot be changed. For a given period of time, the injector will deliver a measured quantity of fuel. As with any injection system, what has to be varied is timing*(start of injection)* and duration *(pulse width)*. The injector will continue to inject fuel into the cylinder as long as: a) the solenoid is energized, and b) the injector plunger is moving downwards.

With the mechanical system, timing was set initially and could not be varied. The pulse width of all injectors were controlled simultaneously by the governor through the rack mechanism. One major advantage of the EUI system is that both *timing and pulse width* are now electronically-controlled by the ECM's for each *individual* injector. This allows the system to better compensate for changing engine and ambient conditions.

3.2.7.5

Bleeder Passages

There are two additional passages shown in the illustration. These "bleed passages" prevent the escape of high pressure fuel to the outside of the injector.

During the high pressure process, fuel bleeds upwards around the EUI's plunger for lubrication. This fuel is collected in the bleed passage and fed into the EUI's fuel return system to prevent further migration upwards. Due to the extremely high pressures involved, some leakage will take place between the components above the injector tip. A second bleed passage gathers fuel in this area to prevent leakage between the body portion and the lower housing. Again, this fuel is fed back to the low pressure return system of the EUIs.

3.2.7.6

End Of Injection

When the ECM has determined that injection should cease, it simply "turns off" the injector by de-energizing the solenoid. This allows the armature return spring to drop the armature and poppet valve against the bench in the lower fuel chamber.

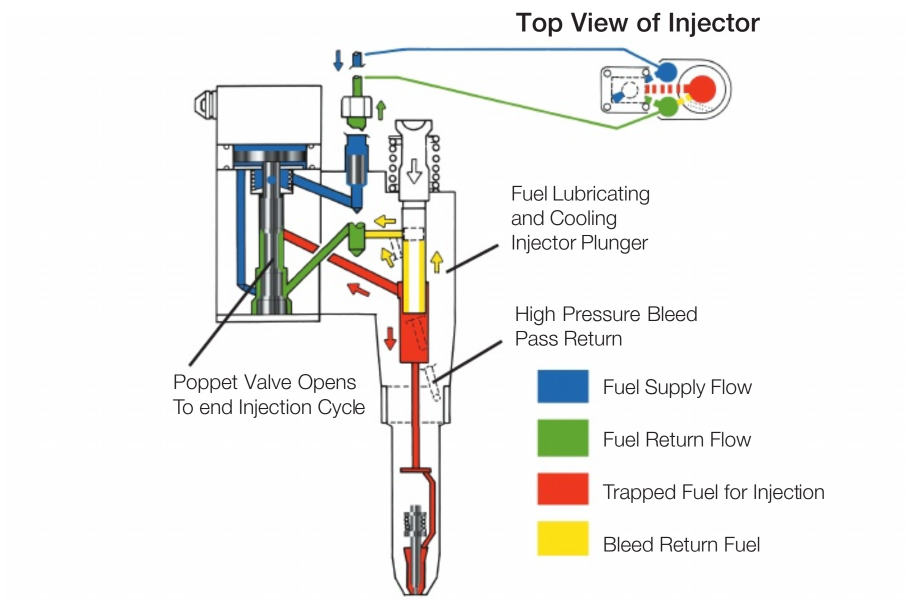


Figure 3.4 *Flow of Fuel Through EUI (end of injection).*

As the poppet valve opens, the high pressure fuel in the pump chamber is allowed to escape back through the valve to the return fuel system. The pressure in the chamber drops instantly to end injection. When the pressure coming from the pump chamber to the injector tip drops below 2000 psi, the needle valve return spring pushes the needle valve back against its seat to close the passage through the tip to the spray orifices.

Note that the check valve in the injector will not allow the flow of fuel pressure back into the pump chamber from the tip. This serves several purposes. First, by retaining a certain amount of pressure in the tip *(slightly below the injectors cracking pressure)* the response time of the injector for the next sequence is improved. Second, in the event of a leakage in the needle valve, combustion gases will not be allowed to work their way through the injector into the fuel system.

The final action in the injector is the return of the plunger to its initial position. As the camshaft mechanism rotates further, the plunger return spring moves the plunger upwards to the top position. This upwards movement draws fuel back into the chamber from the poppet valve, refilling the chamber for the next injection sequence.

3.2.7.7 Injector Feedback To The ECM (response time)

The ECM's monitor the *electronic* performance of each individual injector. As the control signal is sent from the ECM to the injector solenoid, the circuit characteristics are watched. As the poppet valve comes up against the body seat, the coil is effectively stalled. The voltage and current levels in the circuit will change as this happens, providing the ECM with a feedback.

3.2.7.8 Injector Response Time

This feedback is called injector response time. Typical response times will be in the range of 1.30 to 1.50 milliseconds. Each injector will vary slightly, but all should have *approximately* similar times. When checking injector response times using a laptop computer, any injector with a response time significantly different from the rest may indicate a faulty injector or defect in the wiring harness. The problem must be diagnosed, and corrected before the engine is returned to service.

Although the ECM's can monitor the injector's electronic performance, the mechanical portions are still subject to failure requiring more in depth diagnosis. These procedures will be covered in the section on Troubleshooting settings and adjustments are covered in a separate section.

3.3 H SERIES ELECTRONIC INJECTION EQUIPMENT

The injection pump and nozzle (*figure* 3.6) function in an identical manner to the electronic unit injector found on the 710 series of engine, however they have now been divided into two separate, larger components. The injection pump is located on the upper right corner of the cylinder head, and is driven directly off the camshaft by a short pushrod and cam follower. As the cam rotates, the lobe forces the follower and pushrod upwards, in turn pushing the injection pump plunger upwards.

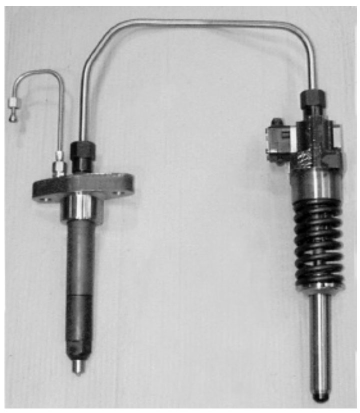


Figure 3.6 *Injection Pump & Nozzle.*

3.3.1 Pump Operation

Internally, the pump *(figure 3.7)* is similar to the pump portion of the 710 electronic injector. The plunger travels in a chamber that is connected to the fuel supply system by a fill passage. Operation of the fill passage is controlled by the Engine Control Module, using a poppet valve mechanism with a 24 volt coil. In the de-energized state, upwards movement of the plunger displaces fuel from the pump chamber, back through the poppet valve to the supply system.

3.3.1.1 Start Of Injection Sequence

When the ECM determines that injection should begin, the coil is energized to close the valve. Further upward movement of the plunger results in pressurization of the fuel in the chamber, which is delivered to the nozzle through the delivery passage and check valve.

3

3.3.1.2 End Of Injection Sequence

On completion of injection, the poppet is de-energized to release the fuel pressure back to the supply system. The downward return stroke of the plunger will draw a fresh volume of fuel through the open poppet and fill passage, to refill the pump chamber.

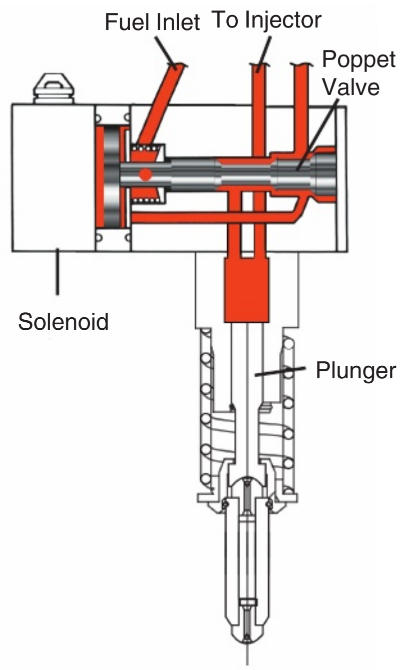


Figure 3.7 *Injection Pump.*

3.4 INJECTOR OPERATION

The injector (*figure* 3.8) is mounted on the top of the cylinder head on the vertical centerline of the cylinder. The injector receives a supply of high pressure fuel from the pump through the high pressure jumper line during the injection cycle. As the fuel pressure rises due to the closing of the poppet valve, the pressure builds internally in the nozzle. When the pressure is sufficient to lift the needle valve off its seat against the spring, fuel is allowed to flow into the engine cylinder through the spray tip. The fuel is atomized and mixes with the air in the cylinder for combustion. At the end of the injection phase as fuel pressure drops, the needle reseats to block the flow of fuel into the cylinder.

3.5 BLEED OR LEAK OFF LINE

The bleed off (or leak off) line serves the same function as the internal bleed passages in the older style unit injectors. Internal high pressure leakage between components in the nozzle assembly is collected and routed back to the return fuel system before it can cause fuel leaks into the top deck area, or affect injector operation. When the engine is shut down, trapped high pressure fuel in the jumper line will also bleed off to return.

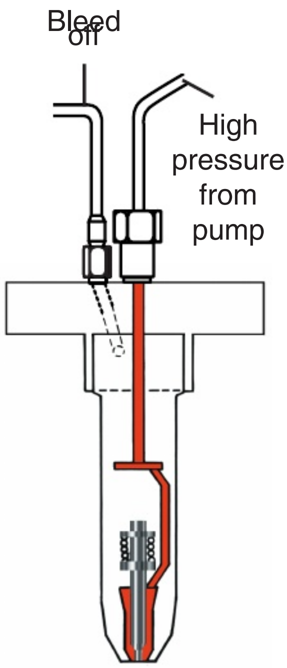


Figure 3.8 *The Injector.*

Notes:

3

Notes:

EMDEC Electronic Components & Operation

4.1 INTRODUCTION

This section of the text will concentrate on the electronic components that make up EMDEC, and how the systems function to control injection. For the purpose of instruction, a typical 16-cylinder 710 engine application is used. 265H engine applications use a similar control method.

The text will use a building block approach, discussing each component in detail as it pertains to operation. The main electrical and electronic components of the EMDEC system are:

4

1. ECM's (Engine Control Modules): The actual injection control computers.
2. Power Supply: 74 VDC to 24 VDC EMDEC power source.
3. Interface Module: Communication interface between EMDEC and the main control system.
4. Sensors: Engine sensors for pressure, temperature, and injection timing / speed inputs.
5. Wire Harnesses: External, injector, sensor and power.
6. Annunciator Panel: EMDEC Fault Panel for diagnostic functions (if equipped).

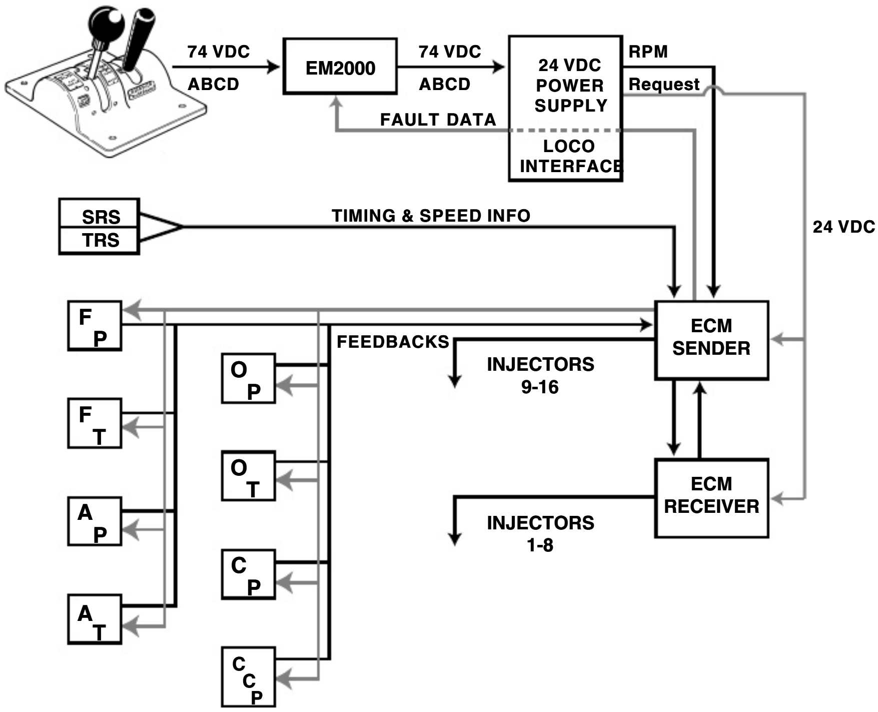


Figure 4.1 *16-Cylinder EMDEC System.*

Figure 4.1 shows an overview of a typical EMDEC locomotive application for a 16-cylinder 710 series engine *(actual componentry may differ slightly between applications)*. At the heart of the system are the ECM's, or Engine Control Modules that perform all control functions. The ECM's receive control signals from the main control system through the interface panel. This panel is part of the power supply that steps down the 74 VDC input voltage to 24 VDC for use by EMDEC. Attached to the ECM's are the various sensors used for performance and protective data, and the injectors themselves. On certain applications, an annunciator panel may be fitted for diagnostic purposes.

We will now examine each component in more detail and "build up" a functional EMDEC system

4.2 ENGINE CONTROL MODULES (ECM'S)

As stated before, the main components of the system are the engine mounted ECM's. These units are self-contained microprocessors that operate on 24 VDC. Each ECM has the ability to control up to 8 injectors.

Therefore, the number of ECM's applied depends on the engine configuration for example:

- 8-cylinder engine has one ECM.
- 12-cylinder engine has 2 ECM's (right bank 1 thru 6, left bank 7 thru 12).
- 16-cylinder engine has 2 ECM's (right bank 1 thru 8, left bank 9 thru 16).
- 20-cylinder engine has 3 ECM's (right bank 3 thru 10, left bank 13 thru 20, center (1,2,11, and 12).

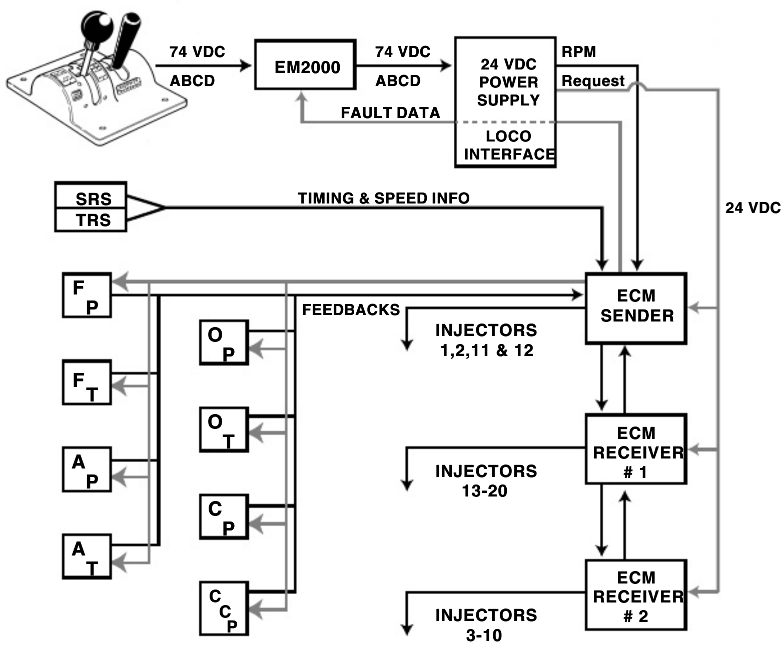


Figure 4.2 *20 Cylinder EMDEC Locomotive Type System.*

Physically all ECM's are identical, but the software is different for each unit. Every application has one ECM designated as a sender (or controlling) ECM. The software provides the units identity as well as the application specific operating parameters (speed schedules for example). The sender is responsible for primary data processing, and overall control of engine functions. The remaining ECM's carry the designation of receiver(s).

Receiver ECM's are controlled by the sender ECM, which provides basic information such as injection pulse width (fuel amount), and base injection timing. Remember, the number of receiver ECM's depends on the number of engine cylinders. The software allows for some independent operation of the unit, and engine RPM requests and basic timing feedbacks are fed to the receiver(s), independent of the sender. This will allow the system to overcome intermittent communication problems between the sender and receiver(s).

4.2.1 Arrangement

The location of the ECM's on the engine will vary depending on application.

Early 16-cylinder 710 models have the ECM's mounted on the sides of the engine near the front end, symmetrically opposite each other.

The sender ECM will be located at cylinder number nine (left front), and the receiver ECM at cylinder number one (right front).

Later 16-cylinder and all 12 and 20 cylinder 710 models have the ECM's located on the front camshaft housing cover.

The sender will be on the left side of the engine and the receiver on the right (16-cylinder).

Current 16-cylinder 710 G3C-2T models have the ECMs located on the electrical locker near the door. The sender will be on the top side and the reciever will be on the bottom.

All 256H engines have the ECM's mounted on the front of the engine. Note that on some applications, the ECM's may be mounted in a remote location adjacent to the engine.

Cold Plates (if applied) are attached to the front face of each ECM.

The ECM's are connected to each other, to the interface module, to all sensors, and to all injectors by means of external and internal wiring harnesses. System diagrams showing the various plug connections, and component and sensor locations on a typical application may be found in **Appendix A**.

Ensure the proper schematic is available for reference

before performing any diagnostic tasks on this equipment. In order for the ECM's to operate, they must receive a constant 24 VDC from the power supply, and a speed input from the control system via the interface module. The operation of this power supply and interface module will be discussed next.

4.3 POWER SUPPLY

In previous models, the Power Supply*(figure 4.3)* on the following page is located in the AC Cabinet towards the rear of the locomotive. Later models have the power supply located in the electrical locker near the door.The function of the power supply is to step down and filter the 74 VDC control system voltage to 24 VDC. EMDEC was srcinally designed for heavy truck type applications, therefore operates on a system voltage of 24 VDC. The output of the power supply is fed directly to the interface module, and through a power harness, to the engine mounted ECM's.

In applications other than locomotive, control system voltage will be filtered and regulated to provide a stable 24 VDC supply. While the appearance of the power supply will be different, the function remains the same.

The Power supply is fed through the engine control circuit breaker located on the fuse and circuit breaker panel. Note that both the positive and negative sides of the circuit are protected. The power supply is equipped with two LEDs (light emitting diodes) on its face to indicate status.

The green LED (normally on) indicates that the power supply is producing 24 VDC. The red LED (normally off) illuminates during an over-current situation. This LED could indicate a problem in the ECM's, wiring harness, or in the power supply itself. In this situation it will be necessary to isolate the components of the system in sequence, to determine where the fault is located.

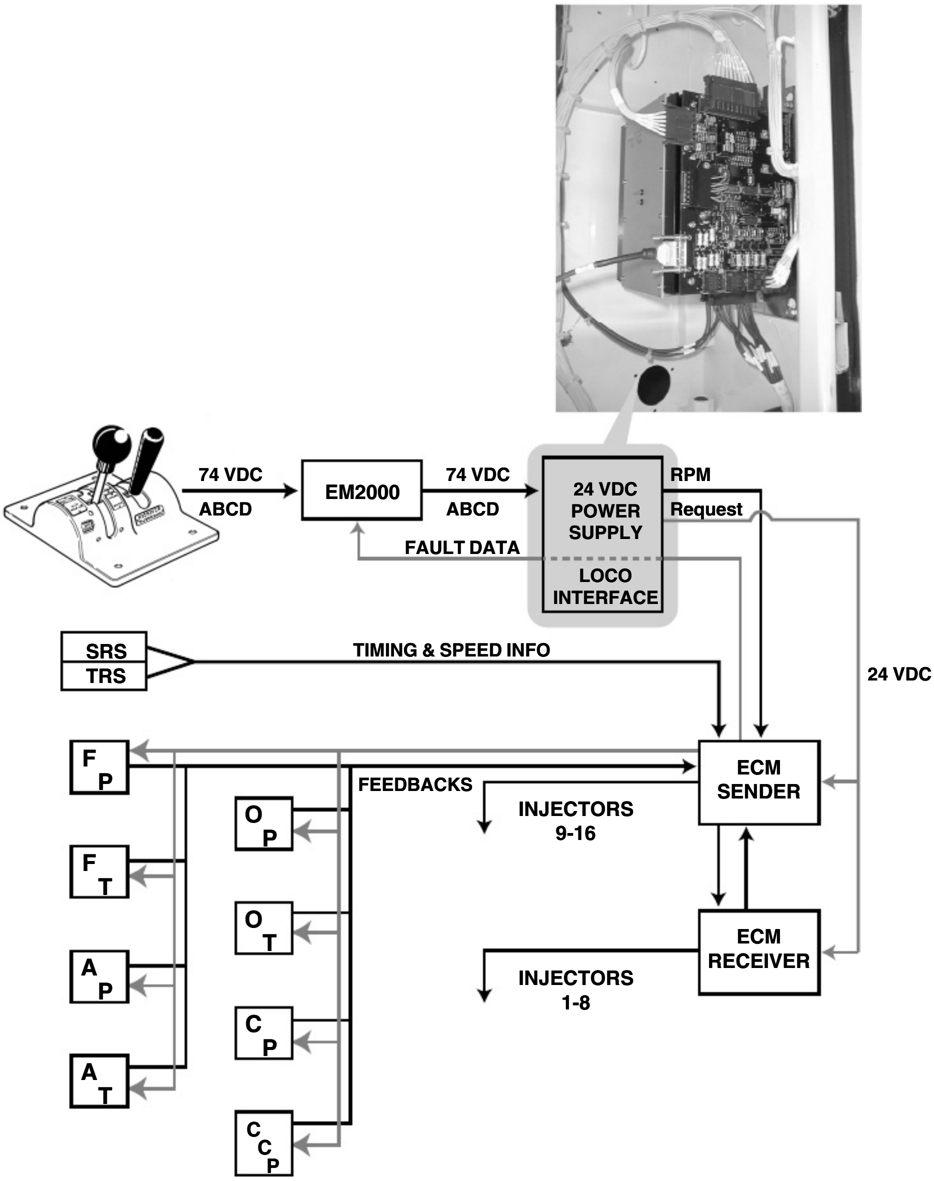


Figure 4.3 *Power Supply & Interface Module.*

4

4.4 INTERFACE MODULE

In previous models, the Interface Module is located in the AC cabinet of the locomotive, and is typically mounted on the side of the power supply. Later models have the interface module located in the electrical locker. The function of the module is to translate signals being sent from the control system to EMDEC, and data traveling from EMDEC back to the control system.

Engine speed information is communicated from the control system to the ECM's through an interface board.

Depending on the application, the connection from the interface module to the control system may be a one-way or two-way serial data link.

The main difference between the two types of links is in the amount of data that can be transmitted. The one-way link allows for simple speed instructions from the EM2000 to EMDEC, and simple fault messages and performance feedbacks from EMDEC to the EM2000. The two-way serial link allows for enhanced data transmission both ways.

4.5 SPEED CONTROL

4.5.1 Speed Control - One-Way Serial Link (Locomotive Application)

With the one-way serial link, the ECM's are programmed to accept 4 input signals, which are then translated into set speeds. Throttle information is sent from the control system to the interface module as 0 or 74 VDC governor solenoid signals. The interface module translates these 0 or 74 VDC signals into inverse logic 0 or 24 VDC signals for the ECM's. Consider the following examples:

Example #1 - Throttle in Normal Idle (300 RPM)

Control System Signals	Interface Signals	ECM Set Speed
A Valve 0 VDC	A Valve 24 VDC	
B Valve 0 VDC	B Valve 24 VDC	
C Valve 0 VDC	C Valve 24 VDC	
D Valve 0 VDC	D Valve 24 VDC	

Example #2 - Throttle in Run 6 (730 RPM)

Control System Signals	Interface Signals	ECM Set Speed
A Valve 74 VDC	A Valve 0 VDC	
B Valve 74 VDC	B Valve 0 VDC	
C Valve 74 VDC	C Valve 0 VDC	
D Valve 74 VDC	D Valve 0 VDC	

Example #3 - Throttle in Run 8 (900 RPM)

Control System Signals	Interface Signals	ECM Set Speed
A Valve 74 VDC	A Valve 0 VDC	
B Valve 74 VDC	B Valve 0 VDC	
C Valve 74 VDC	C Valve 0 VDC	
D Valve 0 VDC	D Valve 24 VDC	

4.5.2 Speed Control - Two-Way Serial Link (Locomotive Application)

The two-way serial link functions much differently for engine speed control. Instead of speed signals sent to EMDEC as governor solenoid signals (signals are still generated for trainline control), EM2000 creates exact RPM requests (for example 1000 RPM), and relays these to the ECM's over the serial link. This method is very fast and decreases the chance of problems in the speed signals. Note that the two-way serial link passes all communication through the interface panel.

Fault data and load control information are sent back to the control system from EMDEC through the interface module. These types of data will be looked at in greater detail in later chapters.

4.5.3 Speed Control - (Marine Application)

In a marine application, control signals are relayed to the ECM's as a variable speed governor signal. Note that the signal is supplied to the ECM's as Vref (ECM#ID). As the srcinal voltage is increased, the ECM's will translate the reference signal to an RPM request.

4.5.4 Speed Control - (Power Generation)

Power generation applications typically use two separate engine speeds only; IDLE (standby) and Run2. Speed reference is supplied by the control system to the ECM's as a calibrated reference voltage for each speed. Note that most systems allow for fine adjustment of these speeds by fine adjustment of the reference voltage.

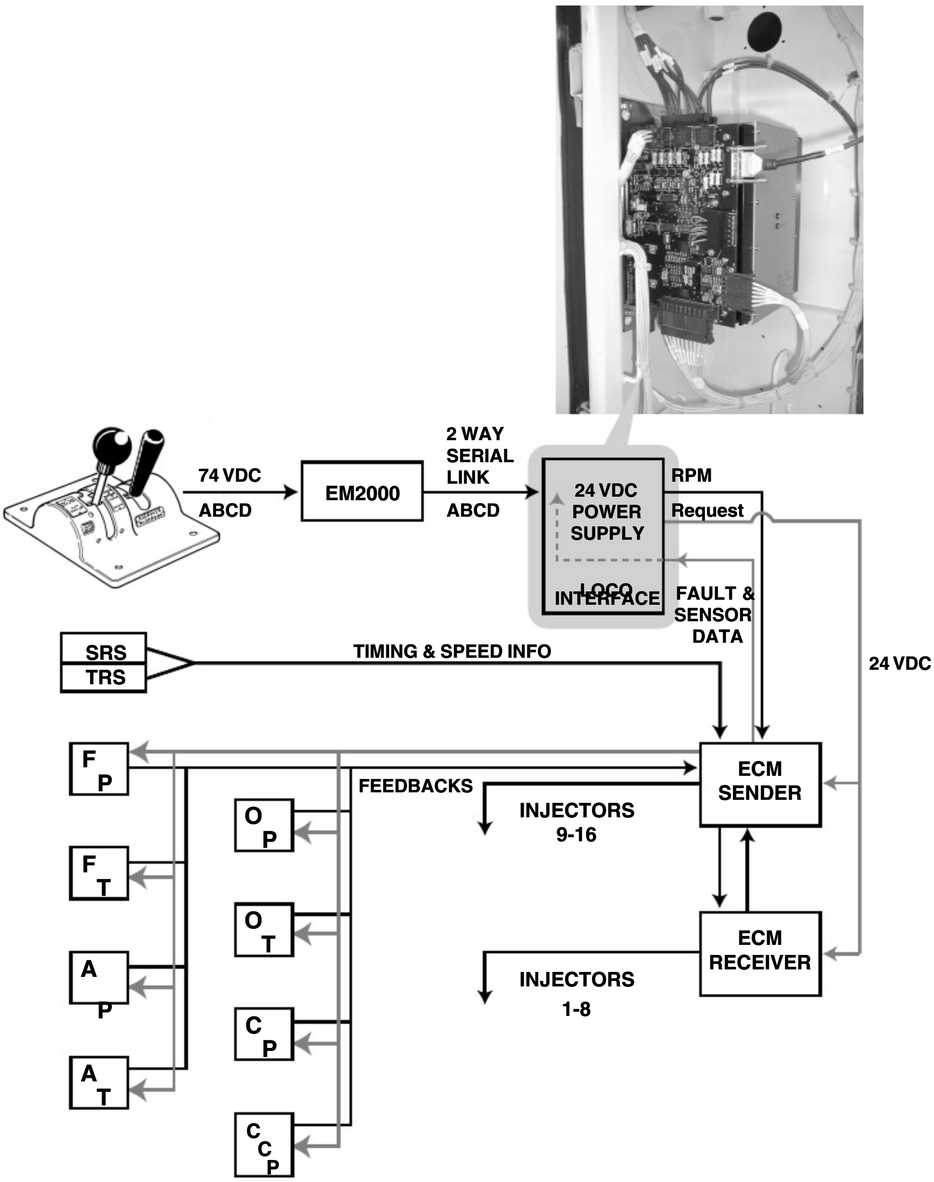


Figure 4.4 *Power Supply & Interface Module.*

4

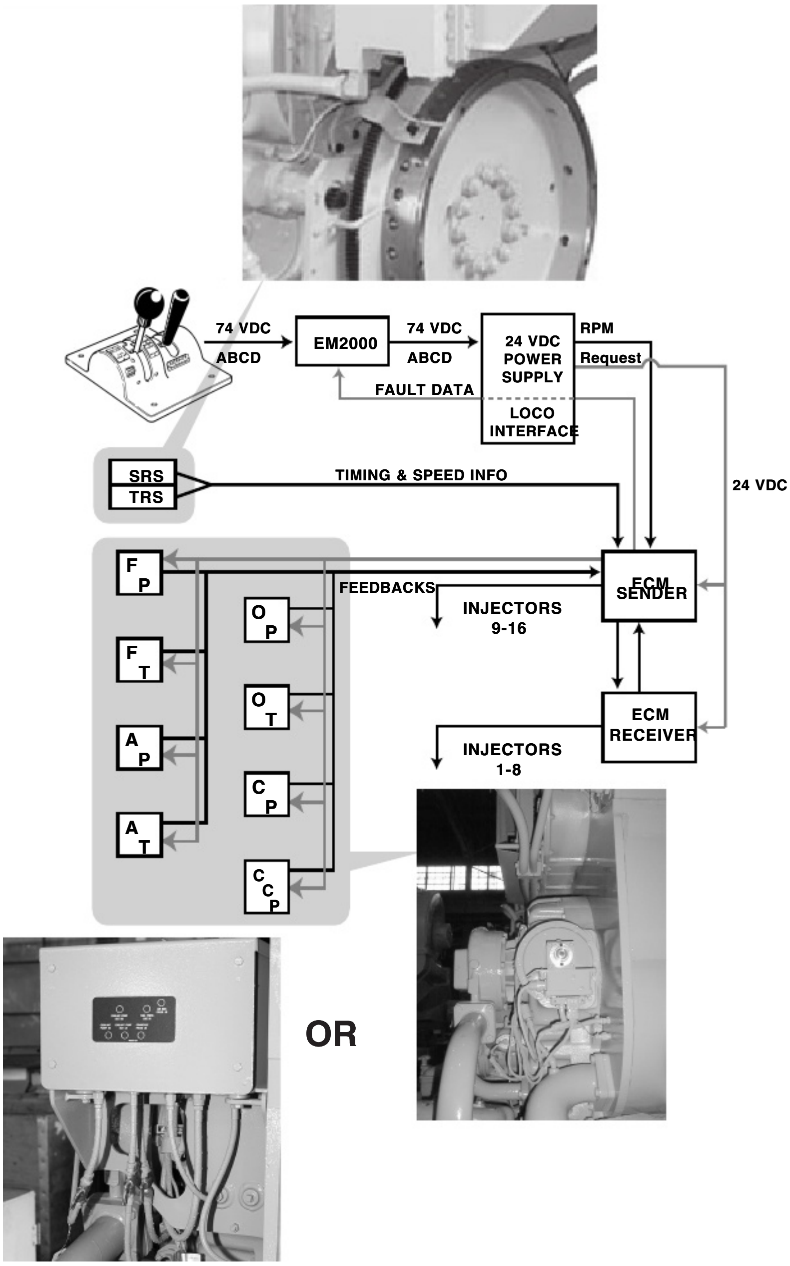


Figure 4.5 *Engine Sensors.*

4.6 SENSORS

At this point, the system has been supplied with 24 VDC for operation, and has received speed inputs from the control system. Before EMDEC can operate the injectors, additional information is required such as timing and speed data, engine performance data, and engine protection data. All this information comes into the ECM's in the form of sensor inputs. The sensors can be broken down into three major groups:

1. **System Sensors for timing and speed information:**
   - Synchronous Reference Sensor (SRS)
   - Timing Reference Sensor (TRS)

2. **Performance Sensors for calculating fuel injector operation:**
   - Fuel Pressure Sensor (FPS)
   - Fuel Temperature Sensor (FTS)
   - Turbo Boost or Air Pressure Sensor (TBS)
   - Air Temperature Sensor (ATS)

3. **Protective Sensors for monitoring of support systems:**
   - Oil Temperature Sensor (OTS)
   - Oil Pressure Sensor (OPS)
   - Coolant Pressure Sensor (CPS)
   - Crankcase Pressure Detector (CCP) (or)
   - Crankcase Pressure Sensor (CCP)

For each group of sensors, we will examine the sensors themselves, their operation, and overall effect on the system in the event of failure.

Note that later EMDEC applications will have their performance and protection sensors all mounted in the same location, at the left front of the engine, in a metal protective box. See Figure 4.5. The function of these sensors are identical to the earlier versions that are located in various places on the engine.

4.6.1

System Sensors

The system sensors *(figure 4.6a and 4.6b)* provide two functions for EMDEC operation. *Timing* information is used by the ECM's to determine when to energize the injector solenoids. *Speed* information is used to compare actual engine speed to desired engine speed. Fuel rates are then adjusted by the ECM's to correct any variation. Unlike other sensors on the engine, the system sensors (SRS & TRS) are magnetic pickups. Operation of the system sensors is identical between the 710 and H series engines, however the mounting arrangement is very different.

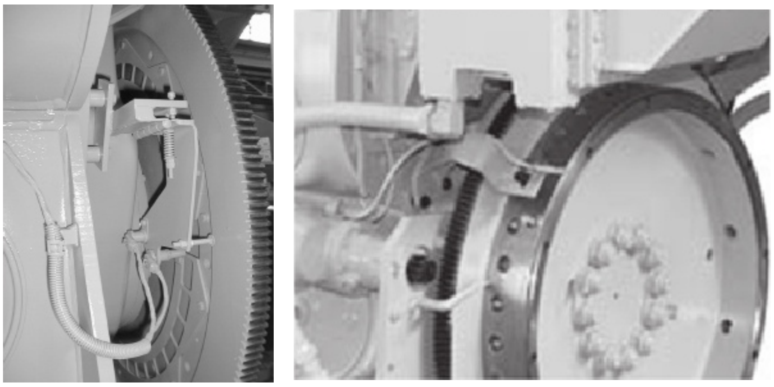


Figure 4.6a *710 Series System Sensors, Previous Models (Left) Recent Models (Right).*

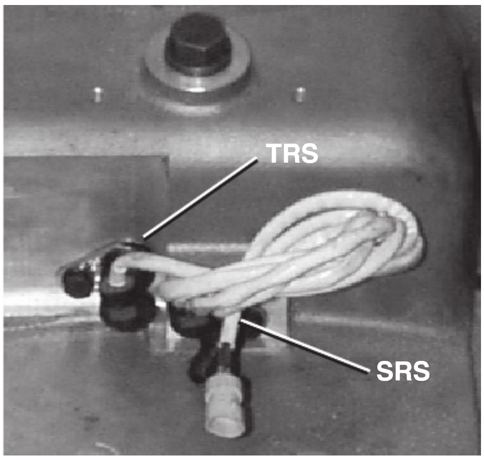


Figure 4.6b *H Series System Sensors.*

4.6.1.1

System Sensor Mounting Arrangements - Early 710 Series

The early 710 series of engines have three timing plates *(figure 4.7a)* attached to the inside face of the coupling disk between the engine and ring gear. The plates have openings cut into them leaving 36 "spokes" that are used to generate signals by the TRS sensor. One of the plates has a (Position Indicator Pointer) PIP attached, that is used by the SRS sensor to generate signals.

SRS and TRS share a common mounting bracket located on the left rear corner of the engine. This bracket serves two functions; first to hold SRS and TRS in precise alignment with the PIP and spokes on the timing plates; and second, the spring and stop mechanism allows the bracket to swing back and then return to the srcinal position should the coupling disk flex. This serves to protect the sensors from damage caused by contact with the timing plates.

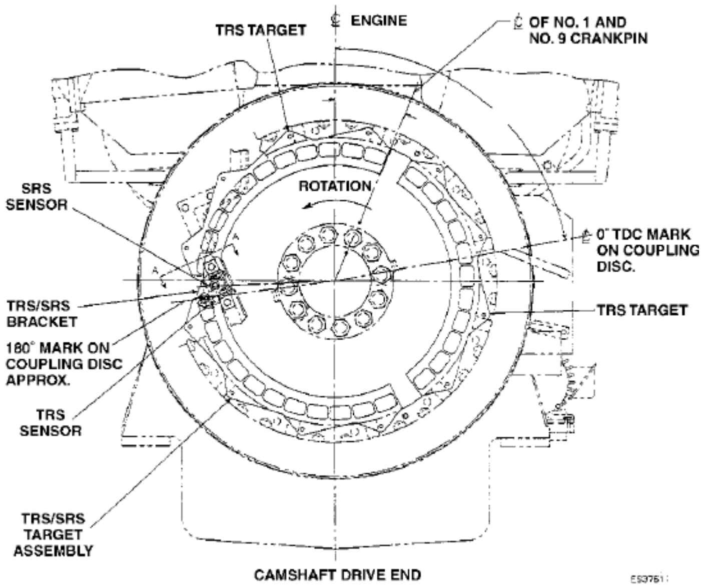


Figure 4.7a *"710 Series Timing Plates" (Early Models).*

4.6.1.2

Setting SRS and TRS Sensors

An improved feature on the 16-710G3C-T2 engine is the mounting and accessability of the SRS and TRS sensors.

Figure 4.7b *SRS and TRS Sensors.*

4.6.1.3

System Sensor Mounting Arrangements - H Series

The H series of engines does not use coupling disk mounted timing plates like the 710. Instead, these engines have timing disks attached to the front and rear of the camshaft *(figure 4.7c)*. The timing disks have a circle of 36 raised bumps stamped into them, that are used to generate signals by the TRS sensor. Each disk also has a stamped PIP that is used by the SRS sensor to generate signals. Note that although there is a disk on each end of the camshaft, only the rear plate is used at this time.

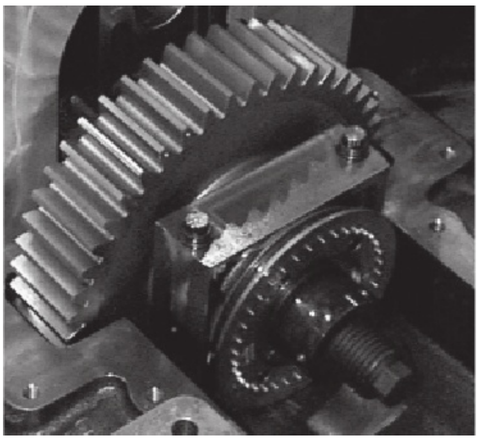


Figure 4.7c *"H Series Timing Disks".*

SRS and TRS are rigidly mounted in the cover housing the rear camshaft gear. They are arranged to read the stamped protrusions on the timing disk and relay this information to the ECM's. Reading camshaft speed (one half crank speed) allows for the use of the same ECM's as the 710 series.

4.6.1.4 Synchronous Reference Sensor

The Synchronous Reference Sensor or SRS provides a signal to the ECM’s when the Position Indicator Pointer (PIP) passes in front of it. The action of the PIP passing in front of the pick-up causes a small current to be induced in the sensor, which then passes through the wiring harness to the ECM’s. This signal is provided once, for every revolution of the crankshaft, and indicates when the number one cylinder is four degrees before top dead center.

This signal synchronizes the ECM’s with respect to engine speed and crankshaft position, this tells the ECM’s when to start the timing count.

4.6.1.5 Timing Reference Sensor

The Timing Reference Sensor or TRS reads the metal spokes of the timing plates. As the engine rotates, the metal spokes pass in front of the TRS. As each spoke moves past the pickup, a signal is generated and sent to the ECM’s. Since there are 36 spokes in total, each pulse from TRS indicates that the crankshaft has moved 10 degrees.

Note that unlike other systems, there are no specific timing indicators for each cylinder. Instead, the firing order of the engine is contained in the ECM's software. With this type of a system, the same pick-ups, timing plates, and wiring harness may be used with any engine configuration.

The calculation of engine speed is quite simple. The ECM's simply look at the elapsed time between TRS pulses to calculate engine speed. This is then compared to the set speed. If actual speed is lower than set speed, EMDEC will lengthen the injector pulse width to add fuel to the engine. If actual speed is higher than set speed, EMDEC will shorten the pulses to reduce the amount of fuel injected.

4.6.2 Performance Sensors

> **NOTE:**
> The sensors used as examples in this section are for a generic 16 cylinder 710 series engine. The feedbacks portrayed are to be used as examples only as there are several different models of sensors used in service depending on specific application. Note also that the number of sensors used will vary.

The performance sensors *(figure 4.8)* provide information that is used for adjustment of fuel rates. By examining the air and fuel parameters, EMDEC can "fine tune" injector operation *(timing and pulse width)* to maximize fuel economy and minimize exhaust emissions. All performance sensors are connected to the sender ECM only. Inside the ECM is a 5 VDC regulated power supply. Each sensor is fed this 5 VDC and, depending on conditions at the sensor, will return a certain feedback to the sender ECM. The text will now look at each of these sensors.

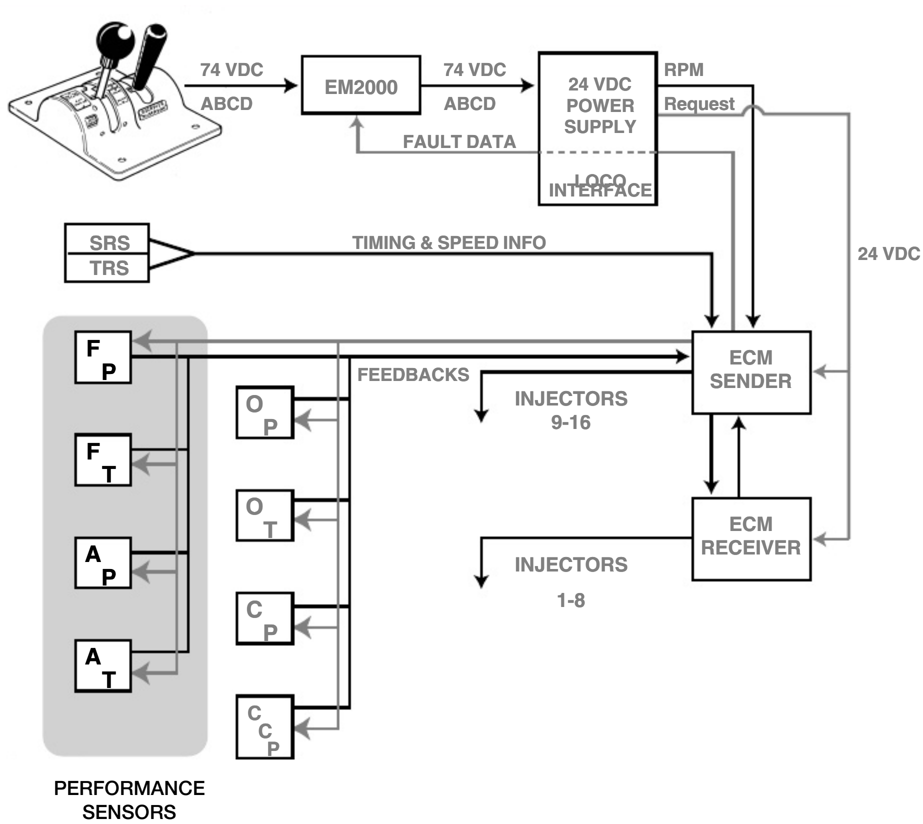


Figure 4.8 *Performance Sensors.*

4

4.6.2.1 Turbo Boost Sensor (TBS)

The Turbo Boost or Air Box Pressure Sensor *(figure 4.9)* provides data to the sender ECM for use primarily in emission control. It is also known as the smoke sensor. The sensor is connected to the ECM with a three wire plug, and to the engine with a sensing hose off the left front corner of the engine. The device is mounted just below the crankcase pressure sensor, (early 710 systems), in the sensor box (late 710 systems), or on the front of the aftercooler ducts (H Engines).

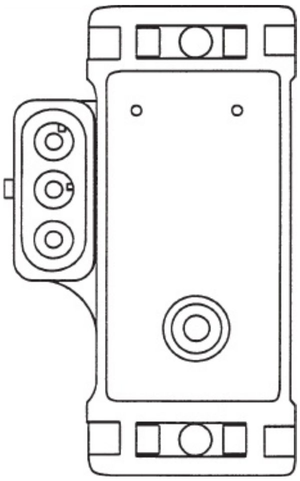


Figure 4.9 *Turbo Boost Sensor.*

Note that there are early and later versions of this sensor which, while quite different in appearance, function in an identical manner.

The boost sensor is a capacitive pressure transducer. In simple terms, it is inserted into a circuit with a +5 VDC connection and a -5 VDC connection. Depending on the pressure the device is exposed to, it will generate a feedback signal on the third connection that will range from 0 to 5 VDC. The ECM looks at the signal from the device and translates it into a pressure reading.

Figure 4.10 shows a typical feedback graph. Note that the device measures absolute pressure and at 0 psi, the feedback voltage is approximately 0.5 VDC. Note also that at 45 psi, the feedback is approximately 4.5 VDC.

The ECM looks at this feedback signal for three conditions.

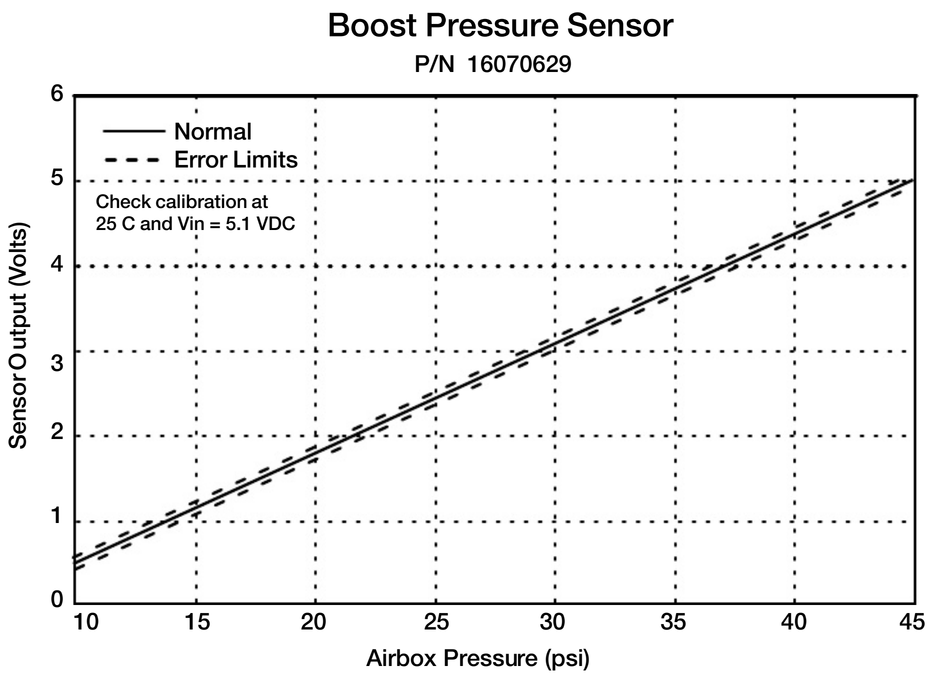


Figure 4.10 *Turbo Boost Sensor Feedback.*

1. If the feedback is between 0.5 and 4.5 VDC, the ECM considers the signal to be valid, and will use the feedback for its fuel calculations.

2. If the feedback is less than 0.5 VDC, the ECM considers the input voltage low.

3. If the feedback is above 4.5 VDC, the ECM considers the input voltage as too high.

In either case, the following happens:

- the feedback is ignored for calculations,
- a nominal "standard" pressure is used,
- a "fault" is generated in the archives specific to the feedback failure *(voltage low or high)*.

Remember that the fault archive can be accessed by use of a laptop computer (with WinEMMON or PC Reader software), or the FIRE display (two-way serial link).

4.6.2.2 Air Temperature Sensor

The Air Temperature Sensor or ATS*(figure 4.11)* measures the temperature of the air charge in the engine airbox. This feedback is necessary for fuel consumption calculations and emission control by the ECM's. The sensor is applied to the left front corner of the engine next to the turbo boost sensor, with the probe inside the airbox. On some applications, a second sensor, inlet air temperature (IATS) has been applied to the inlet eye of the turbocharger. This second sensor is identical to the Air Temperature sensor.

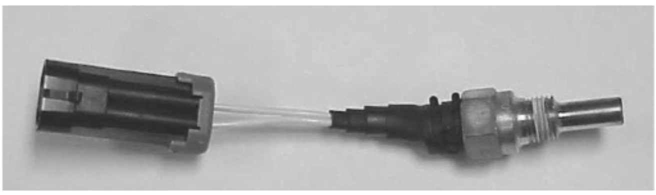


Figure 4.11 *Air Temperature Sensor.*

This sensor is a thermistor type device. As the temperature changes at the sensor probe, the internal resistance of the device changes. The voltage and current characteristics of the circuit are looked at by the ECM, and are converted into a temperature reading.

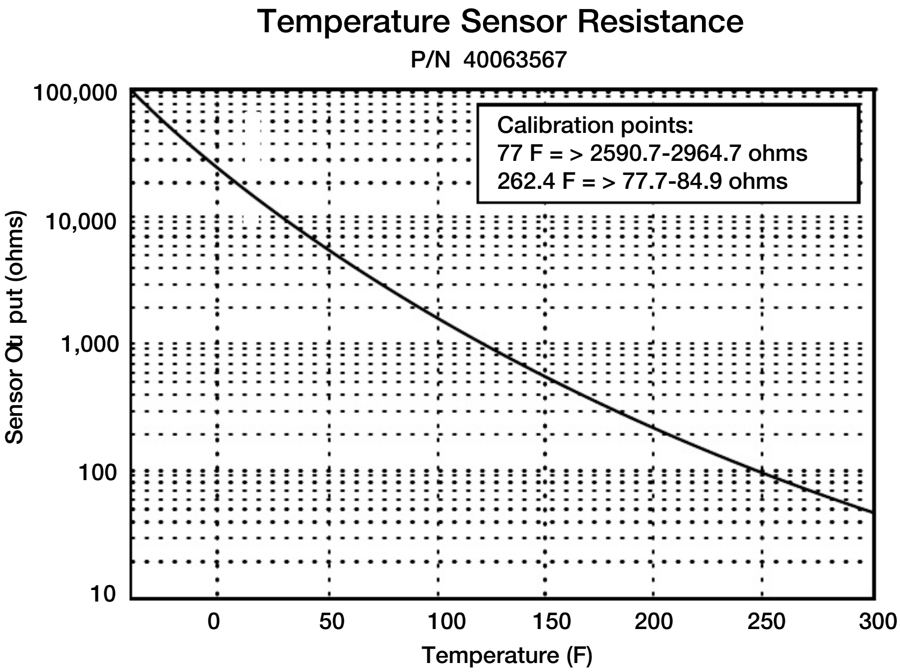


Figure 4.12 *Air Temperature Sensor Feedback.*

As with other sensors, the ECM expects to see a certain feedback from the device. A voltage between approximately 0.5 to 4.5 VDC is considered a valid signal, and the information will be used in calculations. Should the voltage go below 0.5 VDC or above 4.5 VDC, the ECM considers the data invalid and logs a fault. Again, there is a specific fault for each mode of failure *(voltage high or voltage low)*.

4.6.2.3 Fuel Temperature Sensor

The Fuel Temperature Sensor or FTS*(figure 4.13)* measures fuel supply temperatures necessary for fuel consumption calculations, and fuel input compensation by the ECM's. This is one of the functions that goes beyond the possibilities of the mechanical system. The fuel temperature sensor is an identical device to the air temperature sensor(s). It is located on the secondary fuel filter manifold and examines the temperature of the fuel as it enters the engine. As fuel temperature increases, performance decreases. EMDEC will compensate for high fuel temperatures by adjusting pulse width and timing as required.

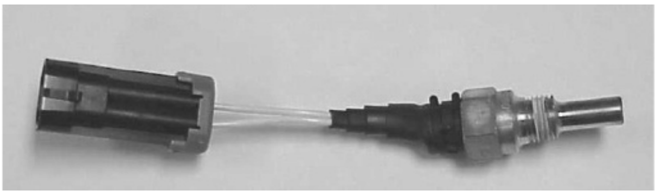


Figure 4.13 *Fuel Temperature Sensor.*

4.6.2.4 Fuel Pressure Sensor

The Fuel Pressure Sensor or FPS *(figure 4.14)* monitors fuel supply pressure for two reasons. First, the fuel pressure reading is an input to the sender ECM where it forms part of the fuel rate calculations.

Second, should fuel pressure drop below an acceptable level, the system will log a fault to warn of any impending power loss.

Figure 4.14 *Fuel Pressure Sensor.*

The device is a capacitive pressure transducer. Operation is quite similar to that of the boost pressure sensor, however the two are very different in appearance. The sensor is connected to the ECM with a three wire plug, similar to the boost pressure sensor, and mounted on the secondary fuel filter manifold. The fuel pressure at the filter inlet is monitored at this point.

On some applications, a second sensor is used to monitor fuel pressure in the return fuel manifold. Should the pressure drop across the filters, and engine rise beyond an acceptable level, the system will register a fault. This could be caused by plugged filters or leakage in the system.

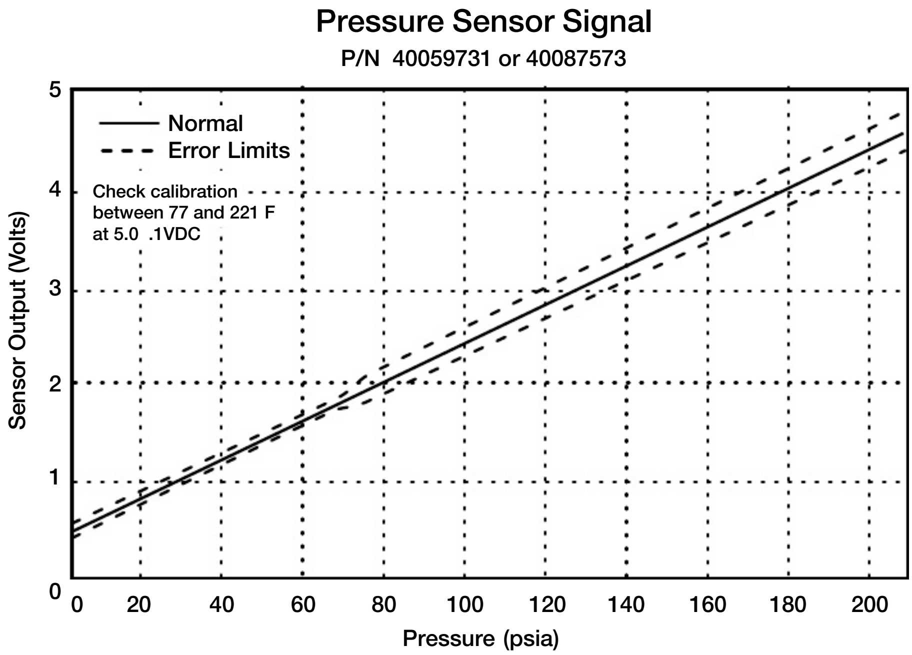


Figure 4.15 *Fuel Pressure Sensor.*

Figure 4.15 shows a graph of the sensor output. Note that the cut off points for feedback voltage are approximately 0.5 VDC and 4.5 VDC. If the feedback is maintained within this range, the ECM will consider the signal valid and use the feedback for calculations. A signal outside of these parameters is considered invalid and a fault condition. Again, if a fault is logged, it will be specific as to the voltage level *(voltage too low or voltage too high)*, to aid in diagnostics.

NOTE:
While similar to the coolant pressure sensors in appearance, the fuel pressure sensors are calibrated differently. Always refer to the parts catalogue for proper sensor application.

4.6.3 PROTECTIVE SENSORS

NOTE:
The sensors used as examples in this section are for a generic 16 cylinder 710 series engine. The feedbacks portrayed are to be used as examples only as there are several different models of sensors used in service depending on specific application. Note also that the number of sensors used will also vary.

The protective sensors *(figure 4.16)* provide information that is used by the sender ECM to monitor the performance of the engine support systems. In the event of a system failure *(lube oil, cooling, or crankcase ventilation)*, EMDEC can shut down the engine to prevent costly component damage. The protective functions of EMDEC have been programmed to react in exactly the same manner as a Woodward governor. All shutdown pressures, temperatures, and timing remain the same as on the mechanical system.

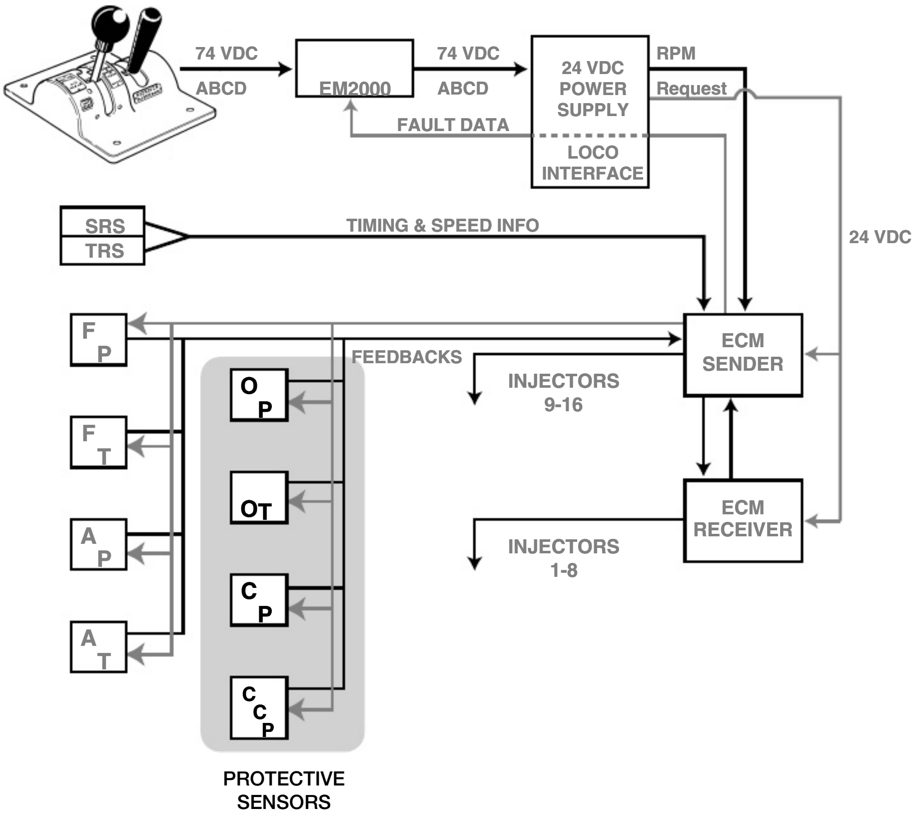


Figure 4.16 *Protective Sensors.*

4.6.3.1

Oil Pressure Sensor

The Oil Pressure Sensor or OPS *(figure 4.17)* provides a feedback of engine lube oil pressure to the ECM. A shutdown will occur if the engine lube oil pressure at the turbocharger drops below a predetermined setpoint, relative to engine speed and duration of time. The oil pressure sensor is an identical unit to the fuel pressure sensors, and is mounted in the top of the turbo lube filter head *or on the left front corner of the engine in some applications.* The shutdown times and pressures are identical to previous systems.

Figure 4.17 *Oil Pressure Sensor.*

Note that with this sensor there are three types of fault conditions possible. Input voltage high or input voltage low will each generate a separate fault condition. If the signal from the sensor is valid *(between 0.5 and 4.5 VDC)*, but below the operating parameters, a shutdown fault is logged and fuel injection is cut off, stopping the engine. For example, if the engine is operating at a normal idle speed, if oil pressure drops below 12 psi for more than 10 seconds, the engine will shut down.

4.6.3.2

Oil Temperature Sensor

Physically, the Oil Temperature Sensor or OTS *(figure 4.18)* is identical to the fuel and air temperature sensors. The input to the sender ECM allows it to monitor the temperature of the oil entering the lube oil systems in the engine. An engine shut down will occur if the oil temperature exceeds 256°F *(124°C)*. The sensor is located in the same position as the hot oil detector on the mechanical injection system.

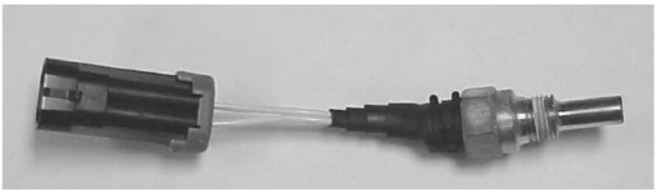


Figure 4.18 *Oil Temperature Sensor.*

This sensor also has three possible types of fault conditions. Input voltage high or input voltage low will each generate a separate fault condition. If the signal from the sensor is valid *(between 0.5 and 4.5 VDC)*, but above the operating parameters, a shutdown fault is logged and fuel injection is cut off, stopping the engine. This will prevent damage to engine components caused by excessive oil temperatures.

4.6.3.3 Coolant Pressure Sensors

The Coolant Pressure Sensors or CPS , monitor coolant pressure at the water pump discharges, and at the "Y" pipe *(engine discharge)*. The sender ECM may be connected to one, two, or three CPS depending on system requirements and engine configuration. A typical system will use two sensors. The coolant pressure sensors *(figure 4.19)* are identical units to the oil and fuel pressure sensors. If coolant pressure drops below a programmed set point, an engine shut down will be initiated.

Figure 4.19 *Coolant Pressure Sensor.*

When two sensors are used for a specific application, generally one sensor is considered a backup. Typically, if two sensors are used, the primary sensor is located on the right bank water pump, the secondary sensor is located in the "Y" pipe. A failure of a sensor will not initiate a protective shut down in this case.

> **NOTE:**
> While similar to the fuel pressure sensors in appearance. The coolant pressure sensors are calibrated differently. Always refer to the parts catalogue for proper sensor application.

4.6.3.4

Crankcase Pressure Detector (CCP)

The Crankcase Pressure Detector *(figure 4.20)* activates if crankcase pressure increases to a positive pressure of 1 1/2" of water. Unlike other sensors, the CCP is a mechanical device. The detector consists of a sensing diaphragm, trip button, and electrical switch. It is located in the same location as the EPD on mechanical injection systems.

Figure 4.20 *Crankcase Pressure Detector.*

WARNING:

DO NOT attempt to restart the engine until the cause of the shutdown has been determined and corrected.

Following a crankcase pressure shutdown do not open any engine covers for a minimum of two hours. Any rise in crankcase pressure pushes on the rear face of the sensing diaphragm. When the pressure reaches the trip pressure of the detector, the button is pushed outwards to indicate the over pressure condition. Internally, is a switch connected to the button mechanism that is thrown by the movement of the button. This completes a circuit to the ECM so that it will recognize the fault condition and shut the engine down.

The mechanical portion of the device must be qualified on maintenance inspections to ensure proper operation. Consult section 13 of the EMM for test procedures.

4.6.3.5
Crankcase Pressure Sensor

The crankcase pressure sensor has been developed to replace the crankcase pressure detector. It is located in the sensor box on the left front corner of the engine *(figure 4.20)*. Unlike other pressure sensors this device can read both positive and negative pressures. Engine protection parameters and responses remain the same as the CCP.

This completes the section on electronic components of the EMDEC system. The following chapters will deal with load control, fault data, troubleshooting, and diagnostic tools.

Notes:

Load Control

5.1 INTRODUCTION

The term load control refers to the matching of electrical load on the main generator to engine performance. In one way, this may be considered as another protective system for the diesel engine. If there is a problem with the engine that will reduce available horsepower, such as plugged air or fuel filters, it is necessary to reduce the load on the engine to prevent damage to components or over-fueling. Over-fueling leads to unacceptable levels of exhaust emissions and possible engine damage.

Control of the actual load on the generator, commonly referred to as excitation level, is the responsibility of the locomotive control system. The injection system must provide the control system with a feedback that will indicate the engine's ability to maintain speed at the given load level.

This section of the text will look at this feedback, how it is generated, and how it is used by the control system to modify the load.

Load control with EMDEC protects the diesel engine against overloading and overfueling.

The operator establishes a desired power level using the control system (figure 5.1). The control system determines excitation levels and engine speeds. The control system speed relays commands to EMDEC,

EMDEC, through the interface module.

Once the ECM's receive the signal from the interface module, this is converted to a set speed. As we saw in the previous chapter, the ECM's will control the fuel injectors based on sensor inputs, to maintain actual engine speed at the set speed level.

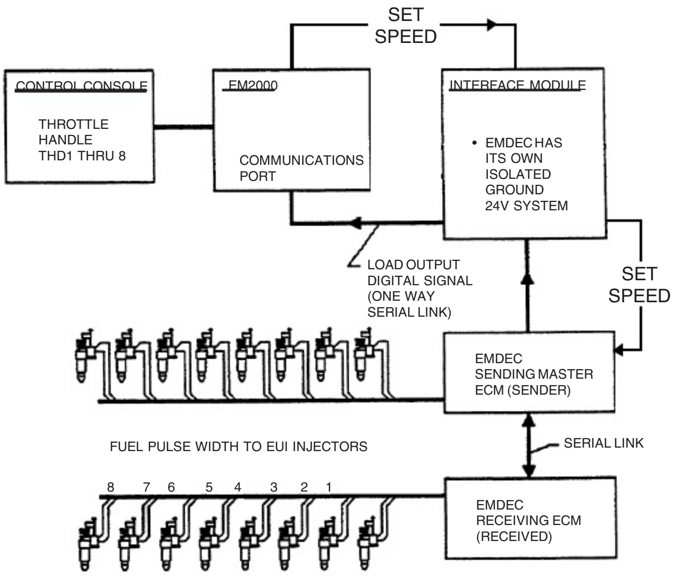


Figure 5.1 *Control System With EMDEC.*

5.2 FUEL MAPS

Fuel maps are programmed into the ECM's "software" (figure 5.2), that indicate allowable pulse widths for each throttle position. Remember that the injector pulse widths refer to the duration o f the injection pulse, measured in degrees of crankshaft rotation. The longer the pulse width, the more fuel is injected into the engine's cylinders.

As we see in the below, there is a different map for each throttle position. These are examples only; actual maps vary according to application. For example, in throttle 5, an allowable pulse width for injection would be anything from 0° to 15°. In throttle 8, any pulse width between 0° and 23° may be used by the ECM's. The fuel maps indicate the total available fuel for each throttle position.

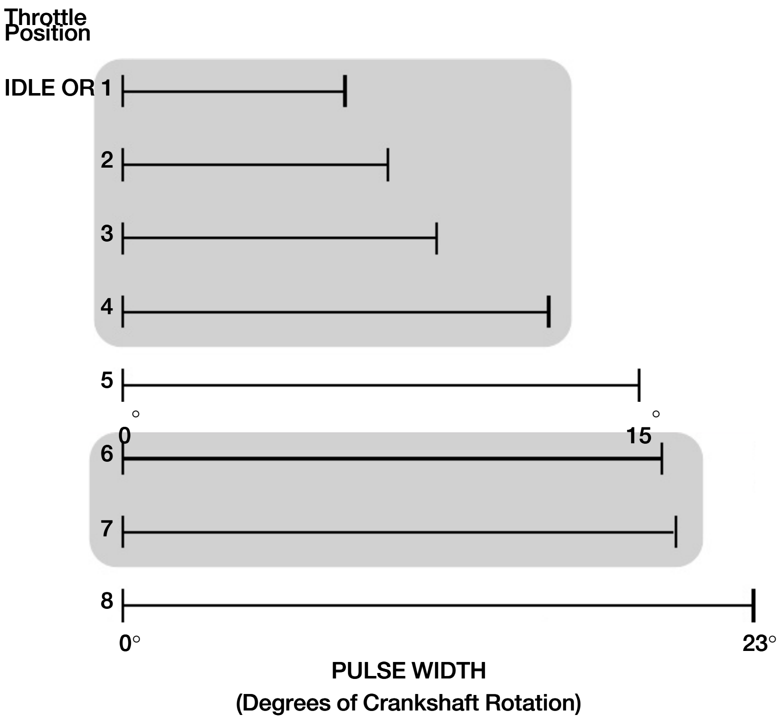


Figure 5.2 *Typical "Fuel Maps" (for illustration only).*

5.3 CONTROLLING ENGINE SPEED

EMDEC works just like a Woodward governor to control engine speed. If speed drops, it adds fuel (opens the injector pulse widths). If speed rises, it cuts fuel (closes the injector pulse widths). A feedback to the control system is still required to prevent overfueling. EMDEC will generate a reference signal proportional to the amount of fuel being consumed *(figure 5.3)*.

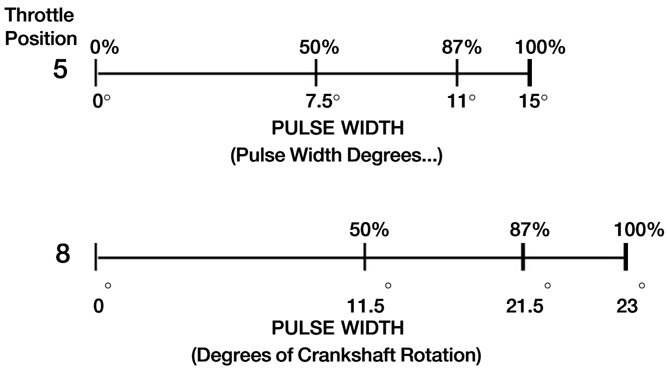


Figure 5.3 *Engine Ratio Signal.*

In the above illustration, we see examples of the fuel maps for throttle 5 and throttle 8. As EMDEC operates the injectors, it generates the Engine Ratio signal. This is the actual pulse width divided by the maximum pulse width expressed as a percentage. Simply put, the Engine Ratio is the percent of the total available fuel for a given throttle position that is actually being used.

Consider the following examples:

Throttle Position	Pulse Width	Engine Ratio
5	0°	0%
5	7.5°	50%
5	15°	100%
8	0°	0%
8	11.5°	50%
8	23°	100%

Normally, if everything is operating properly under load conditions, the engine will require approximately 78% to 80% of the total available fuel. Actual consumption will vary according to engine and ambient conditions. For example, in Load Test 1, the engine typically will use a pulse width of about 18.5 ° in throttle 8. This would equate to an engine ratio signal of approximately 80%; it is consuming 80% of the total available fuel in throttle 8. Should there be any problems with the engine, for example plugged air filters, performance will drop, and EMDEC will have to add more fuel to the engine to maintain speed against the load on the generator. As the pulse width is opened by the ECM's, the Engine Ratio signal increases proportionally.

The Engine Ratio signal is sent to the EM2000 via the interface module, and the serial data link. By looking at this signal, the EM2000 can assess the engine's ability to make horsepower. As long as the Engine Ratio is less than 87%, the EM2000 will assume that the engine can make full power, and will regulate generator excitation to produce the proper kilowatt output for the throttle position.

5

However, should the Engine Ratio rise to 87% for any reason, the EM2000 will assume that the engine is having difficulty maintaining horsepower. It will reduce excitation to prevent fueling from exceeding the 87% level. As the load on the engine drops, engine speed increases, EMDEC reduces the pulse width, and the Engine Ratio signal drops. The EM2000 then increases generator excitation. Thus the generator load is balanced with the engine's ability to produce horsepower, much the same as the Woodward governor system. Note however that all load control is done entirely within the control computer, EMDEC simply sends a reference signal to the control system.

The electronic system is much faster and more accurate than the mechanical system.

Should the EM2000 reduce excitation due to a high engine ratio signal, this will be apparent on the display panel as a reduction in the signal LR%MAX. If everything is operating pr operly, the Engine Ratio signal (seen on the display as ENGINE_R) should be less than 87%, and the signal LR%MAX will be equal to 100%. Note that in actual practice, because the two systems try to balance load demand against fuel consumption, typically the Engine_R signal will fluctuate between approximately 84 and 89%.

5.4 % ALLOWABLE TORQUE SIGNAL

A signal that is useful for diagnostic purposes is the % Allowed Torque signal. This may be viewed on the Engine Parameter Section of the main PC Reader screen. The signal normally shows 100% but may be reduced by the sender ECM, should certain support system parameters move outside of acceptable levels. These parameters include air pressure (boost), air temperature, fuel pressure, or turbine speed (H series only).

When the parameters move outside of acceptable levels, such as low boost pressure, EMDEC calculates that the engine is not capable of generating rated horsepower at desirable fuel levels. The % allowable torque signal is reduced, and the fuel maps scaled downwards. As the % allowable torque signal is reduced, the engine ratio signal increases to signal EM2000 to reduce generator excitation. In this case, generator output is in fact limited by EMDEC.

In a situation where the engine is not producing rated horsepower at a stable engine speed, this signal can be a good indication of engine condition.

Notes:

5

Notes:

Diagnostic Tools

6.1 INTRODUCTION

This section of the text covers the use of diagnostic tools to access the EMDEC ECM's. These tools are required for troubleshooting, loading software, and injector calibration. Covered, are procedures for using the WinEMMON or PC Reader program with a laptop computer and the FIRE display for applications equipped with a two-way serial link.

Note that EMDEC is an evolving system that is constantly being upgraded to improve service reliability and performance. Every effort has been has been made to ensure that the information contained in this section is current, however, always consult the proper system schematics and EMM for specific service data.

6.2 WINEMMON & PC READER (DIAGNOSTICS WITH A LAPTOP PC)

The WinEMMON kit *(figure 6.1)* is the recommended EMDEC interface tool. Some locations will have the older PC Reader system as a diagnostic tool, so this will be covered as well. The primary difference between the two system diagnostic tools is that WinEMMON is a Windows© based system while PC Reader is based on the older DOS (Digital Operating System) technology

The following instructions are provided to assist the troubleshooter in using this tool. The PC reader enables you to:

- monitor all sensor inputs to the ECM's;
- view ECM outputs to the injectors (pulse width and timing);
- view injector response times;
- calibrate the injectors;
- load ECM software;
- view and download fault data.

The software generates a diagnostic screen and interface protocol on the laptop. To use the program, it must be loaded into the laptop, the laptop connected to the EMDEC system through the cable and translator assembly, and the program initiated. The following instructions will list the steps needed to prepare the system for use.

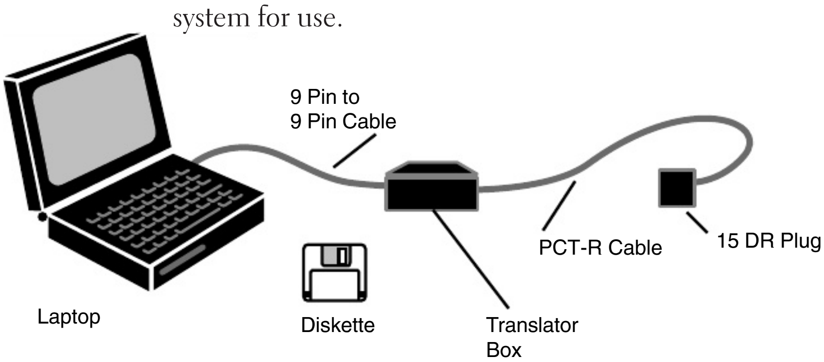


Figure 6.1 *PC Reader Diagnostic Kit.*

6.2.1 Using the WinEMMON or the PC Reader Kit

WinEMMON and PC Reader are software programs that are run on a personal computer interfaced with the EMDEC system. It is recommended that WinEMMON be used in a laptop PC running a Windows© 95 operating system or newer, such as Windows© 98, 2000, NT, XP, or XP PRO. You will also need the WinEMMON Diagnostic Kit (#40094241), which consists of the following:

- WinEMMON Translator Box #40094242
- WinEMMON Software Disk #40094243
- 15 D-R Plut #40055365
- PCT-R Cable #40055364
- 9 Pin Male to 9 Pin Female Cable #40055366
- PC Carry Case #40055367

The minimum requirement for using PC Reader is a 386SX/DX-type laptop with one megabyte of RAM. In addition, the PC Reader kit (#40055368), consisting of the following items, is required:

- EMDEC Translator Box #40055363
- EMDEC Reader Software Disk #40055362
- 15D-R Plug #40055365
- PCT-R Cable #40055364
- 9 Pin Male to 9 Pin Female Cable #40055366
- PC Carry Case #40055367

6.2.2

Loading WinEMMON Software On To A Laptop Computer

1. Insert disk #1 of the WinEMMON software (#40094243) into the floppy disk drive of your laptop computer (usually the A: drive).

2. Click on the Start button in the lower left corner of your computer screen.

3. When “Run” appears above the “Start” button, click on “Run”.

4. When the command box opens, type in “A: setup”, without the quotations marks, then put the mouse on “OK” and click it.

5. The computer will then copy the initialization files required from disk #1. When that is done, the computer will tell you to insert disc #2.

6. Remove disk #1 from the floppy drive and insert disk #2, then click on the “ok” button.

7. This will allow the setup program to proceed. Close any other programs you are running as required, and then click on the “OK” button.

8. Next you will be asked where you would like the WinEMMON directory to be placed on your computer. The default locations is “Program Files” on the “C:” drive. If you wish to put your WinEMMON program somewhere else on your computer than the default choice (not recommended), click on the “Change Directory” button and follow the instructions that appear. If you are going to use the default location (recommended), then click on the large box in the upper left of the pop up box (it has a computer icon on it).

9. The computer will now copy the WinEMMON files to the chosen directory. When the computer tells you that the installation has been successfully completed, click on the “OK” button.

You have now successfully installed WinEMMON on your computer. Connection and diagnostics use will be covered later in this chaper.

6.2.3

Loading The PC Reader Software On To A Laptop Computer

1. Escape out of Windows and get to the C:\> prompt. It is imperative that windows not be active, or the program will not function as desired. Press Alt+F4 or double click the cursor on the upper left bar on the windows screen to exit Windows.

2. Create a new directory (For example: C:\> md emdec).

3. Change the directory to the pcreader (For example: C:\> cd emdec).

4. Once in the directory, copy the files from the disk into the directory (For example: C:\emdec> copy a:*.*).

Occasionally the PC Reader software is upgraded to enhance its operation, or to reflect changes in the equipment installed on the engine. After receiving a new version of PC Reader, it will be necessary to change the files in the laptop. To ensure proper operation, use the most recent software.

6.2.3.1

To Edit The EMMON Command File

1. While in the EMDEC directory, type in: edit emmon.bat. A screen will appear showing the contents of the emmon file.

   Example: @ECHO OFF
   rp1202
   emmon11a (or current version number)
   ECHO ON

2. Use the cursor to select the existing executable file (For example emmon11a or current version number), and rename it to the latest executable file name loaded (such as emmon11a).

3. Press Alt + F to highlight the File task bar, and open the dialog box.

   Select SAVE and press <RET>.

4. Press Alt + F to highlight the File task bar and open the dialog box once again.

   Select EXIT <RET> to return to the emdec directory.

6.2.3.2

Connecting WinEMMON & The PC Reader To EMDEC

Once the software has been loaded into the laptop, the computer must be connected through the translator box and cable, to the EMDEC system.

6.2.3.3

Access Ports

On most applications there are two access locations for EMDEC *(figure 6.2)*.

One is located in the cab of the locomotive, inside the center door of the Computer Chassis Cabinet. The EMDEC access port is located to the right of the EM2000 computer chassis, and is labeled "EMDEC".

The second access port is located on the interface module mounted to the 24 VDC power supply. It is usually found in the AC Cabinet in the Engine Compartment.

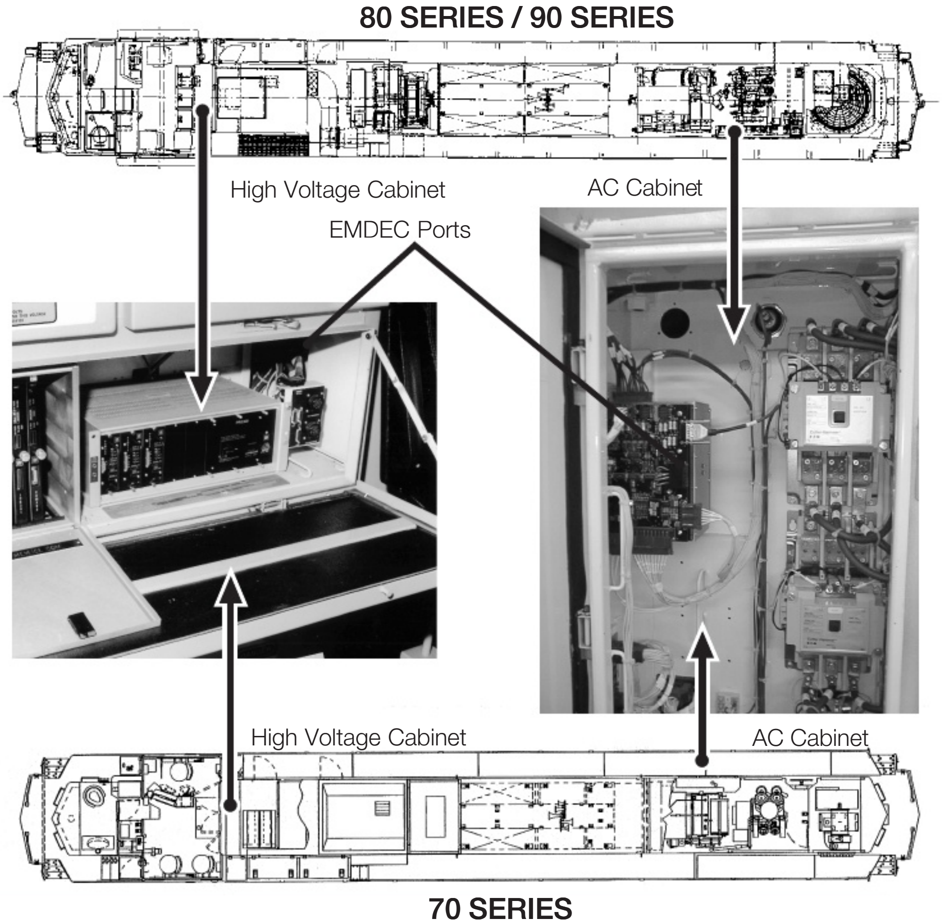


Figure 6.2 *EMDEC Access Ports.*

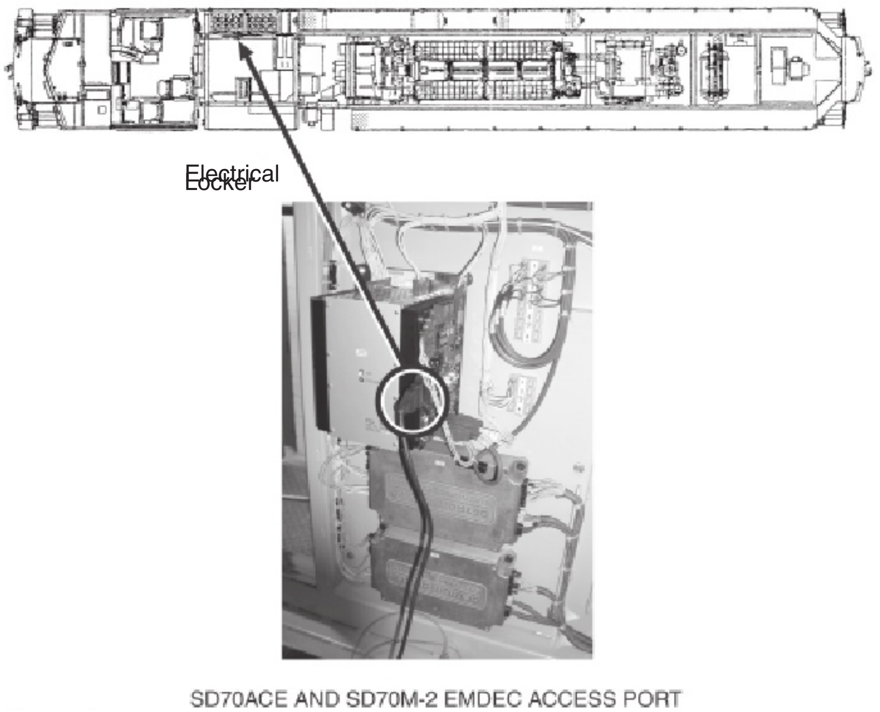


Figure 6.3 *EMDEC Access Port (SD70ACe/ SD70M-2).*

6.2.4 Utilizing WinEMMON & The PC Reader Program

1. Connect the 9 Pin cable from the PC to the translator box.
2. Connect the 15D-R plug to the PCT-R cable, and the other end of the cable to the translator box.
3. Connect the 15D-R plug into the EMDEC reader port, and note that both the red and green LED's on the side of the translator box are illuminated.

   The EMDEC Communications (EMMON) program will not work if the hardware is not connected to the locomotive.

4. Click on the Start button in the lower left corner of the computer screen. When the menu options appear, click on all Programs/Programs (depending on which version of Windows© you are using). Move the cursor (arrow) to the WinEMMON option, and click there. For PC Reader change the directory on the PC to C:\emdec> and type EMMON <RET> to start the program.

   A message will appear stating that the program is searching for the interface box (WinEMMON or text line PC Reader).

> **USER TIP!**
> The PC Reader and EMMON program will not function correctly through Windows, Windows 95/98 and Windows NT, even from the MS-DOS prompt within Windows. Exit out of Windows completely before using PC Reader and EMMON.

5. Once in either EMDEC reader program, an EMMON main screen will appear.

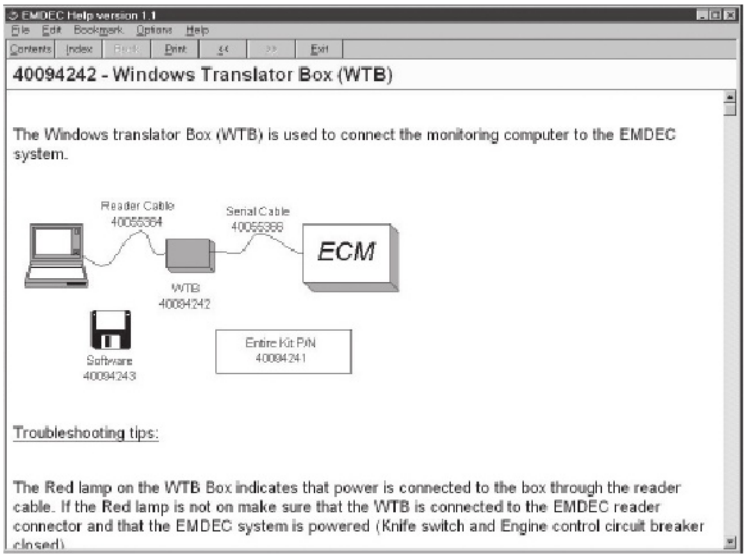


Figure 6.4 *Communication Problem.*

If the software is loaded correctly, and the system is properly connected, a main screen should appear on the laptop *(figure 6.4)*.

The systems (EMDEC, WinEMMON or PC Reader), are communicating when the green light on the translator box is illuminated, and the red light is flashing. If there is a problem with the connection, another message box will appear *(figure 6.5)*. This figure will be the small box labeled "Communication Problem" on the screen save below.

This Communication Problem box gives you the option of trying the connection again (the retry button), canceling (the cancel button) or getting help. If you press on the help button, another box will appear *(figure 6.5)*. This box gives you a diagram of the proper cable setup for connecting to EMDEC, as well as the correct part numbers to ensure you have the correct translator box and cables. There is also a description of the light functions on the translator box.

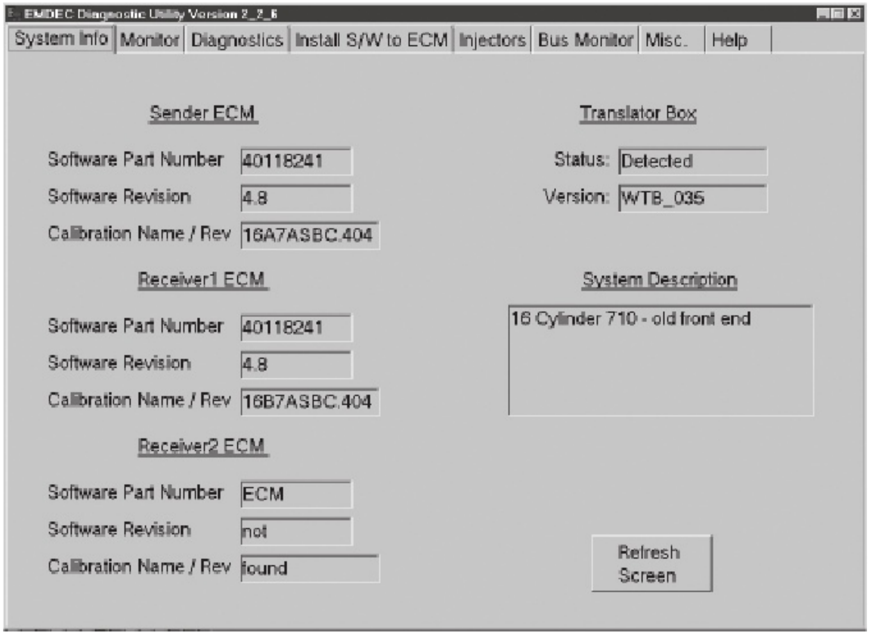


Figure 6.5 *Communication Problem.*

6.2.5 WinEMMON Main Screen

The main WinEMMON screen consists of five sections, covering Sender ECM, Receiver 1 ECM, and Receiver 2 ECM. As well, there are sections for Translator Box and System Description. In the lower right corner of the Main Screen is a refresh button. The ECM sections give you the software part number, which revision of the software is being used, and which calibration name/revision is loaded into the ECMs.

Note that Receiver 2 ECM will only show data and be active on 20 cylinder engines.

Across the top of the Main Screen are the options we can select from. These are System Info, Monitor, Diagnostics, Downloads, Injectors, Bus Monitor, Misc. and Help. We will cover each of these in turn.

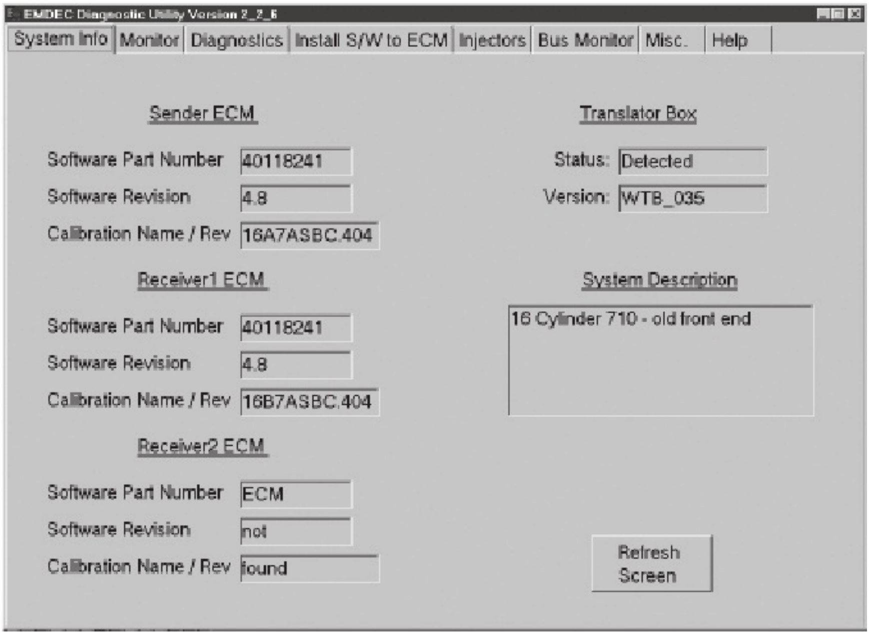


Figure 6.6 *WinEMMON Main Screen.*

6

Figure 6.7 *System Information Dialog Box.*

The WINEMMON main screen appears whenever you open the WinEMMON program, regardless if you are connected to the locomotive. The System Information Dialog Box *(see Figure 6.7)* will then appear on the computer screen. This will document the connection to the locomotive.

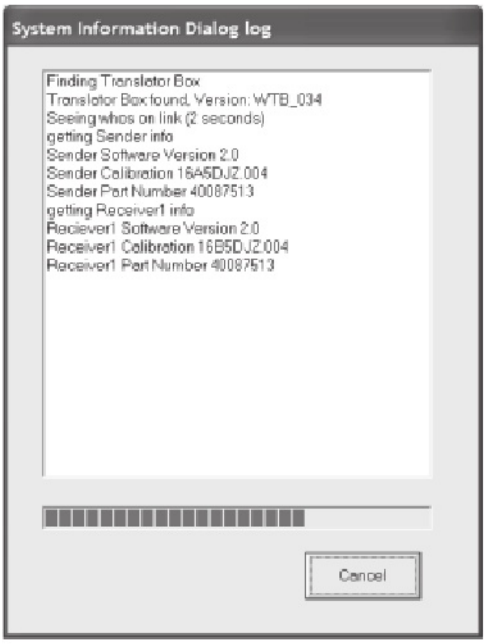


Figure 6.8 *System Information Dialog Box.*

6

If the connection is successful the System Information Dialog Box will show the connection data *(see Figure 6.8)*.

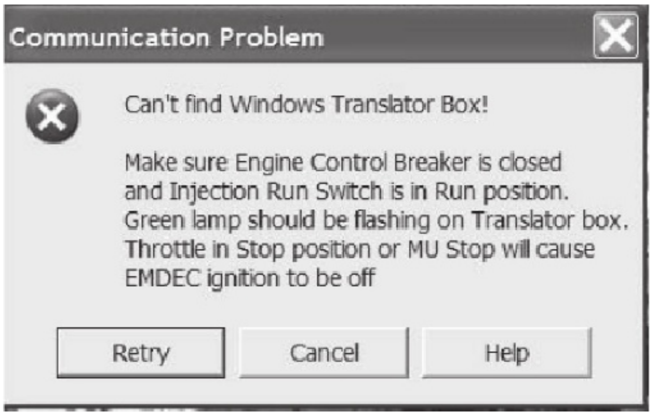


Figure 6.9 *Communication Problem.*

If the connection wasn't successful, an error box will appear *(see Figure 6.9)*.

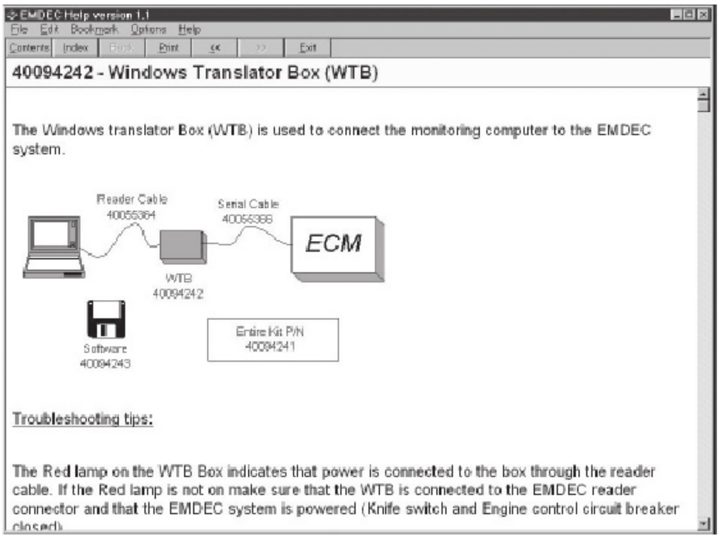


Figure 6.10 *Windows Translator Box Help Screen.*

This Communication Error box will give you three options, Retry, Cancel, and Help. Retry tells the system to attempt to communicate with the locomotive again. Cancel will stop the whole process and close the WinEMMON program. Help is a shortcut to the WinEMMON Help program, in particular the section on Translator Box connections, that gives a diagram of the proper connections and a description of same *(see Figure 6.10)*.

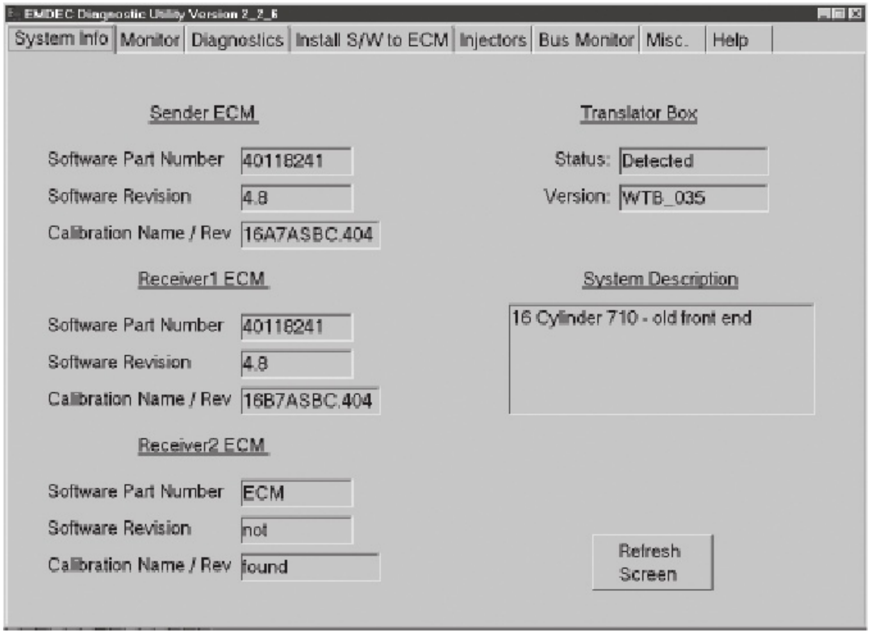


Figure 6.11 *WinEMMON Main Screen (System Information)*

This Help screen describes the two lights on the Translator Box and gives some helpful suggestions to correct any connection problems you may encounter.

If the connection was successful, the WinEMMON Main screen will appear *(see Figure 6.11)*. Across the top of the screen are the option selection buttons. Moving the cursor arrow on the computer screen to one of theses buttons will allow the operator to select that screen. These screens are:

- System Info
- Monitor
- Diagnostics
- Download
- Injectors
- Bus Monitor
- Miscellaneous (Misc.)
- Help

We will cover each of these screens in turn, starting with the System Info, or Main Screen (as this is the screen that will automatically come up if the translator box connection was successful).

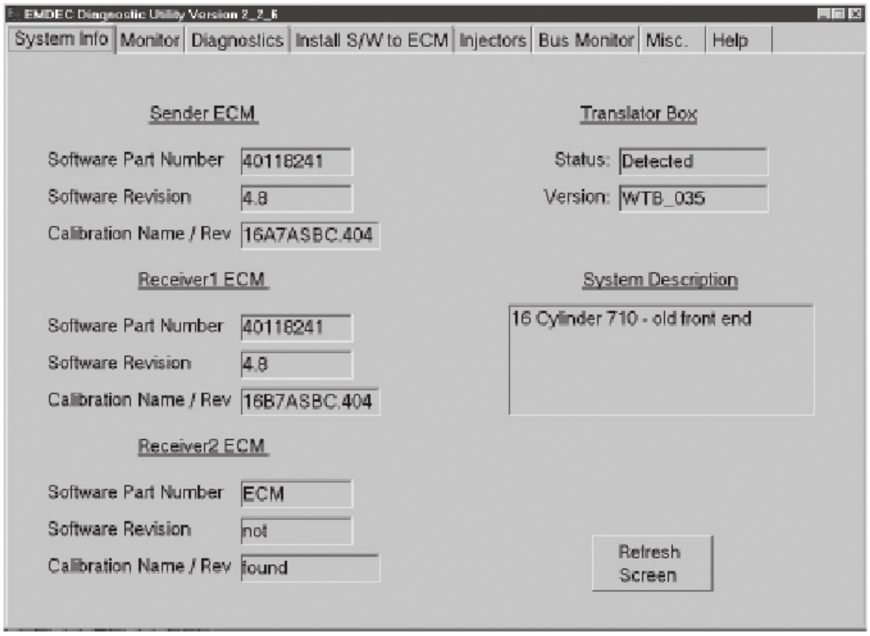


Figure 6.12 *WinEMMON Main Screen (System Information).*

6

6.2.5.1
ECM Data

On the left of the System Information Screen there are three sets of ECM information fields. The sets of data are labeled, from top to bottom:

- Sender ECM
- Receiver 1 ECM
- Receiver 2 ECM

Although all three sets of data are on the screen, the information fields for the Receiver 2 ECM will be blank when working with an 8, 12, or 16 cylinder engine. This data only applies when working with a twenty cylinder engine, which has three ECM's.

The information in these fields shows:

- The software part number
- The software revision number
- The calibration name revision

This will be useful data when determining if the software loaded into the ECM's is correct for the application. The data in these fields serves one other useful function; having the data in the fields serves to confirm that the ECM's are communicating correctly with WinEMMON.

6.2.5.2
Secondary Data

On the right hand side of the screen are three other data fields. The two in the upper right hand corner of the screen are for the Translator box. These fields show:

- Status of the Translator Box (connected or disconnected)
- Version of the Translator Box being used

This data will help to trouble shoot a connection problem, to determine if the fault lies within the physical connection, with the WinEMMON program, or with engine systems. The version field will let the operator know if they are using a current or outdated version of the software or translator box. Note that the WinEMMON translator box is the only one that will work with WinEMMON. Earlier versions of the translator box are for DOS based operating systems only.

The field in the lower right hand side of the screen is for system information, that is which engine/wiring combination is used on that particular engine. Below that is the Refresh button, which will replace the data with fresh data whenever clicked on.

If you move the computer cursor (usually an arrow) to the top of the screen and on to the Monitor button, then click on it (on the keyboard of the computer, usually close to the mechanism for moving the cursor, will be two buttons. The left of these buttons will usually be the selector button that you press, or click, to make your selection. The mechanism for moving the cursor will usually be a small pad that you drag your finger across, known as a touch pad, or a small button called a pointer) the Monitor screen will appear, see Figure 6.13.

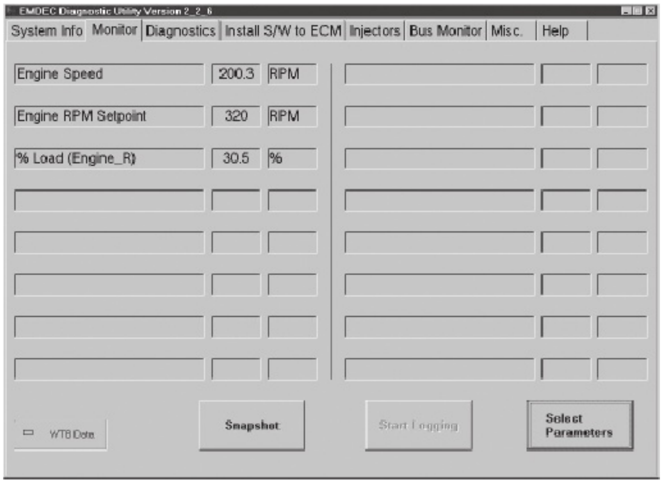


Figure 6.13 *Monitor Screen.*

6.2.5.3

Monitor Screen

The Monitor screen allows the operator to look at, or monitor, engine functions in real time. All sensor feedbacks monitored by EMDEC can be monitored. These include engine speed, engine RPM set point, engine R (as shown), as well as such things as temperatures and pressures. The signals (known as parameters) shown in Figure 6.13 are the default signals that are loaded when you first open the monitor screen. Other parameters can be selected by moving the cursor to the Select Parameters button in the lower right hand side of the screen and clicking on it. This will open a parameter selection box which will allow the operator to select from a large variety of parameters, by simply moving the cursor to the desired parameter and clicking on it. Parameters can also be selected from separate ECM's from this box, by moving the cursor over the individual parameter desired and clicking on it. Thus you can compare output from the individual ECM's. A large variation between the ECM's indicates a serious problem.

Once the desired parameters have been selected, move the cursor to the Save button and click on it if those parameters selected are the parameters the operator wishes to keep using. Note that the parameters can be changed at any time, as required.

There are two signals that are extremely valuable for troubleshooting. The first one is Engine Ratio, that was discussed in the Load Control Section. It is the bottom line of the box and is labeled as "% max fuel".
The second signal is labeled "% allowable torque".

If EMDEC is satisfied with the performance sensor inputs *(fuel temp, fuel pressure, air temp, and air pressure)*, it will maintain this signal at 100%.

If EMDEC itself must cut back on horsepower because of an engine performance problem (such as low boost pressure), this signal will be reduced.

Reducing the allowable torque signal has the effect of lowering the top ends of the fuel maps. This in essence will increase the Engine_R signal to the EM2000, causing it to reduce generator excitation.

Remember the three signals.

On a properly operating engine in a steady load state:

ENGINE_R	<	87%
%ALLOWABLETORQUE	=	100%
LR%MAX	=	100%

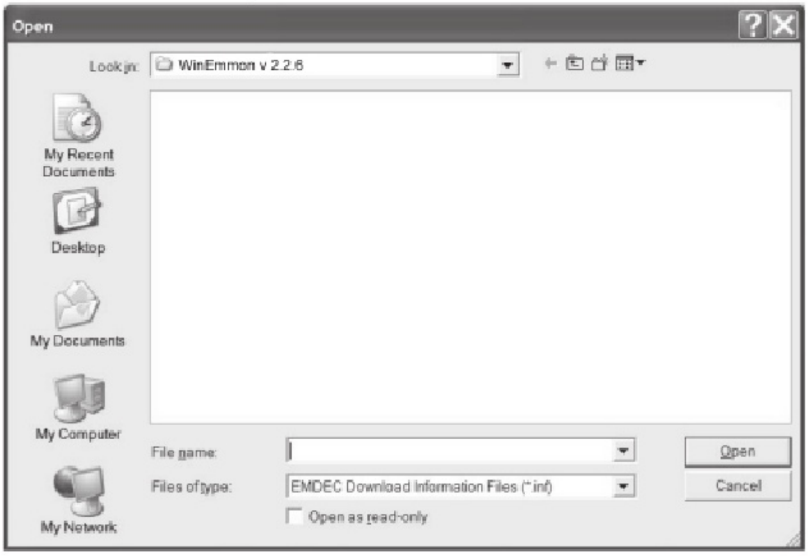


Figure 6.14 *Data Save Box.*

6.2.5.4

Saving Data

A "Snapshot" of data can be taken and saved by moving the cursor to the "Save" button and clicking on it. A "Save" box then opens*(see Figure 6.14)*, requiring the operator to name the data file (unit number, date, or other relevant information that identifies the data should be used) and then move the cursor tothe "Open" button and click on it. A second "Save" box then opens, with a "Save" button. Move the cursor to this button and click on it and the data will be saved as the named file. This allows the operator to keep a tally of running conditions and document any problems diagnosed. Once saved, the save box will close, and the Monitor screen will appear once again.

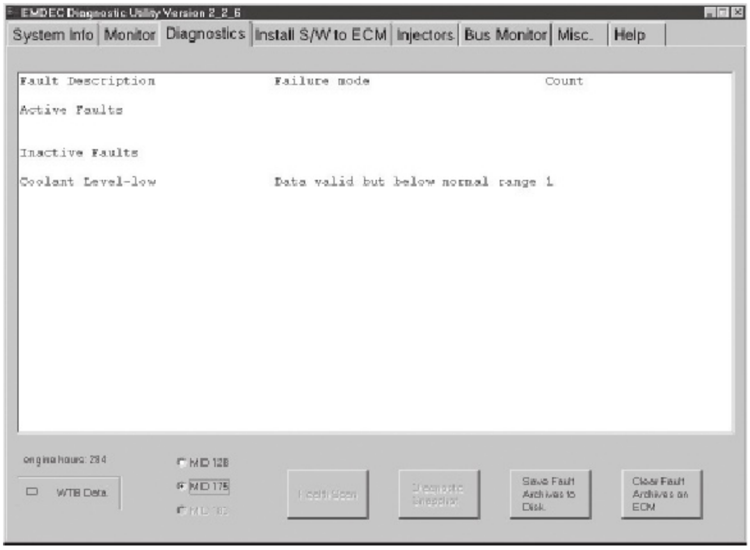


Figure 6.15 *Diagnostics Screen.*

6.2.6 Diagnostics

If the operator then moves the cursor to the top of the Monitor screen and places it on the Diagnostics button, and clicks on it, the Monitor screen will close and the Diagnostics screen will appear *(see Figure 6.15)*.

The Diagnostics screen is a "Real time" display of current faults both active and inactive, from the ECM's. This screen shows:

- Fault description (Active or Inactive)
- Failure mode (what the Failure is)
- Count (how many times the Failure occurred)

6.2.6.1 Understanding The Fault Screen

For example, in Figure 6.15, the Diagnostics screen shows us that there are no Active Faults. Under Inactive Faults, “Proprietary Data Link” is displayed. This tells the operator that there was a proprietary data link failure sometime in the past, but it is not currently active. Under failure mode, we read “Abnormal frequency, PW (Pulse Width) or period”. This is what the fault to the Data Link actually was. To the right of that data on the screen is the count, in this case “6”, which tells us that the fault has occurred six times.

6.2.6.2 Selecting The Fault Source

The faults can be read from either ECM. The selection of which ECM to read is done on the bottom of the Diagnostics screen, where there two circles, one below the other, labeled “MID 128” and “MID 175”. MID stands for Message ID. In this case, which ECM the data is coming from. Note that there are only two active options, even though a third can be seen below. This third selection will only be accessible when connected to a twenty cylinder engine. By moving the cursor to the circle beside the MID desired, and then clicking on it, the fault input data source will be changed.

Along the bottom of the Diagnostics screen are four buttons, these are:

- Health Scan
- Diagnostic Snapshot
- Save Diagnostics
- Clear All

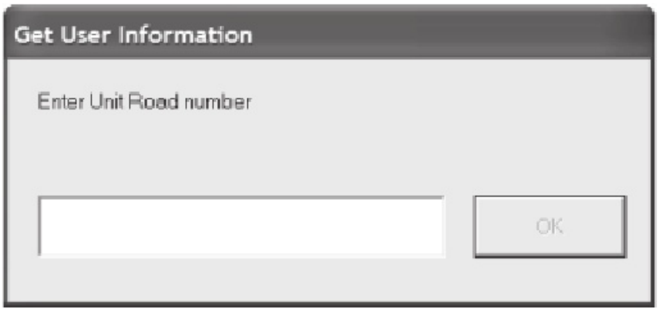


Figure 6.16 *Unit Road Number Box.*

6.2.6.3

Saving Fault Data

Note that some buttons are clear, while others seem faded. This differentiates between active and inactive buttons. If the cursor is moved to an inactive button and clicked nothing will happen. An inactive button means that the option the button leads to is not available in this particular operation. In this version of the Diagnostics screen, only the "Save Diagnostics" and "Clear All" buttons are active.

Moving the cursor to the Save Diagnostics button and clicking on it will open a Request Unit Number Box, see Figure 6.18. This is to identify the data.

Once the unit road number is entered (which is done by moving the cursor to the open field and clicking on it, then typing in the unit road number), move the cursor to the OK button and click on it. A Save Box will then open,

as in Figure 6.16. The same file name requests will be made as with the previous Save Box. Once these requests are fulfilled, move the cursor to the open button, click on it, then move the cursor to the Save button, and click on it. This will allow the operator to save any data found in the fault files, either for later perusal, record keeping, or fault verification.

6.2.6.4

Clearing Faults

The Clear All button will clear all Inactive Faults. Any fault that is currently active cannot be cleared until the fault is corrected.

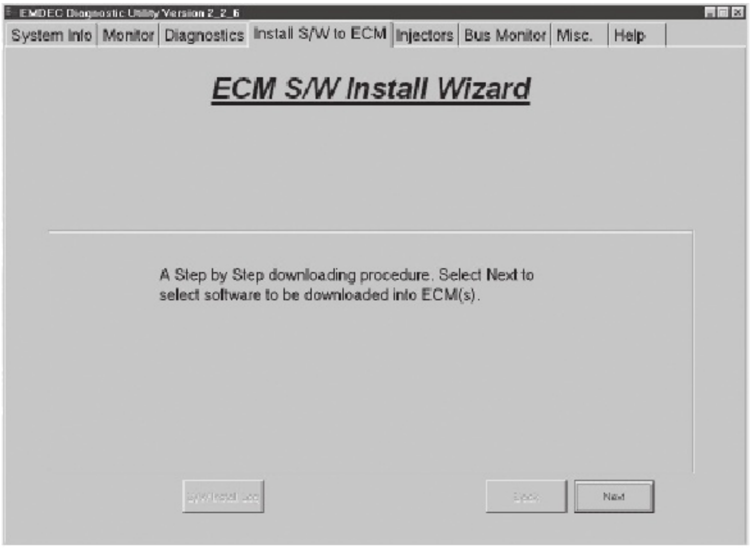


Figure 6.17 *Download Screen.*

6.2.7

Using The Download Wizard

Moving the cursor to the top of the Diagnostics screen and to the "Install S/W to ECM" button and clicking on it will open the Download Screen, see Figure 6.17.

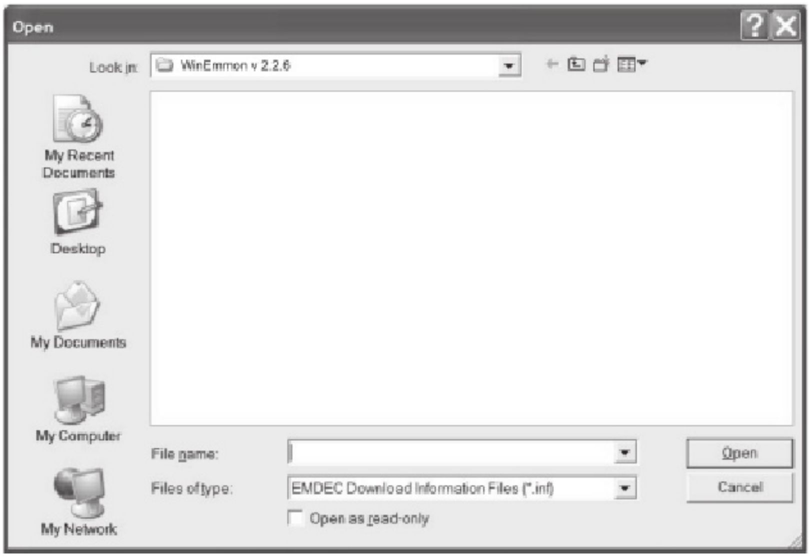


Figure 6.18 *Download Save Box.*

This screen will allow the operator to download data to the ECM's, such as when installing new software. Moving the cursor to the next button and clicking on it will start the "Wizard". A "Wizard" is a sub-program that walks the operator through the stepsrequired to install new software into the ECM's. Once Next is selected, a Save box will open, see Figure 6.18.

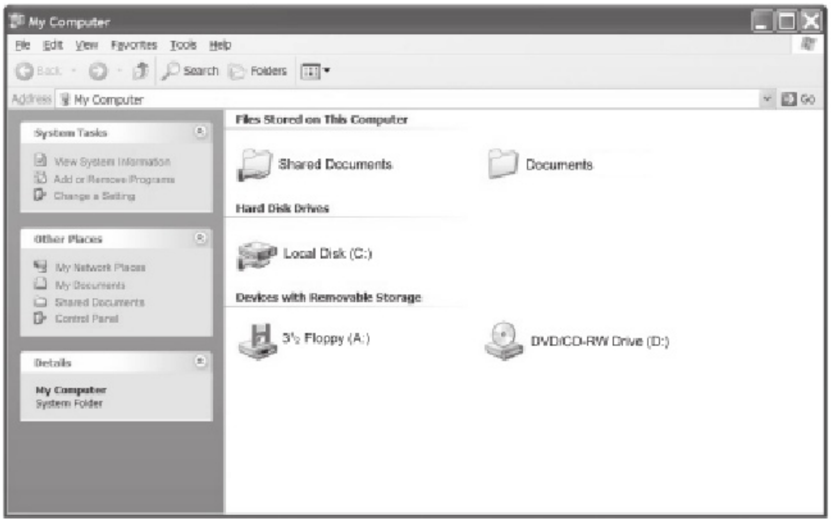


Figure 6.19 *My Computer Box.*

This operates the same as the previous Save Boxes, except in this case, the operator will select the file that the download for the ECM's is located. This will usually be the A: drive on the computer, as the software will likely be on disc. Insert the disc into the A drive. Move the cursor to the "My Computer" icon (picture) on the left of the Save Box and click on it. This will open another box that will show the various drives on the computer, see Figure 6.19.

Move the cursor to the icon labeled 3 _ Floppy (A), and click on it. This will activate the A: drive and open another box which will show the contents of the disc in the drive. Move the cursor to the software icon in the A: drive box and click on it. This will usually take you back to the Download Save Box *(see Figure 6.19)*, which should show the file from the A: drive that was selected in the upper field. Move the cursor to the Open button and click on it, and the Download should commence.

You can also save a log of the downloads applied to the ECM's in this Save Box, as well. After the down load is complete, click on the download file, then click on the OK button, and then click on the Save button.

Note that if communication problems should arise, you can try moving the Translator Box EMDEC connection to the connection located in the #1 Electrical cabinet, directly on the interface board in early applications with two access port locations for EMDEC.

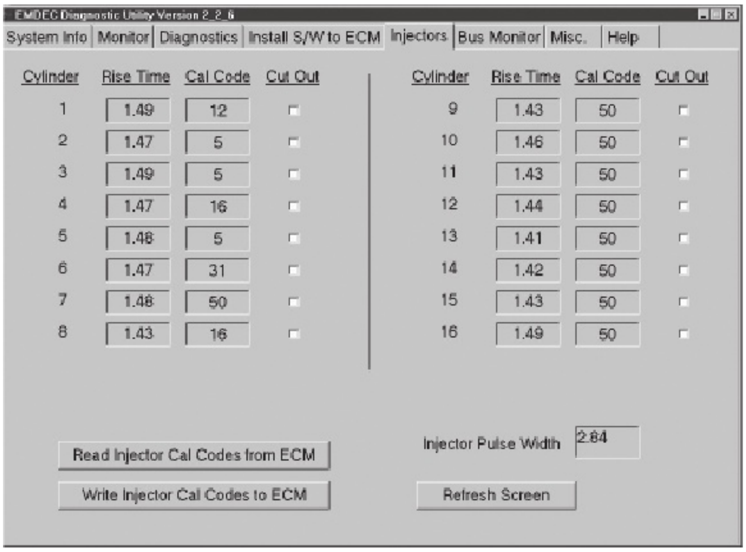


Figure 6.20 *Injectors Screen.*

6.2.8 Injectors Screen

Moving the cursor to the top of the Download screen and selecting the Injectors button and clicking on it will activate the Injectors screen, see Figure 6.20.

The Injectors screen will show:

- Cylinder (Which One)
- Rise Time
- Cal Code (Calibration)
- CutOut
- Pulse Width

This screen will also allow us to "Read" from the ECM's, "Write" to the ECM's, ad refresh the data shown on the screen.

Cylinder has a list of numbers beneath it, from 1 to 16 in this particular example. These are the cylinders on the engine, shown in numerical order. If we happened to be on an 8 cylinder engine, we would see 8 cylinders or 20 on a twenty cylinder.

6.2.8.1 Injector Rise Time

Next to the cylinder number is the Rise Time column. This is the "Response" time of each individual injector. This is real time feedback of injector rise time (or response time) from the ECM's.

These fields can also indicate problems with the electrical side of the injectors.

Rise times should remain stable throughout the entire engine speed range. Rise times should be between 1.20 – 1.60 ms, and there should be little variance between cylinders.

6

6.2.8.2 Injector Calibration

To the right of the Rise Time column is the Cal Code fields. These are the calibration numbers for each injector.

Each EMDEC injector requires correct calibration be entered to compensate for assembly line tolerance differences in the mechanical portion.

Calibration changes the output of each injector to bring it to a nominal standard.

Calibration codes should be verified on a regular basis.

Therefore, units having trouble making horsepower with good injectors will benefit from this feature.

Calibration is the electrical equivalent of "setting the rack", and **must** be done each time an injector is renewed.

The injectors proper calibration code is marked on the top plate of the electrical solenoid portion of the injector.

6.2.8.3

Calibration Process

1. Open the top deck covers and record the two digit calibration number from each injector, taking care to ensure that the corresponding cylinder number is also noted.
2. Check the cylinder number sorted calibration codes from the injectors against those in the Cal code columns of the Injectors Screen of WinEMMON.
3. Verify that the numbers are the same between the cylinders and the Cal Code column.
4. If the numbers are different, move the cursor to the field of the first cylinder with a non-matching Cal Code, and click on it.
5. Type in the correct Cal Code.
6. Move on to the next mismatched cylinder/ injector as required.
7. Once all the corrected Cal Codes are entered, move the cursor to the "Write to ECM" button and click on it.

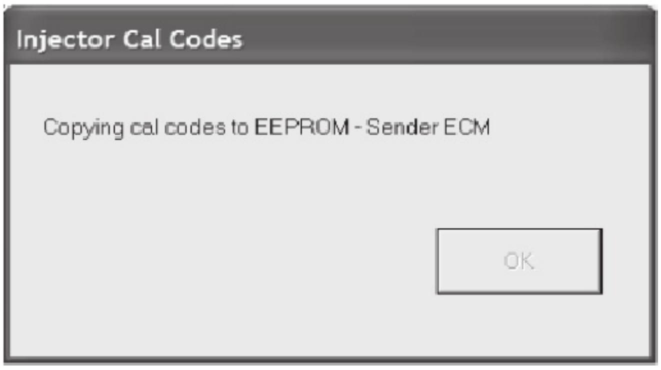


Figure 6.21 *Copying Cal Codes Box (Sender ECM).*

A "Copying Cal codes to EEPROM" box will appear, see Figure 6.21. At first it will read "-Sender ECM", move the cursor to the OK button and click on it, then it will read "- Receiver ECM".

Move the cursor to the OK button and click on it when the copying is done (a message will appear in the copying box). This will take the operator back to the Injectors screen.

6

6.2.8.4 Injector Cut Out

The next column to the right of Cal Codes is Cut Out. Again these are displayed in numerical order. To cut out a cylinder for diagnostic purposes, move the cursor to the display field of the cylinder you wish to cut-out. Click on that field, and the cylinder will be cut-out. When you wish to cut it back in again, simply click on the same field a second time.

Note that when you leave this screen, all cut out injectors are cut in again by the program. Do not cut out more then one injector at a time.

6.2.8.5 Pulse Width

The Pulse Width field is located in the lower right corner of the Injectors screen. When you cut out an injector, monitor the Pulse Width as it should change. Pulse Width is an average measurement, taken across the engine, of the length of time the injectors are held open. This is measured in degrees of crankshaft rotation. As the computer will attempt to put more fuel in the engine to compensate for a cut out cylinder, the Pulse Width will widen (the injectors will be held open longer). When you cut out an injector and no discernable difference is noticed in the Pulse Width, the computer has already compensated for that cylinder, indicating that there is a problem with it. For more detail see the Troubleshooting section of this manual.

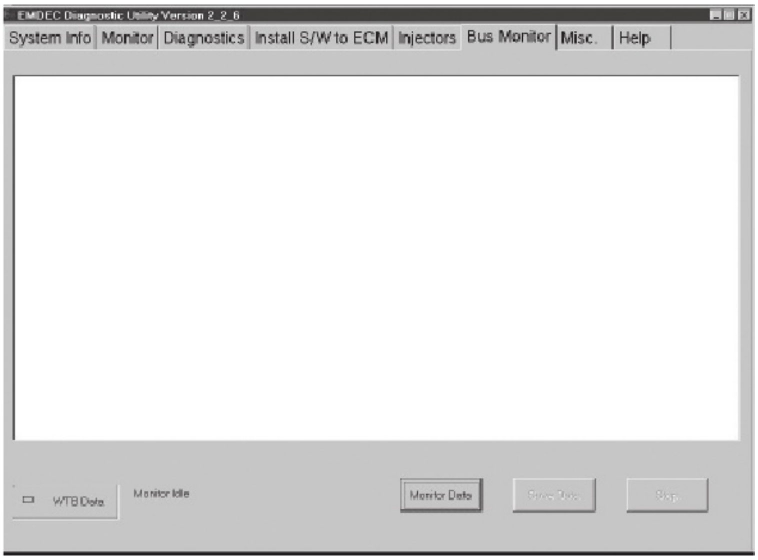


Figure 6.22 *Bus Monitor Screen.*

6.2.9 Bus Monitor

Moving the cursor to the top of the Injectors Screen and selecting the Bus Monitor button, and then clicking on it, will bring us to the Bus Monitor screen, see Figure 6.22.

6

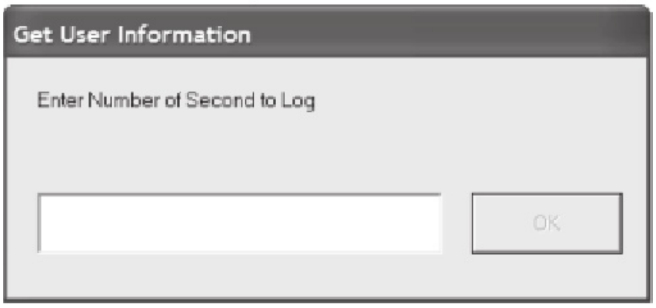


Figure 6.23 *Get User Information Box.*

The Bus Monitor screen will allow the user to monitor and save the data accumulated in the bus. When this screen is first opened it will be blank. Move the cursor to the Monitor Data button and click on it. This will open a Get User Information Box, see Figure 6.23.

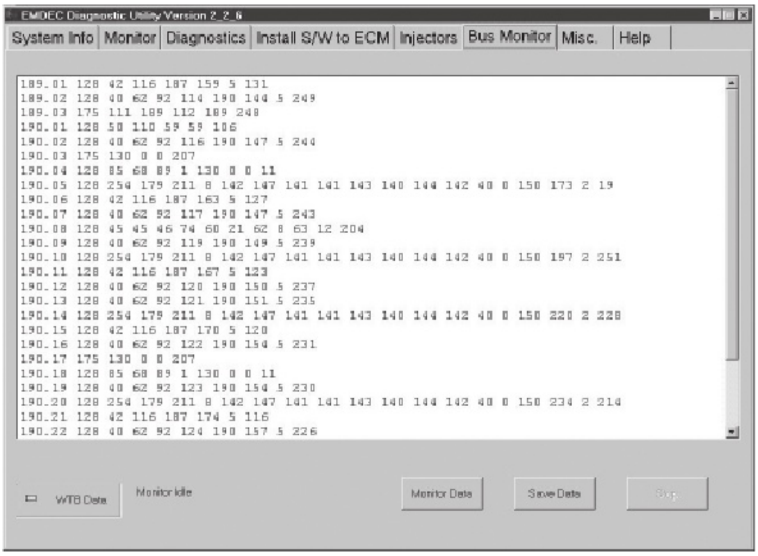


Figure 6.24 *Bus Monitor Screen Gathering Data.*

The data we can get from the bus is time related, so the program wants to know which second to log. Enter a time here, click on the OK button, and the Bus Monitor Screen will reopen with data, see Figure 6.24.

6

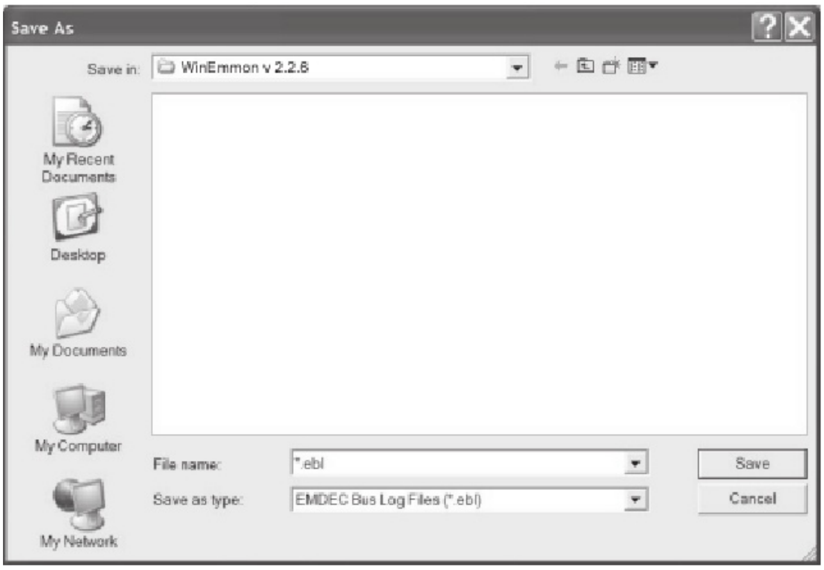


Figure 6.25 *Bus Monitor Data Save Box.*

This data gathering process will continue until the Save or Stop button is clicked on. If the Save button is selected, a Save Box will open, see Figure 6.25.

Moving the cursor to the File Name field and clicking there will allow the operator to type in an identifying File Name. Once a File Name has been typed in, move the cursor to the Save button and click on it. The file will then be saved. Note that all file saves will be placed in the WinEMMON v 1.3 Folder unless otherwise specified.

Other folders can be selected by moving the cursor to the Save In field at the top of the DataSave box, clicking on it, and typing in an alternate folder. The operator can also move the cursor to the downward facing arrow at the right of this field box, and by clicking on it, browse through other folders until the one sought is found.

Once the file is saved, the Bus Monitor screen will once again appear. Moving the cursor to the buttons along the top and selecting the Misc. (Miscellaneous) button and clicking on it, will open the Miscellaneous screen.

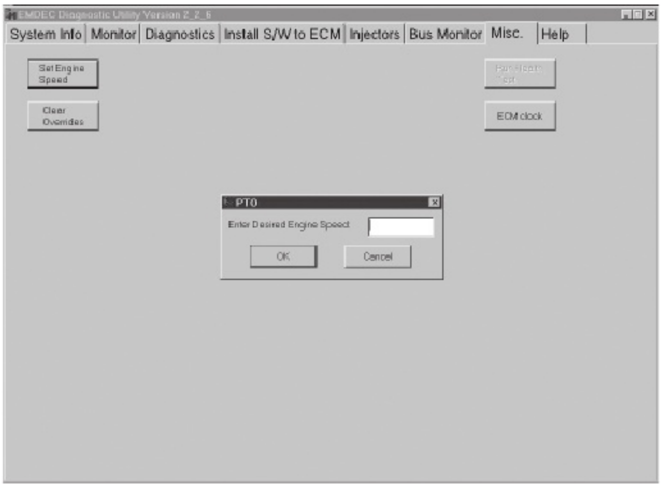


Figure 6.26 *Miscellaneous Screen.*

6.2.10 Miscellaneous Screen

The Miscellaneous screen has buttons for:

- Set Engine Speed
- Clear Overrides
- Run Health Test
- ECM Clock

Moving the cursor to one of these buttons and clicking on it will activate the buttons stated function.
Note again that faded buttons are not active, and can not be selected.

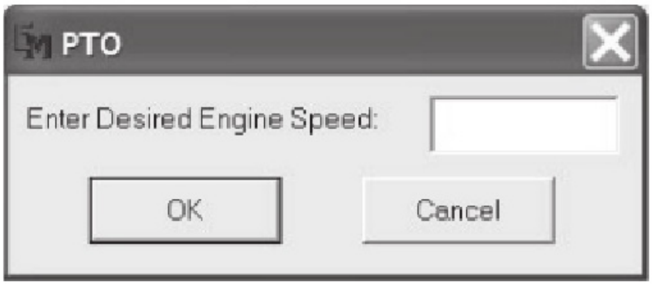


Figure 6.27 *Set Engine Speed (PTO) Box.*

The first button on the Miscellaneous screen (hereafter called Misc.) is the Set Engine Speed button. Moving the cursor to this button and clicking on it will open the Set Engine Speed box, see figure 6.27.

The desired engine speed is typed into the field in the upper right of the box (move the cursor to the field, then click on it, then type). Once the speed is typed in, move the cursor to the OK button and click on it. The computer will then run the engine at the requested speed. This option is mostly used in stationary or marine engines for certain testing functions. If the operator decides not to change the engine speed, simply move the cursor to the Cancel button and click on it. This will return you to the Misc. screen.

The Clear Overrides button will clear any settings

changes the operator has made while testing the system. The Run Health Test button is not available in version.

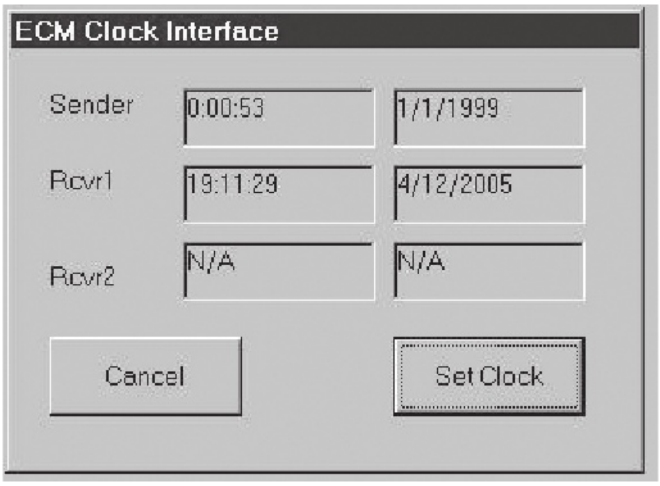


Figure 6.28 *ECM Clock Interface Box.*

The ECM Clock button allows the ECM clocks to be set and synchronized. Moving the cursor to the ECM Clock button and clicking on it will open the ECM Clock Interface box, see Figure 6.28.

This box has data fields for:

- Sender – time and date
- Receiver 1 – time and date
- Receiver 2 – time and date

The fields on the left of the box are the time fields, and the ones on the right are the date fields. Time is given in hour/minute/second form, and date is given in month/day/year form.

There are two buttons on the bottom of the box, one to cancel the operation and the other to set the clocks. Setting and synchronizing the ECM clocks is important for data identification and troubleshooting.

For example, if you can determine the date and time of a series of injector faults, and find it corresponds to the date and time of a loading problem, that would be an important clue as to identifying the root cause of the failure.

To adjust the ECM time, move the cursor to the Set Clock button and click on it. The ECM times (and dates if necessary) should update. Note that the times and dates will update to the times and dates that the are on the computer being used to read the program.

Once the clock has been set, move the cursor to the Cancel button, and click on it. This will return the operator to the Misc. Screen. Moving the cursor to the top of the screen and to the right, brings us to the last options button, the Help Screen.

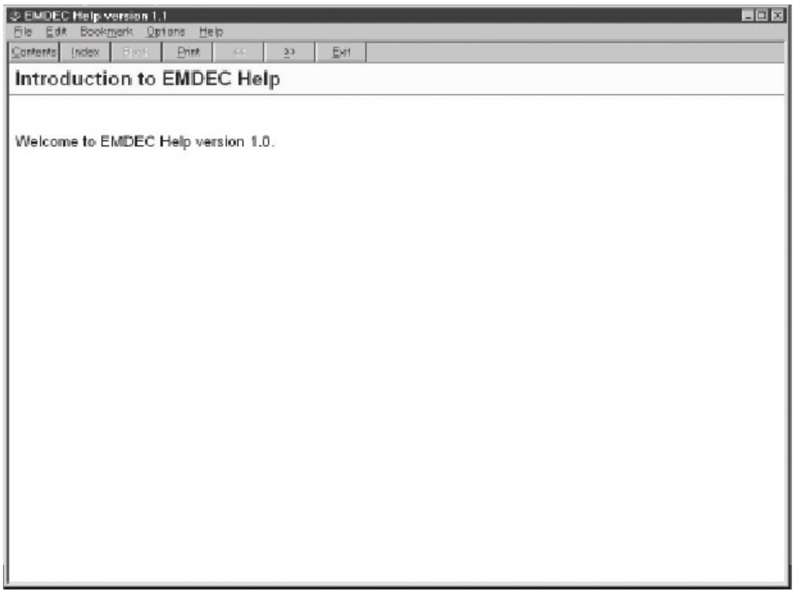


Figure 6.29 *EMDEC Help Screen*

6

6.2.11
Help

Clicking on the Help button opens the Helps screen, see Figure 6.29.

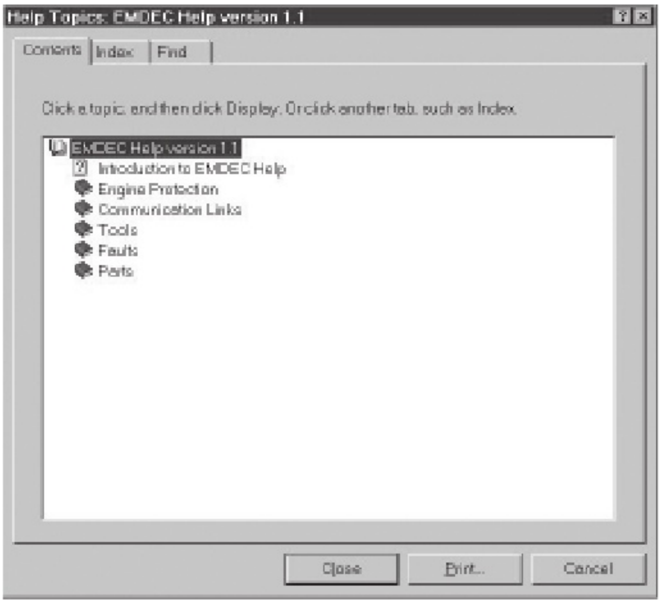


Figure 6.30 *Help Contents Screen.*

The first screen that comes up is the welcome screen, which doesn't have a lot of data on it, but does allow the operator to select from a few options. By moving the cursor to the upper left corner of the screen to the Contents button, and clicking on it, the Help file Contents will be displayed, see Figure 6.30.

The Help Contents Screen has several options on it.

Across the top are:

- Contents
- Index
- Find

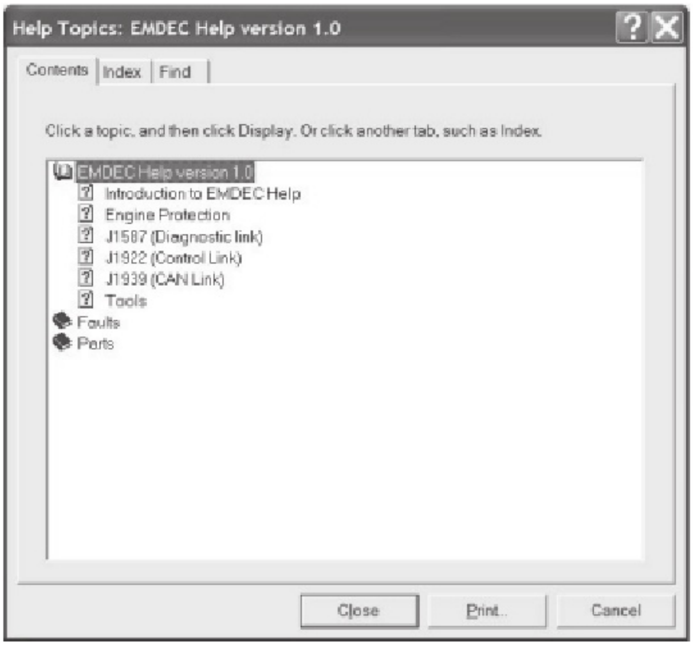


Figure 6.31 *EMDEC Help Topics.*

6

6.2.11.1
Help Topics

Moving the cursor to the Contents button and clicking on it opens the Contents screen, Figure 6.31. Moving the cursor to the first option within the box (a small book icon) and clicking on it, will open the EMDEC Help Topics, see Figure 6.32.

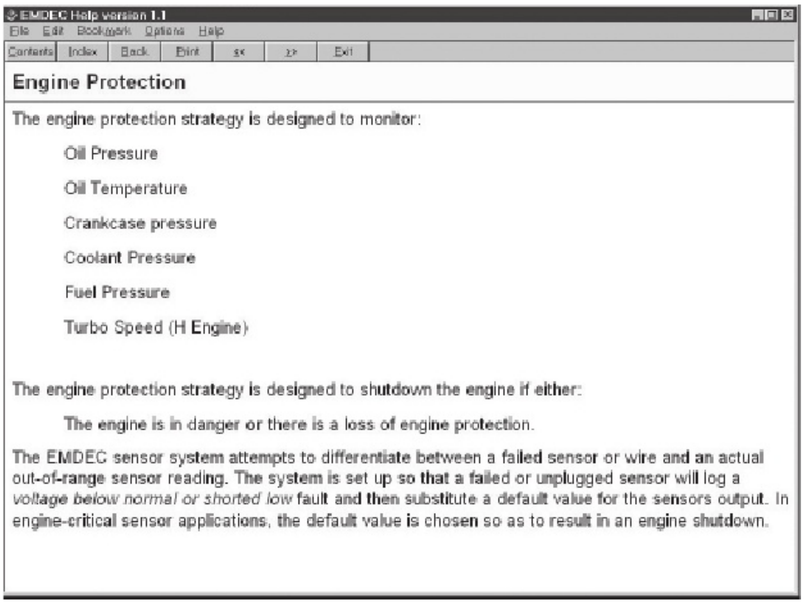


Figure 6.32 *Engine Protection Help Screen.*

These topics include:

- Introduction To Help
- Engine Protection
- Diagnostic Link
- Control Link
- CAN Link
- Tools

Introduction to Help is simply a repeat of the Introductory help screen.

The Engine Protection help screen, see Figure 6.32, documents the various elements involved in Engine Protection, and describes what those sensors monitor and what parameters the program has to deal with the data.

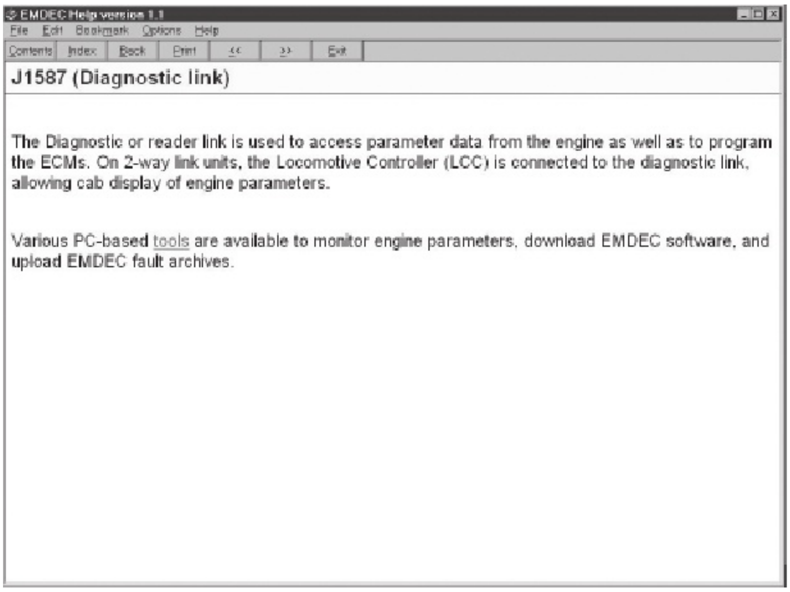


Figure 6.33 *Diagnostic Link Help Screen.*

6

Diagnostic Link help screen, see Figure 6.33, simply tells the operator what the diagnostic link is.

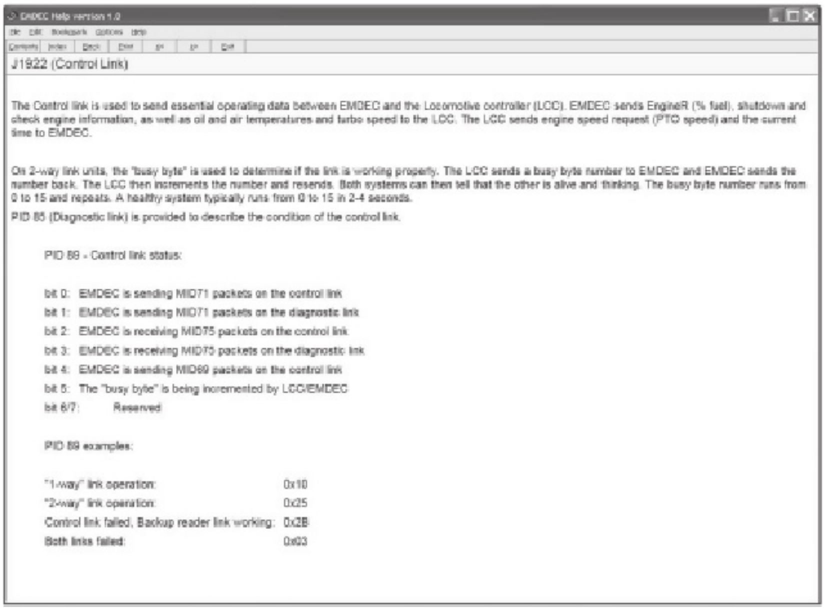


Figure 6.34 *Control Link Help Screen.*

The Control Link help screen, see Figure 6.34, explains what the control link is, how it works, the PID (Parameter ID) that corresponds to the link, and gives an example of the “busy byte” numbers.

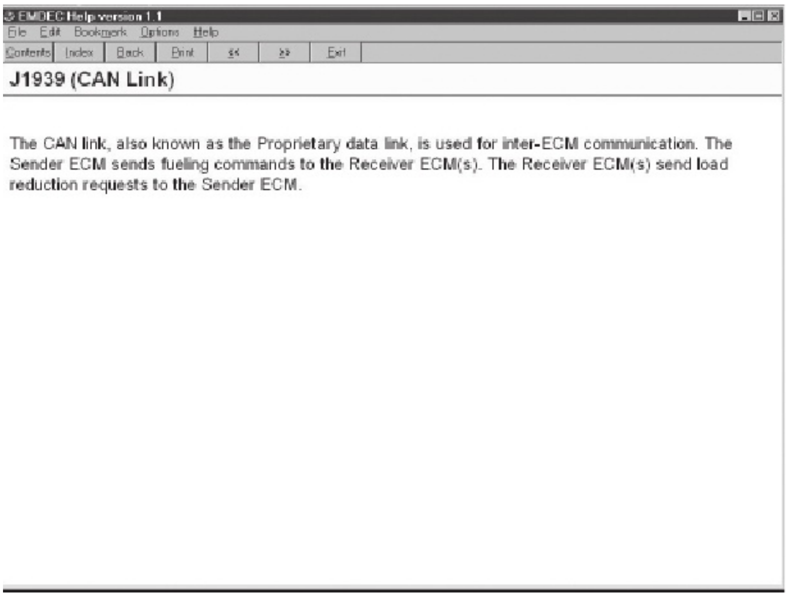


Figure 6.35 *CAN Link Help Screen.*

6

The CAN Link help screen, see Figure 6.35, describes what a CAN link is and does.

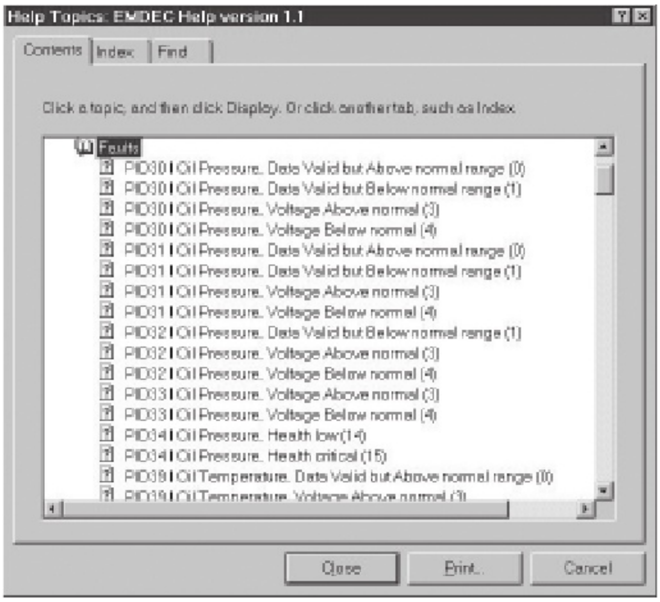


Figure 6.36 *Faults Help.*

6.2.11.2
Faults

The next item that can be selected from help topics are Faults. Moving the cursor to the Faults icon (the second little book) and clicking on it, opens the Fault Topics, see Figure 6.36.

The list of items under the Faults topic consists of PID's (Parameter Identifications) and SID's (System Identifications). The majority of the PID's and SID's are in this list.

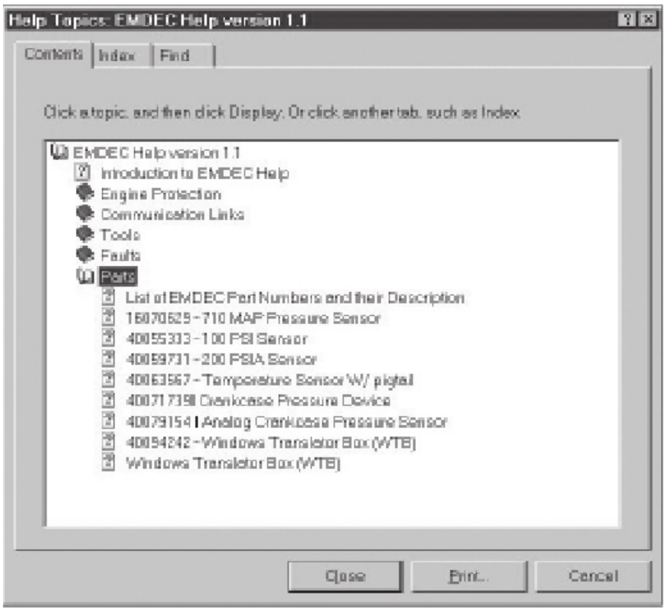


Figure 6.37 *Parts Help Screen.*

6

The next Topic selectable from the Contents Screen is parts, see Figure 6.37. This is a list of the common EMDEC sensor parts, their numbers, and the Translator box part number.

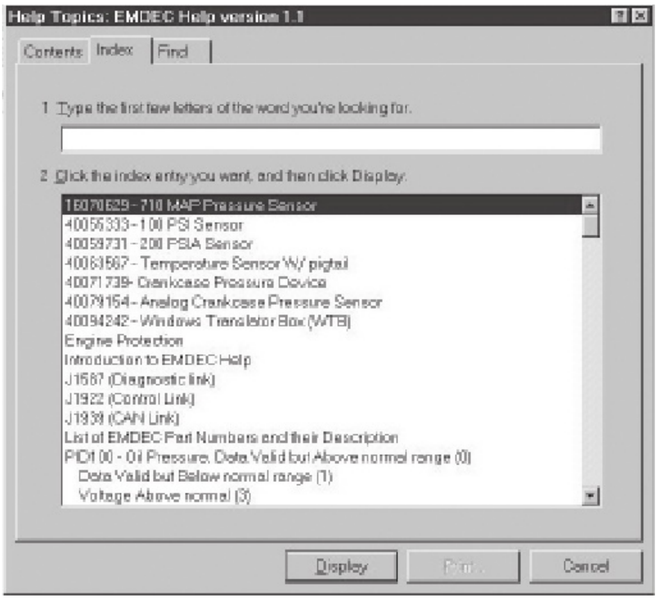


Figure 6.38 *Help Index Box.*

If the operator closes this help box and then moves the cursor to the next tabbed item in the top of the Help Contents Screen, and clicks on it, the Help Index Box will open, see Figure 6.38.

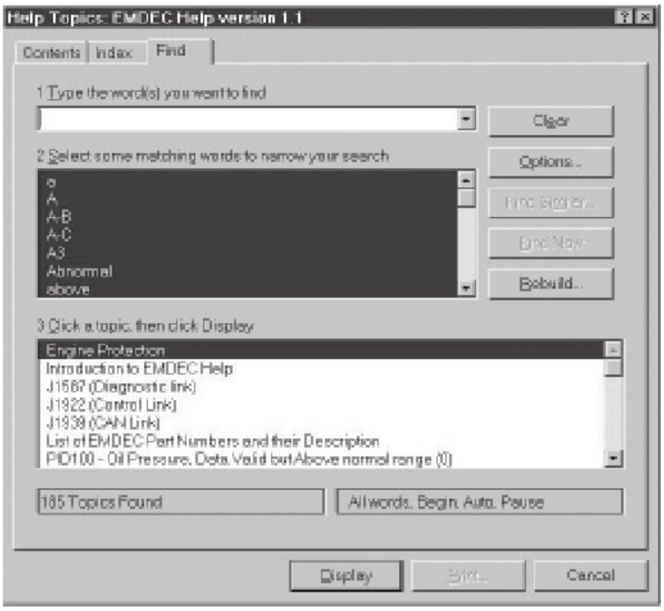


Figure 6.39 *Help Find Screen.*

This box has two fields in it, number1 and number 2. The number 1 field is a search field, if you move the cursor there and click on it, then type in the first few letters of the subject you're trying to find, the Help program will search through its data base and try to find a match. The second field (number 2) has a list of all the subjects in the database. You can look through them by moving the cursor to the downwards facing arrow on the right hand side of the field and clicking on it. This will cause the list to scroll down, allowing the operator to read all the items. Once you see an item you want to see more detail about, move the cursor over to the item and click on it. This will cause a blue box to appear on the item you wish to see. This is called "highlighting". Once you have highlighted the item you want, move the cursor to the button labeled "Display" and click on it. More information will appear about the item highlighted. Moving the cursor back to the top of the Help Contents screen, click on the Find button. This will open the Help Find screen, see Figure 6.39.

This screen works basically the same as the Find feature on the Index screen. There are three fields:

1. WordsSearch

2. LettersSearch

3. TopicsSearch

In the first you move the cursor to the open field and then click on it. Type in the first words of the subject you are trying to find.

In the second the operator can scroll down (again, by moving the cursor to the downwards facing arrows to the right of the field and clicking on them) and select matching words and letters from the list. This selection

is done by moving the cursor to the words or letters you wish to select and clicking on them. This will highlight the selected words or letters. The operator will then move the cursor to the right, where there are five buttons. These buttons are:

- Clear
- Options
- Find Similar
- Find Now
- Rebuild

Moving the cursor to the Clear button and clicking on it will clear the field that is active (the one you've been typing in).

The options button will let you select from a couple of choices for finding items in the search.

Find similar allows you to search for something similar to an item you've already selected in the active field.

Find now tells the program to search for what you've identified immediately.

Rebuild rebuilds the list that the choices can be made from.

At the bottom of the Help Find screen are two more fields, the one on the left will tell you how many topics have been found after a search, and the one on the right identifies the search criteria that was selected (ie: alphabetical, etc).

There are three buttons along the bottom of the Help Find screen, Display, Print, and Cancel. If you highlight an item in the #3 or topic field, you can then move the cursor to the Display button, click on it, and your topic detail will appear. Print is an option when a printer is connected to the computer being used (note that the button is faded, indicating that it isn't active at this time). Cancel will close the Help Find box and return the operator to the main screen again.

6

Note that WinEMMON Help is a work in progress. As other information becomes available, it will be added to the program periodically.

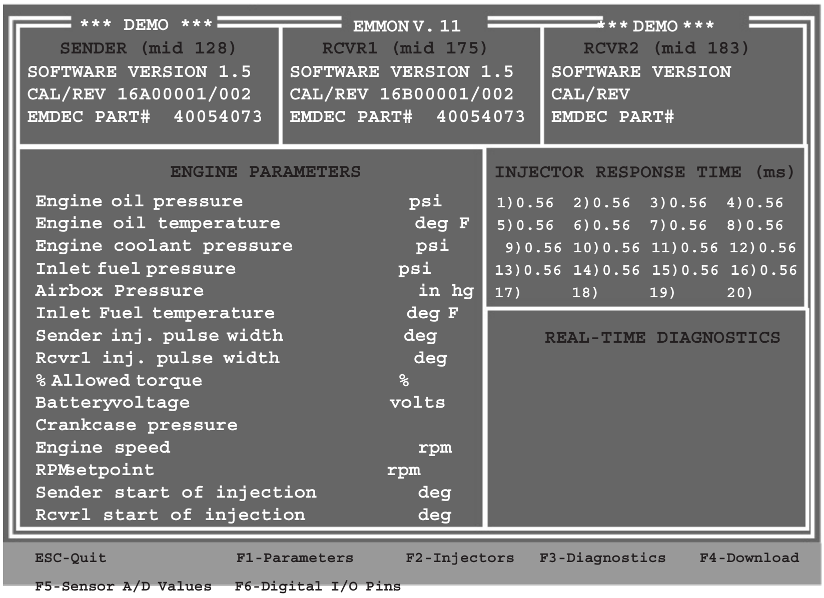


Figure 6.40 *PC Reader Main Screen.*

6.3.1 PC Reader Main Screen

The main PC Reader screen consists of six separate information areas, or dialogue boxes, plus a list of function keys located across the bottom of the screen.

Each of these areas operates independent of the others, and portrays a different type of data.

6.3.1.1 ECM Data Boxes

The three boxes across the top of the screen *(figure 6.40)* display ECM identification data. The boxes labeled, from left to right:

- Sender,
- Receiver 1, and,
- Receiver 2.

Although all three boxes are on display, the information fields in the Receiver 2 box will be blank when working with a 8, 12 or 16-cylinder engine. This box only applies when working with a twenty-cylinder engine with three ECM's.

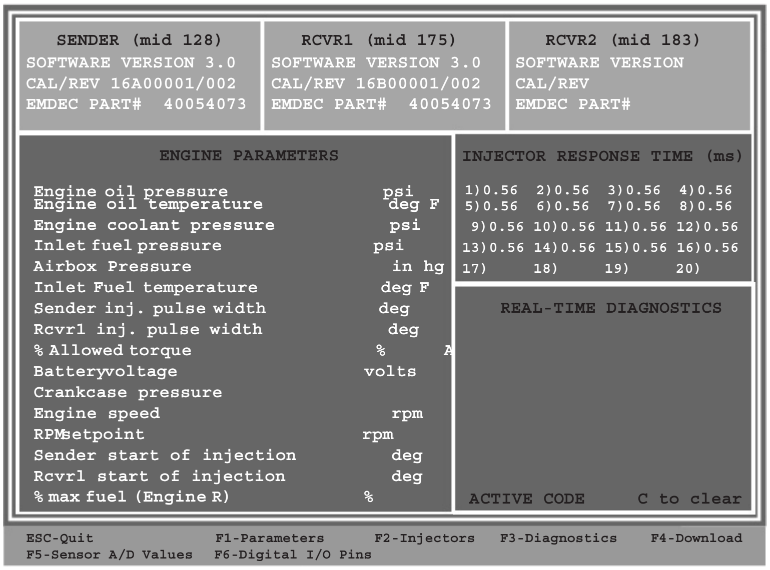


Figure 6.41 *ECM Data Dialogue Boxes.*

The information contained in these boxes shows:

- the MID code for the ECM,
- the calibration number, and,
- version of ECM software.

This will be useful when determining if the software loaded in the ECM's is correct for the application. The boxes serve one other useful function. Having information shown in the boxes also serves to show the ECM's are communicating correctly tothe PC Reader.

6.3.1.2 Engine Parameter Data Box

On the left side of the main screen is a large box labeled "Parameters" *(figure 6.41)*. The data shown in this area is real time feedback from the various engine sensors. In addition, other data critical to engine operation is also displayed in this dialogue box. This other information is based on ECM calculations, and signals sent to the EM2000.

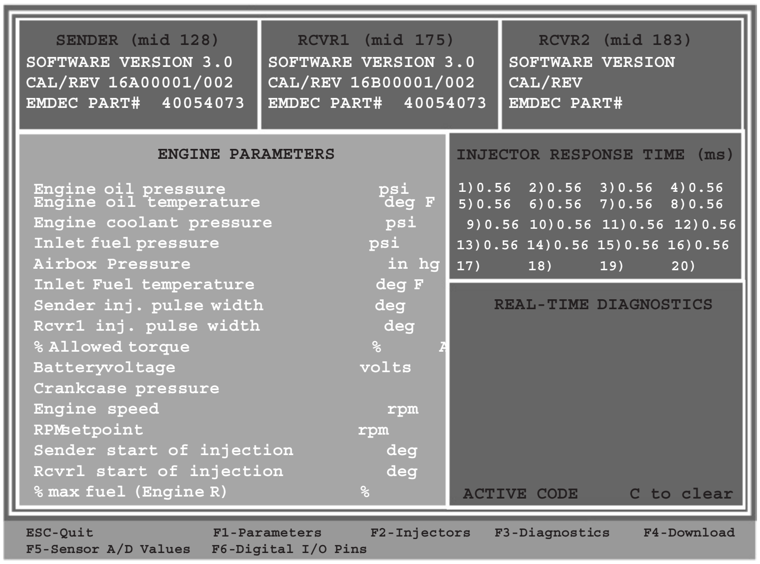


Figure 6.42 *Engine Parameter Dialogue Box.*

As shown in figure 6.42, all sensor feedbacks such as pressures and temperatures are displayed. For example, the lube oil pressure and temperature may be monitored on this screen.

The signal called "Battery Voltage" is actually the output of the 24 VDC power supply. This is an easy way to assess the condition of the output. Remember that the power supply must be 24 VDC plus or minus 10%.

Shown in this area are the base pulse widths and the base start of injection for the Sender and Receiver ECM (s). Normally the data shown for the different ECM's should be very similar. A large variation between Sender and Receiver indicates a serious problem. Again, this is very important information to have when diagnosing engine problems.

There are two signals that are extremely valuable for troubleshooting. The first one is Engine Ratio, that was discussed in the Load Control Section. It is the bottom line of the box and is labeled as "% max fuel".

The second signal is labeled "% allowable torque".

If EMDEC is satisfied with the performance sensor inputs *(fuel temp, fuel pressure, air temp, and air pressure)*, it will maintain this signal at 100%.

If EMDEC itself must cut back on horsepower because of an engine performance problem (such as low boost pressure), this signal will be reduced.

Reducing the allowable torque signal has the effect of lowering the top ends of the fuel maps. This in essence will increase the Engine_R signal to the EM2000, causing it to reduce generator excitation.

Remember the three signals.

On a properly operating engine in a steady load state:

ENGINE_R	<	87%
%ALLOWABLETORQUE	=	100%
LR%MAX	=	100%

6.3.1.3 Editing The Main Screen

To change or rearrange parameters displayed in the dialogue box:

1. Press the **F1-Parameters** key on the EMMON Main screen.

   Two columns will appear. The left column lists parameters that are displayed, the right column is the choice of parameters available.

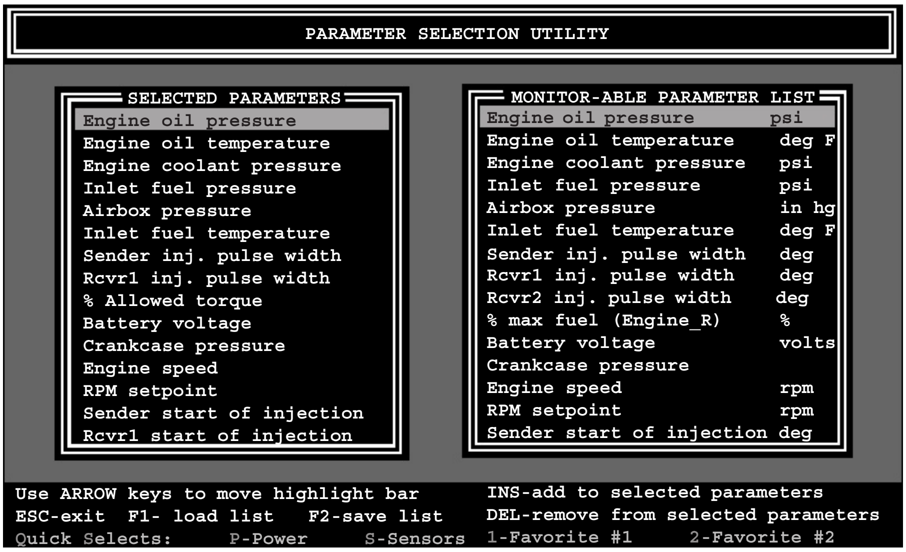


Figure 6.43 *Engine Parameter Selection Utility Screen.*

2. Shift between the columns by using the horizontal arrow keys.

   Move the cursor to the desired column and the first item will be highlighted in a white box in bold print.

   Move the highlighted box using the vertical arrow keys.

3. Press the **DELETE** key to remove items selected from the left column.

4. Press the **INSERT** key to insert items selected from the right column, into open lines on the left column.

   The operator cannot insert parameters into the left column unless blank lines are available.

5. Hit the **ESC** key to return to the display screen.

6. To save the set up, press**F2** and name the file as desired (i.e. “cool” for the Cooling System).

6

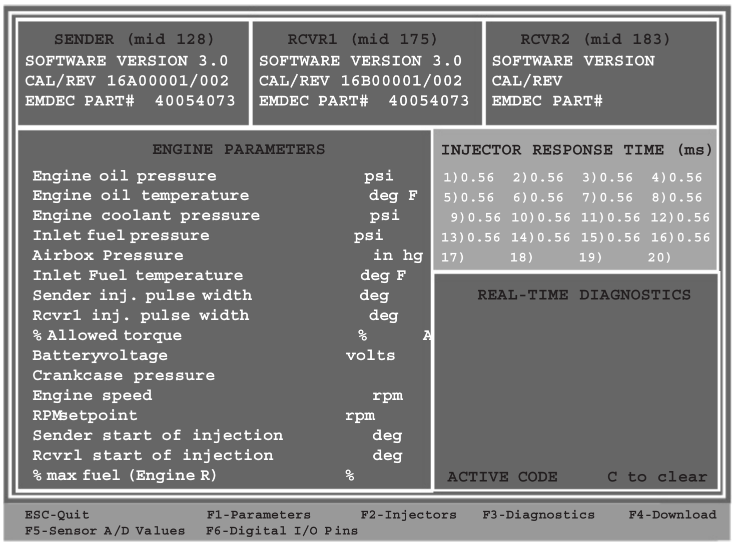


Figure 6.44 *Injector Response Times.*

6.3.1.4

Injector Response Time

On the right side of the main screen are two smaller boxes. The upper of the two is labeled "Injector Response Times" *(figure 6.44)*.

The data shown in this area contains real time feedback of injector response times from the ECM's. Note that while there are spaces for twenty injectors (corresponding to engine cylinder numbers), not all will contain data on every application *(depends on how many cylinders the engine you are working on has)*.

The display also indicates problems with the electrical side of the injectors.

Response times should remain stable throughout the entire engine speed range. Response times should be between 1.20 - 1.60 ms, and there should be little variance between cylinders.

6.3.1.5

Using The Injector Screen

To utilize the **F2-Injector** Screen, reference the Injector Calibration Codes section on **page 125** for more information.

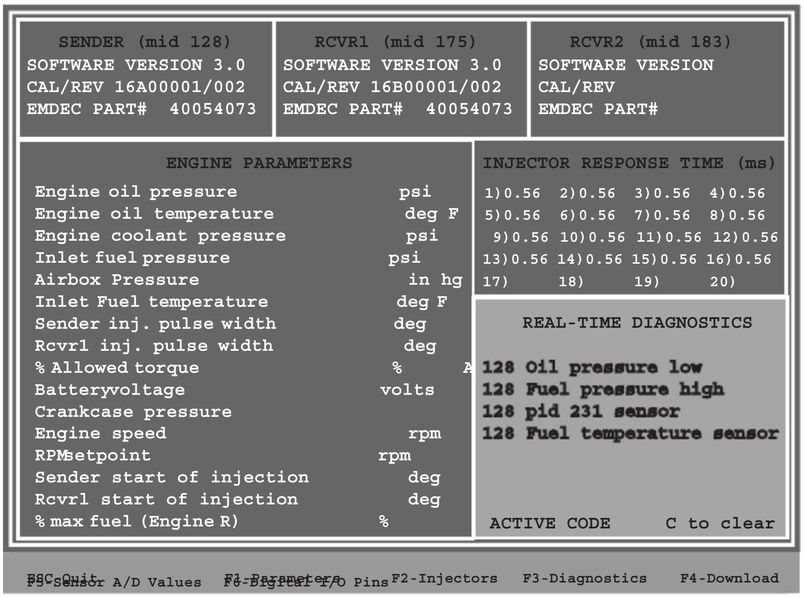


Figure 6.45 *Fault Data - Real Time Diagnostics.*

6.3.1.6 Fault Data

On the lower right side of the main screen is a box labeled "Real Time Diagnostics" *(figure 6.45)*. The data shown in this area contains real time feedback of active and inactive system faults.

The “Real Time Diagnostics” screen is limited in size and the type of information displayed. Therefore an identification number and brief description of the fault is shown. Active faults will be shown in black type that is blinking, inactive faults will be displayed in solid white type.

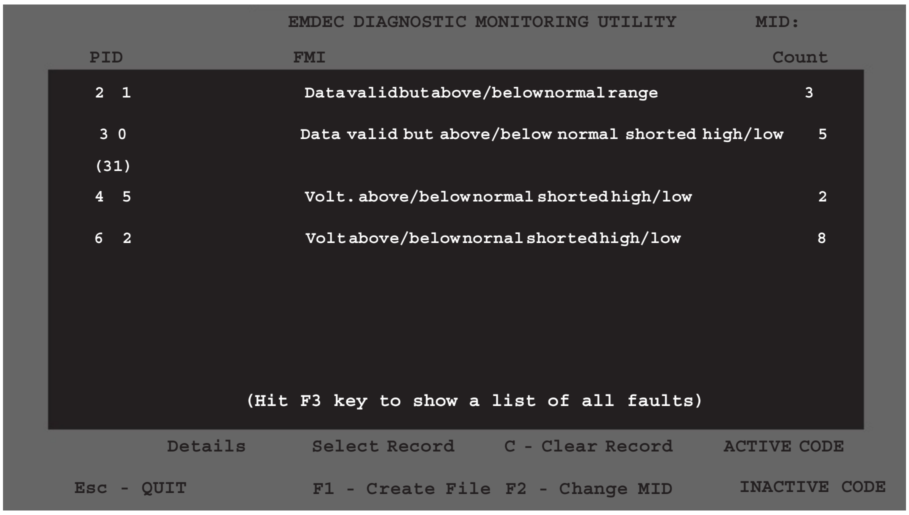


Figure 6.46 *Fault Data - Diagnostic Screen.*

6.3.2 Using The Diagnostics Screen

Due to main screen limitations, a more extensive fault diagnostic screen is provided.

1. At the EMMON main screen, press **F3- Diagnostics** to select the diagnostics or EMDEC fault archive feature.

2. The list of archived diagnostics will be displayed on the screen. Active faults are shown in red, inactive faults are shown in green, or light on dark text on monochrome screens.

6.3.2.1
To View The Faults

1. Select **F2 Change MID** to view the faults on the other ECM's.
2. Press **C** to clear Inactive faults. They can be cleared one at a time.
3. Active Faults cannot be cleared, and must be corrected.
4. Once an active fault is corrected, it will become inactive.
5. Use the arrow keys to scroll through the faults. Press <RET> for details on the fault selected.

6.3.2.2
To Save Archived Faults To A File (EMDEC Fault Download)

1. Press **F1-Create File**. A box will appear that requests the file name.
2. Type in the file name (i.e. 82340912.128 for the Sender, 82340912.175 for Receiver 1), and press <RET>.

   This file will be saved in the emdec directory and can be viewed and printed in any Windows compatible word processing program *(such as Microsoft Word)*.

3. Press **ESC** to return to the EMMON main screen.

6.3.3

Using The Download Function

1. Shut down the engine, and write down on a piece of paper, the cylinder number with the individual injector calibration codes stamped on top portion of the injector solenoid.

2. If already in EMMON, go to step 5. Otherwise, start up the PC Reader program EMMON.

> **Programming Tip!**
> The EMMON program will not function correctly through Windows, even with MS-DOS prompt within Windows. Exit Windows completely before using EMMON.

3. Within DOS, change the directory to EMDEC or PCREADER as shown below:

   C:\cd emdec or pcreader

   At this point, plug in the EMDEC translator box cable (Kit # 40055368) to the EMDEC communications port within the #1 Electrical cabinet, and to the laptop.

> **Programming Tip!**
> If experiencing difficulty communicating with EMDEC, check to see if the PRG300 is in boost mode. EMDEC does not function, or program well with low battery voltage.

If unable to communicate, or program from the EMDEC communication connection in the #1 Electrical cabinet, try using the connection mounted directly on the interface board back in the AC Cabinet.

4. Type EMMON, and the PC Reader program should begin. After the reader displays the home page, check the EMDEC part number located in the upper left hand corner. Write the EMDEC part number down.

CAUTION:
Do not apply 108% EMDEC software to a locomotive that previously had 100% software. Incorrect software could result in catastrophic engine failure.

Check the EMDEC part number to make sure you are applying the correct software version.

5. From the EMMON Main screen, press **F4-Download** to select the download feature.

6. Insert the correct EMDEC software disk into the disk drive.

6

7. The screen will ask you to select the appropriate drive, A or B. Press the appropriate key, A or B, and the system will automatically load the calibration software into the laptop.

8. A menu screen will appear that offers eight selections:

   1. Sender Program and Calibration.
   2. Sender Calibration Only.
   3. Recvr1 Program and Calibration.
   4. Recvr1 Calibration Only.
   5. Recvr2 Program and Calibration
   6. Recvr2 Calibration Only.
   7. Escape.
   8. M - Manual Download Options.

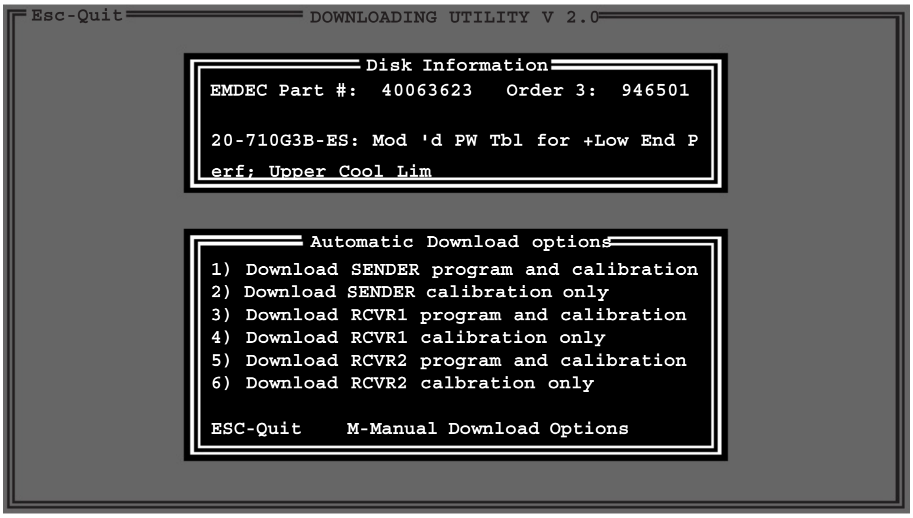


Figure 6.47 *Downloading Utility Screen.*

9. The disk information window contains the EMDEC part number of the software being applied, the order number it should be applied to and some miscellaneous information on the engine. The box below the disk information box is the download options window. In the lower right hand portion of the "Automatic Download option" there is an option choice for Manual Download mode. In this case, the ECM not being programmed must have the power disconnected. Please note: if programming a blank ECM or new ECM or cross-programming ECM's, the Manual Download mode must be used. Whatever mode displayed around the download options is actually the mode you are in. For instance, the programmer is in the Automatic Downloading mode.

Programming Tip!

If programming a blank ECM or experiencing difficulties programming a used ECM, try unplugging the power harness on the opposite ECM (s). This can be easily done by unplugging the PS plug for Sender, and PR1 plug for receiver in the AC cabinet.

10. Place the program option into Automatic Download mode.

11. Press 1 to begin programming the software for the Sender ECM. If loading calibration software only, press 2 (Please note: loading calibration software is only allowed when upgrading cals with the same software. For example - going from 100% software to 108% software or back). The screen will prompt you to turn ON and turn OFF the ENGINE CONTROL circuit breaker at appropriate times to boot the system. The ECM should be programmed in approximately 11 minutes.

12. Immediately after loading the program, the system will **automatically** load the calibration software. Upon completion of the Sender download, the system will once again prompt you to turn the ENGINE CONTROL Circuit Breaker ON and OFF.

13. If programming was a success, the programming screen will reappear. Now that the Sender ECM has been programmed, the Receiver 1 ECM needs to be programmed.

14. Press 3 to program the Receiver 1. Again, if loading calibration software only, press 4. The screen will prompt you to turn ON and OFF the ENGINE CONTROL circuit breaker at appropriate times to boot the system.

15. Immediately after loading the program, the system will automatically load the calibration software. Upon completion of the Receiver1 download, the system will once again prompt you to turn the ENGINE CONTROL Circuit Breaker ON and OFF.

Programming Tip!

If experiencing downloading difficulties at this point, try shutting down the laptop and rebooting.

Go back to the EMMON and start programming at step 13.

16. If programming a 20-cylinder engine, press 5 to program the Receiver 2. As before, cycle the ENGINE CONTROL Circuit Breaker as instructed upon completion of the download.

17. If programming was a sucess, the programming screen will reappear. Now that the Receiver 1 ECM has been programmed, the Receiver 2 ECM (if equipped with a 20-cylinder engine) needs to be programmed.

> **Programming Tip!**
> If experiencing downloading difficulties at this point, try shutting down the laptop and rebooting. Go back into EMMON and start programming at step 15.

18. If experiencing difficulty programming the ECM's, try changing the programming mode to Manual Download by pressing M on the keyboard from the ECM Programming Screen. In the Manual Download mode, the power of the ECM **not** being programmed must be disconnected.

19. To program the Sender ECM in Manual mode, disconnect the power connection *(See Figure 6.48)* from the Receiver 1 ECM and Receiver 2 ECM if equipped. Follow the programming steps 11 through 13.

Please note: For a 20-cylinder 710 engine, facing the accessory end of the engine, the Sender ECM will be the center ECM, the Receiver 1 ECM will be to the left "conductor's side of locomotive" and Receiver 2 will be on the right side of the "engineer's side of locomotive."

For 16-cylinder platform style 710 engine, the Sender ECM will be on the right "engineer's side of the locomotive" and the Receiver ECM will be on the left "conductor's side of locomotive".

For 16-cylinder side mounted ECM's, the Sender ECM will be on the right "engineer's side of locomotive" and the Receiver will be on the left "conductor's side of locomotive."

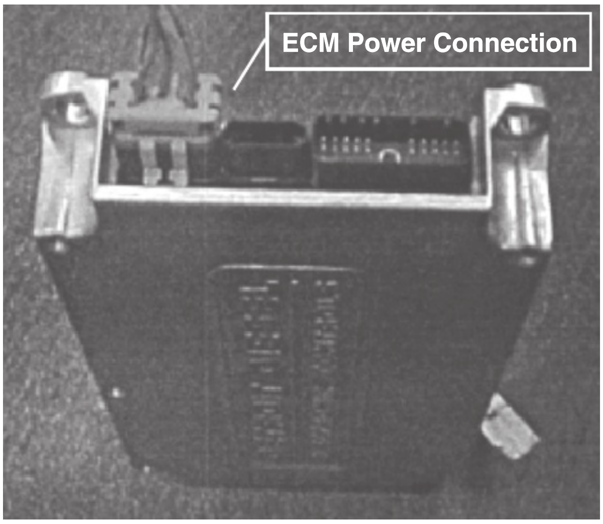


Figure 6.48 *ECM Power Connector Top View.*

20. Repeat steps 13 and 14 for Receiver 1 with all other ECM's disconnected and steps 15 and 16 for Receiver 2 if equipped with all other ECM power disconnected.

21. From the EMMON main screen, verify the software version and calibration number at the top of the page agree with the Software disk.

22. Once the ECM's have been successfully programmed, the injector calibration codes must be entered. Please reference the Section titled USING THE INJECTOR CALIBRATION CODES (F2) Programming the Injector Calibration Codes.

WARNING:

Remember, the software must only be used in conjunction with the respective injector calibration codes that are inscribed on each injector body. The calibration codes must be entered after new software has been applied to both the Sender ECM and Receiver ECM's. The calibration codes will default to either --, 1 or 50 after the ECM has been programmed. As a result, the injector calibration codes must be entered properly, this software will not function as intended, and faulty engine operation may result.

23. After entering the calibration codes, from the EMMON main screen, Press **F3 - Diagnostics** for the fault archive of EMDEC. If there are any faults in the archive, press C to clear each individual fault. After clearing out all the faults from MID 128, press F2 to switch to the Receiver ECM's archive. The number in the upper right-hand corner should switch to MID 175. If there are any faults in the archive, press C to clear.

    If equipped with a 20-cylinder engine, Press **F2** again to switch to Receiver 2 ECM. Clear out the faults, if any, in the archive. Press ESC key to quit the diagnostics screen.

24. After the engine has started, check the diagnostics screen within EMMON for any faults. If any faults were logged, investigate. Otherwise, exit EMMON by pressing the ESC key twice.

```
<<< ADC Counts >>>

Fuel Temperature            0        0.00 Volts
Air Temperature             0        0.00 volts
Oil Temperature             0        0.00 volts
Coolant Temperature         0        0.00 volts
Oil Pressure                0        0.00 volts
Turbo Pressure              0        0.00 volts
Barometer                   0        0.00 volts
Throttle Position           0        0.00 volts
PTO Position                0        0.00 volts
Coolant Level               0        0.00 volts
Fuel Pressure               0        0.00 volts
Battery Voltage             0        0.00 volts
Sensor Supply Voltage       0        0.00 volts
Oil Level                   0        0.00 volts
Fire Pressure               0        0.00 volts
Crankcase Pressure          0        0.00 volts
Blower Door Position        0        0.00 volts
Coolant Pressure            0        0.00 volts
```

Figure 6.49 *ADC Count Screen.*

6.3.4 Using The Sensor A/D Value Screen

1. From the EMMON main screen, press **F5 - Sensor A/D Values**

   A list of sensors will appear in the left-hand column. Some values will not displayed, specifically if the sensor is not configured, please reference the **EMREPORT** for sensor configuration. The last column lists the voltage as seen by the Sender ECM. The sensor voltage feedback should be within the specified voltage range provided in the sensor troubleshooting procedures in Chapter 8.

```
                         <<< Digital I/O >>>

  INPUTS                              OUTPUTS

  PIN   FUNCTION   STATE       PIN   FUNCTION          INTENDED    ACTUAL

  J1                           B2
  F1                           B1
  G3                           F3
  F2                           A2
  J2                           S3
  G2                           T3
  G1                           W3
  E1                           X3
  H1                           Y3
  H2                           A1
  K2
  K3

     (Esc to return to Monitor, F1 to see a list of digital functions)
```

Figure 6.50 *Digital Input Output Screen.*

6.3.5 Using The Digital I/O Pins

1. From the EMMON main screen, Press **F6 - Digital I/O Pins**.

   A list of pin locations will appear in the left-hand column *(See Figure 6.50)*. The second column lists a set of inputs with their respective status. The output functions correspond to the status that EMDEC is in *(i.e shutdown status, ECMON, etc.)*. The INTENDED column lists the desired state, and the ACTUAL column shows the real time status of the function. For instance, if the engine shutdown bit was activated, the shutdown function's actual state would flash from ON to OFF.

6.3.6 Other PC Reader Functions

In addition to the real time diagnostic functions, discussed earlier, the PC Reader serves other purposes.

1. Entering the Injector Calibration Codes.
2. Checking Individual Injectors Using the EMDEC PC Reader Cylinder Cutout Feature.

6.3.6.1 Injector Calibration Procedure

Each EMDEC injector requires correct calibration be entered to compensate for assembly line tolerance differences in the mechanical portion.

Calibration changes the output of each injector to bring it to a nominal standard.

Therefore, units having trouble making horsepower with good injectors will benefit from this feature.

It is the electrical equivalent of "setting the rack", and must be done any time an injector is renewed.

Codes should also be verified on a periodic basis.

6.3.6.2

Calibration Process

1. Before entering Injector calibration codes, ensure that the PC Reader software has a Phase III designation on the label.

2. If the disk is not available, the revision level can be confirmed by looking at the pcreader directory and verifying that at minimum, an EMMON11a file or current version exists.

   This procedure must only be done when the engine is shut down.

3. Open each of the top deck covers and:

   1. Record the two-digit number that is scribed on the top of each cylinder solenoid, and

   2. Record the corresponding cylinder number.

4. With the laptop connected to EMDEC through the translator box, verify that the EMDEC software level is at least V1.5.

   Calibration code cannot be utilized on older EMDEC revisions.

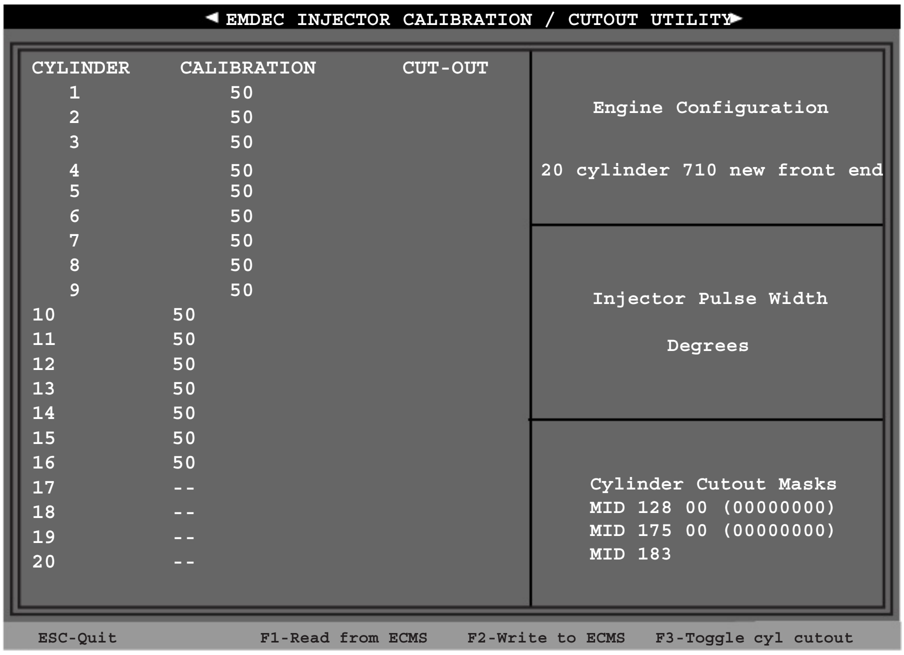


Figure 6.51 *Injector Calibration Screen.*

6.3.7 Entering The Injector Calibration Codes

1. From the EMMON main screen, press **F2 - Injectors.**

   A list of cylinders from one to twenty will appear, followed by a row for the calibrations of each injector. *(Figure 6.51)*

   If programming a 16-cylinder engine, do not put any values in the cylinder 17-20 blanks.

2. Enter the calibration numbers for each cylinder within the calibration row, using the arrow key.

DO NOT PRESS ENTER.

3. Upon completion of all applicable cylinders, press **F2 - Write to ECM's** to save the calibration codes to each ECM.

   A box will appear requesting a password. Type 0000 and press ENTER. The computer will then display "uploading to Sender...ok, Receiver1...ok and Receiver2...ok *(if equipped)*.

4. To verify the upload, press**F1- Read From ECM's** to read the injector calibration codes that have been stored.

   The codes should match the codes just entered.

   Press the ESC key to exit the injector screen.

6.3.7.1 Checking Individual Injectors Using The EMDEC PC Reader Cylinder Cutout Feature

1. From the EMMON main screen, press **F2 - Injectors.** A list of cylinders from one to twenty will appear *(Figure 6.51)*.

WARNING:

DO NOT ATTEMPT THE CYLINDER CUT-OUT TEST ABOVE THROTTLE 5.

2. Use the arrows to scroll up or down the injector list. Press **F3 - Toggle Cylinder Cutout** to cut injectors in or out.

   The screen will display YES next to the injector calibration code when the cylinder is cut out.

   The column under cut-out will be blank when the injector is cut in. It is not recommended to cut-out more than one injector at a time.

3. Put locomotive in Load Test and set Throttle to notch 5. Note the number that is displayed on the pcreader under the heading **Injector Pulsewidth.**

4. Select the cylinder to cut out, and toggle **F3** to enable the command.

   If the pulsewidth displayed changes when the cylinder is cut out, the remaining cylinders have begun compensating for its removal.

   This indicates that the cut out injector is healthy.

   If the pulsewidth displayed does not change when the cylinder is cut out, the remaining cylinders are already compensating for its loss of power.

   This indicates the injector is not healthy, and must be removed.

5. Once the cylinder cut out test is completed, scan the list of cylinders on the PC Reader, and make sure YES is not displayed indicating that a cylinder remains cut out.

   Use F3 to clear the YES, and cut the cylinder back in.

6

6.3.7.2 Software Download Procedure

In the event of an unprogrammed ECM change out, refer to the Software Download Procedures on page 148.

6.4 THE ANNUNCIATOR PANEL

Annunciator or Fault Panel is normally located on the side of the AC electrical cabinet. (70/75 Series)

The panel:

- is the center of the EMDEC Engine Protection and Diagnostic System in the locomotive engine room.
- contains the LED indicating lights and switches available to the operating or maintenance crew to control the EMDEC system operation and diagnostic function.

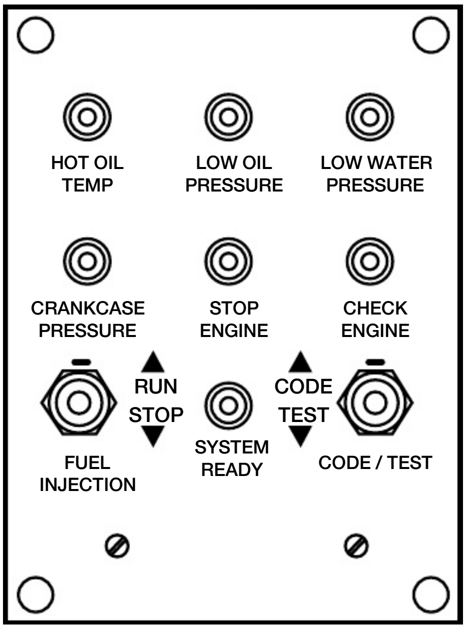


Figure 6.52 *Annunciator Panel.*

6.4.1 Fault Indicating Lights (LED's)

The fault indicating lights are used to determine if a specific condition has caused an engine protection shutdown.

> **CAUTION:**
> Following an engine shutdown, **DO NOT** attempt to restart the engine until the cause of the shutdown has been determined and action has been taken to correct the fault condition.

The following paragraphs describe the fault indicating lights.

6.4.1.2
Hot Oil Temp Light

The red Hot Oil Temp Light will come on to indicate that a high engine oil temperature condition has caused an engine shutdown. The EMDEC Engine Protection System determines this fault when the engine oil temperature exceeds a specified trip level for a minimum of 10 seconds.

6.4.1.3
Low Oil Pressure Light

The red Low Oil Pressure Light will come on to indicate that engine lube oil pressure has dropped to a dangerously low level, and caused an engine shutdown. The Engine Protection System determines this fault when engine oil pressure remains below the specified trip level after a time delay, which will vary according to engine speed.

6.4.1.4
Low Water Pressure Light

The red Low Water Pressure Light will come on to indicate that a low water flow condition has caused an engine shutdown. The Engine Protection System determines this fault when the difference in pressures between sensing points in the engine cooling system is greater than a specified value after a time delay relative to engine speed.

6.4.1.5 Crankcase Pressure Light

The red Crankcase Pressure Light will come on to indicate that a positive crankcase pressure condition has caused an engine shutdown. This fault is determined when crankcase pressure increases to a specified positive trip level after a time delay of 5 seconds with engine at speed. In addition to the fault light, a protruding button on the crankcase pressure detector indicates the device has tripped, and caused the engine to shutdown.

> **WARNING:**
>
> Following an engine shutdown caused by the crankcase pressure detector, make no further engine room inspections until the engine has been allowed to cool off for at least two hours. The action of the pressure detector indicates the possibility of a condition within the engine that could ignite hot oil vapors with an explosive force. **DO NOT** attempt to restart the engine until the cause of the detector trip has been determined and corrected. When activated, the detector must be manually reset by pushing in the reset button. If the button cannot be reset, **DO NOT** operate the engine until the pressure detector has been replaced, as it may have internal damage.

6.4.1.6 System Reset

To reset the system, it is necessary to toggle the FUEL INJECTION switch on the panel to the OFF (down) position. When the switch is returned to the RUN (up) position, the fault light indicating cause of the shutdown should go OFF, and the System Ready Light should come back ON.

6.4.1.7

Engine Diagnostic Lights

The Engine Diagnostic Lights provide the means to access the EMDEC self-diagnostic system. The system continuously monitors itself and the other system components including sensors, injectors, connectors, and associated wiring. If a fault is detected during locomotive operation, one or both of the diagnostic lights will be illuminated depending on the severity of the fault. Any faults that occur are stored as codes in the ECM memory. The stored codes may be accessed by toggling the CODE/TEST switch on the panel to the CODE (up) position and observing the "flashing" displayed on one or both of the diagnostic lights. This is provided that the power is being supplied to the EMDEC system (with the engine at idle or shutdown), and the engine is not in a protection condition. Moving the switch to the TEST (down) position will illuminate all lights to ensure their operation.

6.4.1.8

Stop Engine Light (SEL)

The red Stop Engine Light (SEL) will come ON to indicate that a potential engine damaging condition has been detected. If the system is programmed to shutdown for this condition, the engine will shutdown in approximately 30 seconds and a corresponding fault indicating light on the annunciator panel will come ON.

This light is also used to "flash out" the active fault codes using the TEST/RESET switch on the annunciator panel. An active code is a fault that is currently keeping one or both of the diagnostic lights ON, as well as a corresponding fault light. Active codes are displayed (flashed) in order from the most recent to the least recent based on engine running hours. Active codes are also immediately stored in the ECM memory as inactive codes.

> **NOTE:**
> The stop engine light (SEL) will come ON for 5 seconds when power is first applied to the EMDEC system as a test of the light and system circuit.

6.4.1.9

Check Engine Light (CEL)

The yellow Check Engine Light (CEL) will come ON to indicate that a fault has occurred and lasted for at least 2 seconds in duration. If the fault goes away, the light will go out, but a fault code will be stored in the ECM memory as an inactive code. The condition should be diagnosed at the next unit service or maintenance check point.

The light is also used to "flash out" the inactive fault codes using the CODE/TEST switch on the annunciator panel. All inactive codes are faults that have previously occurred. Inactive codes are displayed (flashed) in order from the most recent to the least recent based on engine running hours.

> **NOTE:**
> The Check Engine Light (CEL) will come ON for 5 seconds when power is first applied to the EMDEC system, as a test of the light and system circuit.

6.4.1.10

Fuel Injection Switch

This device is a two position latching toggle switch. It must be placed in the RUN position in order to start and operate the diesel engine. It enables fuel injection. The engine will shutdown whenever this switch is placed in the STOP position. It disables fuel injection.

> **NOTE:**
> The Fuel Injection switch provides the ONLY means to stop the diesel engine from within the engine room. Placing the fuel injection switch in the STOP position also allows the engine to be cranked without firing the cylinders.

To clear a fault indication from the annunciator panel, the switch is placed momentarily in the STOP (down) position. When returned to the RUN (up) position, the fault light should be off and the System Ready Light should come back ON.

6.4.1.11

System Ready Light

The green System Ready Light will be ON provided that the power is being supplied to the EMDEC system. This light will be OFF if the engine has been shutdown using the Emergency Fuel Cut-Off (EFCO) switch, the M.U. Engine stop switch (on units with control consoles), or the throttle handle STOP position (on units with AAR type control stands), and the engine shutdown circuit has not been reset.

> **NOTE:**
> Shutdown circuit is reset by momentarily placing the Fuel Prime/Engine Start switch in the FUEL PRIME position.

6.4.1.12 Code/Test Switch

This device is a toggle type switch with two momentary contact positions; CODE (up) and TEST (down), and a spring return to the center (release) position. This switch is also called the Diagnostic

Request switch.

Holding the switch in the CODE (up) position activates the EMDEC Self Diagnostic "flash code" system. This can be done at any time power is being supplied to the EMDEC system (with the engine at idle or shutdown), and the engine not in a protection condition. Active codes will be flashed first on the Stop Engine Light (SEL) followed by the inactive codes flashed on the Check Engine Light (CEL).

With the switch held in the TEST position, all of the

indicating lights on the panel should come ON, and then reset to OFF when the switch is released. If any light fails to come ON, the annunciator panel needs to be replaced.

> **NOTE:**
> Correcting the condition that caused the fault and resetting the annunciator panel DOES NOT clear the fault code from the ECM memory. Actual clearing of codes can only be done using the PC Reader.

6.4.2 Reading Diagnostic Codes - Flash Method

The following are the basic procedural steps that can be used for reading the diagnostic flash codes of the EMDEC system.

1. Cycle the injection control switch to the off position, and observe the yellow Check Engine Light (CEL) on the annunciator (fault) panel for inactive codes, and the red stop engine light (SEL) on the annunciator (fault) panel for active codes.

a. If the light comes on and stays on, or stays on for 5 seconds and then goes out, proceed to step 2.

b. If light is flashing, then check for an intermittent condition.

c. If light remains off; hold the CODE/TEST switch in the TEST position to check LED indicator lights. If light will then come on, check for possible opens or grounds in system wires and connectors.

2. Read out Diagnostic Codes by holding CODE/TEST switch in the CODE position momentarily and releasing.

   a. If light is flashing out code(s), proceed to step 3.

   b. If light remains on, but does not flash out any code(s), repeat step 1 to check operation of red Stop Engine Light (SEL).

3. Note and record flash code(s).

   a. Light is flashing out code 25, (two blinks, a 1/2 second pause, followed by five blinks) indicates there are no codes set and system is functioning normally.

   b. Light is flashing out code 52 possibly followed by other code(s). This indicates an ECM failure *(see code listing to identify other code(s) which should also be serviced)*.

   c. Light is flashing out code(s) NOT beginning with code 52, proceed to step 4.

d. No codes flashing; if problem persists, system must be checked with PC Reader.

4. Go back to Step 1 to verify codes a second time.

6.4.3 EMDEC Diagnostic Codes

> **NOTE:**
> The following code listing is presented for reference only. The list of codes is also contained in the EMM for engines equipped with EMDEC.

FLASH CODE 14 (SAE 175/3)
* Oil Temperature Sensor (OTS) input voltage to the ECM is high.

FLASH CODE 15 (SAE 175/4)
* Oil Temperature Sensor (OTS) input voltage to the ECM is low.

FLASH CODE 23 (SAE 174/3)
* Fuel Temperature Sensor (FTS) input voltage to the ECM is high.

FLASH CODE 24 (SAE 174/4)
* Fuel Temperature Sensor (FTS) input voltage to the ECM is low.

FLASH CODE 25 (SAE N/A)
* No codes set.

FLASH CODE 32 (SAE 238/4)
* Stop Engine Light (SEL) circuit is open or shorted to ground.

FLASH CODE 32 (SAE 238/3)
* Check Engine Light (CEL) circuit is shorted to battery (+), and the ECM is unable to turn on the Stop Engine Light (SEL).

FLASH CODE 32 (SAE 239/4)

* Check Engine Light (CEL) circuit is open or shorted to ground.

FLASH CODE 33 (SAE 102/3)

* Turbo Boost Sensor (TBS) input voltage to the ECM is high.

FLASH CODE 34 (SAE 102/4)

* Turbo Boost Sensor (TBS) input voltage to the ECM is low.

FLASH CODE 35 (SAE 100/3)

* Oil Pressure Sensor (OPS) input voltage to the ECM is high.

FLASH CODE 36 (SAE 100/4)

* Oil Pressure Sensor (OPS) input voltage to the ECM is low.

6

FLASH CODE 37 (SAE 94/3)

* Fuel Pressure Sensor (FPS) input voltage to the ECM is high.

FLASH CODE 38 (SAE 94/4)

* Fuel Pressure Sensor (FPS) input voltage to the ECM is low.

FLASH CODE 41 (SAE 21/0)

* Synchronous Reference Sensor (SRS) has detected extra pulses, or Timing Reference Sensor (TRS) has detected missing pulses.

FLASH CODE 42 (SAE 21/1)

* Synchronous Reference Sensor (SRS) has detected missing pulses, or Timing Reference Sensor (TRS) has detected extra pulses.

FLASH CODE 44 (SAE 175/0)

* Oil Temperature Sensor (OTS) has detected HIGH engine oil temperature (above safe operating range).

FLASH CODE 45 (SAE 100/1)

* Oil Pressure Sensor (OPS) has detected LOW engine oil pressure *(below safe operating range)*.

FLASH CODE 46 (SAE 168/1)

* ECM has detected LOW locomotive battery supply voltage *(below required operating range)*.

FLASH CODE 47 (SAE 94/0)

* Fuel Pressure Sensor (FPS) has detected HIGH fuel supply pressure *(above safe operating range)*.

FLASH CODE 52 (SAE 254/12)

* ECM internal Analog to Digital (A/D) Convertor has malfunctioned. NOTE: This is an intermittent condition usually caused by faulty external electrical system.

FLASH CODE 53 (SAE 254/2 or 12)

* ECM unable to read (2) or update (12) an engine data record (calibration, faults or accumulators) stored in nonvolatile memory.

FLASH CODE 55 (SAE 248/8 or 9)

* Master ECM has stopped receiving status information from one (or both) Receiver ECM's.

  OR

  Receiver ECM has stopped receiving fueling information from Master ECM.

FLASH CODE 56 (SAE 250/12)

* ECM unable to transmit over data link circuit due to an open or short in the wiring.

FLASH CODE 61 (SAE xxx/0)

* Time from ECM request to turn on injector to when injector solenoid valve closes, exceeds high limit of expected range. Injector Subsystem Identifier (SID) will indicate which cylinder has injector with long response time. Wide variations in response time at steady RPM usually indicate electrical problem. Consistently long response time may indicate sticking Solenoid valve.

FLASH CODE 67 (SAE 109/3 or 4)

* Coolant Pressure Sensor (CPS) input voltage to the ECM is high.

  OR

* Coolant Pressure Sensor (CPS) input voltage to the ECM is low.

6

FLASH CODE 71 (SAE xxx/0)

* Time from ECM request to turn on injector to when injector solenoid valve closes, is less than the lower limit of expected range. Injector Subsystem Identifier (SID) will indicate which cylinder has injector with short response time.

  Wide variations in response time at steady RPM usually indicate electrical problem. Consistently short response time may indicate sticking solenoid valve.

FLASH CODE 75 (SAE 168/0)

* ECM has detected HIGH locomotive battery supply voltage *(exceeds required operating range)*.

FLASH CODE 81 (SAE 101/3)

* Crankcase Pressure Detector input voltage to the ECM is high.

FLASH CODE 82 (SAE 101/4)

* Crankcase Pressure Detector input voltage to the ECM is low.

FLASH CODE 83 (SAE 101/0)

* Crankcase Pressure Detector has detected HIGH engine crankcase pressure *(above safe operating range)*.

FLASH CODE 84 (SAE 101/1)

* Crankcase Pressure Detector has detected LOW engine crankcase pressure *(below safe operating range)*.

FLASH CODE 88 (SAE 101/1)

* Coolant Pressure Sensor (CPS) has detected LOW engine coolant pressure *(below safe operating range)*.

Notes:

6

Notes:

MAINTENANCE PROCEDURES

7.1 EMDEC Injector Change-Out and Setting Procedures

7.1.1 Change-Out and Setting Procedures for 710 Series Electronic Unit Injectors (including timing procedures)

CAUTION:
All shop safety rules and practice must be followed at all times during this procedure.

7.1.1.1 Removing Existing Injectors From Engine

1. Apply the locomotive handbrake (locomotive applications), shutdown the engine and lockout the start switch. Open the battery knife switch and remove the start fuse or otherwise lock out the starting system.

2. Remove the two 7/16" hex-head bolts that secure the oil jumper to the top of the camshaft bearing bracket and set them aside.

3. Remove the two 1 1/2" nuts, washers, and rocker shaft caps that hold the rocker arm shaft to the rocker arm studs and set them aside.

4. Carefully lift the rocker arm shaft assembly up off the rocker arm studs and place it on the top deck between the camshaft and rocker arm studs.

5. Remove the flexible fuel jumper lines from fuel manifold.

6. Using a 5mm wrench or socket, disconnect the two injector wire harness leads to each injector.

7. Remove the 5/8" crab nut and special washer that secure the injector to the cylinder head and set them aside. Remove the injector crab and set it aside.

8. Making sure the adapter ring stays in the cylinder head, carefully remove the injector from the engine. After the injector is removed from the engine, drain any unused fuel from injector, cap the jumper lines, and place injector in a suitable shipping container for return.

9. Protect injector well to prevent foreign material or debris from entering.

7.1.1.2 Installing New Injectors In Engine

NOTE:
Several jumper failures have been attributed to mishandling. The injector should never be handled by the jumper lines. The proper way to handle the injector is by the body.

1. Handling the injector by the body, carefully install in the cylinder head, taking care to center it between the valves.

2. Record the two digit calibration code etched in the top of the injector solenoid. This will be required to calibrate the injector.

3. Position injector crab assembly. Using a calibrated torque wrench, tighten the injector crab nut to 50 ft-lb.

4. Carefully reinstall the rocker arm assembly. Using a calibrated torque wrench, tighten each nut to 300 ft-lb.

5. Ensure the oil jumper gasket is in place. Reinstall the two 7/16" hex-head bolts to secure the jumper to the camshaft bearing bracket. Using a calibrated torque wrench, tighten the bolts to 7 ft-lb.

6. Install new o-rings (P/N 40061536) in both fuel manifolds connections.

7. Loosely connect the end of the supply jumper (left) to the supply manifold (left upper). Repeat for the return jumper (right) to the return manifold.

CAUTION:
If any clearance between the hose and other machinery is found to be less than 1/8", the hose needs to be reset before tightening.

NOTE:
Two wrenches are required to tighten the ends of the jumper lines. The jumper line will fail if twisted or kinked.

8. Using a 3/4” open end wrench to hold the hex of the swivel fitting on the supply line in position, hand tighten the swivel nut to the fuel manifold with a 15/16” open end wrench.

9. Repeat step 7 for the return line.

10. Using a calibrated torque wrench, tighten each jumper manifold connection fitting to 40 ft-lb.

11. With one person at an emergency fuel cut-off station, leak test the fuel system by operating the fuel pump with the engine still shut down. Particular attention should be given to the jumper line connections at the injector body and fuel manifolds.

NOTE:

If any leaks are observed, the fuel pump should be immediately stopped by depressing one of the Emergency Fuel Cut-Off switches.

12. Reconnect the two injector harness leads. The solenoid is not polarity sensitive so crossing the leads will not cause the injector to malfunction. Torque the terminal screws on the solenoid to 7 inch lbs (0.6 ft lbs).

NOTE:

The injector solenoid screw will not withstand excessive torque. Extreme care should be exercised to prevent breakage of the screw due to overtorque.

13. Use the PC reader program to enter the calibration code for the replacement injector. Refer to **Chapter 6** for the calibration procedure.

14. After starting the engine, check for blow-by between the injector body and the cylinder head. Also ensure that the valve mechanism is functioning properly and is adequately lubricated.

7.1.1.3 Timing The Electronic Unit Injectors

1. Bar engine over in the normal direction of rotation until flywheel pointer indicates the correct crankshaft position in degrees relative to top dead center of the cylinder being timed. Refer to setting instructions on Injector Timing Plate (located on right rear side of crankcase).

NOTE:

Always refer to the proper EMM and timing plate affixed to the right rear corner of the engine for correct setting procedures.

2. Slowly run each injector follower adjusting screw down until it bottoms, then back off 1- 1/2 turns.

3. Tighten adjusting screw locknut while holding adjusting screw in position with a screwdriver.

4. Perform for each cylinder in the engine.

7.1.2 Change-Out Procedure for H Series EMDEC Fuel Pumps and Injector Nozzles

CAUTION:
All shop safety rules and practices must be followed at all times during this procedure.

7.1.2.1 Change-Out of Injection Nozzles

1. Apply the locomotive hand brake and shut down the engine. Open the battery Knife switch and lock out the EFCO with a lock or tag.

2. Remove the rocker box cover from the cylinder to be worked on. *(figure 7.1)*

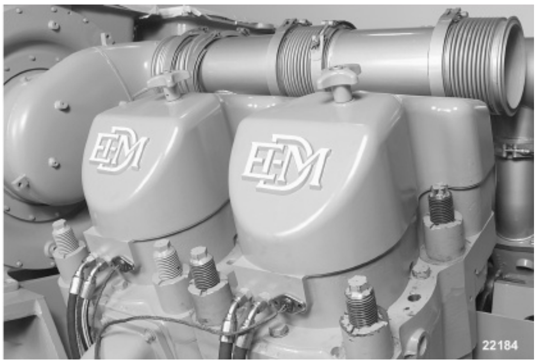


Figure 7.1 *Rocker Box Cover.*

3. Remove clamp from internal fuel lines using 3/8” ratchet and internal hex socket. *(figure 7.2)*

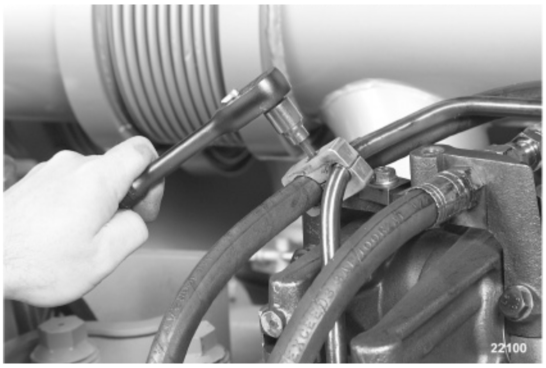


Figure 7.2 *Internal Fuel Line Clamp.*

4. Disconnect high pressure fuel line from pump and nozzle; remove line. *(figure 7.3)*

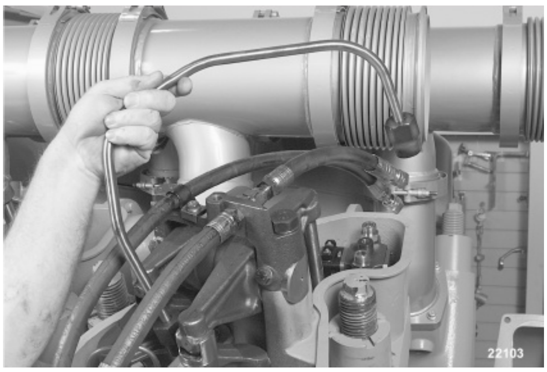


Figure 7.3 *High Pressure Fuel Line.*

NOTE:
The rocker arm assembly is shown removed in the following illustrations for clarity. DO NOT REMOVE IN SERVICE CHANGE-OUT OF PUMP AND NOZZLES!

5. Disconnect and remove nozzle bleed line. *(figure 7.4)*

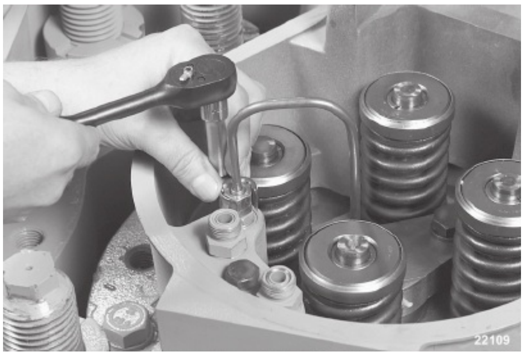


Figure 7.4 *Nozzle Bleed Line.*

6. Remove the two nozzle flange retainer bolts. *(figure 7.5)*

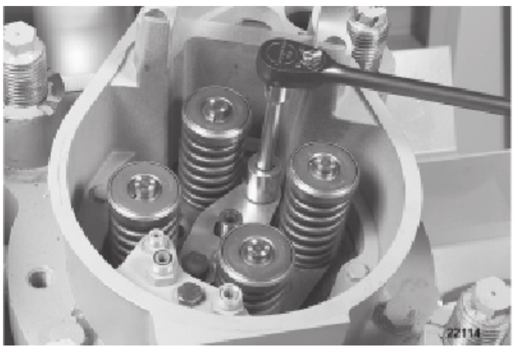


Figure 7.5 *Nozzle Flange Bolts.*

7. Remove nozzle and flange from cylinder head with nozzle puller Part # 40080121 by threading the puller onto the high pressure fuel line connection. Slide the hammer portion upwards with a brisk motion to lift the nozzle assembly.

CAUTION:
Ensure tool is held in line with nozzle and guard against pinching hand between sliding and fixed portions of puller. *(figure 7.6)*

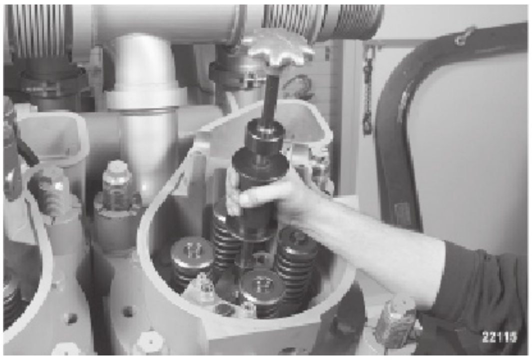


Figure 7.6 *Nozzle Puller.*

8. Using new o-rings, apply nozzle flange to new nozzle and insert assembly into cylinder head; ensure assembly is fully seated.
9. Loosely start retainer flange bolts.
10. Apply injector bleed line between nozzle flange and rocker box.

11. Torque retainer flange bolts per current torque specs card.

12. Apply high pressure fuel line; torque per reference card.

13. Apply internal fuel line clamp.

14. Close battery knife switch and run "Fuel System Check" from the EM2000 computer. Examine all fuel lines for evidence of leakage.

15. Release EFCO switch and start engine. Examine pump and nozzle for proper operation; check for high pressure fuel leakage correcting as required.

16. Replace rocker box cover.

7.1.2.2 Change-Out of Injection Pumps

CAUTION:
All shop safety rules and practices must be followed at all times during this procedure.

NOTE:
The pump may be changed out at the same time as the nozzle or as a separate unit.

1. Apply the locomotive hand brake and shut down the engine. Open the battery Knife switch and lock out the EFCO with a lock or tag.

2. Remove the rocker box cover from the cylinder to be worked on. *(figure 7.7)*

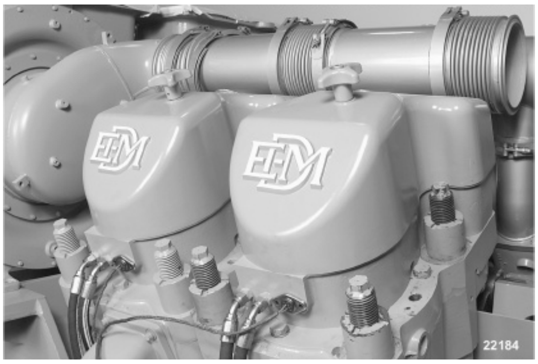


Figure 7.7 *Rocker Box Cover.*

3. Remove clamp from internal fuel lines using 3/8" ratchet and internal hex socket. *(figure 7.8)*

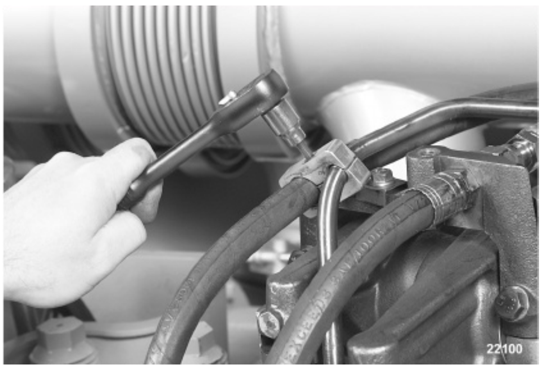


Figure 7.8 *Fuel Line Clamp.*

4. Disconnect injection pump wires and fuel supply and return lines ant the pump. Secure them back out of the way of further steps.

5. Disconnect high pressure fuel line from pump and nozzle; remove line. *(figure 7.9)*

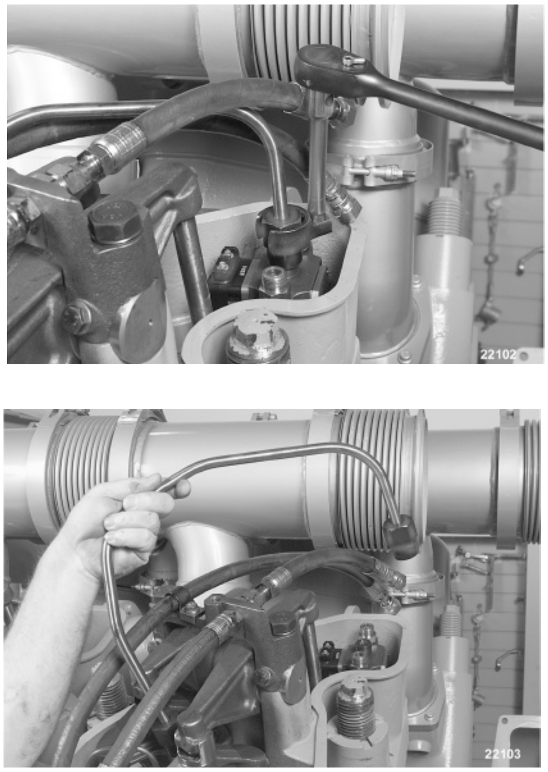


Figure 7.9 *High Pressure Fuel Line Removal.*

6. Loosen the four fuel pump mounting bolts; DO NOT REMOVE THE BOLTS FROM THE PUMP AS THE WASHERS WILL DROP INTO THE ENGINE!!

NOTE:
The rocker arm assembly is shown removed in the following illustrations for clarity. DO NOT REMOVE IN SERVICE CHAN GE-OUT OF PU MP AND NOZZLES!

7. Carefully lift pump, bolts, and pushrod from cylinder head as an assembly. Do not drop pushrod. *(figure 7.10)*

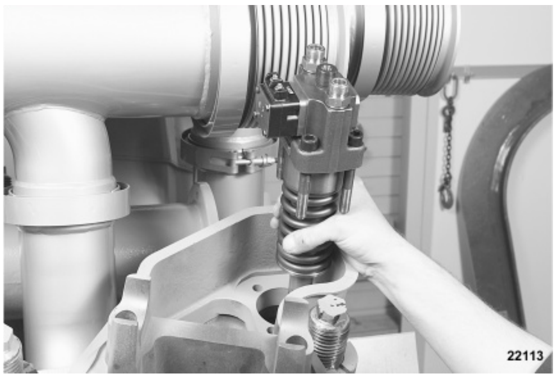


Figure 7.10 *Injection Pump.*

8. Apply pushrod, bolts, and washers to new pump assembly.

9. Carefully set assembly into cylinder head ensuring proper engagement of pushrod with cam follower.

10. Tighten bolts in sequence until pump fully seats in cylinder head.

11. Torque mounting bolts per reference card.

12. Apply wires to pump; note that these leads are not polarity sensitive.

13. Apply high pressure fuel line to pump and nozzle; torque per reference card.

14. Using new o-rings, reconnect fuel supply and return lines to pump.

15. Replace fuel line clamp.

16. Close battery knife switch and run "Fuel System Check" from the EM2000 computer. Examine all fuel lines for evidence of leakage.

17. Release EFCO switch and start engine. Examine pump and nozzle for proper operation; check for high pressure fuel leakage correcting as required.

18. Replace rocker box cover.

NOTE:

At the time this document was published the H Series injection pump requires no adjustment. However, in the future it is likely that you will be required to enter a calibration code into the ECMs in the same manner as with the 710 Series of engines. There will be a two digit cal code stamped on the top of the injection pump. Follow the same procedures as the 710 for loading the codes into the ECMS.

7.2 TRS/SRS BRACKET APPLICATION AND ADJUSTMENT (EARLY MODELS)

7.2.1 Checking The Sensor Airgaps

1) All shop safety rules and practices must be followed at all times during this procedure.

2) Apply the locomotive handbrake and shutdown the engine. Open the battery knife switch and remove the Start fuse.

3) Remove the door from the flywheel guard in order to access the TRS (outermost) sensor. Measure the airgap from the closest timing spoke to the sensor. It must be no larger than 0.150 inch. If necessary, open each of the cylinder relief valves and bar the engine over until a timing spoke is positioned in front of the TRS sensor. Use gauge P/N 40094650 to check the gap.

4) If the gap exceeds 0.150 inch, reset the airgap by adjusting the 1/4 inch screw located at the top of the bracket *(See figure 7.11, page 193)*. Once the gap is achieved, tighten the locknut located beneath the adjusting screw securely against the underside of the bracket. Adjusting the TRS sensor will also properly gap the SRS sensor.

7

5) Adjust the bumper bolt so that is has a 0.050 air gap from the ring gear. Exercise the TRS/SRS bracket and verify that it returns to position and maintains the correct air gaps. If it does not, examine the bracket spring to make sure it is compressed to 1.5 inches. If the spring is properly compressed and the bracket does not return to position, replace thebracket.

7.2.2 Replacing The TRS/SRS Bracket

1) All shop safety rules and practices must be followed at all times during this changeout.

2) Apply the locomotive handbrake and shutdown the engine. Open the battery knife switch and remove the Start fuse.

3) Remove the four bolts that secure the flywheel guard legs to the locomotive mounting pads and set them aside. Remove the guard and set it aside. (For 80MAC only, remove the starter motors on the conductor's side of the locomotive to access the bracket).

4) Open each of the cylinder relief valves and bar the engine until the flywheel pointer is at the 0 degree mark.

5) Disconnect the terminal connectors from the TRS and SRS sensors. Remove the two 1/2-20 bolts that secure the sensor mounting bracket to the rear housing of the engine and set them aside. Remove the mounting bracket from the engine. Remove each of the sensor mounting screws (9420156) and both the TRS (8929388) and SRS (8929387) sensors from the bracket and set them aside. Examine each for signs of damage and replace if necessary.

6) Reapply the TRS and SRS sensors to the new bracket using the self-tapping screws from the previous assembly. The TRS is the outermost s ensor. Position each o f the spacers included with the new sensor so that the smaller diameter neck fits into the bracket slot. Mount the sensor bracket to the rear housing making sure the spacers remain between the rear housing and the bracket, and tighten the bolts hand-tight. With the flywheel pointer at the 0 degree mark, adjust the sensor position until the tip of the TRS sensor is centered on the target spoke. Using a calibrated torque wrench, tighten the bracket mounting bolts to 65 ft-lbs.

7) Set the air gap between the sensors and the target plates to .150 inch by adjusting the 1/4 inch screw located at the top of the bracket *(See figure 7.11)*. Once the gap is achieved, tighten the locknut located beneath the adjusting screw securely against the underside of the bracket. Adjusting the TRS sensor will also properly gap the SRS sensor.

8) Adjust the bumper bolt so that is has a 0.050 air gap from the ring gear. Exercise the TRS/SRS bracket and verify that it returns to position and maintains the correct air gaps. If it does not, examine the bracket spring to make sure it is compressed to 1.5 inch.

9) Connect each of the harness terminals to the appropriate sensor (Note: these sensors have keyed connectors and cannot be reversed). Reinstall the flywheel cover and tighten each of the 1/2-13 mounting bolts to 75 ft-lbs using a calibrated torque wrench.

10) Slowly bar the engine and check closely for obstructions. Close each of the cylinder relief valves and reinstall the Start fuse. Upon engine startup, check for any EMDEC diagnostic faults resulting from the bracket change.

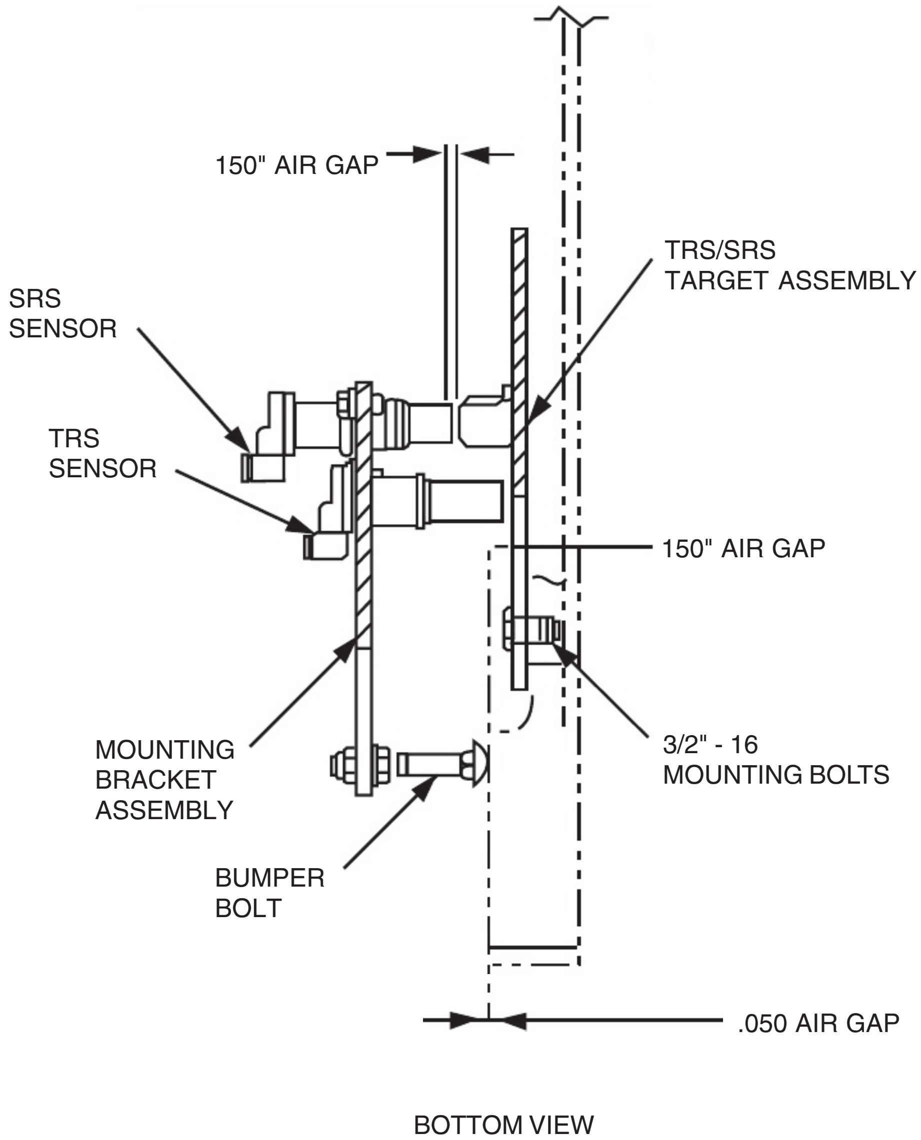


Figure 7.11 *TRS/SRS Bracket (Early Models).*

7.3 TRS/SRS BRACKET APPLICATION AND ADJUSTMENT (LATE MODELS)

7.3.1 Setting SRS and TRS Sensors

An improved feature on the 16-710G3C-T2 engine is the mounting and accessibility of the SRS and TRS sensors, Figure 7.12.

Figure 7.12 *SRS and TRS Sensors.*

These sensors provide basic position and speed information to the EMDEC ECMs and as such are critical to engine performance. The adjustment of these sensors must be periodically checked, ensuring that alignment and air gap is correctly set. The adjust the sensors, use the following procedures:

1. All shop safety rules and practices must be followed at all times during this procedure.

2. Apply the locomotive's handbrake and shut down the engine, turn off the fuel pump breaker, lock out the EFCO switch in the cab and tag the engine "DO NOT START".

3. Slightly loosen the sensor bracket mounting bolts as shown in Figure 7-13.

Figure 7.13 *Sensor Bracket Mounting Bolts.*

Adjust the bracket so that the TRS air gap to the surface of the coupling disk is 0.050" ± 0.010" as shown in Figure 7-14. Note that the TRS sensor will be centered over the barring hole when Cylinder #1 is at top dead center as shown in Figure 7-15. The air gap gauge (40094650) should touch the metal surface of the coupling disk.

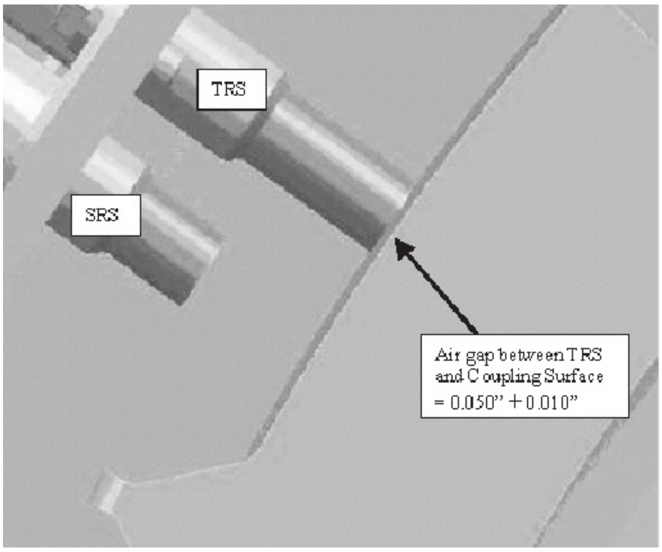


Figure 7.14 *Setting TRS Air Gap.*

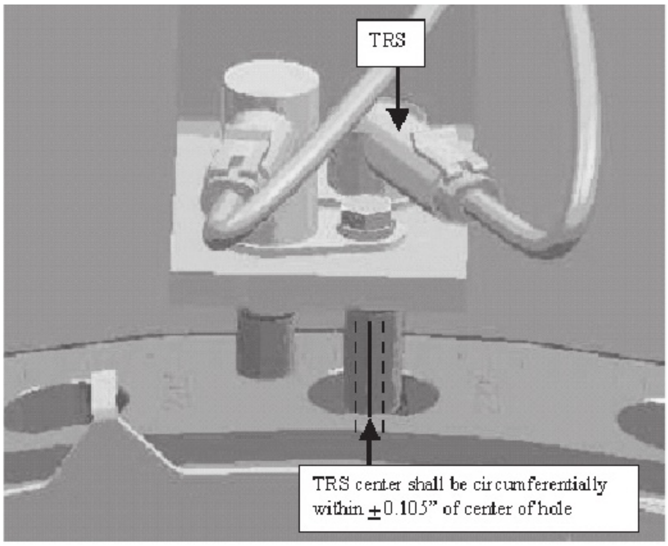


Figure 7.15 *Sensor Locations.*

2. Tighten the 1/2"-20 bracket mounting bolts and torque to 65 ft-lbs (88 N-m).

3. Rotate the crankshaft until the SRS sensor is aligned with theSRS target, as shown in Figure 7.16, and verify that the air gap is 0.050" /+0.02. 20" /-0.010". If the gap is incorrect, repeat the setting procedure.

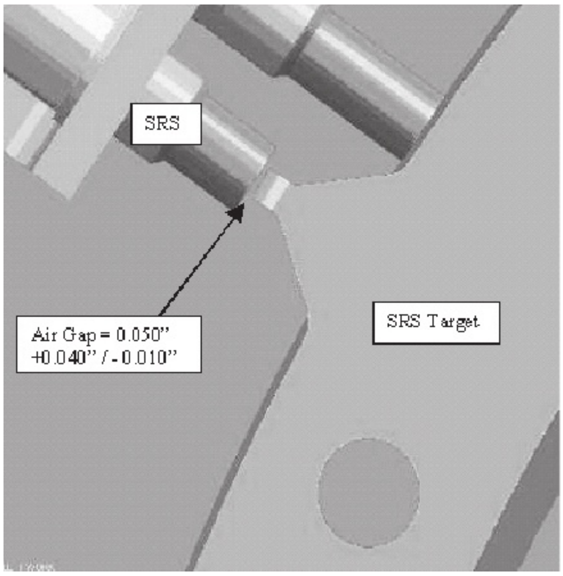


Figure 7.16 *Checking SRS Air Gap.*

7.4 70/80/90 MAC "PLATFORM STYLE" FUEL SYSTEM CHECK VALVE REMOVAL INSTRUCTIONS

Special Tool Required:
Snap-ring removal tool #8237117

7.4.1 Instructions for Engines with Filters Mounted on Front Right Corner of Engine - 40 PSI Valve

1. All shop safety rules and practices must be followed at all times during this procedure.

2. Apply the locomotive handbrake, shut down the engine, open all Circuit Breakers and open the Battery Knife switch.

3. Using the large filter wrench, remove the outboard fuel filter and set it aside.

4. Using the snap-ring pliers, remove the snap-ring that secures Item 6, #40053450 (Vendor #2410), as shown in Figure 7.12. Use a long instrument with a barbed end (such as a dental pick) to grab the inside of the check valve and slide it out of the manifold.

> **NOTE:**
> This check valve has an O-ring seal and will not slide easily).

5. The size of the 40 psi and 120 psi check valves are identical so it is important to verify the part number before installation (as a quick check, the 40 psi has a hole in the relief valve, the 120 psi does not).

6. Reinsert a new 40 psi check valve into the manifold and replace the snap-ring using the snap-ring pliers.

7. Reinstall the outboard fuel filter. Close the Battery Knife switch and begin closing each Circuit Breaker ON one at a time, making sure the **COMPUTER CONTROL** Circuit Breaker is last. Once the fuel pump begins running, check the system for leaks.

7.4.2 Instructions For Engines With Filters Mounted on Right Front Corner of Engine - 120 PSI Check Valve

1. All shop safety rules and practices must be followed at all times during this procedure.

2. Apply the locomotive handbrake, shut down the engine, open all Circuit Breakers and open the Battery Knife switch.

3. Using the large filter wrench, remove the outboard fuel filter and set it aside.

4. Remove the plug, Item 9 shown in Figure 7.12 and set it aside.

5. Using the snap-ring pliers, remove the snap-ring that secures Item 5, #40053449 (Vendor #2445), as shown in Figure 7.12. Use a long instrument with a barbed end (such as a dental pick) to grab the inside of the check valve and slide it out of the manifold.

NOTE:

This check valve has an O-ring seal and will not slide easily.

6. The size of the 40 psi and 120 psi check valves are identical so it is important to verify the part number before installation (as a quick check, the 40 psi has a hole in the relief valve, the 120 psi does not).

7. Reinsert a new 120 psi check valve into the manifold and replace the snap-ring using the snap-ring pliers. Reinstall the plug and retighten.

8. Reinstall the outboard fuel filter. Close the Battery Knife switch and begin closing each Circuit Breaker ON one at a time, making sure the **COMPUTER CONTROL** Circuit Breaker is last. Once the fuel pump begins running, check the system for leaks.

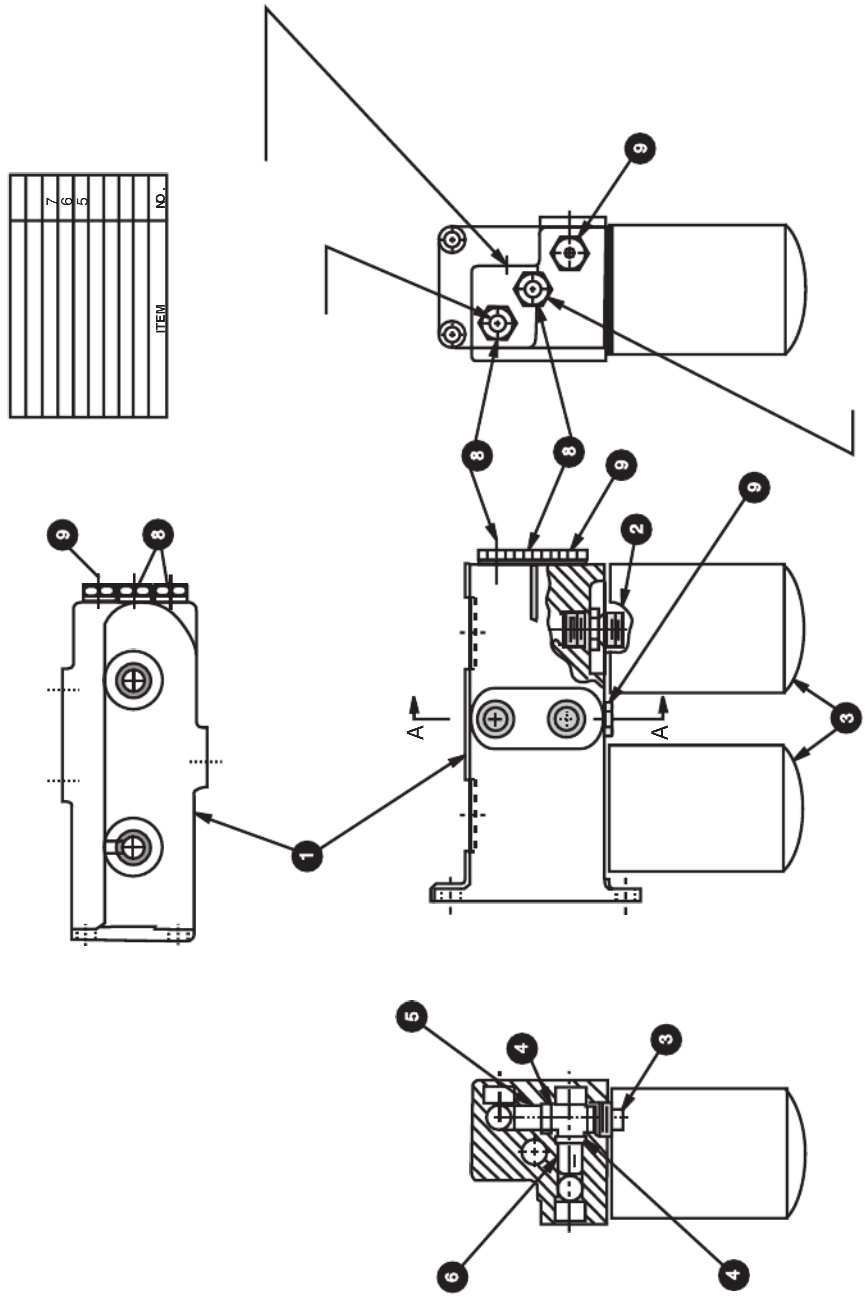


Figure 7.17 *Fuel Filter Assembly (For 70/90MAC "Platform Style Engine").*

7.4.3 Instructions For Engines with Center Mounted Filters - 120 PSI or 40 PSI Check Valve

1. All shop safety rules and practices must be followed at all times during this procedure.
2. Apply the locomotive handbrake, shut down the engine, open all Circuit Breakers and open the Battery Knife switch.
3. Using the large filter wrench, remove both fuel filters and set them aside.
4. Remove the appropriate plug (40 psi outboard, 120 psi inboard) Item 5 as shown in Figure 7.13, and set it aside.
5. Using the snap-ring pliers, remove the snap-ring that secures the appropriate check valve, either item 8, #40053449 (Vendor #2445) or item 9, #40053450 (Vendor #2410) shown in Figure 7.13. Use a long instrument with a barbed end (such as a dental pick) to grab the inside of the check valve and slide it out of the manifold (check valve has an O-ring seal and will not slide easily).
6. The size of the 40 psi and 120 psi check valves are identical so it is important to verify the part number before installation (as a quick check, the 40 psi has a hole in the relief valve, the 120 psi does not).
7. Reinsert a new check valve into the manifold and replace the snap-ring using the snap-ring pliers. Reinstall the plug and retighten.
8. Reinstall the fuel filters. Close the Battery Knife switch and begin closing each Circuit Breaker ON one at a time, making sure the **COMPUTER CONTROL** Circuit Breaker is last. Once the fuel pump begins running, check the system for leaks.

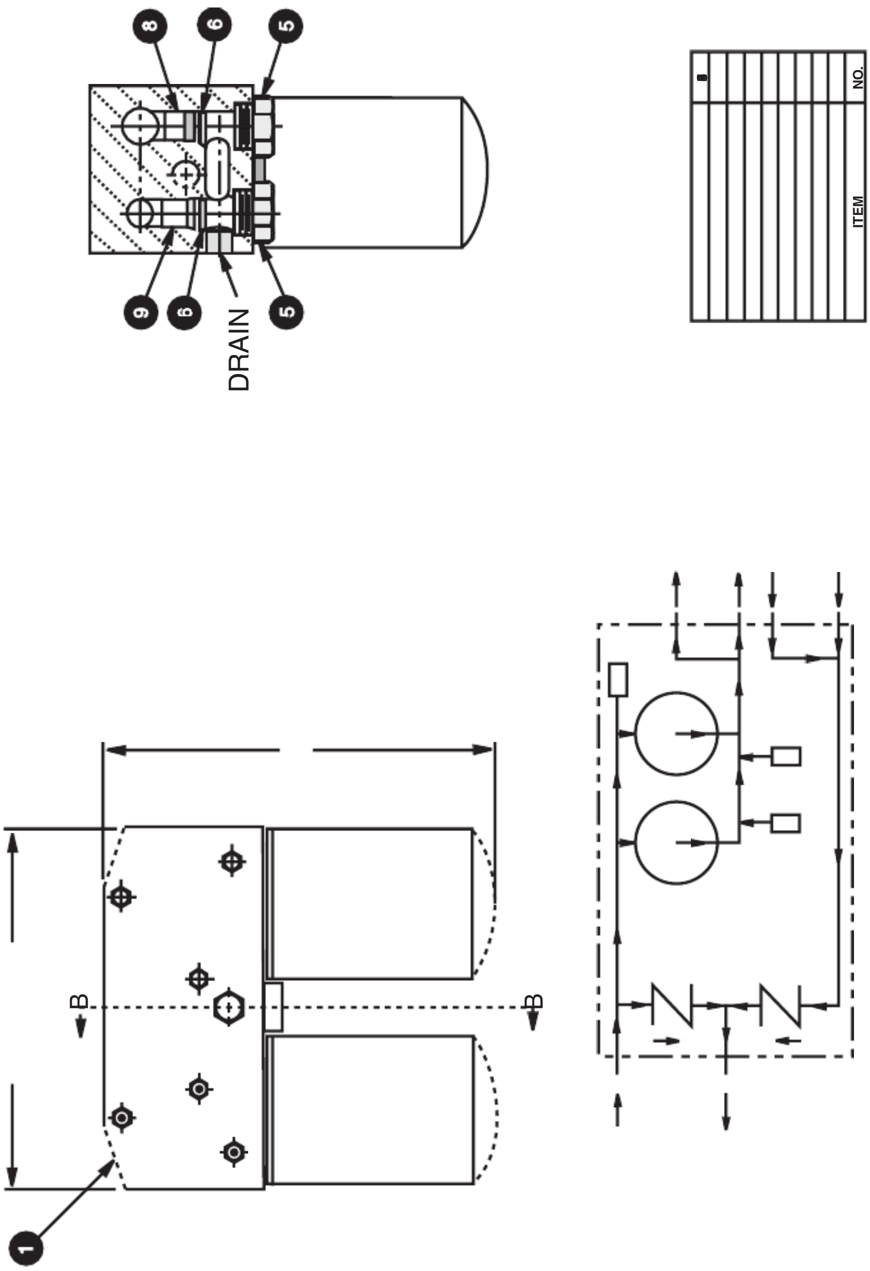


Figure 7.18 *Fuel Filter Assembly (For 80MAC).*

7.5 REPLACING EMDEC TERMINALS

7.5.1 Airbox Pressure (MAP) Sensor

1. Use the barrel of an AMP #305183-R (EMD #9576512) extraction tool to remove the terminals (this is the same tool that is used on EM2000 terminals).

2. Slide the barrel over the terminal from the front of the plug to depress its locking tabs and pull the wire/terminal back from the rear of the connector.

3. Remove the old terminal and strip the wire back approximately three-sixteenths (3/16") inch.

4. Slide the new terminal (#12089040) in place and crimp to the exposed wire using tool #12085271. Crimp the back portion of the terminal to the insulation using tool #12085270.

5. Reinsert the terminals into the appropriate cavity in the connector from the rear and push them forward until the locking tabs snap into place.

PlugA	**Wireharness2Y**
PlugB	**WireharnessEHC1P**
PlugC	**Wireharness1W**

6. Reapply the connector to the MAP sensor and verify its operation using the PC reader. The **Allowed Torque** should be 100% and an airbox pressure reading should be displayed.

7.5.2 Engine Protector

1. Slide the white end of terminal extraction tool #40003920 over the wire and push the tool into the rear of the connector as far as possible. Place a firm grip on both the wire and the tool and carefully slide the terminal from the rear of the connector. Cut the old terminal from the wire.

2. Strip back each of the three harness wires approximately .25" inch. Position each of the three female terminals (Plug Kit #40063588) on the appropriate wire. Before crimping the terminal, look through the inspection hole on the terminal to make sure the wire is visible.

   Crimp the terminal in place using either tool #40051636 or #40052278. Use the *blue* portion of extraction tool #40003920 to insert each of the terminals into the appropriate cavity in the connector. Numbers appearing after the 2Y or 1W wire tag are splice numbers and can be ignored.

PlugA	**Wireharness2Y**
PlugB	**WireharnessEHC1N**
PlugC	**Wireharness1W**

NOTE:
The application of isopropyl alcohol to each terminal as a lubricant eases the insertion of the terminal through the rubber seal in the plug.

7

3. Visually inspect the front of the plug to verify that the three terminals are seated to the same depth. Screw the backshell to the plug making sure the slot on the plug faces up and the backshell faces down.

4. Connect the sensor harness plug to the engine protector. Close the **ENGINE CONTROL** Circuit Breaker, note any Crankcase Pressure diagnostics and clear them out. Start the engine and verify protector operation by placing a hose over its vent hole and creating suction to simulate a crankcase pressure condition. Once the crankcase overpressure button trips mechanically , the EMDEC system should shut down the engine in two (2) seconds. Clear out the Crankcase Pressure diagnostics.

7.5.3 Remaining Sensors And All Connectors Into The ECM

1. Disconnect the plug and position it so that it faces the operator. Use a pointed tool such as an awl or pick to remove the terminal. Position the to ol underneath the terminal, between the terminal and the connector. Pick up on the terminal and pull it forward out of the connector.

2. Remove the old terminal and strip the wire back approximately three-sixteenths (3/16") inch.

3. Slide the terminal in place and crimp to the exposed wire using tool #12085271. Crimp the back portion of the te rminal to the insulation using tool #12085271.

4. Reinsert the terminals into the appropriate cavity in the connector from the rear and push them forward until the locking tabs snap into place.

7.5.4 Power And Sensor Harness Connectors - 12 Cylinder Engines

1. Slide the *white* end of terminal extraction tool #40052279 over the wire and push the tool into the rear of the connector as far as possible. Place a firm grip on both the wire and the tool and carefully slide the terminal from the rear of the connector. Cut the old terminal from the wire.

2. Strip back each of the three harness wires approximately .25" inch. Position each of the female terminals on the appropriate wire. Before crimping the terminal, look through the inspection hole on the terminal to make sure the wire is visible. Crimp in place using tool #40052278. Slide the *yellow* portion of extraction tool #40052279 over the wire until the terminal is seated against the tip. Insert each of the terminals into the appropriate cavity until they are seated in the connector.

> **NOTE:**
> The application of isopropyl alcohol to each terminal as a lubricant eases the insertion of the terminal through the rubber seal in the plug.

3. Visually inspect the front of the plug to verify that the terminals are seated to the same depth. Tug lightly on each wire at the rear of the plug to ensure the terminals are properly seated.

4. Reconnect the plug and verify operation by noting data from the system is displayed on the EMDEC Reader.

7.5.5 Sensor Harness Connector - 16 Cylinder Engines

1. Use an AMP #305183-R (EMD #9576512) extraction tool to push the terminals out the rear of the plug.

2. Strip back each of the harness wires approximately .25" inch. Position each of the sockets (#40024951) on the appropriate wire. Before crimping the terminal, look through the inspection hole on the terminal to make sure the wire is visible. Crimp the terminal in place using either tool #40051636 or #40052278.

3. Reinsert the terminals into the appropriate cavity in the connector from the rear and push them forward until the locking tabs snap into place.

4. Visually inspect the front of the plug to verify that the terminals are seated to the same depth. Tug lightly on each wire at the rear of the plug to ensure the terminals are properly seated.

7.5.6 Power Harness Connector - 16 Cylinder Engines

1. Use an AMP #91019-3 extraction tool to push the terminals out the rear of the plug.
2. Strip back each of the harness wires approximately .25" inch. Position each of the terminals (#12077413) on the appropriate wire. Crimp the terminal in place using AMP tool #69710-1. Slide the terminals into the appropriate cavity in the connector from the rear and push them forward until the locking tabs snap into place.
3. Visually inspect the front of the plug to verify that the terminals are seated to the same depth. Tug lightly on each wire at the rear of the plug to ensure the terminals are properly seated.

7.5.7 Pig-Tail Temperature Sensor Plug

1. Cut the existing plug off the wire harness, one wire at a time and identify each wire. Slide a wire seal over each wire (wide end first) far enough down so as not to impede the crimping process.
2. Strip the insulation back approximately .25" inch and install the new terminals (#12048074) on each wire using a #12085271 tool to crimp the terminal to the wire. Slide each wire seal up towards the terminal until the narrow end fits into the tangs at the end of the terminal. Use tool #12085270 to crimp the terminal to the wire seal.

3. Insert each terminal into the rear of the plug until it is fully seated and engaged. The **A Terminal** is on the sensor common wire typically identified on the wire as **EHC2Y** (any number after the EHC2Y is a splice number and should be ignored). The **B Terminal** should be inserted into the remaining cavity.

4. Check for terminal engagement by resistance to a gentle pull on each wire. Slide the wire seal down each wire and push it into the rear of the plug.

5. Install the plastic secondary lock onto the back of the plug. Install the lock so the notched side will allow viewing the molded letters "A" and "B" on the plug. The secondary lock prevents the wire seals from pulling out of the plug.

7.5.8 AMP Plugs At Power Supply And Interface Board

1. Use an AMP #305183-R (EMD #9576512) extraction tool to push the terminals out the rear of the plug.

2. Strip back each of the harness wires approximately .25" inch. Position each of the terminals (#9555811) on the appropriate wire. Crimp the terminal in place using AMP tool #90310-2.

3. Reinsert the terminals into the appropriate cavity in the connector from the rear and push them forward until the locking tabs snap into place.

4. Visually inspect the front of the plug to verify that the terminals are seated to the same depth. Tug lightly on each wire at the rear of the plug to ensure the terminals are properly seated.

Notes:

TROUBLESHOOTING

8.1 INTRODUCTION

The purpose of this guide is to describe the probable causes and suggest responses to troubles that may occur during the operation of an EMD diesel engine equipped with the Electro-Motive Diesel Engine Control (EMDEC) system. To derive the maximum benefits from this guide, it is recommended that the reader refer to the Table of Contents to locate the fault condition or specific area of interest that best describes the problem. The sections pertaining to this condition should be read in the sequence in which they appear, and all references to other possible related causes or conditions should be reviewed. Additional information pertaining to the EMDEC system, engine maintenance, adjustments and testing can be found in the Diesel Engine Troubleshooting Guide, Engine Maintenance Manual or in Maintenance Instructions (M.I.'s).

NOTE:

To ensure compliance with emission standards, only O.E.M. certified replacement parts can be used. Refer to the applicable service parts catalogue for ordering reference.

8.2 General Engine Troubleshooting

8.2.1 ENGINE CRANKS - WON'T START

8.2.1.1 Check Switch Positions

- Check that Engine Control Circuit Breaker is closed.

- Make sure the "MU Engine Stop" switch is in the "Run" position.

- Make sure the "Emergency Fuel Cutoff" button is not pushed in.

- Make sure the "Injector Run" switch is in the "Run" position. (Note: this is a normally open circuit when the switch is set to "Run". The switch must be pulled out before changing position).

8.2.1.2 Check Power Into EMDEC

- Check for a *green* light on the power supply. If no light, or a *red* light is present.

8.2.1.3 Check Battery Voltage

- Make sure the starter motors are sufficiently cranking the engine. Battery voltage should be at least 60 to 65 volts. The EMDEC system will not allow the electronic injectors to meter fuel into the power assemblies until the crankshaft is turning at least 30 rpm.

8.2.1.4 Check Fuel Pump Operation

- Verify that at least 60 psi of fuel pressure is present in the system. Reference **Chapter 6** for instruction on checking fuel pressure readings using the EMDEC reader.
- If the fuel pump motor is turning slowly or not at all, refer to the appropriate electrical schematic diagram to troubleshoot the fuel pump motor circuit (Note: low battery voltage can cause erratic fuel pump operation).

8.2.1.5 Check Magnetic Pickups (TRS/SRS)

- Check the TRS and SRS sensors that are mounted behind the flywheel on the left side of the engine. Note: SD80MAC locomotives have the sensors mounted on the **right** side of the engine beneath the electric starter motors. If damaged, change out and restart.
- Check the airgap between each sensor and the target plate. Each gap should be 0.150 inch.(Note: the SRS airgap appears larger, but it should be measured against the Position Indicator Pointer (PIP). In later models, an improved feature on the 16-710 G3C-T2 engine is that the air gap to the surface of the coupling disk is 0.050” ± 0.010”. The air gap gauge (40094650) should touch the metal surface of the coupling disk and SRS should be aligned with SRS target and verify that air gap is 0.050”/10.020”/-0.010”. Reference **7.2 - TRS/SRS Bracket Application & Adjustment (Early Models)** and **7.3 TRS/SRS Bracket Application & Adjustment (Late Models)** for instructions as to how to adjust the airgap.

8

- If the sensors are not damaged, open the Engine Control circuit breaker and disconnect each plug and check the resistance across each sensor. The resistance should be between 100 & 200 ohms. If not, replace the sensor and restart.

- If the sensors are okay, check the wire harness for a short. Reference **8.5 - Troubleshooting TRS & SRS** for instructions as to how to troubleshoot the TRS/SRS circuit. (If available, use the TRS/SRS simulator box.)

8.2.1.6 Check For Active Communication Failures

- If equipped with two way serial link, reference **8.7 - Troubleshooting The Two-Way Serial Link** for troubleshooting tips.

8.2.1.7 Check Plug Connections

- Check both the **Power** and **Sensor** harness plug connections into each ECM to make sure they are properly seated and tight.

- Check the **Power** harness plug connections into the AC Cabinet to make sure they are properly seated and tight.

8.2.1.8 Check For Injector/Sensor Harness Grounds

- Disconnect the injector harness plugs, one at a time, from the Receiver ECM and try restarting. A grounded wire could cause enough noise to disturb the TRS/SRS signal. If okay, replace the receiver injector harness plugs and disconnect each injector harness plug from the sender ECM, one at a time. Try restarting. If okay, continue the process by unplugging and replugging each sensor to see if a sensor is grounded.

- Check each of the eight rubber ECM isolator mounts. If the ECM is grounded to the crankcase, it will disturb the TRS/SRS signal.

- Using EMMON, check the injector response times and pulse width during cranking to see if injectors are attempting to fire.

8.2.1.9 Check Turbocharger

- Verify the turbocharger impeller is turning while the engine is being cranked. If not, consult the EMD Diesel Engine Troubleshooting manual for turbocharger inspection instruction. A failed turbo will not allow the engine to start due to lack of air.

8.2.1.10 Replace ECM Module

- If the above checks fail to identify the problem, it is likely that the Sender ECM is bad. Replace and reprogram the Sender ECM.

8.2.2 UNIT NOT MAKING HORSEPOWER

8.2.2.1 Check The EngineR Value

- Enter the Programmable Meter on the EM2000 screen and pull up the "EngineR" value. A typical EngineR value will be some number between .82 and .875 in throttle eight. The lower the EngineR value the better. A number higher than .875 will cause the load regulator to back off and indicate that the engine has a problem and is overfueling. If the EngineR value is greater than .875 and LR%MAX is less than 100%, proceed to the next step. If the load regulator is backing off and the EngineR value is lower than .82, the engine is healthy. The electrical system may be the source of the problem and should be investigated.

8.2.2.2 Check The Individual Injector Response Time

NOTE:
The injector response time is defined as the amount of time it takes for the armature/control valve to open when the ECM energizes the solenoid. The normal response time range is approximately 1.2ms to 1.6ms.

- An injector that is not metering fuel has a default reading of .55ms. If the injector response time is .55ms, replace the injector. Refer to the Injector Changeout Procedure in **Chapter** 7 for changeout instructions. For instructions on how to view injector response times using the EMDEC Reader, refer to **Chapter 6**. If injectors 1-8 are blank, try cycling the fuel injection switch.

8.2.2.3 Check The Inlet Fuel Pressure

- Check the Fuel Inlet pressure value. If the value is below 60.0 psi in throttle eight, check the 50 psi check valve located in the #1 fuel sightglass (for 70 Platform/80/90 series locomotives).

- If Fuel Inlet pressure is okay, check the #2 sight glass in throttle eight to see if fuel is bypassing.

- If the fuel is bypassing in throttle 8, replace the two spin-on fuel filters and the primary fuel filters.

- Check the strainer to make sure it is not clogged.

- If fuel continues to bypass, replace the 130 psi check valve located in the #2 sightglass (for 70 Platform/80/90 series locomotives).

8.2.2.4 Check Plug Connections

- Check both the **Power** and **Sensor** harness plug connections into each ECM to make sure they are properly seated and tight.

8.2.2.5 Check The Airbox Pressure Sensor (MAP Sensor)

- If the check valves are okay, check the "Allowed Torque or % Allowed Torque" value on the EMDEC reader. It should be at 100%. If the value is lower than 100%, the MAP sensor is limiting fuel because of inadequate airbox pressure. If the allowed torque is at 100%, check the hose that connects the MAP sensor to the airbox anyway. If it is damaged or clogged, replace it. A damaged or clogged hose can result in a 20% loss in horsepower. Typically, the turbo will not come off the geartrain and the load regulator will back way off.

- If the hose is okay, check the MAP sensor wiring and plug, if okay, replace the MAP sensor and verify whether the horsepower has returned. If not, consult the Diesel Engine Troubleshooting Guide for instructions as to how to inspect the engine if the airbox pressure remains low.

8.2.2.6 Check The Injectors

- Open the top deck covers and inspect each of the injector stator/ wire harness connections to make sure they are properly seated and tight. Check for foreign material (such as a loose fuel line I.D. tag) that can contact the terminals causing intermittent problems.

- If the unit still remains low on horsepower, perform an injector cutout test. Refer to **Chapter 6** for instructions as how to perform an injector cutout test.

- If the cutout test does not highlight the suspect injector, inspect the top of each piston for signs of a wet crown. To check the piston crown, remove the Start fuse and open the CRV valves. Make sure the fuel pump is running. Bar the engine over until the top of each piston is visible through the liner port. The system fuel pressure will cause fuel to leak if the injector tip is damaged.

8.2.3 UNIT LOADING AT 90%

8.2.3.1 Check For EMDEC Communication Faults

- Examine the EM2000 and see if an EMDEC communication failure fault is an active crew message.

- Enter the Programmable Meter on the EM2000 screen and pull up the “EngineR, ECMON, ECFail and EDFail” value.

- Verify that the "EngineR" value exists and continues to change rapidly. The value should range from .1 to .875. ECMON should be ON, ECFail should be OFF (if ON the control link is failed) and EDFail should be OFF (if ON the diagnostic link is failed).
- If no value is displayed, the EMDEC system and EM2000 are not communicating and the load regulator will back off to 90%. The serial link must be traced to find the source of the disconnect or ground. Refer to the appropriate electrical schematic drawing to identify the proper serial link connections. If equipped with two way serial link refer to **8.7.1 Troubleshooting The Two-Way Serial Link**.
- If a problem with the wiring is not found, the EMDEC interface board should be replaced.

8.2.4 THROTTLE REQUEST PROBLEMS

8.2.4.1 Check The EM2000

- If the EM2000 fails, the engine will continue to run in a high idle or Throttle 1 position because the interface board will be receiving a “no valve” signal.

- If the EM2000 is not failed and one or more throttle valve requests are not being acknowledged, check each of the DIO modules in the EM2000 chassis to make sure they are properly seated and tight. Note: units with two-way serial link will not have the valve requests. Instead, an engine speed request is used (EgSpRq). Verify that the EgSpRq in the EM2000 matches the RPM request in EMMON.

8.2.4.2 Check The Connections At The Interface Board

- Using EMMON, place the unit in throttle 6 and verify that the valves ABCD are all ON. If not, check appropriate string. Note: If equipped with two-way serial link look at the RPM setpoint in EMMON versus the RPM (EgSpRq) request sent from EM2000.

- Reference **Chapter 6** for instructions on accessing Governor Valve signals. This can be further verified by removing the L plug from the interface board and using a voltmeter, check for approximately +0V input to the requested valve(s) (A,B,C & D valve to rpm information can be found in the locomotive electrical schematics). If +74V is registered on the voltmeter, the valve is de-energized.

- The valve locations are as follows:

  L1 - A valve
  L2 - B valve
  L3 - C valve
  L6 - D valve
  L11 - Negative

- If approximately +0V is not coming into the requested valve location, verify the functionality of the EM2000 DIO module and controller microswitches.

- If approximately +0V is present, reconnect the L plug and remove the metal plate that covers the Sender ECM. Disconnect the VHC plug from the Sender ECM and check for approximately +1V at the desired valve by placing one lead of the voltmeter into the desired socket and touching the other lead to the metal skin of the ECM. The ECM is isolated so it is important that the other lead not touch carbody ground, such as the metal cover. The following socket locations on the VHC connector match governor valves:

  VHC1E - A valve
  VHC1H - B valve
  VHC2H - C valve
  VHC2K - D valve

  If the desired valve is not de-energized, replace the interface board. If it is, replace the ECM.

8.2.5 PROTECTIVE ENGINE SHUTDOWN

8.2.5.1 Protective Engine Shutdown - Crankcase Pressure

> **NOTE:**
> The crankcase pressure detector will tell EMDEC to shutdown the engine if it sees either: A crankcase over pressure condition for two (2) consecutive seconds, or a wiring fault condition for thirty-two (32) consecutive seconds.

1) **Check The Button On the Crankcase Pressure Device**

- If the button is popped, a crankcase pressure condition exists. Refer to the EMD Diesel Engine Troubleshooting Guide for instructions on troubleshooting a crankcase overpressure condition.

- If the button is functioning correctly and has not popped, an electrical fault has occurred either in the EMDEC system itself or in the crankcase pressure device and resulted in a spurious shutdown. Refer to **8.6 - Troubleshooting Sensor Circuits** for instructions on how to troubleshoot an electrical fault in the crankcase protection circuit.

8.2.5.2 Protective Engine Shutdown - Coolant Pressure

NOTE:
The coolant pressure sensor will tell EMDEC to shutdown the engine if it sees either: A low water pressure condition for ten (10) consecutive seconds, or a wiring fault condition for forty (40 consecutive seconds. The EMDEC system will not shutdown the engine for low coolant pressure in Idle.

1) **Check The EM2000 Archive**

- Examine the EM2000 archive and verify whether a Hot Engine fault has occurred that would indicate a coolant problem. Note throttle position, water temperature and shutter/fan faults that would be indicative of cooling system problems.

2) **Check The Cooling System**

- Check the water level. If the water level is low, inspect the coolant system for obvious leaks. If the water level is not low, check cooling fan operation and direction.

- Check the vent line that extends from the water tank to the water pump intake. Make sure it is not damaged or kinked.

- If no defect is found but the unit is obviously losing coolant, refer to the Diesel Engine Troubleshooting Guide for instructions on troubleshooting coolant leaks. Perform a low pressure leak test on the entire system (including the air compressor). If no leak is apparent, perform a high pressure leak test on the engine to uncover any internal leaks.

- If the water level is okay and no leaks are apparent, check within EMMON for coolant related faults. Refer to 8.6 - **Troubleshooting Sensor Circuits** for instructions on how to troubleshoot the coolant pressure sensor circuit.

8.2.5.3 Protective Engine Shutdown - Oil Pressure

> **NOTE:**
> The oil pressure sensor will tell EMDEC to shutdown the engine if it sees either: A low oil pressure condition for ten (10) consecutive seconds, or a wiring fault condition for forty (40) consecutive seconds. Upon start up, oil pressure is ignored for 60 seconds.

1) **Check The EMDEC Archive**

- Using a EMDEC Reader, check the EMDEC fault archive. If the fault display is a wiring fault such as signal voltage high/low, refer to 8.6 - **Troubleshooting Sensor Circuits** for troubleshooting information. If the shutdown is for low oil pressure proceed with the following checks.

2) **Check The Lube Oil System**

- Check the main lube oil filter tank drain line shutoff valve and make sure it is closed. If not, close it and restart the engine to verify proper oil pressure.

- Check for adequate oil level in the engine oil pan.

- Check the lube oil line feed line to the pressure sensor. This feed line is located inside the top deck on the right side of the engine, near top of the headframe. Make sure it is not kinked or disconnected.

- Check for lube oil dilution by fuel. If fuel is found:

    - Check all fuel jumper lines to the injectors for breaks or damage.
    - Inspect all brazed joints in the top deck fuel manifold and check all manifold pipe plugs for leakage.
    - Check injectors for leaks.
    - Check for piston rings which are not free to rotate in the piston groove.
    - Pressure test as required to isolate the source of the leak.
    - Inspect the main bearings for damage and replace as necessary.

- Replace the lube oil if required. Verify that the oil pressure value changes when the throttle position is changed. With the engine oil hot, verify that the oil pressure value decreases with each throttle setting reduction. If the oil pressure reading does not change when the throttle is moved, change the sensor. It may be desirable to replace the sensor with new to verify the low oil condition. Note: when the engine is cold, the oil pressure value will be higher at each throttle setting until the oil heats up and becomes more viscous.

- If no defects are found at this point, refer to **8.6 - Troubleshooting Sensor Circuits** for instructions on troubleshooting the oil pressure sensor circuit with data valid but above/below range. It is possible the sensor is hard-failed at a low pressure reading.

- Change the turbocharger soakback filter and examine the check valve for proper orientation.

- Remove all oil pan handhole covers. Visually inspect the piston pins, the external surfaces of the main and connecting rod bearings for evidence of overheating and look for missing or loose components.

- Operate the engine at idle. Remove the crankcase pressure detector, but leave the MAP sensor mounted to its cover. Check the oil pressure relief valve for excessive oil loss (some leakage may be evident but it should not be in bypass). If the valve is found to be stuck open, it should be replaced.

- Check the rear gear train for oil line problems:

- Use the recommended tool to check the clearance in the No. 1 idler stubshaft bushing. Inspect the interior of the end housing for debris under the gear train.

- Remove the auxiliary generator drive or the cover plate on the rear right bank. Inspect the manifold piping to the turbocharger filter for loose or missing components or seals. Make sure that the upper pipe plug is installed in the gauge line connecting block and inspect the camshaft manifolds.

- If all the above conditions are found to be within specification, remove and requalify the main oil lube pump.

8.2.5.4 Protective Engine Shutdown - Oil Temperature

> **NOTE:**
> The oil temperature sensor will tell EMDEC to shutdown the engine if it sees a hot oil conditionfor sixty (60) consecutive seconds. This sensor ill not shutdown the engine for a wiring fault condition but will log a "Check Engine Fault" in the EMDEC archive.

1) **Check EM2000 Fault Archive**

- Check the EM2000 fault archive for shutdown information. If the archive information indicates that the oil could have been above the safe operating range, (i.e. hot engine water) check the engine for the source of the hot oil condition. The oil temperature should normally be approximately 15 to 20 degrees hotter than the coolant temperature. Note: if the locomotive has been run in tunnel service, this shutdown maybe a result of this service and not a cause for concern. Perform a load test on the unit to verify the hot oil condition has cleared. If the unit has not been in tunnel service and a hot oil condition is indicated, reference the Diesel Engine Troubleshooting Guide published by EMD for further information on troubleshooting the condition.

2) **Check EMDEC Fault Archive**

- If the archived fault indicates an electrical problem such as signal voltage high or low, refer to **8.6 - Troubleshooting Sensor Circuits** for information on troubleshooting the oil temperature circuit.

- If EMDEC displays an “Oil Temperature Data Valid But Above Normal” fault, but indications are that the fault is suspect, note the EMDEC failure information and clear the EMDEC faults.

- Disconnect the connector from the sensor and examine both for corrosion or damage. If corrosion is evident, replace both the terminals and sensor. If none is evident, proceed to the next step.

- Restart the engine and monitor the oil temperature. If possible, load test the unit to see if the condition repeats.

- The sensor can be checked by unplugging the connector and noting the oil temperature on the reader. Using a voltmeter, check the resistance across the two sensor pins and verify whether it falls within + 10 percent of the resistance/ temperature curve on the graph in **8.6 - Troubleshooting Sensor Circuits**.

- If the sensor resistance is within tolerance, refer to the appropriate electrical schematic and check the sensor wiring harness for an open or short.

8.3 Troubleshooting EMDEC Power Supply

8.3.1 No Lights On 24V Power Supply

- Check that the battery knife switch is closed.
- Check that **ENGINE CONTROL** Circuit Breaker is closed.
- Disconnect and check PI plug. Pins 1 & 2 should be +74V. Pins 5 & 6 should be -74V.
- If power is present, check the pins for corrosion. If pins are okay, change the power supply. If power is not present, refer to the locomotive wiring diagram and trace the wiring back for the source of possible disconnect or open.

8.3.2 Red Light Glows on 24V Power Supply

The *red* light indicates a protective shutdown has occurred. This can be attributed to either overvoltage on the input side or overcurrent on the output side.

- Cycle the ENGINE CONTROL Circuit Breaker and check if the light has returned to *green*. If *green*, the power supply is okay and the condition that made it shutdown has disappeared.

- If the light remains *red*, disconnect the PO plug from the power supply and cycle the Engine Control circuit breaker. If the light remains *red*, there is no short on the output side of the power supply therefore the power supply is bad and should be replaced.

- If the light turns *green*, but goes back to *red* upon replacement of the PO plug, disconnect the power plug from each ECM at the ECM one at a time. If the problem disappears, the respective ECM is the source of the problem. If problem persists after disconnecting the ECM power, disconnect the P plug from the locomotive Interface Board. If problem continues disconnect the blue PS and PR1 wire harnesses that run from the power supply to each ECM controller and check for a short. If okay, check wiring from PO plug to Interface board.

8.4 EMDEC Wiring Visual Inspection

In cases where EMDEC wiring is suspected of creating fault conditions, perform the following visual inspection of the suspected wiring harness to identify the root cause.

8.4.1 Open Circuit

1) Visually inspect connection points to wires.

2) Check for bent or recessed pins.

3) Check for chafed or damaged insulation (including protective looming) where wires may be broken.

4) Check for corroded pins on harness as well as mating part connector.

8.4.2 Short Circuit

1) Check for degraded, chafed, or damaged insulation (including protective looming) where conductive wires may be exposed and touching each other.

2) Check for conductive debris or liquid causing short circuit between connector pins.

3) Check for bent or retracted pins causing short circuit.

8.5 Troubleshooting TRS & SRS

8.5.1 Troubleshooting the TRS/SRS Sensor Circuit

1) Check that the TRS/SRS air gap is within spec.

2) Open the **ENGINE CONTROL** Circuit Breaker and remove the EHC connector from both the sender and receiver ECM. It is recommended that the metal plate the covers the ECM be removed to provide easier access to the EHC.

3) If a simulator box is available, check to see if the problem lies with the sensor or the harness. If a simulator box is not available, please troubleshoot using the following steps.

4) To troubleshoot the TRS circuit, disconnect the plug to the sensor and measure the resistance across Pin 1T and Pin 2T on the EHC connector on the sender ECM. If it is less than or equal to 10,000 ohms, the wire harness is shorted.

5) Re-plug the connector to the sensor and measure the resistance. If it is greater than 10,000 ohms, check the wire harness for open.

6) Disconnect the plug from the sensor. Place a jumper between Pin A and Pin B to short out the plug at the sensor. Check the resistance across Pin 1T and Pin 2T on the EHC on the sender ECM. If it is greater than 5 ohms, the wire harness is open.

7) Check the EHC on the Receiver ECM using the instructions above.

8) To troubleshoot the SRS circuit, disconnect the plug to the sensor and measure the resistance across Pin 1S and Pin 2S on the EHC connector on the Sender ECM. If it is less than or equal to 10,000 ohms, the wire harness is shorted.

9) Replug the connector to the sensor and measure the resistance. If it is greater than 10,000 ohms, check the wire harness for open.

10) Disconnect the plug from the sensor. Place a jumper between Pin A and Pin B to short out the plug at the sensor. Check the resistance across Pin 1S and Pin 2S on the EHC on the sender ECM. If it is greater than 5 ohms, the wire harness is open.

11) Check the EHC on the Receiver ECM using the instructions above.

12) If the above checks do not solve the fault, check the injectors for an internal ground and the injector harness for grounds.

13) Check to make sure the ECM's are not grounded to the carbody. Often the rubber isolation mounts are missing causing a grounded ECM.

8.6 Troubleshooting Sensor Circuits

8.6.1 General Information

Listed below are acceptable voltage readings for sensors used in the EMDEC System, when the engine is "dead." This information is available in EMMON or WinEMMON when the user presses the "F5" Function Key:

- Typical range of the offset voltage for the 58 psig (in early EUI applications used for Turbo Oil Pressure, Coolant Pressure and Fuel Pressure), 87 psia (MAP Sensor on H-Engine and Sensor Box equipped engines) and 100 psig sensors (Coolant Pressure, Turbo Oil Pressure and Fuel Pressure (in some models)) is 0.43 - 0.56 VDC.

- Typical range of the offset voltage for the 200 psia sensor (Fuel Pressure Engine-In, Fuel Pressure Filter-In Engine-In, Fuel Pressure Filter-In, Oil Pressure Engine-In, Oil Pressure Filter-In) is 0.73 - 0.79 VDC.

Defective sensors can be uncovered with a probability near 100%, by testing the device's output vs. pressure (engine off, Engine Control Break is on, then testing again at TH8, full load).

A final tip - if a sensor's output appears to drop exponentially while monitoring the parameter on EMMONxx, WinEMMON or via the EM2000 Display, check for obstructions in the sensor's hose assembly or sensor's port for clogs before permanently removing the suspected failure.

8.6.2 Troubleshooting The Crankcase Pressure Detector Circuit Switch Output

PID xx Data Valid But Above Normal

Where xx Represents the EMDEC Fault Code

NOTE:

A signal voltage of 0.66 volt will be sent to EMDEC when the crankcase pressure detector button is tripped. The microswitch on the detector sends a signal voltage to the ECM of 2.3 volts when the button is latched. The EMDEC system will shutdown if a data valid fault is detected for 0.2 seconds. If an overvoltage or undervoltage condition occurs continuously for 40 seconds in the sensor circuit, EMDEC will shutdown the engine.

1) Check within the EMDEC reader program EMMON for the following ACTIVE fault:

   PID xx - Data Valid but above Normal
   Where xx can be: 42
   Crankcase Pressure - LB

2) This fault could indicate that a true Crankcase Over Pressure situation has occurred. Look at the Crankcase Pressure Detector button to see if it is popped out. If the button is popped out, then proceed with the proper engine mechanical troubleshooting and safety procedures found in Diesel Engine Troubleshooting Guide. If the button is NOT popped out, then troubleshoot for an electrical fault in the respective harness branch and / or the detector itself listed below. Make sure that the button is not sealed into place. If the button is seized, replace the detector device.

3) If other sensors are displayed as grounded or having floating values it can cause the crankcase pressure detector to trip first because of the short time delay. Unplug each sensor, one at a time, until the values either stabilize or return to normal. Replace the sensor that is grounded.

4) If a grounded sensor is not found, disconnect, one at a time, the two injector harness plugs that connect to each of the ECMs. If the source of the ground is the injector harness, replace the harness.

5) If no defect is found with the other sensors, refer to the appropriate electrical schematic and check the sensor wire harnesses for short or grounds. Open the **ENGINE CONTROL** Circuit Breaker and disconnect the plug from the detector. Examine both the plug end and receptacle end for signs of corrosion. If corrosion is evident on the connector pins, either clean the contact surfaces or replace both the sensor and terminals.

6) If no corrosion is evident, use a voltmeter to check sensor resistance. Open the **ENGINE CONTROL** Circuit Breaker. Check the resistance between the pins in the sensor receptacle. The readings should be as follows:

Part Nos. **40084551, 40071740, 40071741 and 40076531**

Set	Tripped
A to B open	A to B 6.6-7.0 kohm
A to C open	A to C 37.0-41.0 kohm
B to C 30.2-34.2 kohm	B to C 30.2-34.2 kohm

If the readings vary by +/- 10%, change the sensor.

8

8.6.3 Troubleshooting The Analog Crankcase Pressure Sensor Circuit (Analog Output)

PID xx Data Valid But Above Normal

Where xx Represents the EMDEC Fault Code

NOTE:

A signal voltage of 2.56 VDC or greater will be sent to EMDEC when the Analog Crankcase Pressure Sensor is subjected to more than 1.0” W.C. If EMDEC is sent a voltage level greater than 2.56 VDC from the Analog Crankcase Pressure Sensor, EMDEC will initiate an engine shutdown event. The Analog Crankcase Pressure Sensor has been configured with two different timers. If the supply voltage to this device goes “open circuit,” EMDEC will detect this condition and initiate an Engine Shutdown event after 40 seconds have elapsed. Any other fault detected by the Analog Crankcase Pressure Sensor will cause EMDEC to initiate an engine shutdown event after 0.2 seconds have elapsed.

NOTE:

Analog Crankcase Pressure Sensor’s wiring definitions:
A = Ground, B= Output & C = 5VDC Supply.

1) Check within the EMDEC reader program EMMON for the following ACTIVE fault:

    PID xx - Data Valid but above Normal
    Where xx can be: 42
    Crankcase Pressure - LB

2) This fault could indicate that a true Crankcase Over Pressure situation has occurred. Perform the proper engine mechanical troubleshooting and safety procedures found in Diesel Engine Troubleshooting Guide. If no defects are found, then troubleshoot for an electrical fault in the respective harness branch and / or the detector itself listed below.

3) If other sensors are displayed as grounded or having floating values it can cause the crankcase pressure detector to trip first because of the short time delay. Unplug each sensor, one at a time, until the values either stabilize or return to normal. Replace the sensor that is grounded.

4) If a grounded sensor is not found, disconnect, one at a time, the two injector harness plugs that connect to each of the ECMs. If the source of the ground is the injector harness, replace the harness.

5) If no defect is found with the other sensors, refer to the appropriate electrical schematic and check the sensor wire harnesses for short or grounds.

6) Open the **ENGINE CONTROL** Circuit Breaker and disconnect the plug from the analog crankcase pressure sensor. Examine both the plug end and receptacle end for signs of corrosion. If corrosion is evident on the connector pins, either clean the contact surfaces or replace both the sensor and terminals.

7) If no corrosion is present within the sensor's connector or the harness plug, reconnect the harness plug to the sensor and perform the following steps:

- Close the Engine Control Breaker.
- Connect PC to EMDEC Diagnostic Port and launch "EMMONxx or WinEMMON software program.
- Build a signal list in EMMON that includes the signal "Crankcase Pressure-LB".
- "Check the Crankcase Pressure-LB" reading with the engine "dead." A reading of less than 1.3" H_2O is an acceptable reading. Confirm the reading by checking the voltage output of the sensor. Press the "F5" function key, then look for the entry "Crankcase Pressure Voltage" while engine is dead. A reading between 2.30 and 2.54 VDC is an acceptable reading.
- Any sensor readings that do not pass this criteria are faulty and should be replaced.

The CCOP Suction Bulb is the recommended device to use in performing engine shutdown tests for crankcase pressure. Basically, the test procedure is to disconnect the hose assembly that is screwed into the Sensor Box Bracket and Analog Crankcase Pressure Sensor. The hose assembly that connects the Analog Crankcase Pressure Sensor to the crankcase through the Sensor Box Bracket has a swivel fitting on one end only, so the house must be disconnected on both ends and reconnected to the sensor. At this point, the engine should be restarted. Insert the CCOP Suction Bulb into one end of the hose assembly and squeeze the bulb a few times. This forces positive air pressure into the sensor's port and forces EMDEC to initiate an engine shutdown event.

8.6.4 Troubleshooting The Coolant Pressure Circuit

PID xx - Shorted High (FMI_Voltage_High) or Shorted Low (FMI_Voltage_Low)
Where xx represents the EMDEC Fault Code

The sensor is considered failed if its voltage is below 0.23 V or above 4.95 V. Check the EMREPORT (found in the .lst files within the EMDEC software disk) for a complete listing of the sensors available and shutdown tables on a particular locomotive order. At startup, EMDEC will allow the cooling system two (2) minutes to pressurize before enabling the coolant pressure protective circuit. After the two (2) minute time period, the system will shutdown for low coolant pressure or wiring faults in throttle positions higher than Idle.

1) Check within the EMDEC reader program EMMON for the following ACTIVE fault:

   PID xx - Shorted High (FMI_Voltage_High) or Shorted Low (FMI_Voltage_Low)

   Where xx can be:60 Coolant pressure RB
   Coolant pressure LB
   Coolant pressure engine out
   Auxiliary water pressure (1.5 Software Version Only)
   Engine Oil Level (really #2 Coolant Pressure 1.5 Software Version Only)
   Coolant Pressure (1.5 Software Version Only)

2) Since this fault can occur from having a disconnected sensor, check the plug for misaligned pins, contaminated (with engine fluids or debris) pins, flattened at the pin contact tip or pushed back from the socket.

3) Check that the plug at the ECM (reference respective wiring schematic) is properly connected and that the pins are not contaminated, pushed back, or flattened at the contact tip. If contaminated clean and check if fault becomes INACTIVE.

4) If no corrosion is evident, replace the sensor with a new sensor. Check EMMON to see if the ACTIVE fault went INACTIVE. If the fault did not clear, proceed to troubleshooting the harness wiring and ECM.

Remember the sensor wiring is always as follows: Terminal A=Ground, Terminal B= Sensor Output, Terminal C=5VDC Supply.

Sensor Resistance Values:

58 PSI Sensor P/N 40059278

Pin A to B	11.52 - 14.08 kohm
Pin A to C	10.35 - 12.65 kohm
Pin B to C	1.26 - 1.54 kohm

100 PSI Sensor P/N 40055333 or 40087572

Pin A to B	10.58 - 13.5 kohm
Pin A to C	9.34 - 11.42 kohm
Pin B to C	1.26 - 1.54 kohm5

5) Check the harness for a short by opening the **ENGINE CONTROL** circuit breaker and disconnecting the plug at the sensor along with the EHC connector at the ECM.

   Measure the resistance across pin 2L and pin 1W for coolant pressure #1, pin 2M and pin 1W for coolant pressure #2 and pin 1R and pin 1W for Y-pipe coolant pressure. If less than or equal to 10,000 ohms then the harness is shorted. Next, run a jumper from pin A to pin B on the sensor plug. Check the resistance across pin 2L and pin 2Y for coolant pressure #1, pin 2M and pin 2Y for coolant pressure #2 and pin 1R and pin 2Y for Y-pipe coolant pressure on the EHC connector at the Sender ECM. If the

   resistance is greater than 5 ohms, the harness is open.

6) If the above tests are inconclusive, replace the ECM.

If no defect is found with any EMDEC component, put the unit in load test at throttle 8 for one-half hour to see if the fault repeats. If no fault reoccurs, release the unit to service. (Note: If the water was over 200 degrees, with a “Hot Engine” shutdown archived, replace the coolant system pressure cap).

8.6.5 Troubleshooting The Coolant Pressure Circuit

PID xx - Data Valid But Above / Below Normal
Where xx represents the EMDEC Fault Code

> **NOTE:**
> The sensor is considered failed if its voltage is below 0.23 V or above 4.95 V. Check the EMREPORT (found in the .lst files within the EMDEC software disk) for a complete listing of the sensors available and shutdown tables on a particular locomotive order. EMDEC will allow the cooling system two (2) minutes to pressurize before enabling the coolant pressure protective circuit. After the two (2) minute time period, the system will shutdown for low coolant pressure or wiring faults in throttle positions higher than Idle.

1) Check within the EMDEC reader program EMMON for the following ACTIVE fault:

   PID xx - Data Valid but above Normal
   Where xx can be:
   - 60 Coolant Pressure LB
   - 61 Coolant Pressure RB
   - 62 Coolant Pressure Engine Out
   - 98 Engine Oil Level (really #2 Coolant Pressure 1.5 Software Only)
   - 109 Coolant Pressure (1.5 Software Version Only)
   - 63 Coolant Pressure Delta LB (Coolant Press LB - Engine out)

64 Coolant Pressure Delta RB (Coolant Press RB - Engine out)
65 Excessive Bank to Bank Coolant Pressure Difference (1.7 only)

> **NOTE:**
> PID's 63, 64 and 65 are *calculated* values and do **not** physically have a sensor assigned to them.

2) This fault can often be associated with a "stuck" or incorrect sensor. Place the locomotive in self test and throttle up watching the sensor value on EMMON.

   If the sensor does not change at each throttle position, replace the suspect sensor and monitor if the ACTIVE fault becomes INACTIVE. If the value does change, go to step 3.

3) Check to determine that there is not a true mechanical problem causing the fault (e.g. entrained air, pump cavitation or failure, head-gasket leak, cracked cylinder head, etc.). Check the sight glass for coolant level with the engine running and follow the recommended mechanical system troubleshooting procedures found in the Diesel Engine Troubleshooting Guide (DET).

4) The cooling system is blocked. Follow the recommended procedure for clearing cooling system debris or other blockage located in the DET.

5) A significant cooling system leak has developed. Follow the recommended procedures for finding and fixing cooling system leaks.

NOTE:

Conditions 3,4, and 5 above are most likely to cause defaults, so look for those on the EMDEC diagnostics to help narrow down the actual root cause. Keep in mind that mechanical problems such as a leaking head gasket or cracked cylinder head, may only produce symptoms under full engine load. Therefore, a load test on a fully warmed-up engine may be the only way to duplicate the problem. When running such a test, have the EMDEC reader program EMMON set-up to display all cooling system data. Pay particular attention to significant changes in Delta-P values since they are the first to indicate entrained exhaust or air bubbles in the cooling system.

8.6.6 Troubleshooting The Oil Pressure Circuit

PID xx - Shorted High (FMI_Voltage_High) or Shorted Low (FMI_Voltage_Low)

Where xx represents the EMDEC Fault Codes

NOTE:
The engine will shutdown if the oil pressure sensor is considered valid and the oil pressure is below the shutdown curve for 10 seconds. The sensor is considered valid if its voltage is above 0.23 V or below 4.95 V. The engine will shutdown for an invalid sensor after 40 seconds. Check the EMREPORT (found in the .lst files within the EMDEC software disk) for a complete listing of the sensors available and shutdown tables on a particular locomotive order. The oil pressure shutdown protection is excluded for 60 seconds after engine start.

1) Check within the EMDEC reader program EMMON for the following ACTIVE fault:

   PID xx - Shorted High (FMI_Voltage_High)or Shorted Low (FMI_Voltage_Low)

   Where xx can be:
   - 30 Oil pressure turbo RB
   - 31 Oil pressure turbo LB
   - 32 Oil pressure engine in
   - 33 Oil pressure filter in

2) Since this fault can occur from having a disconnected sensor, check the plug for pins that are misaligned, contaminated (with engine fluids or debris), flattened at the contact tip or pushed back from the socket.

3) Check that the plug at the ECM (reference respective wiring schematic) is properly connected and that the pins are not contaminated, pushed back, or flattened at the contact tip. If contaminated clean and check if fault becomes INACTIVE.

4) If no corrosion is evident, replace the sensor with a new sensor. Check EMMON to see if the ACTIVE fault went INACTIVE. If the fault did not clear, proceed to troubleshooting the harness wiring and ECM.

Remember the sensor wiring is always as follows: Terminal A=Ground, Terminal B= Sensor Output, Terminal C=5VDC Supply.

Sensor Resistance Values:

100 PSI Sensor P/N 40087572

Pin A to B	10.58-13.5 kohm
Pin A to C	9.34-11.42 kohm
Pin B to C	1.58-1.93 kohm

5) Check the harness for a short by opening the **ENGINE CONTROL** Circuit Breaker and disconnecting the plug at the sensor along with the EHC connector at the ECM.

   Measure the resistance across pin 2P and pin 1W. If less than or equal to 10,000 ohms then the harness is shorted. Next, run a jumper from pin A to pin B on the sensor plug. Check the resistance across pin 2P and pin 2Y on the EHC connector at the sender ECM. If the resistance is greater than 5 ohms, the harness is open.

6) If the above tests are inconclusive, replace the ECM.

7) If no defect is found with any EMDEC components, put the unit in load test at throttle 8 for one-half hour to see if the fault repeats. If no fault reoccurs, release the unit to service.

8.6.7 Troubleshooting The Oil Pressure Circuit

PID xx - Data Valid But Above / Below Normal Where xx represents the EMDEC Fault Code

NOTE:
The engine will shutdown if the oil pressure sensor is considered valid and the oil pressure is below the shutdown curve for 10 seconds. The sensor is considered valid if its voltage is above 0.23 V or below 4.95 V. The engine will shutdown for an invalid sensor after 40 seconds. Check the EMREPORT (found in the .lst files within the EMDEC software disk) for a complete listing of the sensors available and shutdown tables on a particular locomotive order. The oil pressure shutdown protection is excluded for 60 seconds after engine start.

1) Check within the EMDEC reader program EMMON for the following ACTIVE fault:
PID xx - Data Valid but above Normal
Where xx can be: 30 Oil Pressure Turbo LB
31 Oil Pressure Turbo RB
32 Oil Pressure Engine In

2) This fault can often be associated with a "stuck" or incorrect sensor. Place the locomotive in self-test and throttle up watching the sensor value on EMMON.
If the sensor does not change at each throttle position, replace the suspect sensor and monitor if the ACTIVE fault becomes INACTIVE. If the value does change, go to step 3.

3) Check to determine that there is not a true mechanical problem causing the fault (e.g. pump failure, relief valve stuck, fuel in oil, etc.). Follow the recommended mechanical system troubleshooting procedures found in the Diesel Engine Troubleshooting Guide (DET).

4) If equipped with rack mounted sensor, the following additional faults may be logged (although they do not cause engine shutdowns):
PID 34 Oil Pressure Delta Filter (FMI Health Low)
PID 34 Oil Pressure Delta Filter (FMI Health Critical)

These faults indicate that the Lube Oil Filter is nearing or has reached its maximum capacity and should be replaced with a new element, per recommended engine maintenance.

8.6.8 Troubleshooting The Oil Temperature Sensor Circuit

> **NOTE:**
>
> The engine will shutdown if the oil temperature sensor is considered valid and the oil temperature is above 250˚F for 60 seconds (10 seconds for H engine equipped locomotives). The sensor is considered valid if the its voltage is above 0.23 Vor below 4.95 V. The engine will not shutdown for an invalid sensor

1) Check within the EMDEC reader program EMMON for the following ACTIVE fault:
   PID xx - Data Valid but above Normal
   Where xx can be: 39 Oil temperature engine in

2) Clear the active codes.

3) Disconnect the connector from the sensor and examine both for corrosion or damage. If corrosion is evident, replace both the terminals and sensor. If none is evident, proceed to the next step.

4) If the indicated fault is Oil Temperature Circuit Failed High, disconnect the oil temperature sensor plug and install a jumper wire between sockets A and B. If the active code on the reader is Oil Temperature Circuit Failed High, the signal wire has an open.

5) Disconnect the EHC plug from the sender ECM. Use a voltmeter to read the resistance between Pin 2R and Pin 2Y. If the resistance is greater than or equal to 10,000 ohms or open, replace the sensor.

6) If the indicated fault is Oil Temperature Circuit Failed Low, disconnect the oil temperature sensor plug from the sensor after clearing the active faults.

7) If the active fault on the reader is no longer Oil Temperature Circuit Failed Low, replace the sensor.

8) Check the continuity of the wires from the sender ECM to the oil temperature sensor as follows:
   Plug terminal A - EHC 2Y
   Plug terminal B - EHC 2R
   If open or grounded, replace the harness.

9) It is also possible that other sensors may have a short or ground that is causing the oil temperature sensor to have electrical problems.

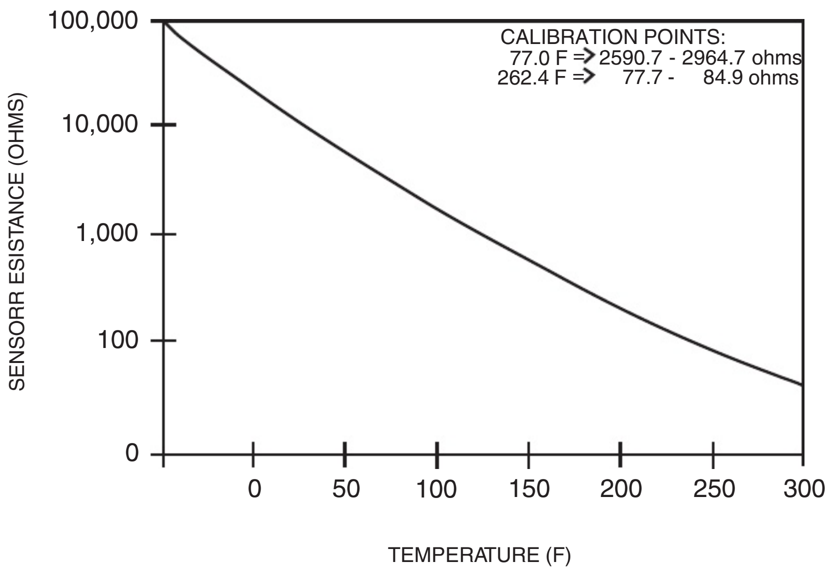


Figure 8.2 *Sensor Resistance vs Temperature Graph.*

8.7 Troubleshooting the Two-Way Serial Link

There are two 2-Way links in the EMDEC system: J1922 Control link and J1587 diagnostic link. The control link consists of one 20 byte message going from the EM2000 to EMDEC (MID 75) and one 20 byte message going from EMDEC to the EM2000 (MID 71). The message packets contain information critical to engine and locomotive control and performance. The diagnostic link transmits data that is not critical to the control of the locomotive or engine such as operating parameters and diagnostic information between the EM2000 and any EMDEC ECM.

1) Check within the EMDEC reader program EMMON for the following ACTIVE fault: PID 247 - J1922 Busy Byte FMI Abnormal Rate

   The "Busy Byte" is used to determine the integrity of the communication link between EMDEC and the EM2000. When an **active** "Busy Byte error" is archived in EMDEC several parameters may be altered due to the loss of the control link.

   - Airbox pressure is clipped at a maximum value of 64.90 in Hg in TN8 Full load.

   - Engine speed is not transmitted over the Sender ECM 128 but is over the Receiver ECM 175.

2) Make sure that the EM2000 COMPUTER CONTROL Circuit Breaker is closed and the EMDEC power supply is functioning correctly.

NOTE:
In order to isolate what link has failed, pull up on the EM2000 programmable screen Ebusy, EbusyA, ECFail and EDFail. Ebusy is the bit sent by the EM2000 and EbusyA is the return bitfrom EMDEC. The EM2000 sends a status bit to EMDEC starting at 1 and counting up to 15. EMDEC, in turn, mimics the response back to the EM2000. If the status bit is inactive for five seconds, a total loss of communication exists. If the ECFail is true (ON) the control link has failed and operation has defaulted to the diagnostic link. If the EDFail is true (ON) the diagnostic link has failed. If both links are lost a No Load condition exists due to complete communication loss.

3) Check supply voltage on PC connector (Pin A and C +24 VDC, Pin B, D and E GND) of power harness. If 24 VDC is not present, troubleshoot power harness using wiring diagram WDO4066 inserted at the end of the manual.

4) Unplug the communications connector on the Sender ECM and make sure that pins A and B are not recessed or loose to insure proper mating to the ECM. Do the same on the Locomotive Interface Board plug E2 pins 1 and 2. Perform a continuity check from pin A of the Sender's Communications Connector (CC) to pin 1 on the E2 connector at the Interface Board. Do the same for pin B of the Sender's CC plug to pin 2 of the E2 plug.

5) Check the wiring between the Interface Board and the EM2000 Serial Distribution Box in the #1 Electrical Cabinet. Unplug the S2 mating connector on the interface board and perform a continuity check from the S2 plug pins 1, 2, 5, 6 and 7 to pins 12, 13, 10, 11 and 14, respectively on the Serial Distribution Box.

6) Check the wiring from the Serial Distribution Box to the COM module. Disconnect the Serial Distribution Box signal #1 plug and test for continuity from pins 10, 11, 14, 12 and 13 to pins 10, 11, 14, 12 and 13, respectively on the 11B plug of the COM module.

7) If there are no errors in the wiring found, then replace the interface board.

8) If that does not fix the problem, replace in order the Sender ECM, COM module and Signal Distribution Box.

8.8 Troubleshooting EMDEC Annunciator Panel (70/75 Series)

8.8.1 No Lights Illuminated On The Annunciator Panel

A) Check that Engine Control Circuit Breaker is closed.

B) Check that the Injector Run Switch located on the EMDEC Annunciator panel is in the "RUN" position.

C) Turn the switch at the Engine Start station to the "Prime" position for a few seconds or

toggle the Computer Control circuit breaker.
If EFCO was used to stop the engine, the EMDEC system will be disabled until the prime switch is used to bring it back up.

D) Make sure the "MU Engine Stop" switch is in the "Run" position.

E) Check for a green light on the power supply.

F) Check the AN plug on the interface board for proper connection.

G) Check the AD plug at Annunciator panel for proper connection.

H) Disconnect plug P from the interface board. Check pin 1 for +24V and pin 3 for -24V.

I) Disconnect and check AD plug, pin 13 at Annunciator panel for +24V. Check AD plug, pin 2 for -24V.

J) A digital voltmeter can be placed across two resistors: R15 (right leg) for positive, and C7 (left leg) for negative. If +24Vis read, ignition is on.

K) Check if reader can access the EMDEC system at the reader port. If it can, the Annunciator panel or interface board may be suspect.

8.9 Troubleshooting the 710 Series Sensor Box

The Sensor Box Simultaor is used to simulate the EMDEC Sensor Box when troubleshooting the Sensor Box or the EMDEC System. The Sensor Box Simulator will output fixed signal to the ECMs, so that EMDEC faults can be isolated to the Sensor Box or wiring/ECMs. Basically, the test procedure to follow is:

1. Open Engine Control Circuit Breaker.

2. Disconnect connector from the rear of the Sensor Box.

3. Plug Sensor Box Simulator P/N 40106322 into harness connection that was removed from Sensor Box.

4. Re-energize EMDEC System by closing the Engine Control Breaker.

5. Launch EMMON or WinEMMON software program.

6. Review sensor parameter list for the following values (depending upon the version of EMMON used, it may be necessary to build this signal list):

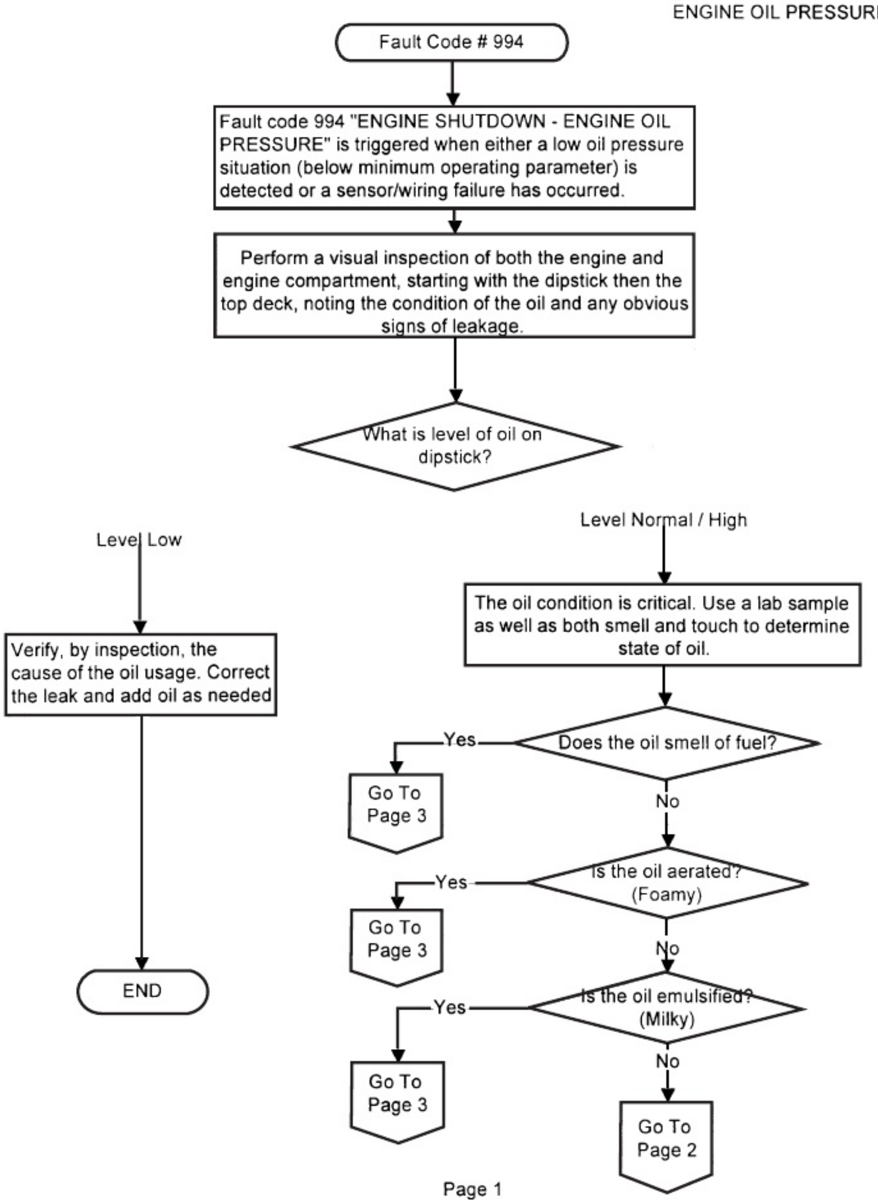
   - CoolantPressure Engine-In LB — 63PSI
   - CoolantPressure Engine-In RB — 35PSI
   - CoolantPressure Engine-Out — 2PSI
   - Oil Pressure Turbo Inlet-RB — 82 PSI
   - Crankcase Press-LB — 2 in H_2O
   - Airbox Pressure-RB — 41 PSI
   - FuelPressure Engine-In — 93PSI

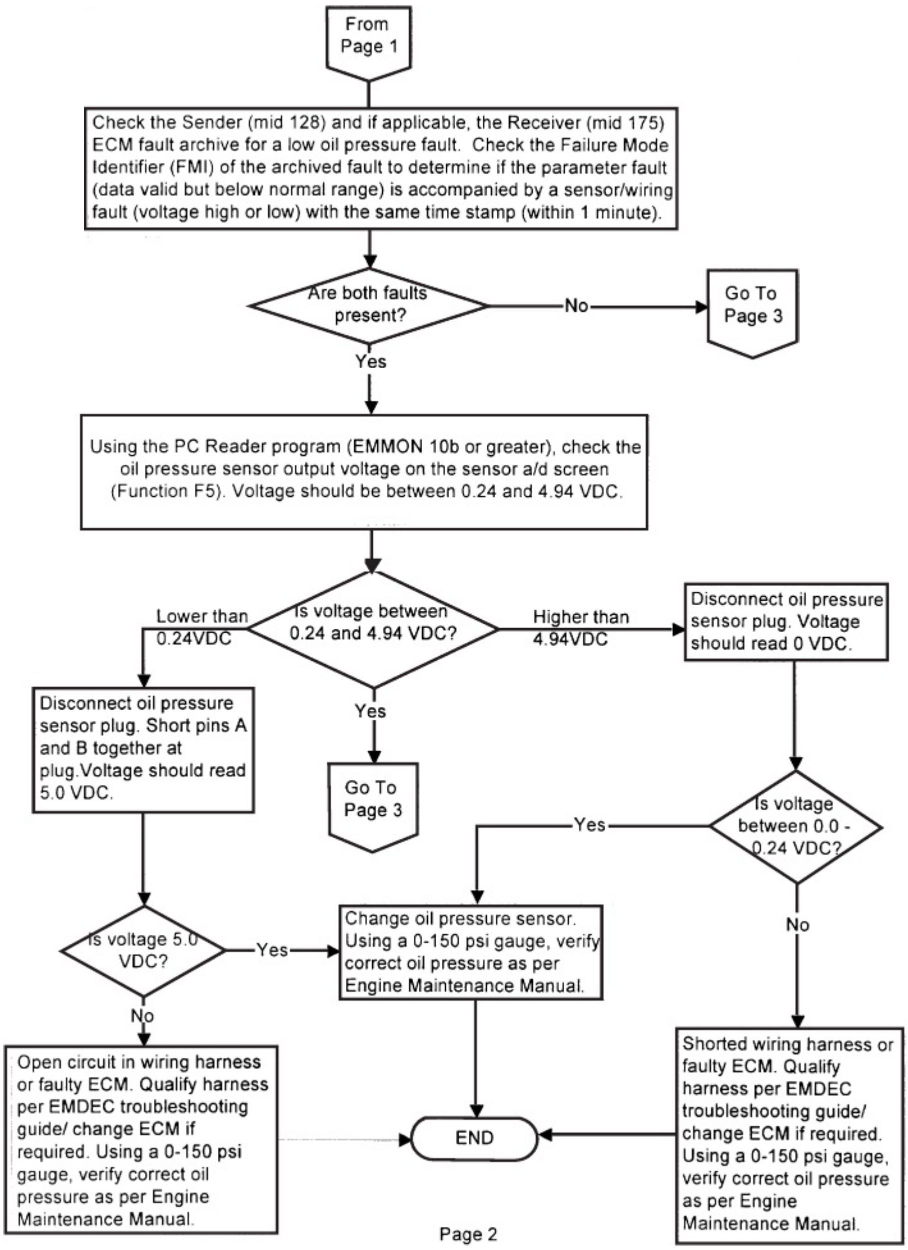
The presence of these signal values indicate wiring upstream of the Sensor Box is “good” and that the fault must reside in the Sensor Box.

8.10.1

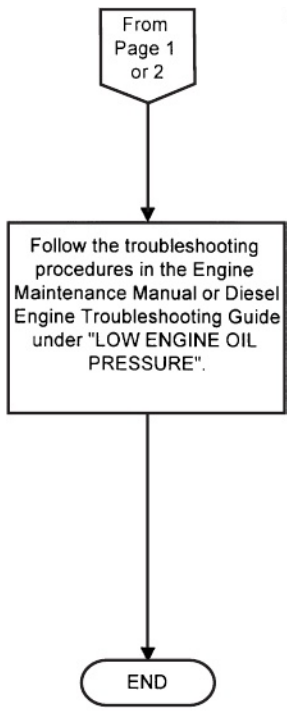
Fault Code: 994

ENGINE SHUTDOWN -
ENGINE OIL PRESSURE




From Page 1
Check the Sender (mid 128) and if applicable, the Receiver (mid 175) ECM fault archive for a low oil pressure fault. Check the Failure Mode Identifier (FMI) of the archived fault to determine if the parameter fault (data valid but below normal range) is accompanied by a sensor/wiring fault (voltage high or low) with the same time stamp (within 1 minute).
Are both faults present?
No
Go To Page 3
Yes
Using the PC Reader program (EMMON 10b or greater), check the oil pressure sensor output voltage on the sensor a/d screen (Function F5). Voltage should be between 0.24 and 4.94 VDC.
Is voltage between 0.24 and 4.94 VDC?
Lower than 0.24VDC
Higher than 4.94VDC
Disconnect oil pressure sensor plug. Voltage should read 0 VDC.
Disconnect oil pressure sensor plug. Short pins A and B together at plug.Voltage should read 5.0 VDC.
Yes
Go To Page 3
Is voltage between 0.0 - 0.24 VDC?
Yes
Is voltage 5.0 VDC?
Yes
Change oil pressure sensor. Using a 0-150 psi gauge, verify correct oil pressure as per Engine Maintenance Manual.
No
No
Open circuit in wiring harness or faulty ECM. Qualify harness per EMDEC troubleshooting guide/ change ECM if required. Using a 0-150 psi gauge, verify correct oil pressure as per Engine Maintenance Manual.
END
Shorted wiring harness or faulty ECM. Qualify harness per EMDEC troubleshooting guide/ change ECM if required. Using a 0-150 psi gauge, verify correct oil pressure as per Engine Maintenance Manual.
Page 2

8

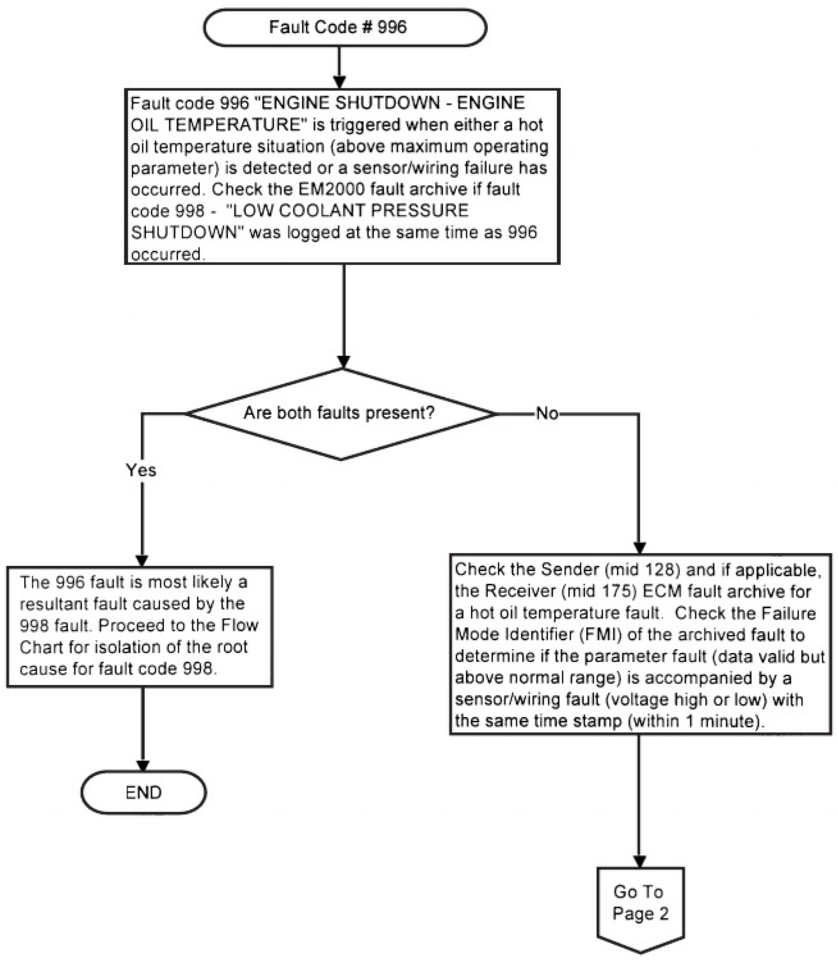

From
Page 1
or 2
Follow the troubleshooting procedures in the Engine Maintenance Manual or Diesel Engine Troubleshooting Guide under "LOW ENGINE OIL PRESSURE".
END

Page 3

8.10.2

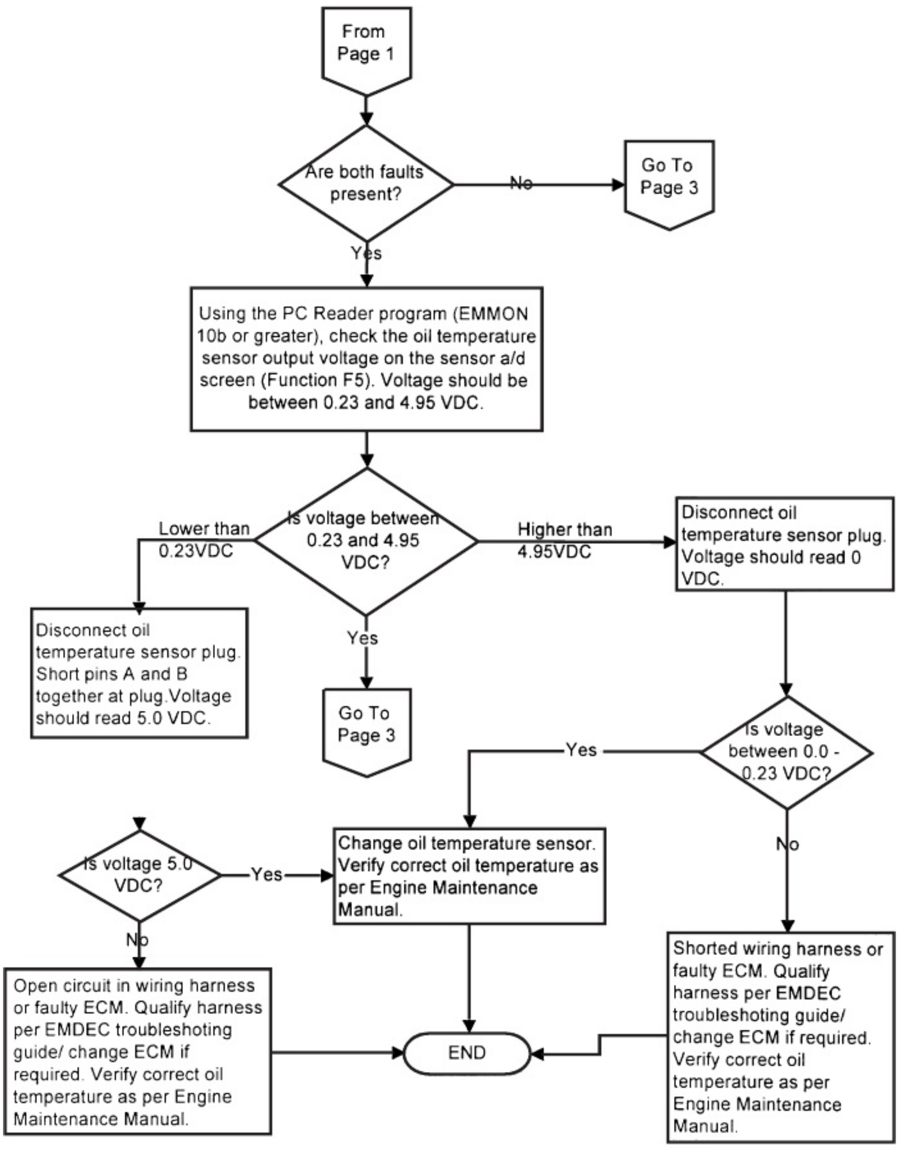
Fault Code: 996

ENGINE SHUTDOWN -
ENGINE OIL TEMPERATURE



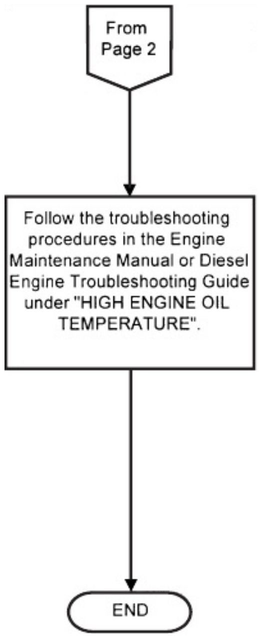
Page 1

8



From Page 1
Are both faults present?
No
Go To Page 3
Yes
Using the PC Reader program (EMMON 10b or greater), check the oil temperature sensor output voltage on the sensor a/d screen (Function F5). Voltage should be between 0.23 and 4.95 VDC.
Is voltage between 0.23 and 4.95 VDC?
Lower than 0.23VDC
Higher than 4.95VDC
Yes
Disconnect oil temperature sensor plug. Short pins A and B together at plug.Voltage should read 5.0 VDC.
Go To Page 3
Disconnect oil temperature sensor plug. Voltage should read 0 VDC.
Is voltage between 0.0 - 0.23 VDC?
Yes
No
Is voltage 5.0 VDC?
Yes
No
Change oil temperature sensor. Verify correct oil temperature as per Engine Maintenance Manual.
Open circuit in wiring harness or faulty ECM. Qualify harness per EMDEC troubleshoting guide/ change ECM if required. Verify correct oil temperature as per Engine Maintenance Manual.
END
Shorted wiring harness or faulty ECM. Qualify harness per EMDEC troubleshoting guide/ change ECM if required. Verify correct oil temperature as per Engine Maintenance Manual.

Page 2

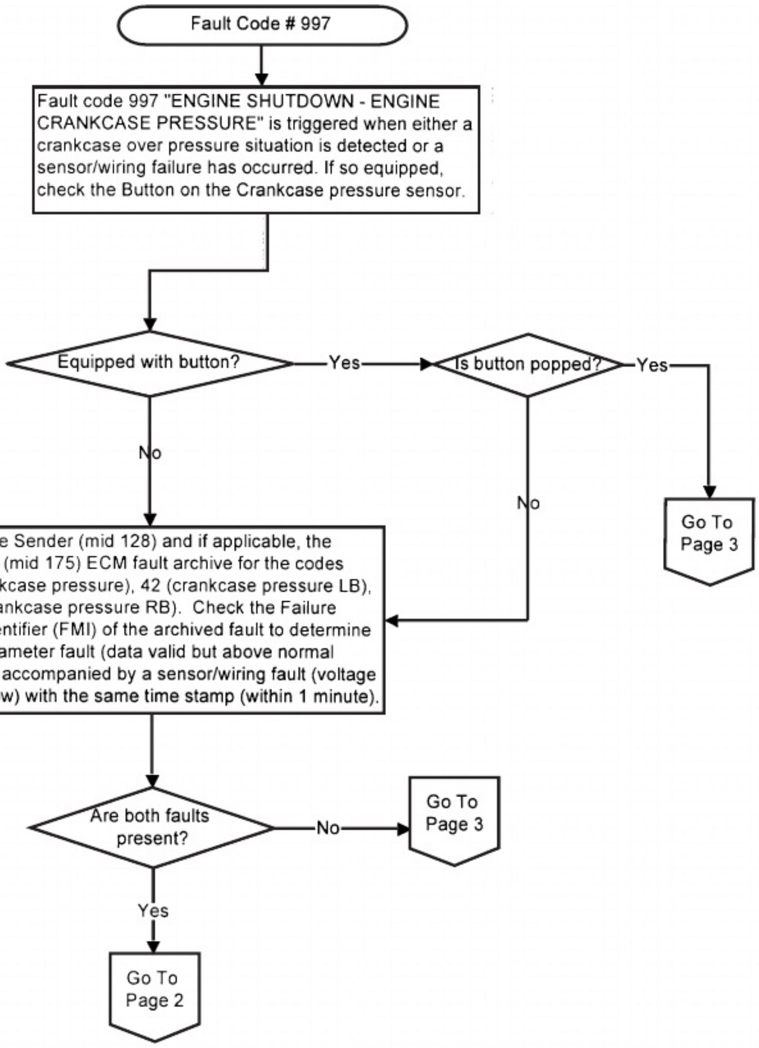

From
Page 2
Follow the troubleshooting procedures in the Engine Maintenance Manual or Diesel Engine Troubleshooting Guide under "HIGH ENGINE OIL TEMPERATURE".
END

Page 3

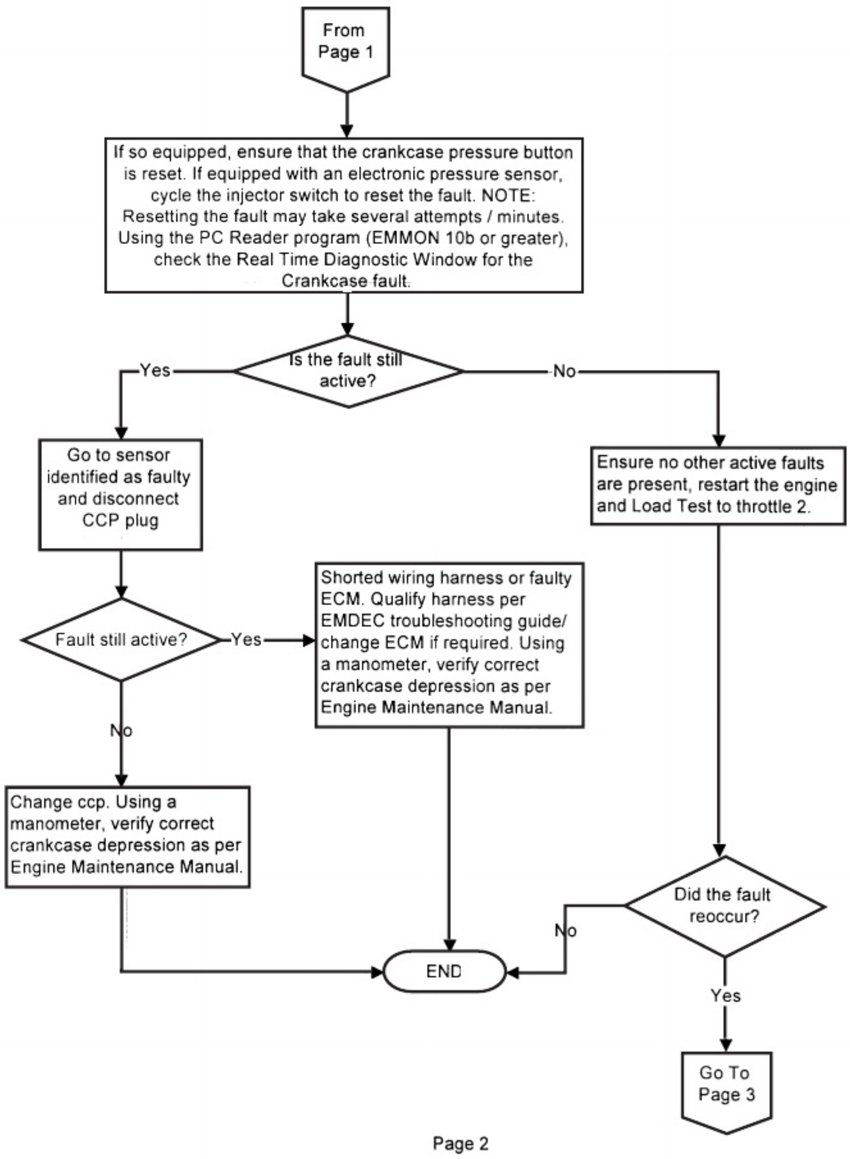
8.10.3

Fault Code: 997

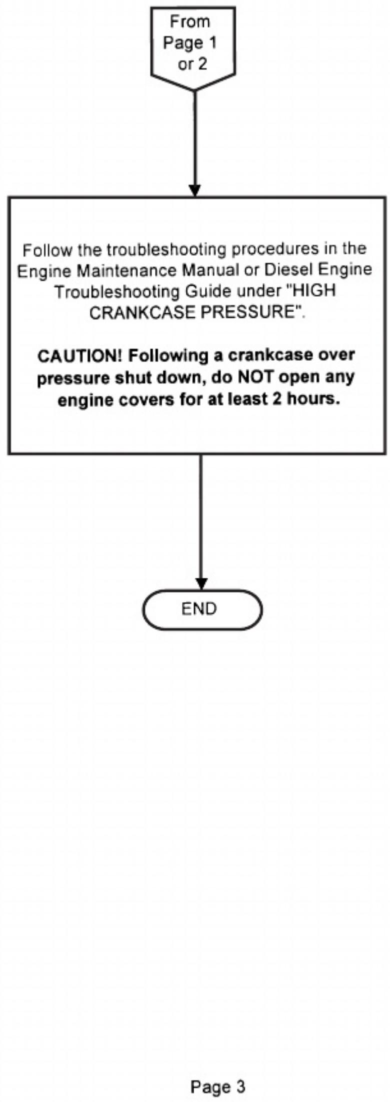
ENGINE SHUTDOWN -
ENGINE CRANKCASE PRESSURE



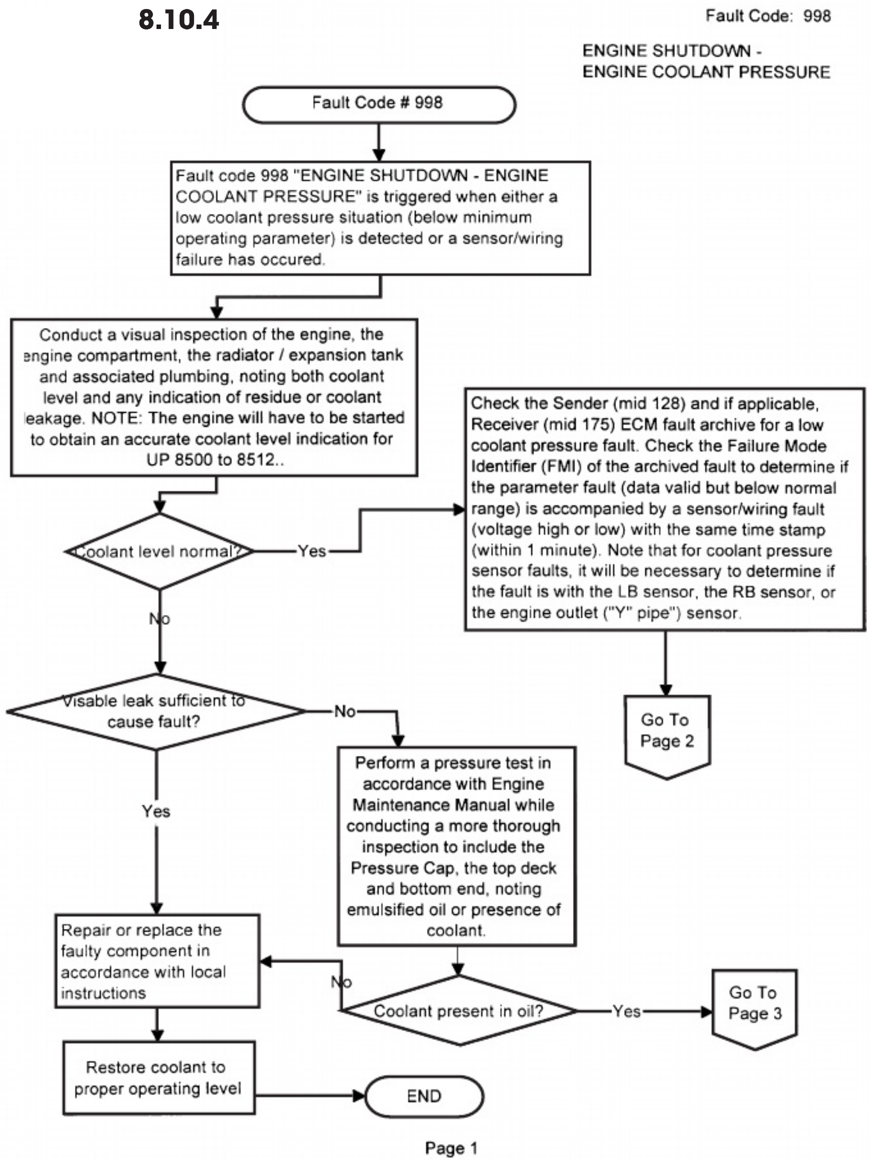
Page 1

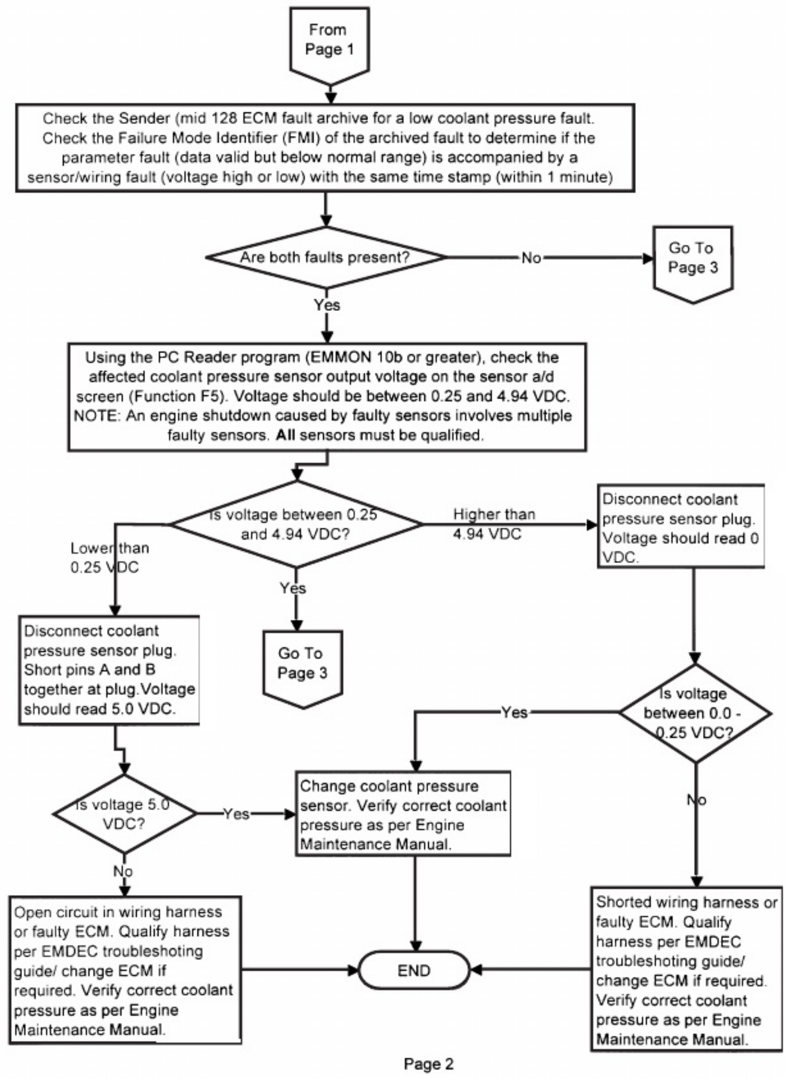


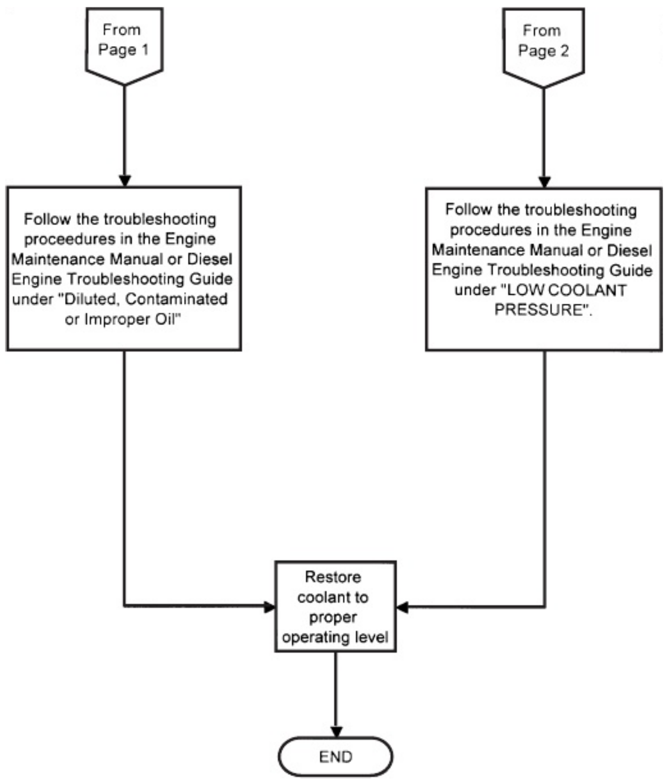
From Page 1
If so equipped, ensure that the crankcase pressure button is reset. If equipped with an electronic pressure sensor, cycle the injector switch to reset the fault. NOTE: Resetting the fault may take several attempts / minutes. Using the PC Reader program (EMMON 10b or greater), check the Real Time Diagnostic Window for the Crankcase fault.
Is the fault still active?
Yes
No
Go to sensor identified as faulty and disconnect CCP plug
Ensure no other active faults are present, restart the engine and Load Test to throttle 2.
Fault still active?
Yes
Shorted wiring harness or faulty ECM. Qualify harness per EMDEC troubleshooting guide/ change ECM if required. Using a manometer, verify correct crankcase depression as per Engine Maintenance Manual.
No
Change ccp. Using a manometer, verify correct crankcase depression as per Engine Maintenance Manual.
Did the fault reoccur?
No
END
Yes
Go To Page 3
Page 2


From Page 1 or 2
Follow the troubleshooting procedures in the Engine Maintenance Manual or Diesel Engine Troubleshooting Guide under "HIGH CRANKCASE PRESSURE".
CAUTION! Following a crankcase over pressure shut down, do NOT open any engine covers for at least 2 hours.
END
Page 3

8.10.4


Fault Code: 998
ENGINE SHUTDOWN -
ENGINE COOLANT PRESSURE
Fault Code # 998
Fault code 998 "ENGINE SHUTDOWN - ENGINE COOLANT PRESSURE" is triggered when either a low coolant pressure situation (below minimum operating parameter) is detected or a sensor/wiring failure has occured.
Conduct a visual inspection of the engine, the engine compartment, the radiator / expansion tank and associated plumbing, noting both coolant level and any indication of residue or coolant leakage. NOTE: The engine will have to be started to obtain an accurate coolant level indication for UP 8500 to 8512..
Coolant level normal?
Yes
Check the Sender (mid 128) and if applicable, Receiver (mid 175) ECM fault archive for a low coolant pressure fault. Check the Failure Mode Identifier (FMI) of the archived fault to determine if the parameter fault (data valid but below normal range) is accompanied by a sensor/wiring fault (voltage high or low) with the same time stamp (within 1 minute). Note that for coolant pressure sensor faults, it will be necessary to determine if the fault is with the LB sensor, the RB sensor, or the engine outlet ("Y" pipe") sensor.
Go To Page 2
No
Visable leak sufficient to cause fault?
No
Perform a pressure test in accordance with Engine Maintenance Manual while conducting a more thorough inspection to include the Pressure Cap, the top deck and bottom end, noting emulsified oil or presence of coolant.
Yes
Repair or replace the faulty component in accordance with local instructions
No
Coolant present in oil?
Yes
Go To Page 3
Restore coolant to proper operating level
END
Page 1


From Page 1
Check the Sender (mid 128 ECM fault archive for a low coolant pressure fault. Check the Failure Mode Identifier (FMI) of the archived fault to determine if the parameter fault (data valid but below normal range) is accompanied by a sensor/wiring fault (voltage high or low) with the same time stamp (within 1 minute)
Are both faults present?
No
Go To Page 3
Yes
Using the PC Reader program (EMMON 10b or greater), check the affected coolant pressure sensor output voltage on the sensor a/d screen (Function F5). Voltage should be between 0.25 and 4.94 VDC. NOTE: An engine shutdown caused by faulty sensors involves multiple faulty sensors. All sensors must be qualified.
Is voltage between 0.25 and 4.94 VDC?
Lower than 0.25 VDC
Higher than 4.94 VDC
Yes
Go To Page 3
Disconnect coolant pressure sensor plug. Voltage should read 0 VDC.
Disconnect coolant pressure sensor plug. Short pins A and B together at plug. Voltage should read 5.0 VDC.
Is voltage between 0.0 - 0.25 VDC?
Yes
No
Is voltage 5.0 VDC?
Yes
No
Change coolant pressure sensor. Verify correct coolant pressure as per Engine Maintenance Manual.
Open circuit in wiring harness or faulty ECM. Qualify harness per EMDEC troubleshoting guide/ change ECM if required. Verify correct coolant pressure as per Engine Maintenance Manual.
END
Shorted wiring harness or faulty ECM. Qualify harness per EMDEC troubleshoting guide/ change ECM if required. Verify correct coolant pressure as per Engine Maintenance Manual.
Page 2

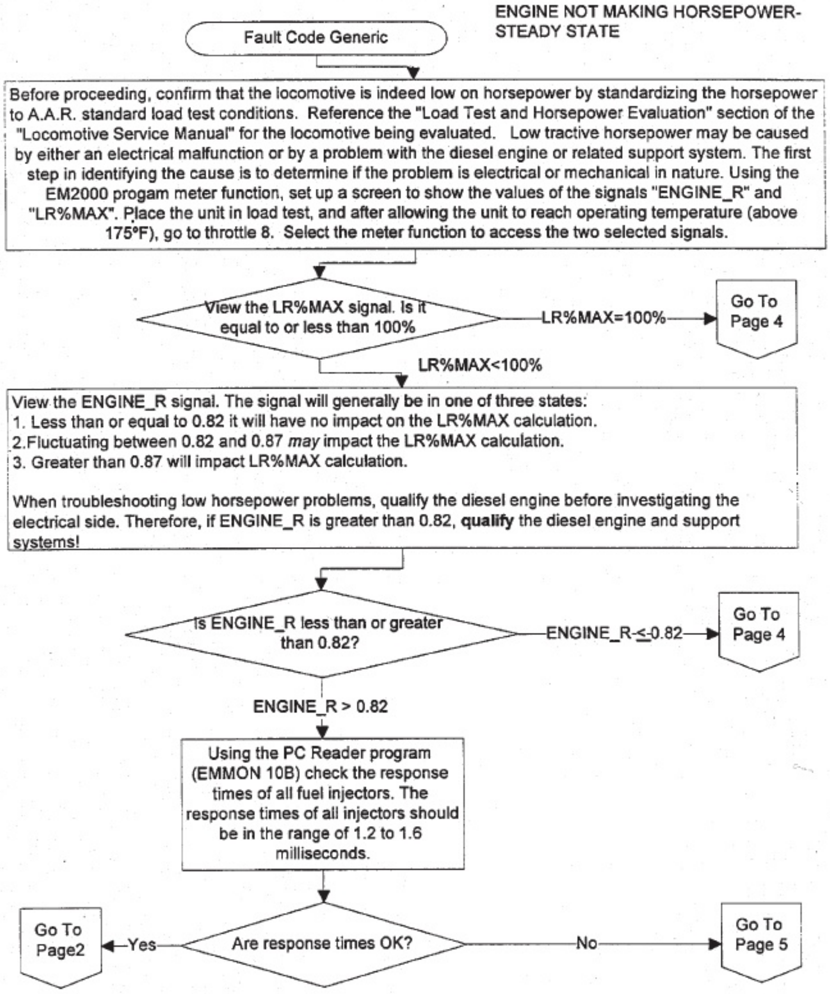

From
Page 1
From
Page 2
Follow the troubleshooting proceedures in the Engine Maintenance Manual or Diesel Engine Troubleshooting Guide under "Diluted, Contaminated or Improper Oil"
Follow the troubleshooting procedures in the Engine Maintenance Manual or Diesel Engine Troubleshooting Guide under "LOW COOLANT PRESSURE".
Restore coolant to proper operating level
END

Page 3

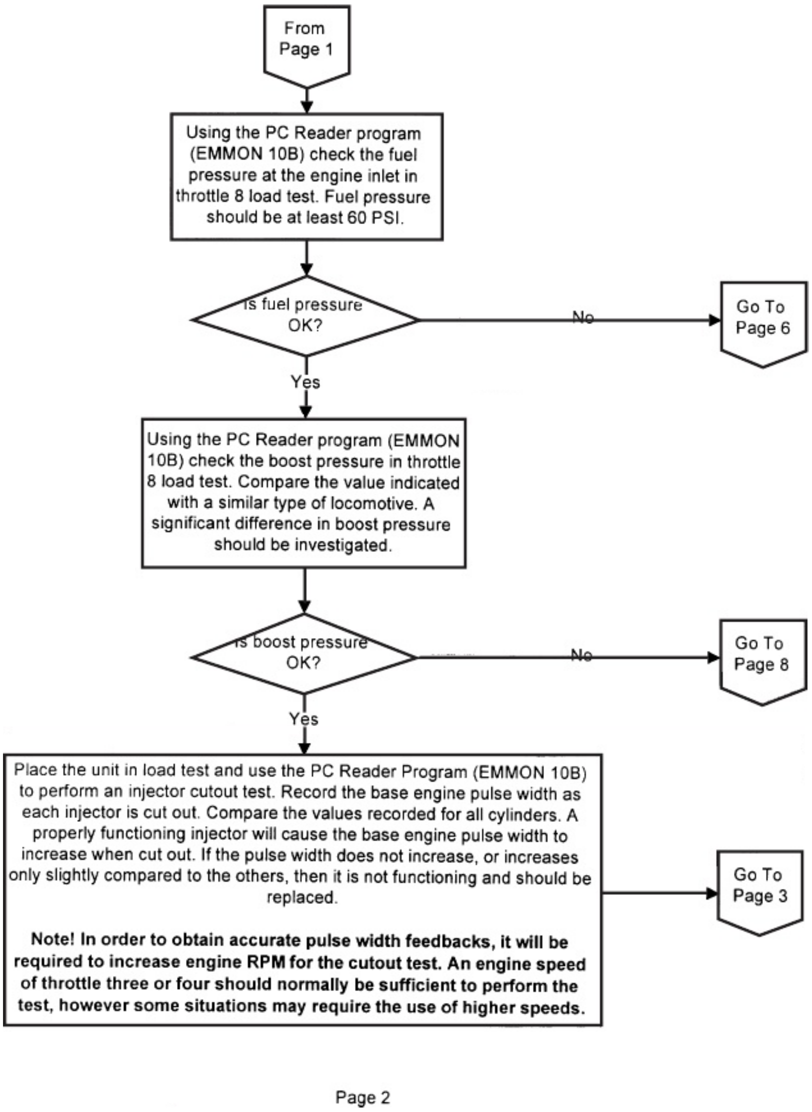
8.10.5

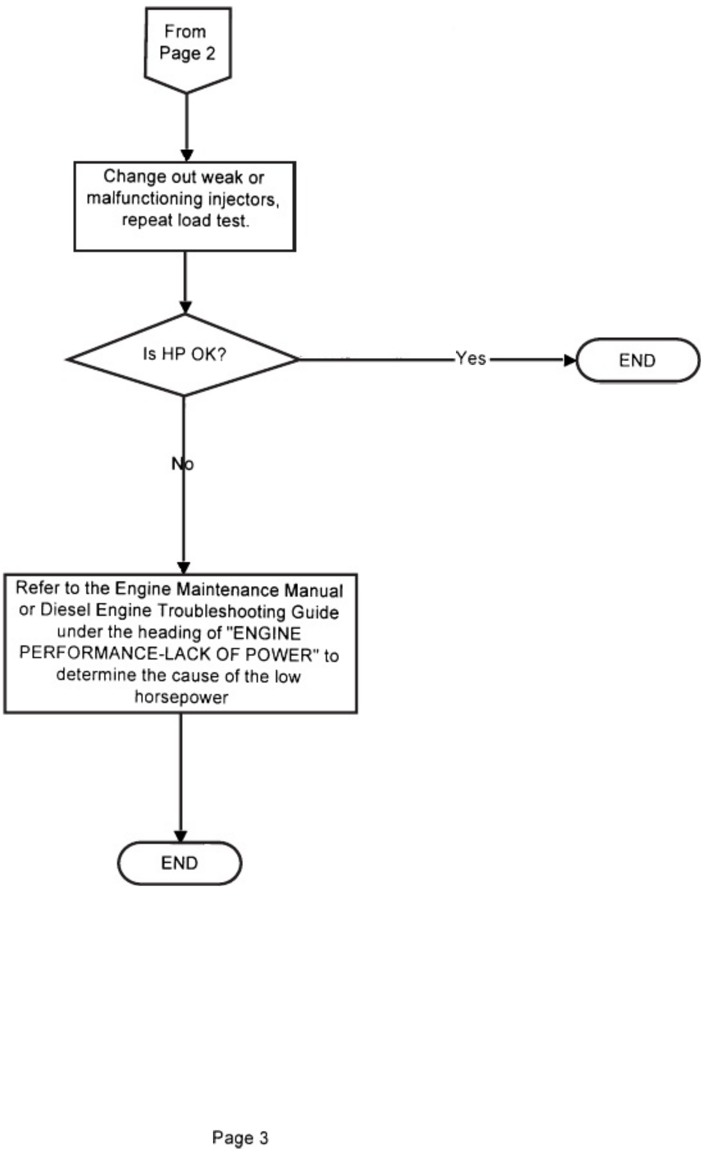
Fault Code: Generic

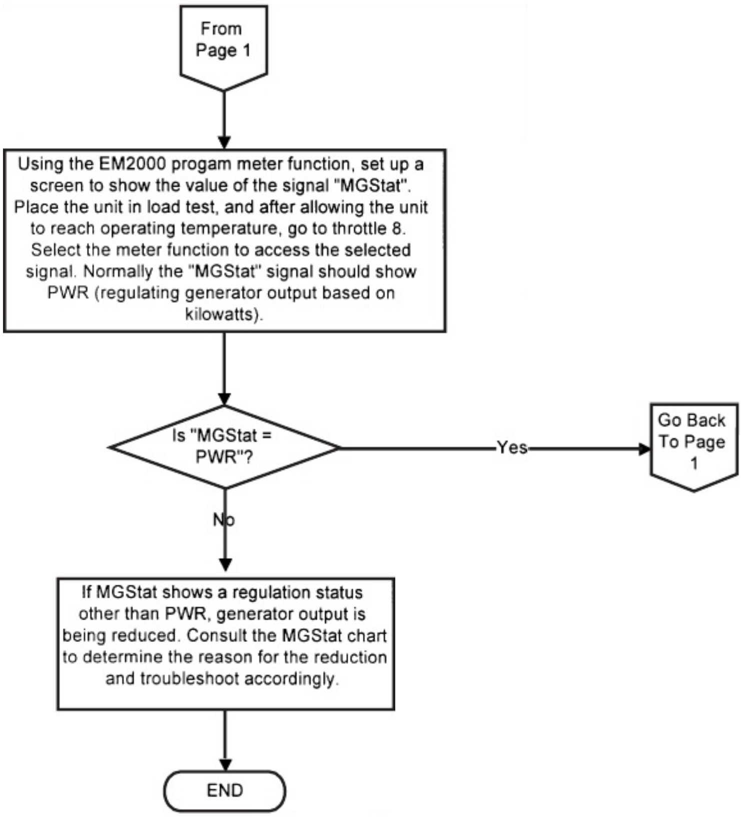
ENGINE NOT MAKING HORSEPOWER-
STEADY STATE



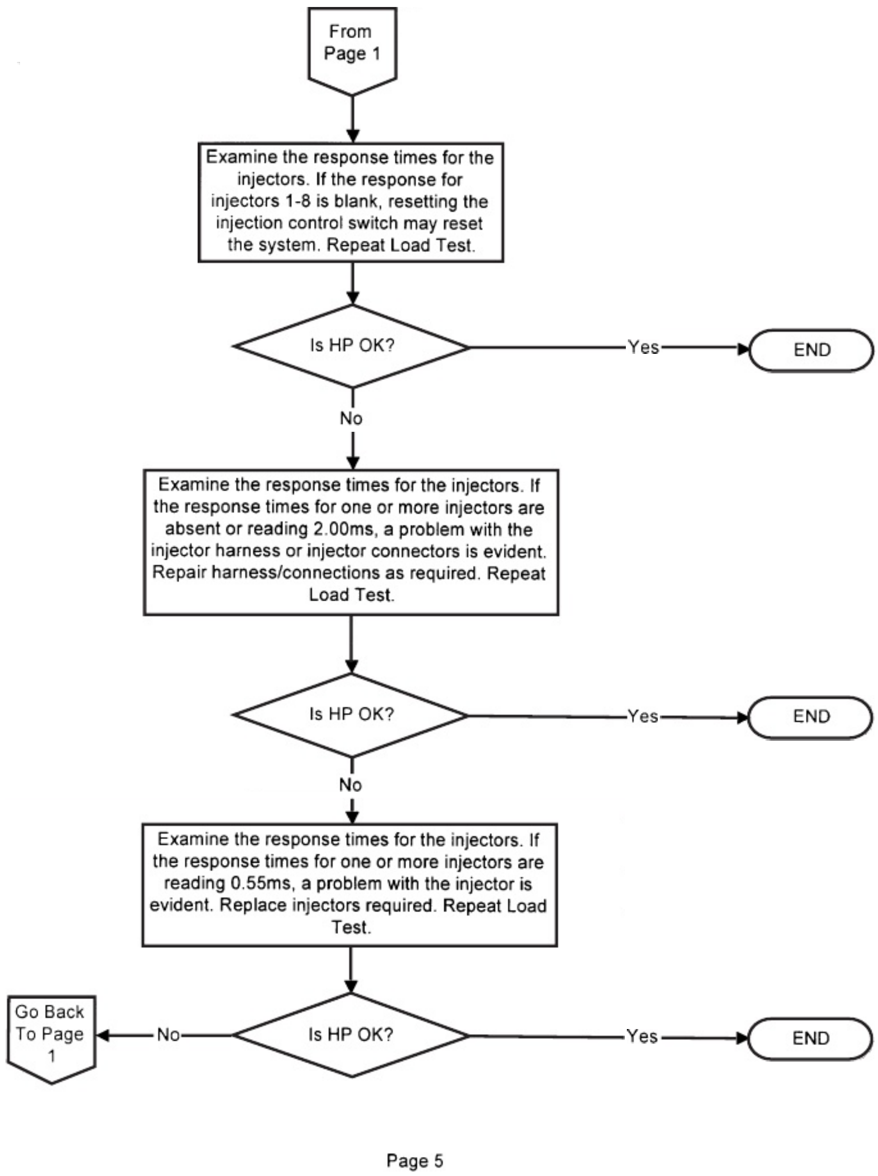
Page 1

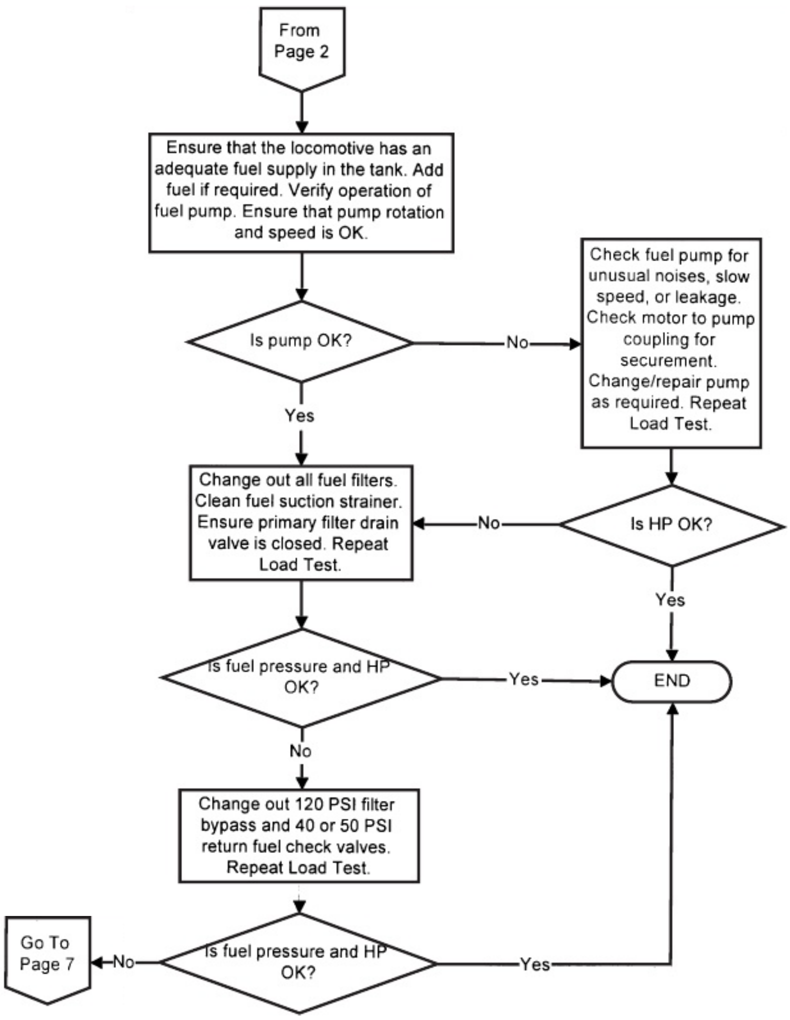

From Page 1
Using the PC Reader program (EMMON 10B) check the fuel pressure at the engine inlet in throttle 8 load test. Fuel pressure should be at least 60 PSI.
Is fuel pressure OK?
No
Go To Page 6
Yes
Using the PC Reader program (EMMON 10B) check the boost pressure in throttle 8 load test. Compare the value indicated with a similar type of locomotive. A significant difference in boost pressure should be investigated.
Is boost pressure OK?
No
Go To Page 8
Yes
Place the unit in load test and use the PC Reader Program (EMMON 10B) to perform an injector cutout test. Record the base engine pulse width as each injector is cut out. Compare the values recorded for all cylinders. A properly functioning injector will cause the base engine pulse width to increase when cut out. If the pulse width does not increase, or increases only slightly compared to the others, then it is not functioning and should be replaced.
Note! In order to obtain accurate pulse width feedbacks, it will be required to increase engine RPM for the cutout test. An engine speed of throttle three or four should normally be sufficient to perform the test, however some situations may require the use of higher speeds.
Go To Page 3
Page 2


From Page 2
Change out weak or malfunctioning injectors, repeat load test.
Is HP OK?
Yes
END
No
Refer to the Engine Maintenance Manual or Diesel Engine Troubleshooting Guide under the heading of "ENGINE PERFORMANCE-LACK OF POWER" to determine the cause of the low horsepower
END
Page 3

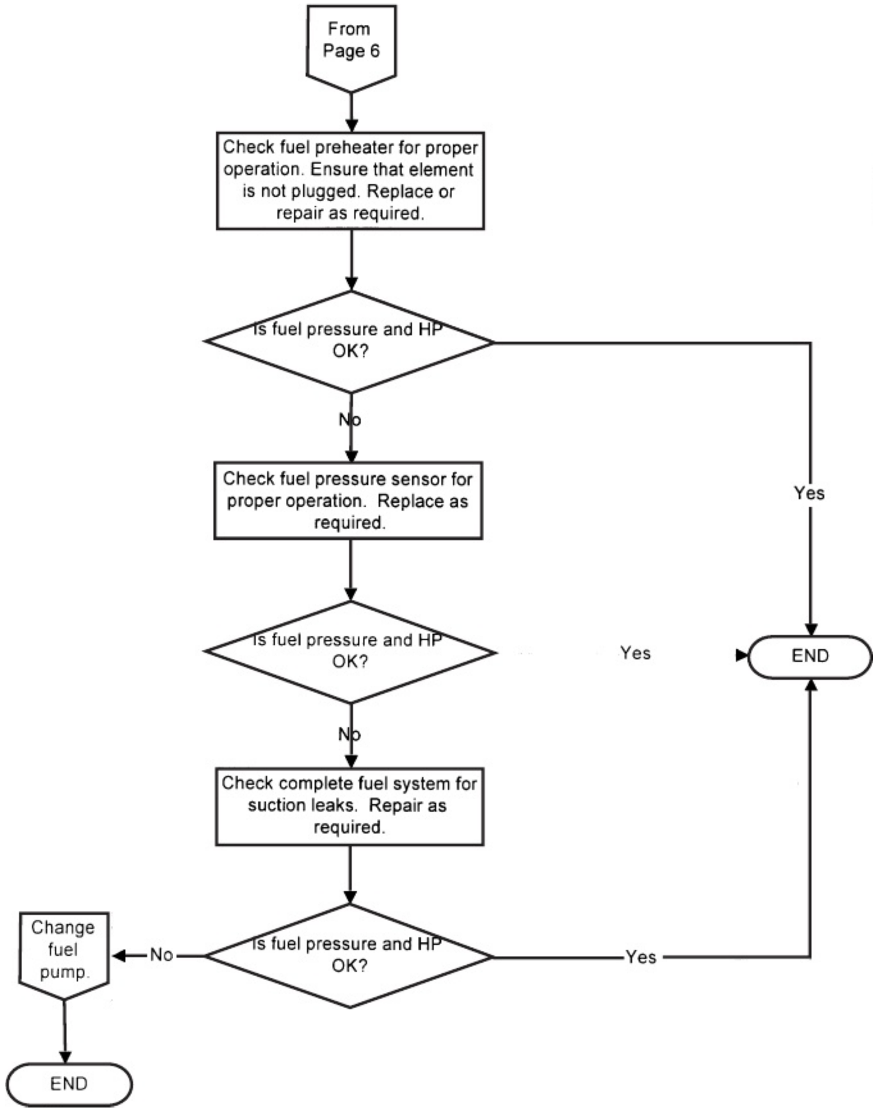

From Page 1
Using the EM2000 progam meter function, set up a screen to show the value of the signal "MGStat". Place the unit in load test, and after allowing the unit to reach operating temperature, go to throttle 8. Select the meter function to access the selected signal. Normally the "MGStat" signal should show PWR (regulating generator output based on kilowatts).
Is "MGStat = PWR"?
Yes
Go Back To Page 1
No
If MGStat shows a regulation status other than PWR, generator output is being reduced. Consult the MGStat chart to determine the reason for the reduction and troubleshoot accordingly.
END

Page 4

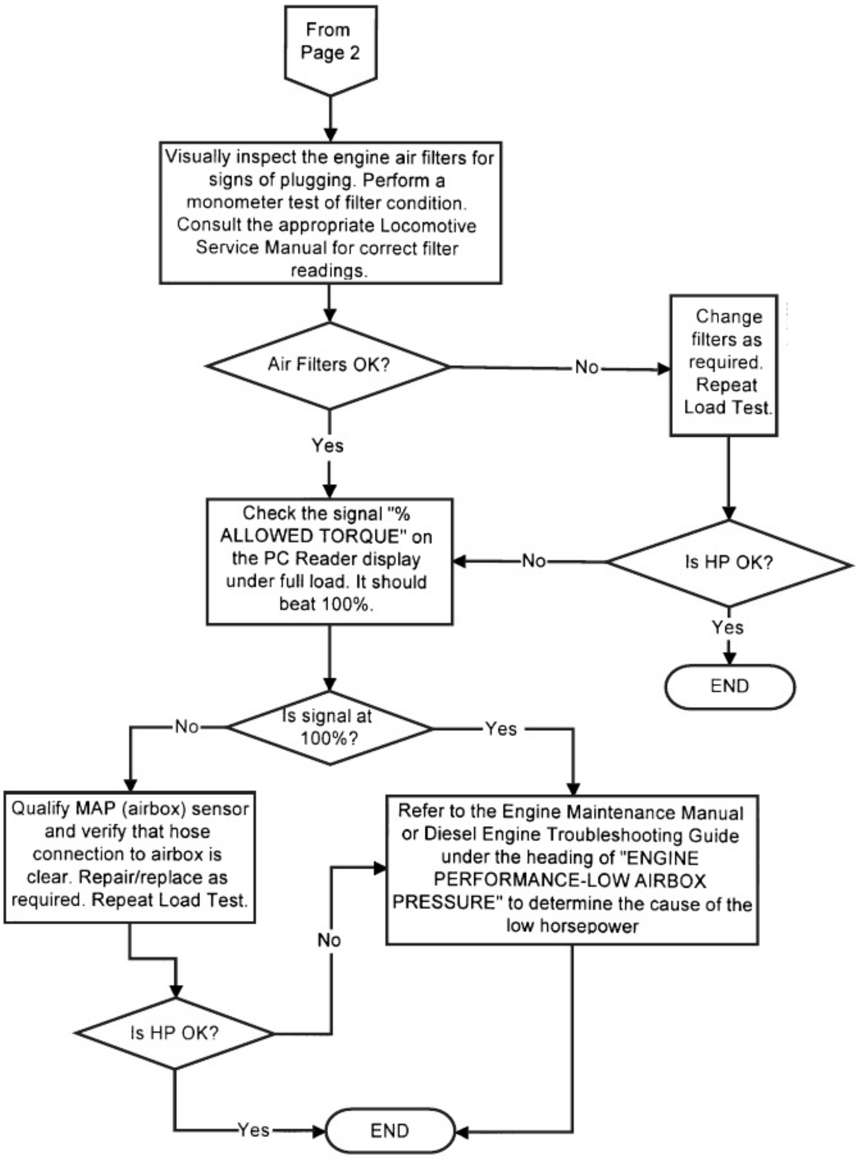

From Page 1
Examine the response times for the injectors. If the response for injectors 1-8 is blank, resetting the injection control switch may reset the system. Repeat Load Test.
Is HP OK?
Yes
END
No
Examine the response times for the injectors. If the response times for one or more injectors are absent or reading 2.00ms, a problem with the injector harness or injector connectors is evident. Repair harness/connections as required. Repeat Load Test.
Is HP OK?
Yes
END
No
Examine the response times for the injectors. If the response times for one or more injectors are reading 0.55ms, a problem with the injector is evident. Replace injectors required. Repeat Load Test.
Is HP OK?
Yes
END
No
Go Back To Page 1
Page 5


From Page 2
Ensure that the locomotive has an adequate fuel supply in the tank. Add fuel if required. Verify operation of fuel pump. Ensure that pump rotation and speed is OK.
Is pump OK?
No
Check fuel pump for unusual noises, slow speed, or leakage. Check motor to pump coupling for securement. Change/repair pump as required. Repeat Load Test.
Yes
Change out all fuel filters. Clean fuel suction strainer. Ensure primary filter drain valve is closed. Repeat Load Test.
No
Is HP OK?
Yes
Is fuel pressure and HP OK?
Yes
END
No
Change out 120 PSI filter bypass and 40 or 50 PSI return fuel check valves. Repeat Load Test.
Go To Page 7
No
Is fuel pressure and HP OK?
Yes

Page 6

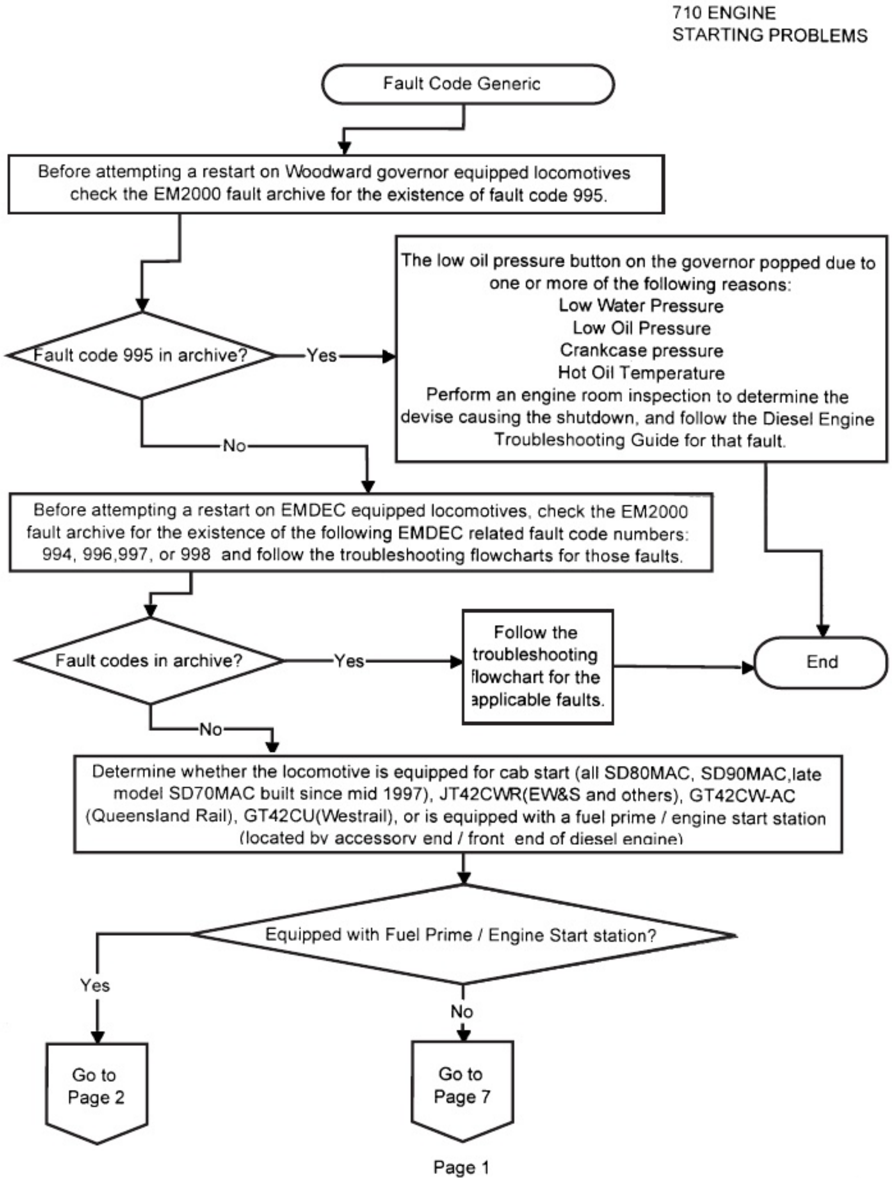

From Page 6
Check fuel preheater for proper operation. Ensure that element is not plugged. Replace or repair as required.
Is fuel pressure and HP OK?
No
Yes
Check fuel pressure sensor for proper operation. Replace as required.
Is fuel pressure and HP OK?
Yes
END
No
Check complete fuel system for suction leaks. Repair as required.
Is fuel pressure and HP OK?
No
Yes
Change fuel pump.
END

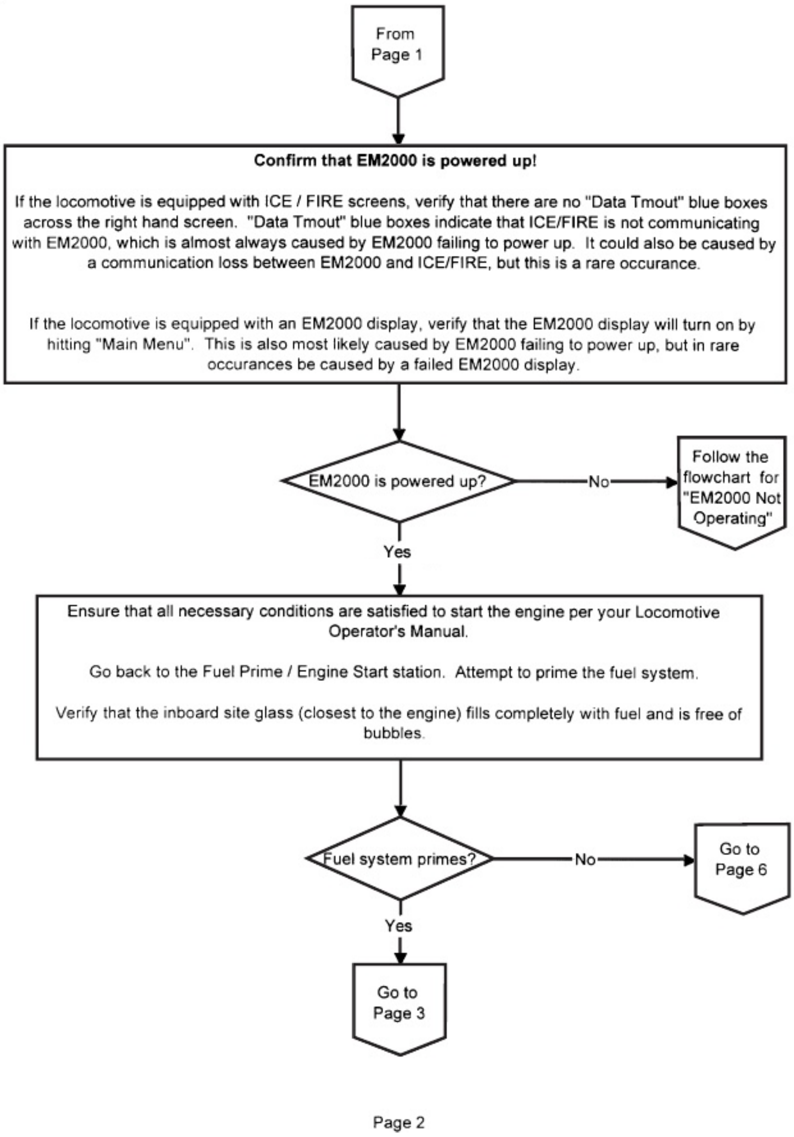
Page 7


From Page 2
Visually inspect the engine air filters for signs of plugging. Perform a monometer test of filter condition. Consult the appropriate Locomotive Service Manual for correct filter readings.
Air Filters OK?
No
Change filters as required. Repeat Load Test.
Yes
Check the signal "% ALLOWED TORQUE" on the PC Reader display under full load. It should beat 100%.
No
Is HP OK?
Yes
END
Is signal at 100%?
No
Yes
Qualify MAP (airbox) sensor and verify that hose connection to airbox is clear. Repair/replace as required. Repeat Load Test.
Refer to the Engine Maintenance Manual or Diesel Engine Troubleshooting Guide under the heading of "ENGINE PERFORMANCE-LOW AIRBOX PRESSURE" to determine the cause of the low horsepower
No
Is HP OK?
Yes
END

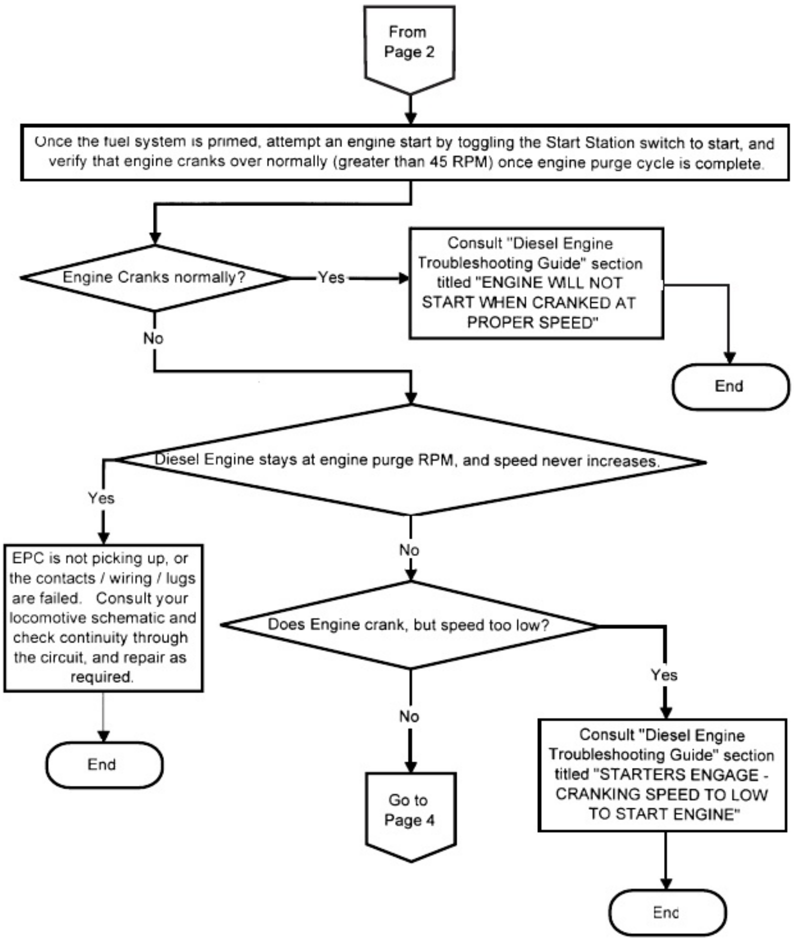
Page 8

8.10.6

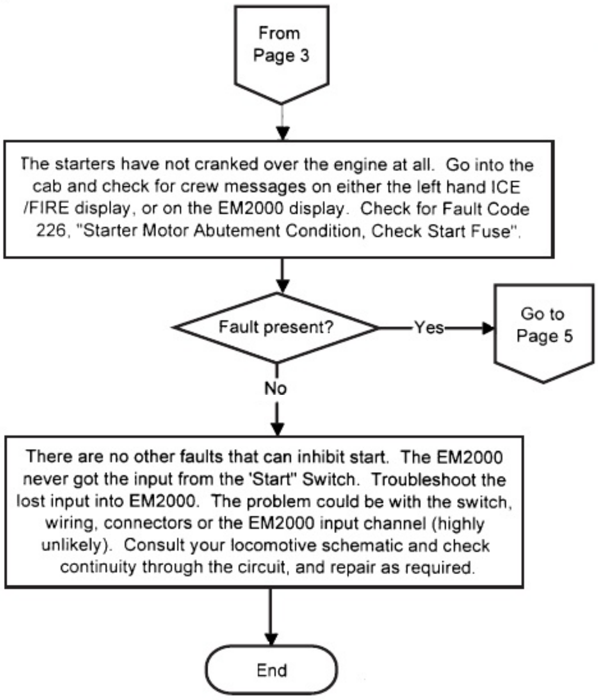

710 ENGINE
STARTING PROBLEMS
Fault Code Generic
Before attempting a restart on Woodward governor equipped locomotives check the EM2000 fault archive for the existence of fault code 995.
Fault code 995 in archive?
Yes
No
The low oil pressure button on the governor popped due to one or more of the following reasons:
Low Water Pressure
Low Oil Pressure
Crankcase pressure
Hot Oil Temperature
Perform an engine room inspection to determine the devise causing the shutdown, and follow the Diesel Engine Troubleshooting Guide for that fault.
Before attempting a restart on EMDEC equipped locomotives, check the EM2000 fault archive for the existence of the following EMDEC related fault code numbers: 994, 996,997, or 998 and follow the troubleshooting flowcharts for those faults.
Fault codes in archive?
Yes
No
Follow the troubleshooting flowchart for the applicable faults.
End
Determine whether the locomotive is equipped for cab start (all SD80MAC, SD90MAC,late model SD70MAC built since mid 1997), JT42CWR(EW&S and others), GT42CW-AC (Queensland Rail), GT42CU(Westrail), or is equipped with a fuel prime / engine start station (located by accessory end / front end of diesel engine)
Equipped with Fuel Prime / Engine Start station?
Yes
No
Go to Page 2
Go to Page 7
Page 1


From Page 1
Confirm that EM2000 is powered up!
If the locomotive is equipped with ICE / FIRE screens, verify that there are no "Data Tmout" blue boxes across the right hand screen. "Data Tmout" blue boxes indicate that ICE/FIRE is not communicating with EM2000, which is almost always caused by EM2000 failing to power up. It could also be caused by a communication loss between EM2000 and ICE/FIRE, but this is a rare occurance.
If the locomotive is equipped with an EM2000 display, verify that the EM2000 display will turn on by hitting "Main Menu". This is also most likely caused by EM2000 failing to power up, but in rare occurances be caused by a failed EM2000 display.
EM2000 is powered up?
No
Follow the flowchart for "EM2000 Not Operating"
Yes
Ensure that all necessary conditions are satisfied to start the engine per your Locomotive Operator's Manual.
Go back to the Fuel Prime / Engine Start station. Attempt to prime the fuel system.
Verify that the inboard site glass (closest to the engine) fills completely with fuel and is free of bubbles.
Fuel system primes?
No
Go to Page 6
Yes
Go to Page 3
Page 2

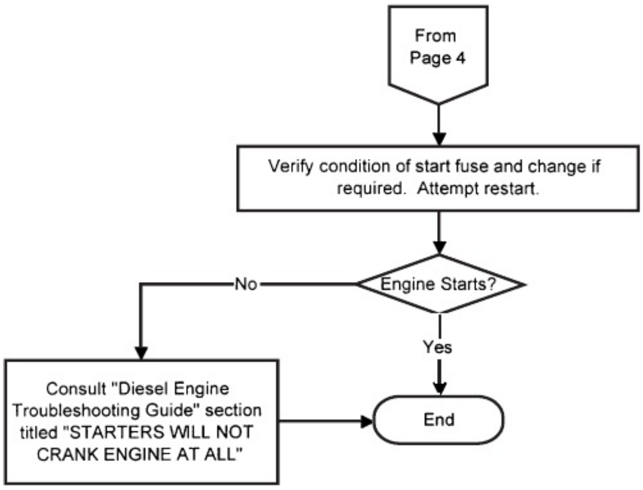
8


From Page 2
Once the fuel system is primed, attempt an engine start by toggling the Start Station switch to start, and verify that engine cranks over normally (greater than 45 RPM) once engine purge cycle is complete.
Engine Cranks normally?
Yes
Consult "Diesel Engine Troubleshooting Guide" section titled "ENGINE WILL NOT START WHEN CRANKED AT PROPER SPEED"
End
No
Diesel Engine stays at engine purge RPM, and speed never increases.
Yes
EPC is not picking up, or the contacts / wiring / lugs are failed. Consult your locomotive schematic and check continuity through the circuit, and repair as required.
End
No
Does Engine crank, but speed too low?
Yes
Consult "Diesel Engine Troubleshooting Guide" section titled "STARTERS ENGAGE - CRANKING SPEED TO LOW TO START ENGINE"
End
No
Go to Page 4

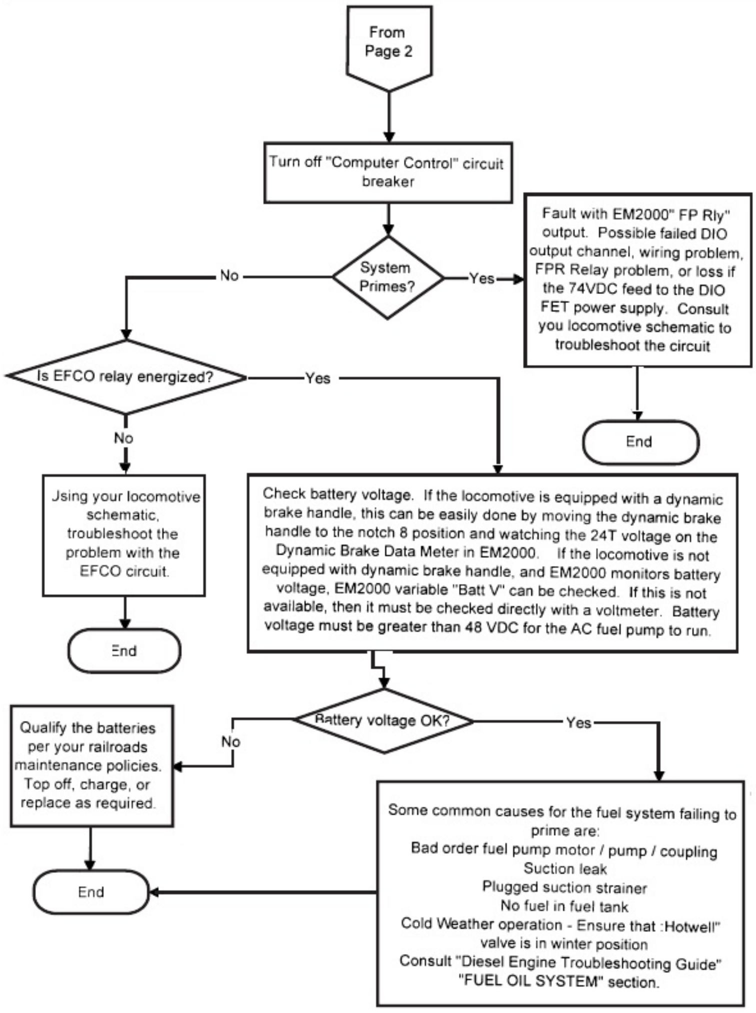
Page 3


From
Page 3
The starters have not cranked over the engine at all. Go into the cab and check for crew messages on either the left hand ICE /FIRE display, or on the EM2000 display. Check for Fault Code 226, "Starter Motor Abutement Condition, Check Start Fuse".
Fault present?
Yes
Go to
Page 5
No
There are no other faults that can inhibit start. The EM2000 never got the input from the 'Start" Switch. Troubleshoot the lost input into EM2000. The problem could be with the switch, wiring, connectors or the EM2000 input channel (highly unlikely). Consult your locomotive schematic and check continuity through the circuit, and repair as required.
End

Page 4

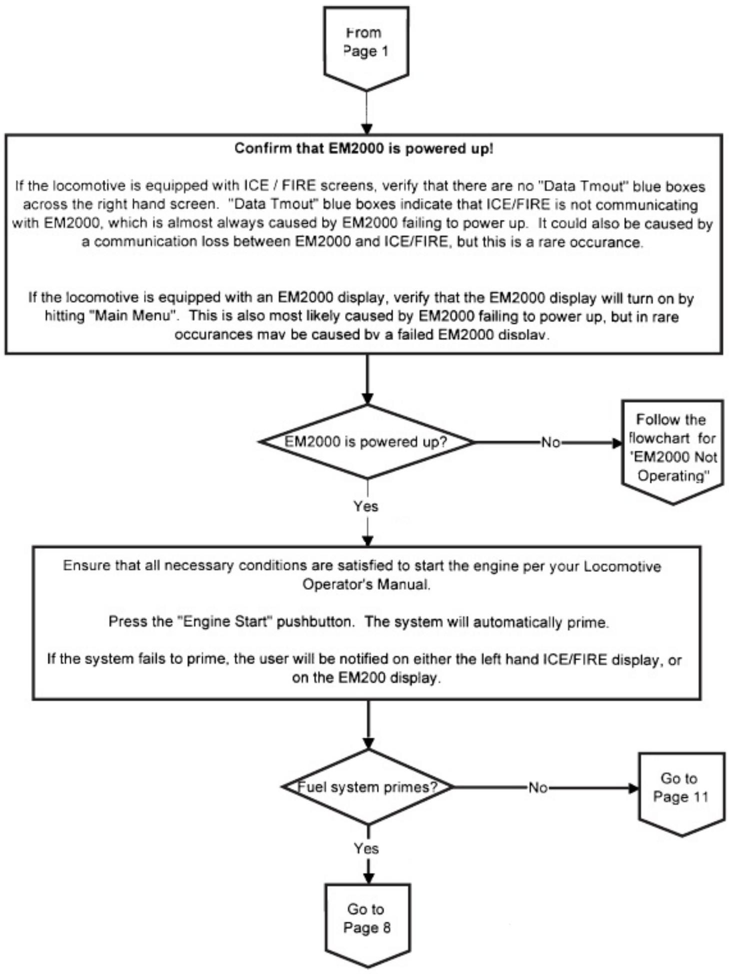

From
Page 4
Verify condition of start fuse and change if required. Attempt restart.
Engine Starts?
No
Yes
Consult "Diesel Engine Troubleshooting Guide" section titled "STARTERS WILL NOT CRANK ENGINE AT ALL"
End

Page 5

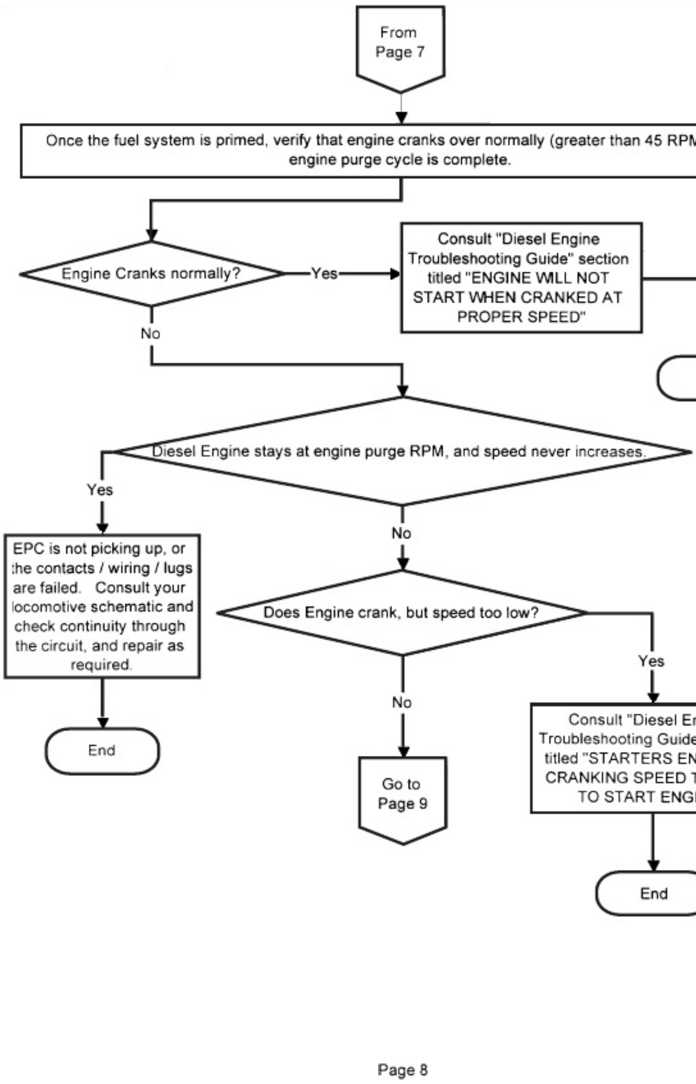

From Page 2
Turn off "Computer Control" circuit breaker
System Primes?
No
Yes
Fault with EM2000" FP Rly" output. Possible failed DIO output channel, wiring problem, FPR Relay problem, or loss if the 74VDC feed to the DIO FET power supply. Consult you locomotive schematic to troubleshoot the circuit
End
Is EFCO relay energized?
Yes
No
Jsing your locomotive schematic, troubleshoot the problem with the EFCO circuit.
End
Check battery voltage. If the locomotive is equipped with a dynamic brake handle, this can be easily done by moving the dynamic brake handle to the notch 8 position and watching the 24T voltage on the Dynamic Brake Data Meter in EM2000. If the locomotive is not equipped with dynamic brake handle, and EM2000 monitors battery voltage, EM2000 variable "Batt V" can be checked. If this is not available, then it must be checked directly with a voltmeter. Battery voltage must be greater than 48 VDC for the AC fuel pump to run.
Battery voltage OK?
No
Yes
Qualify the batteries per your railroads maintenance policies. Top off, charge, or replace as required.
End
Some common causes for the fuel system failing to prime are:
Bad order fuel pump motor / pump / coupling
Suction leak
Plugged suction strainer
No fuel in fuel tank
Cold Weather operation - Ensure that :Hotwell" valve is in winter position
Consult "Diesel Engine Troubleshooting Guide" "FUEL OIL SYSTEM" section.

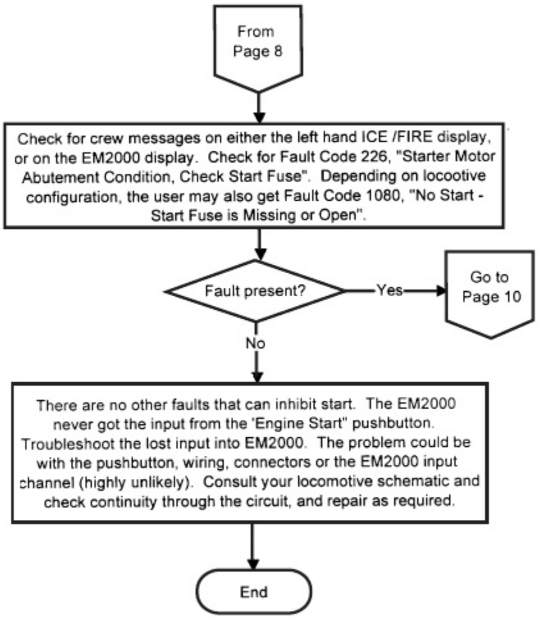
Page 6

8

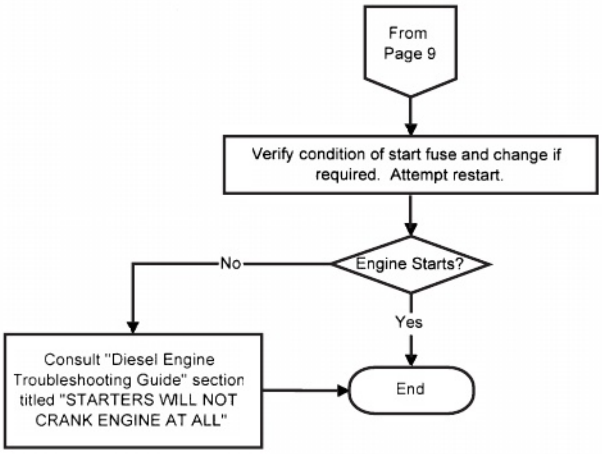

From Page 1
Confirm that EM2000 is powered up!
If the locomotive is equipped with ICE / FIRE screens, verify that there are no "Data Tmout" blue boxes across the right hand screen. "Data Tmout" blue boxes indicate that ICE/FIRE is not communicating with EM2000, which is almost always caused by EM2000 failing to power up. It could also be caused by a communication loss between EM2000 and ICE/FIRE, but this is a rare occurance.
If the locomotive is equipped with an EM2000 display, verify that the EM2000 display will turn on by hitting "Main Menu". This is also most likely caused by EM2000 failing to power up, but in rare occurances may be caused by a failed EM2000 display.
EM2000 is powered up?
No
Follow the flowchart for "EM2000 Not Operating"
Yes
Ensure that all necessary conditions are satisfied to start the engine per your Locomotive Operator's Manual.
Press the "Engine Start" pushbutton. The system will automatically prime.
If the system fails to prime, the user will be notified on either the left hand ICE/FIRE display, or on the EM200 display.
Fuel system primes?
No
Go to Page 11
Yes
Go to Page 8

Page 7


From Page 7
Once the fuel system is primed, verify that engine cranks over normally (greater than 45 RPM) once engine purge cycle is complete.
Engine Cranks normally?
Yes
Consult "Diesel Engine Troubleshooting Guide" section titled "ENGINE WILL NOT START WHEN CRANKED AT PROPER SPEED"
End
No
Diesel Engine stays at engine purge RPM, and speed never increases.
Yes
EPC is not picking up, or the contacts / wiring / lugs are failed. Consult your locomotive schematic and check continuity through the circuit, and repair as required.
End
No
Does Engine crank, but speed too low?
Yes
Consult "Diesel Engine Troubleshooting Guide" section titled "STARTERS ENGAGE - CRANKING SPEED TO LOW TO START ENGINE"
End
No
Go to Page 9
Page 8

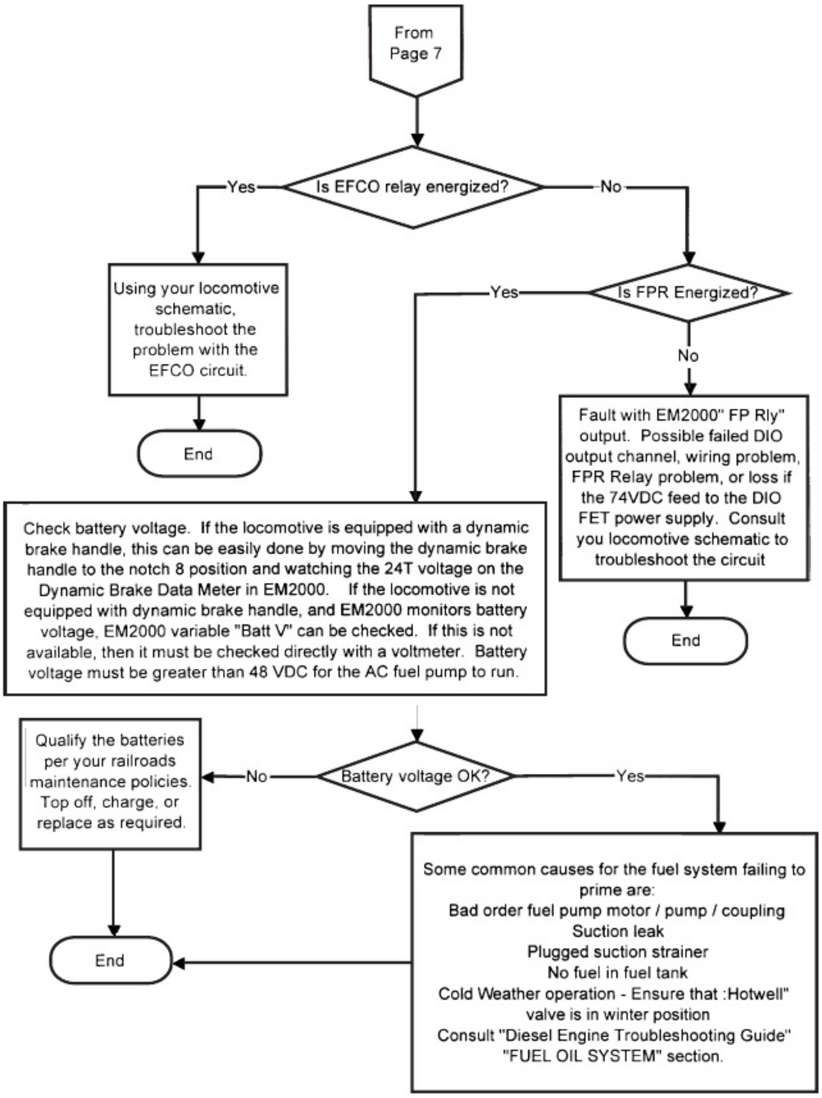

From
Page 8
Check for crew messages on either the left hand ICE /FIRE display, or on the EM2000 display. Check for Fault Code 226, "Starter Motor Abutement Condition, Check Start Fuse". Depending on locootive configuration, the user may also get Fault Code 1080, "No Start - Start Fuse is Missing or Open".
Fault present?
Yes
Go to
Page 10
No
There are no other faults that can inhibit start. The EM2000 never got the input from the 'Engine Start" pushbutton. Troubleshoot the lost input into EM2000. The problem could be with the pushbutton, wiring, connectors or the EM2000 input channel (highly unlikely). Consult your locomotive schematic and check continuity through the circuit, and repair as required.
End

Page 9


From
Page 9
Verify condition of start fuse and change if required. Attempt restart.
Engine Starts?
No
Yes
Consult "Diesel Engine Troubleshooting Guide" section titled "STARTERS WILL NOT CRANK ENGINE AT ALL"
End

Page 10

8


From Page 7
Is EFCO relay energized?
Yes
No
Using your locomotive schematic, troubleshoot the problem with the EFCO circuit.
End
Is FPR Energized?
Yes
No
Fault with EM2000" FP Rly" output. Possible failed DIO output channel, wiring problem, FPR Relay problem, or loss if the 74VDC feed to the DIO FET power supply. Consult you locomotive schematic to troubleshoot the circuit
End
Check battery voltage. If the locomotive is equipped with a dynamic brake handle, this can be easily done by moving the dynamic brake handle to the notch 8 position and watching the 24T voltage on the Dynamic Brake Data Meter in EM2000. If the locomotive is not equipped with dynamic brake handle, and EM2000 monitors battery voltage, EM2000 variable "Batt V" can be checked. If this is not available, then it must be checked directly with a voltmeter. Battery voltage must be greater than 48 VDC for the AC fuel pump to run.
Battery voltage OK?
No
Yes
Qualify the batteries per your railroads maintenance policies. Top off, charge, or replace as required.
End
Some common causes for the fuel system failing to prime are:
Bad order fuel pump motor / pump / coupling
Suction leak
Plugged suction strainer
No fuel in fuel tank
Cold Weather operation - Ensure that :Hotwell" valve is in winter position
Consult "Diesel Engine Troubleshooting Guide" "FUEL OIL SYSTEM" section.

Page 11

EMDEC Troubleshooting Quick Reference Guide

PID SID	FMI	DESCRIPTION	MOST PROBABLE CAUSE [EMDEC Operation & Training Guide Section #] {Diesel Engine Troubleshooting Guide - DET}
21	Data valid but above/below normal range	Engine Position Sensor (SRS)	Check air gap = 0.150" l Check physical damage to SRS/TRS sensors l Check harness wiring between ECM's & sensors l Injector harness ground l ECM ground [EMDEC 8.5]
30 (31)	Data valid but above/below normal range	Oil pressure turbo RB (LB)	Stuck sensor l Mechanical problem such as pump failure, fuel in oil, etc. {DET p. 29-31}
30 (31)	Volt. above/below normal shorted high/low	Oil pressure turbo RB (LB)	Check plugs @ sensor & ECM l Failed sensor l Check harness wiring [EMDEC 8.6.6 & 8.6.7]
32	Data valid but above/below normal range	Oil pressure engine in	Stuck sensor l Mechanical problem such as pump failure, fuel in oil, etc. {DET p. 29-31}
32	Volt. above/ below normal shorted high/low	Oil pressure engine in	Check plugs @ sensor & ECM l Failed sensor l Check harness wiring [EMDEC 8.6.6 & 8.6.7]
33	Data valid but above/below normal range	Oil pressure filter in	Stuck sensor l Mechanical problem such as pump failure, fuel in oil, etc. {DET p. 29-31}
33	Volt. above/ below normal shorted high/low	Oil pressure filter in	Check plugs @ sensor & ECM l Failed sensor l Check harness wiring [EMDEC 8.6.6]

EMDEC Troubleshooting Quick Reference Guide

PID SID	FMI	DESCRIPTION	MOST PROBABLE CAUSE [EMDEC Operation & Training Guide Section #] {Diesel Engine Troubleshooting Guide - DET}
34	Health low/critical	Oil pressure delta filter	Check oil filters/lube system {DET p. 18} [EMDEC 8.6.7]
39	Volt. above normal shorted high	Oil temperature engine in	Check EM2000 for hot eng. faults, if none check plug, sensor, wiring, ECM [EMDEC 8.6.8]
39	Data valid but above/ below normal range	Oil temperature engine in	Check EM2000 for hot eng. faults, if none check for a failed high sensor I Oil system problem {DET p. 23}
40 (41)	Volt. above/ below normal shorted high/low	Air pressure Manifold RB (LB)	Check plugs @ sensor I Failed sensor I Check harness wiring I Failed ECM Troubleshoot similar to procedure found in [EMDEC 8.6.2]
42 (43)	Data valid but above/below normal range	Crankcase pressure LB (RB)	Check if CCP button popped-out, if not popped check wiring/elect. [EMDEC 8.6.2] if popped {DET p. 41-42}
42 (43)	Volt. above/ below normal shorted high/low	Crankcase pressure LB (RB)	Check if CCP button popped-out, if not popped check wiring/elect [EMDEC 8.6.2] if popped {DET p. 41-42}
45	Volt. above/ below normal shorted high/low	Air temperature engine in	Check plugs @ sensor I Failed sensor I Check harness wiring I Failed ECM Troubleshoot similar to procedure found in [EMDEC 8.6.8]

EMDEC Troubleshooting Quick Reference Guide

PID SID	FMI	DESCRIPTION	MOST PROBABLE CAUSE [EMDEC Operation & Training Guide Section #] {Diesel Engine Troubleshooting Guide - DET}
46 (47)	Volt. above/ below normal shorted high/low	Air temp manifold RB (LB)	Check plugs @ sensor I Failed sensor I Check harness wiring I Failed ECM Troubleshoot similar to procedure found in [EMDEC 8.6.8]
50	Volt. above/ below normal shorted high/low	Fuel pressure engine in	Check plugs @ sensor I Failed sensor I Check harness wiring I Failed ECM low fuel press. [EMDEC 8.6.7]
51	Volt. above/ below normal shorted high/low	Fuel pressure engine filter in	Check plugs @ sensor I Failed sensor I Check harness wiring I Failed ECM low fuel press. [EMDEC 8.6.7]
52	Volt. above/ below normal shorted high/low	Fuel pressure primary filter in	Check plugs @ sensor I Failed sensor I Check harness wiring I Failed ECM [EMDEC 8.6.8]
53	Volt. above/ below normal shorted high/low	Fuel pressure delta primary filter	Calc. value in software, check EMREPORT for sensor p/n's
54	Volt. above/ below normal shorted high/low	Fuel pressure delta engine filter	Calc. value in software, check EMREPORT for sensor p/n's
60 (61)	Data vaild but above/below normal range	Coolant pressure LB (RB)	Stuck or incorrect sensor I Cooling system problem, obstruction I Coolant leak {DET p. 34-35}

8

EMDEC Troubleshooting Quick Reference Guide

PID SID	FMI	DESCRIPTION	MOST PROBABLE CAUSE [EMDEC Operation & Training Guide Section #] {Diesel Engine Troubleshooting Guide - DET}
60 (61)	Volt. above/ below normal shorted high/low	Coolant pressure LB (RB)	Check plugs @ sensor & ECM I Failed sensor I Check harness wiring [EMDEC 8.6.4]
62	Data valid but above/below normal range	Coolant pressure engine out	Stuck or incorrect sensor I Cooling system problem, obstruction I Coolant leak {DET p. 34-35}
62	Volt. above/ below normal shorted high/low	Coolant pressure engine out	Check plugs @ sensor & ECM I Failed sensor I Check harness wiring [EMDEC 8.6.4]
63 (64)	Data valid but below normal range	Coolant pressure delta LB (RB)	Calc. value in software (LB or RB-Engine out), check EMREPORT for sensor p/n's
73	Data valid but above/below normal range	Auxiliary water pump pressure	Stuck or incorrect sensor I Cooling system problem, obstruction I Coolant leak {DET p. 34-35}
73	Volt. above/ below normal shorted high/low	Auxiliary water pump pressure	Check plugs @ sensor & ECM I Failed sensor I Check harness wiring [EMDEC 8.6.4]
82	Data valid but above normal	Turbo speed RB	Check sensor I Check harness wiring I Sender ECM I Interface Board Troubleshoot similar to procedure found in [EMDEC 8.5]

EMDEC Troubleshooting Quick Reference Guide

PID SID	FMI	DESCRIPTION	MOST PROBABLE CAUSE [EMDEC Operation & Training Guide Section #] {Diesel Engine Troubleshooting Guide - DET}
83	Data valid but above normal	Turbo speed LB	Check sensor I Check harness wiring I Receiver ECM I Interface Board Troubleshoot similar to procedure found in [EMDEC 8.5]
101	Data valid but above/below normal range	Turbo boost pressure	Check plugs @ sensors & ECM I Failed sensor I Check harness wiring [p. 61] I Turbo prob. {DET p. 63}
101	Volt. above/ below normal shorted high/ low	Turbo boost pressure	Check plugs @ sensor & ECM I Failed sensor I Check harness wiring similar to [EMDEC 8.5] I Turbo prob. {DET p. 63}
231	Bad Component	J1939 Data Link	Check communication wiring between ECM's I Check ECM p/n I Failed ECM
247	Abnormal rate	J1922 Busy Byte	Check wiring from ECM to COM module I Failed interface board I Failed ECM I Failed COM module I Failed Signal Distribution Box
248	Abnormal rate/ frequency, PW or period	Proprietary Data Link	Check communication wiring between ECM's I Check ECM p/n I Failed ECM
249	Bad Component	J1922 Data Link	Check communication wiring between ECM's I Check ECM p/n I Failed ECM
253	Data Erratic/ Bad Component	Calibration Memory	Clear fault I Cycle Injection switch I Reprogram ECM w/cal. only I Failed ECM

8

Notes:

System References Component Locator Charts

Appendix A

A.1

EMDEC QUICK LOCATOR LIST

The locator list below corresponds to the numbers contained on each of the illustrations in this Appendix.

1. Receiver ECM - All Engines
2. Sender ECM - All Engines
3. Receiver2 ECM - 20 Cylinder 710 Only
4. TRS - All Engines
5. SRS - All Engines
6. Oil Pressure - All Engines
7. Oil Pressure Left Bank Turbo - H Engine Only
8. Oil Pressure Right Bank Turbo - H Engine Only
9. Oil Temperature - All Engines
10. Crankcase Pressure - 710 Engine Only
11. Crankcase Pressure #1 - H Engine Only
12. Crankcase Pressure #2 - H Engine Only
13. Airbox Pressure - 710 Engine Only
14. Airbox Pressure Left Bank - H Engine Only
15. Airbox Pressure Right Bank - H Engine Only
16. Airbox Temperature - 710 Engine Only
17. Airbox Temperature Left Bank - H Engine Only
18. Airbox Temperature Right Bank - H Engine Only
19. Fuel Inlet Pressure - All Engines
20. Fuel Pressure 2- Application Specific
21. Fuel Inlet Temperature - All Engines
22. Coolant Pressure #1 (Left Bank) - All Engines
23. Coolant Pressure #2(Right Bank/Aftercooler) - Application Specific
24. Coolant Pressure #3 (engine outlet) - Application Specific
25. Turbo Speed (Left Bank) - H Engine Only
26. Turbo Speed (Right Bank) - H Engine Only
27. Exhaust Temperature - H Engine Only
28. Inlet Air Temperature - Application Specific
29. Sensor In A Box

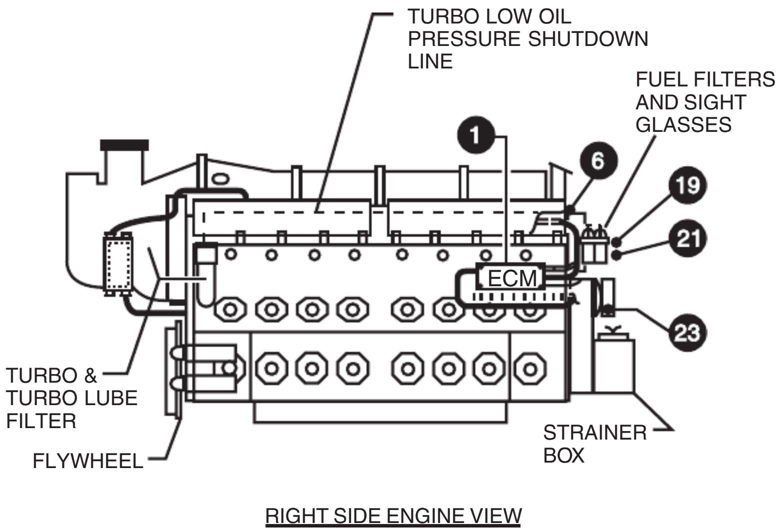


Figure A.1 *Locator - 710 (Side Mounted ECM's).*

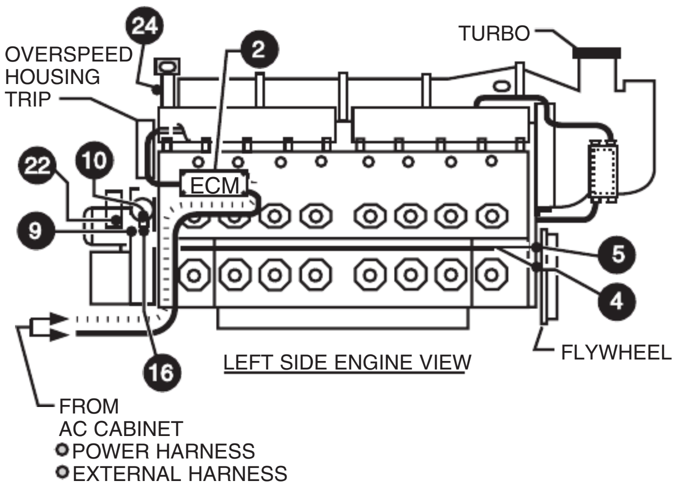


Figure A.2 *Locator - 710 (Side Mounted ECM's).*

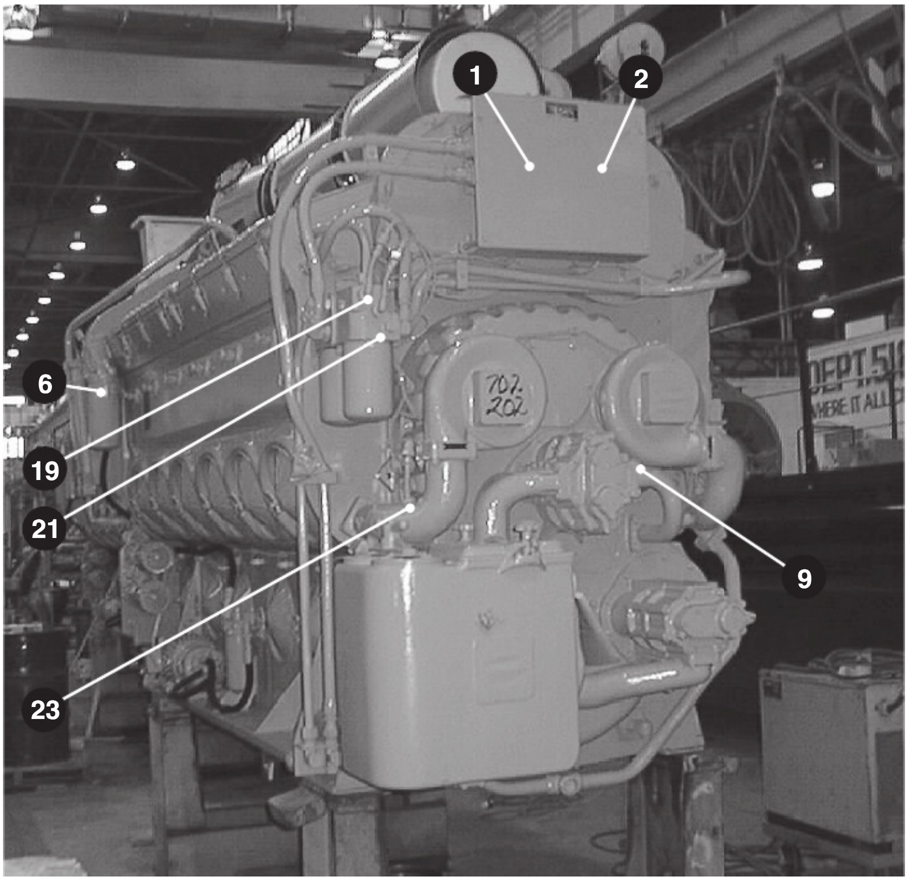


Figure A.3 *Locator - 710 (Typical 16-Cyl & 12-Cyl).*

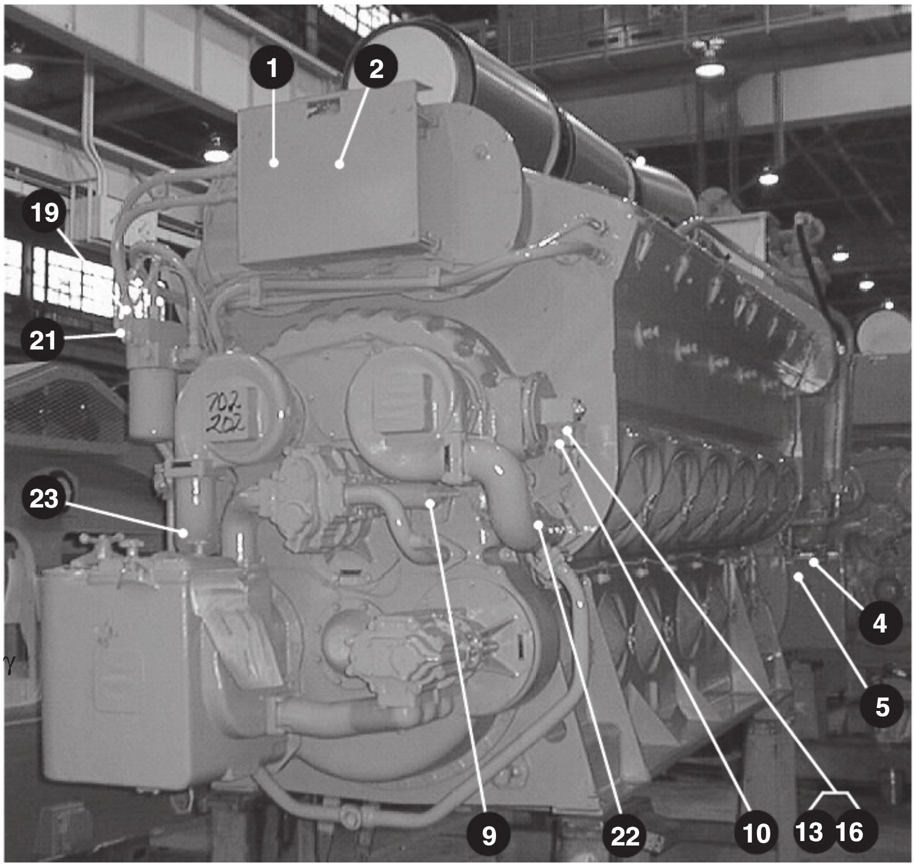


Figure A.4 *Locator - 710 (Typical 16-Cyl &12-Cyl).*

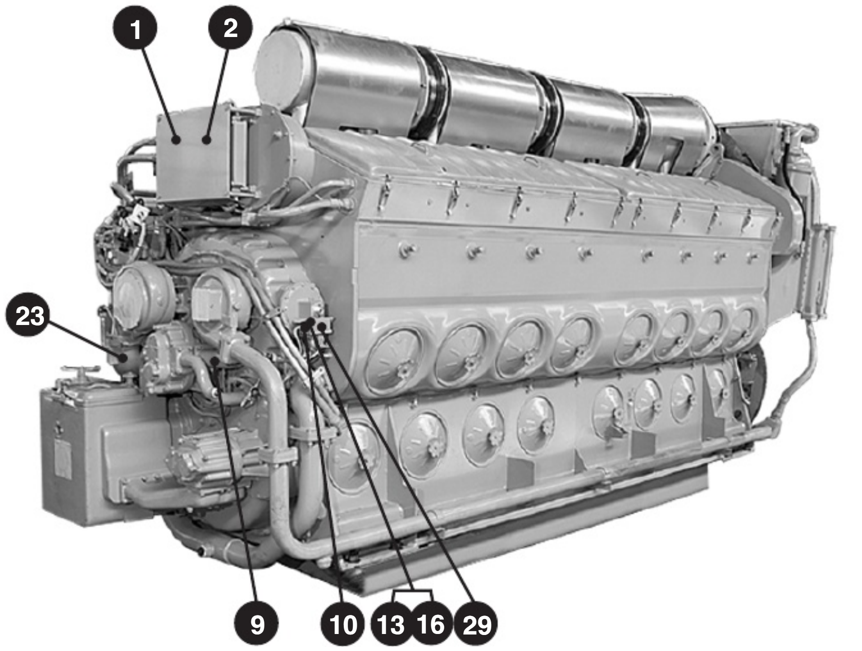


Figure A.5 *Locator - 710 (Typical 16-Cyl).*

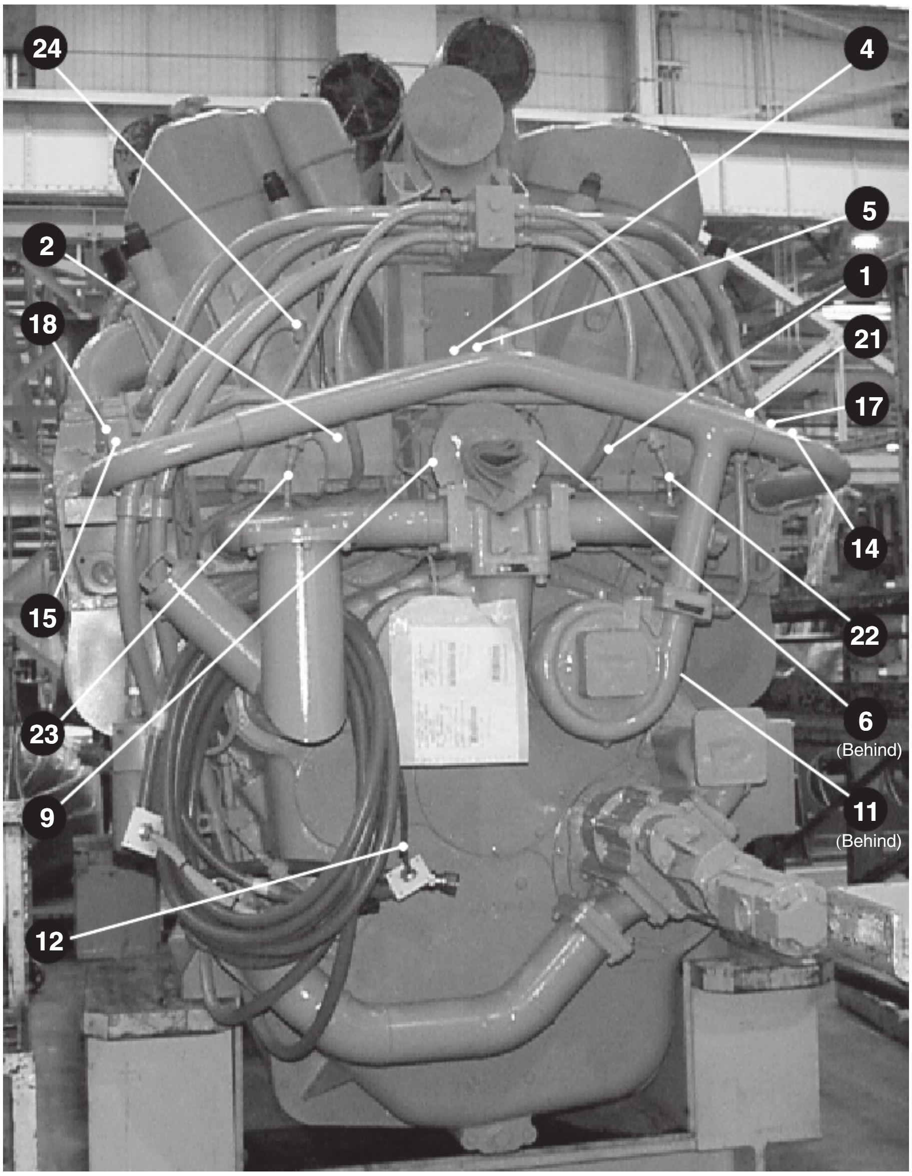


Figure A.6 *Locator - H Engine.*

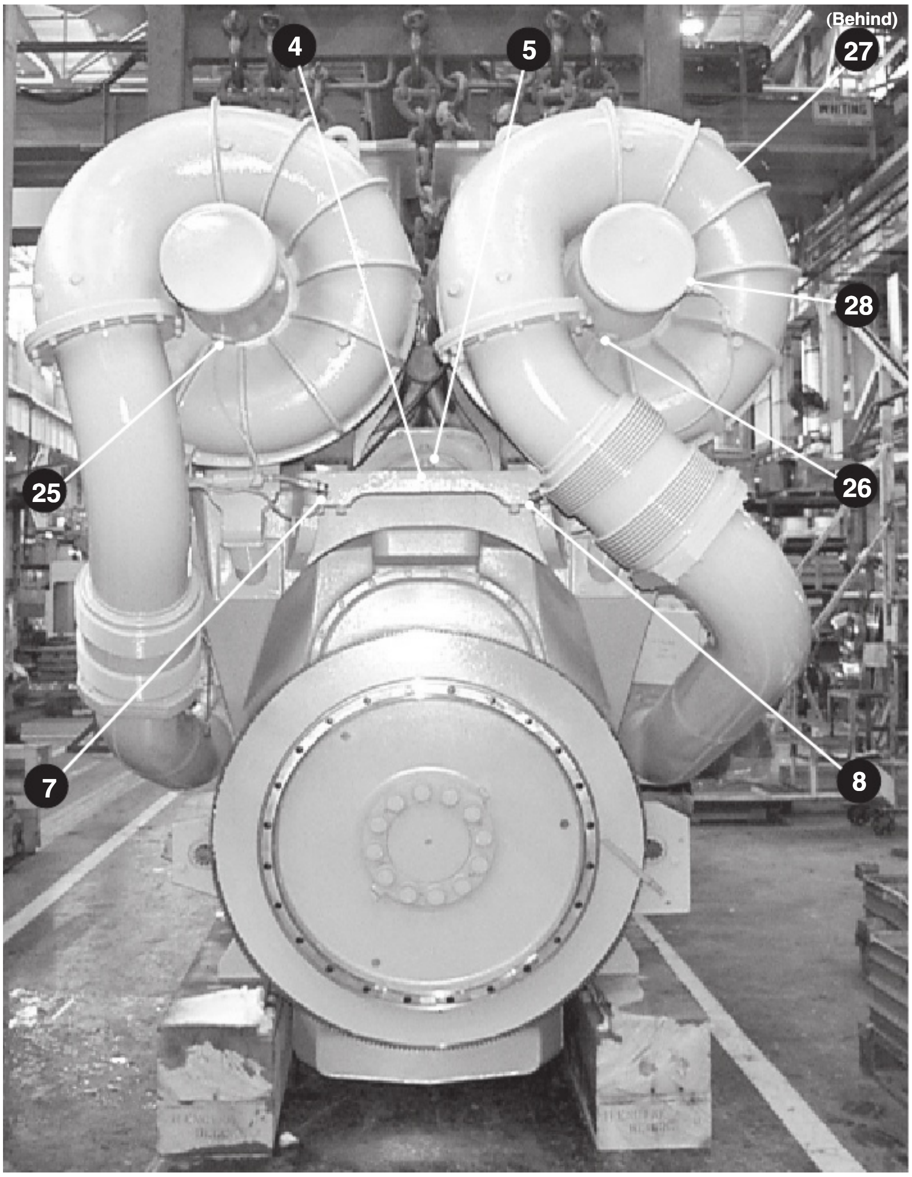


Figure A.7 *Locator - H Engine.*

Notes:

EM2000 EMDEC Signal Acronyms

Appendix B

B.1 EM2000 EMDEC Signal Acronyms

Below is a list of the EMDEC acronyms for the EM2000. The values may be slightly different depending on locomotive order or model.

AirBxDn	Air box density.
AmbDens	Ambient Air density given in Kg/M^
AmbienF	Calculated ambient temperature.
AmbTmpF	Ambient Air Temperature.
APCcLb	Crankcase pressure left bank, always in inches of Hg.
APCcRb	Crankcase pressure right bank.
APImLbP	Air pressure left bank intake manifold.
APImRbP	Air pressure right bank intake manifold.
ATEgIF	Air temperature into engine.
ATImLbF	Air temperature left bank intake manifold.
ATImRbF	Air temperature right bank intake manifold.
AWT AOF	Aftercooler Water Temperature at the Aspirator.
AWT ROF	Aftercooler Water Temperature at the Radiator Output.
AWTF	Aftercooler Water Temperature.
Bar Prs	Barometric pressure: Pascal Version & Up.
BarPres	BAROMETRIC PRESSURE.
BOI1	Injector Timing, beginning of injection in degrees ECM #1.
BOI2	Injector Timing, beginning of injection in degrees ECM #2.
BOI3	Injector Timing, beginning of injection in degrees ECM #3.

EBusy	End to end communications check.
EBusyA	Busy Check: EMDEC will add one to this signal and then send it back.
ECFail	The status of the EMDEC control data link.
ECM On<	A Signal from EMDEC indicating computer is on.
EEngRPM	The engine speed as measured by the EMDEC system.
EgPrLmR	The reason EMDEC requesting an engine power limit.
EgSpRq	The engine speed request that EMDEC uses to control the engine speed.
EMDECMo	EMDEC Operation Mode: To be defined at a later date.
ENG_PU	Engine speed based on a speed pickup.
EngAcl	Engine acceleration feedback.
EngCB<	Engine Control Circuit Breaker.
EngCkCc	Engine controller detects a crankcase pressure problem.
EngCkCP	Engine controller detects a coolant pressure problem.
EngCkFP	Engine controller detects a fuel pressure problem.
EngCkFT	Engine controller detects a fuel temperature problem.
EngCkIn	Engine controller detects an injector problem.
EngCkOP	Engine controller detects an oil pressure problem.
EngCkOT	Engine controller detects an oil temperature problem.
EngCkSS	Engine controller detects a speed sensor (TRS/SRS) problem.
EngCPH<	Engine is in shutdown mode due to high crankcase pressure.
EngCPL<	Engine is in shutdown mode due to low engine coolant pressure.
EngineR	Engine Ratio: The engine ratio generated by the EMDEC.
EngOPL<	Engine is in shutdown mode due to low engine oil pressure.
EngOTH<	Engine is in a shutdown mode due to high engine oil temperature.

EngUdI<	Engine is shutdown mode due to undefined condition #1.
EngUd2<	Engine is in shutdown mode due to undefined condition #2.
EngUd3<	Engine is in shutdown mode due to undefined condition #3.
ETTuILF	Exhaust temperature at the Turbine Inlet of the engine's left bank.
ETTuIRF	Exhaust temperature at the Turbine Inlet of the engine's right bank.
FF1tPrs	Fuel Pressure Into the fuel filter.
FIPrEnI	Fuel Pressure Engine in.
FPDEgF1	Fuel pressure drop across the engine fuel filter.
FPDPrF1	Fuel pressure drop across the primary fuel filter.
FPEgF1I	Fuel pressure into the engine fuel filter.
FPEgIPS	Fuel pressure into the engine.
FPPrF1I	Fuel pressure into the primary fuel filter.
FrPress	Coolant Pressure - Engine In RB.
FTEgIF	Fuel temperature engine in.
FTEngIn	Fuel temperature Engine In.
LOS<	Low Oil Pressure Switch: Engine protector has tripped.
MID I	The MID of the EMDEC packet received.
MID O	The MID of the packet sent to EMDEC.
MIDVerI	The MID version of the data packet received from EMDEC.
MIDVerO	The MID version of the data packet sent to EMDEC.
MnEgSp	Minimum engine speed EMDEC likes to operate at.
MnEgSpP	The priority for the maximum engine speed requested by EMDEC.
MnEgSpR	The reason for the minimum engine speed requested by EMDEC.

O1PrTbR	Oil pressure turbo RB.
OpDpLbP	Oil pressure drop across the left bank of the engine.
OPDpRbP	Oil pressure drop across the right bank of the engine.
OPEgIPS	Oil pressure into the engine.
OPFltDp	Oil pressure drop across the engine oil filter.
OPF1tIP	Oil pressure into the engine oil filter.
OPTuLPS	Oil Pressure into the left bank turbo charger.
OPTuRPS	Oil Pressure into the right bank turbo charger.
OTEgIF	Oil Temperature into the engine.
pwidth1	EMDEC injector pulse width from ECM #1, in degrees.
pwidth2	EMDEC injector pulse width from ECM #2, in degrees.
pwidth3	EMDEC injector pulse width from ECM #3, in degrees.
TbSdLb	Speed of the left bank turbocharger.
TbSdRb	Speed of the right bank turbocharger.
TbSpd	Speed of the right bank turbocharger.
TbSpd1	The turbo speed of the #1 turbo.
TbSpd2	The turbo speed of the #2 turbo.
TmIj1	Injection delay time for cylinder #1's fuel injector.
TmIj10	Injection delay time for cylinder #10's fuel injector.
TmIj11	Injection delay time for cylinder #11's fuel injector.
TmIj12	Injection delay time for cylinder #12's fuel injector.
TmIj13	Injection delay time for cylinder #13's fuel injector.
TmIj14	Injection delay time for cylinder #14's fuel injector.
TmIj15	Injection delay time for cylinder #15's fuel injector.
TmIj16	Injection delay time for cylinder #16's fuel injector.
TmIj17	Injection delay time for cylinder #17's fuel injector.
TmIj18	Injection delay time for cylinder #18's fuel injector.
TmIj19	Injection delay time for cylinder #19's fuel injector.
Tmlj2	Injection delay time for cylinder #2's fuel injector.
TmIj20	Injection delay time for cylinder #20's fuel injector.

TmIj3	Injection delay time for cylinder #3's fuel injector.
TmIj4	Injection delay time for cylinder #4's fuel injector.
Tmlj5	Injection delay time for cylinder #5's fuel injector.
TmIj6	Injection delay time for cylinder #6's fuel injector.
Tmlj7	Injection delay time for cylinder #7's fuel injector.
TmIj8	Injection delay time for cylinder #8's fuel injector.
TmIj9	Injection delay time for cylinder #9's fuel injector.
TPU_RPM	Turbo Speed from 2 - WAY EMDEC link, H - engine only.
TPU1RPM	Engine Turbo RPM from the #1 Turbo on the H - engine.
TPU2RPM	Engine Turbo RPM from the #2 Turbo on the H - engine.
TqAl1w1	Allowed engine torque from EMC 1.
TqAl1w2	Allowed engine torque from ECM 2.
TqAl1w3	Allowed engine torque from ECM 3.
WPdLbPS	Coolant (water) pressure drop across the left bank of the engine.
WPdRbPS	Coolant (water) pressure drop across the right bank of the engine.
WPEgILP	Coolant (water) pressure into the engine's left bank.
WPEglRP	Coolant (water) pressure into the engine's right bank.
WPEgOtP	Coolant (water) pressure out of the engine.

B.2 EMDEC Acronyms

AN Plug AN plug for the fuel injection switch.

BA Plug BA plug for the injector harness on the ECM.

BB Plug BB plug for the injector harness on the ECM.

CC Plug Communications Plug - communications link between the ECM and the EM2000.

CRV Compression Relief Valve.

ECM Engine Control Module-Used for controlling the engine.

EH Plug Engine Harness plug-plug on the ECM for the sensor power and feedback.

EMDEC Electro-Motive Diesel Engine Control.

EMMON Laptop communication program with EMDEC.

EngineR Engine Fuel Ratio-The engine fuel ratio generated by EMDEC: 0.87 is the max steady state fuel or balanced point that the injector can fuel. 0.88-0.99 is a transient zone that should never exist as a steady state condition.

FMI Fault Message Identification.

LB Left Bank.

LR%MAX Load Regulator % Maximum, 0 - 100, 100% engine can sustain RPM with balanced fuel, <100% load requested to back off either due to an engine prob. or elect. prob.

MAP	Mainfold Air Pressure Sensor-Used to detect air box pressure measured in inches of mercury.
PC PLUG	Power Connection plug at the ECM for the 24 VDC.
PI PLUG	Power plug for the 74 VDC power into the EMDEC power supply.
PID	Parameter Identification-Valve obtained from a sensor.
PIP	Position Identification Pointer-Reference point used with the SRS sensor.
PO Plug	Power plug for the 24 VDC power out of the EMDEC power supply to the ECM's and Interface Board.
PR1 Plug	Power plug for the 24 VDC power to the Receiver 1.
PS Plug	Power plug for the 24 VDC power to the Sender ECM.
RB	Right Bank.
S Plug	S communications plug with the EM2000 on the locomotive interface board.
SID	System Identification--Calculated value within EMDEC.
SRS	Synchronous Reference Sensor--Used to let the timing reference sensor know when to start timing.
TRS	Timing Reference Sensor--Used for timing at every 10 degrees.
VHC Plug	Vehicle Harness Connector plug on the ECM.

Notes:

Appendix C

System References

C.1

ELECTRICAL HARNESS & CONNECTIONS

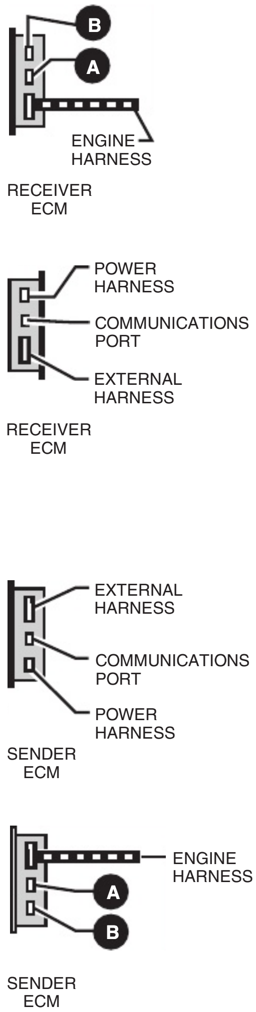


Figure C.1 *ECM Harness Connections.*

The information in this section describes typical configurations. This section is provided for reference only. Always consult the correct application schematics when performing any maintenance or repairs.

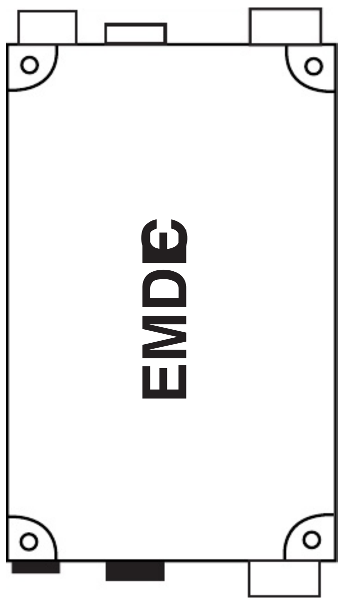


Figure C.2 *Typical ECM.*

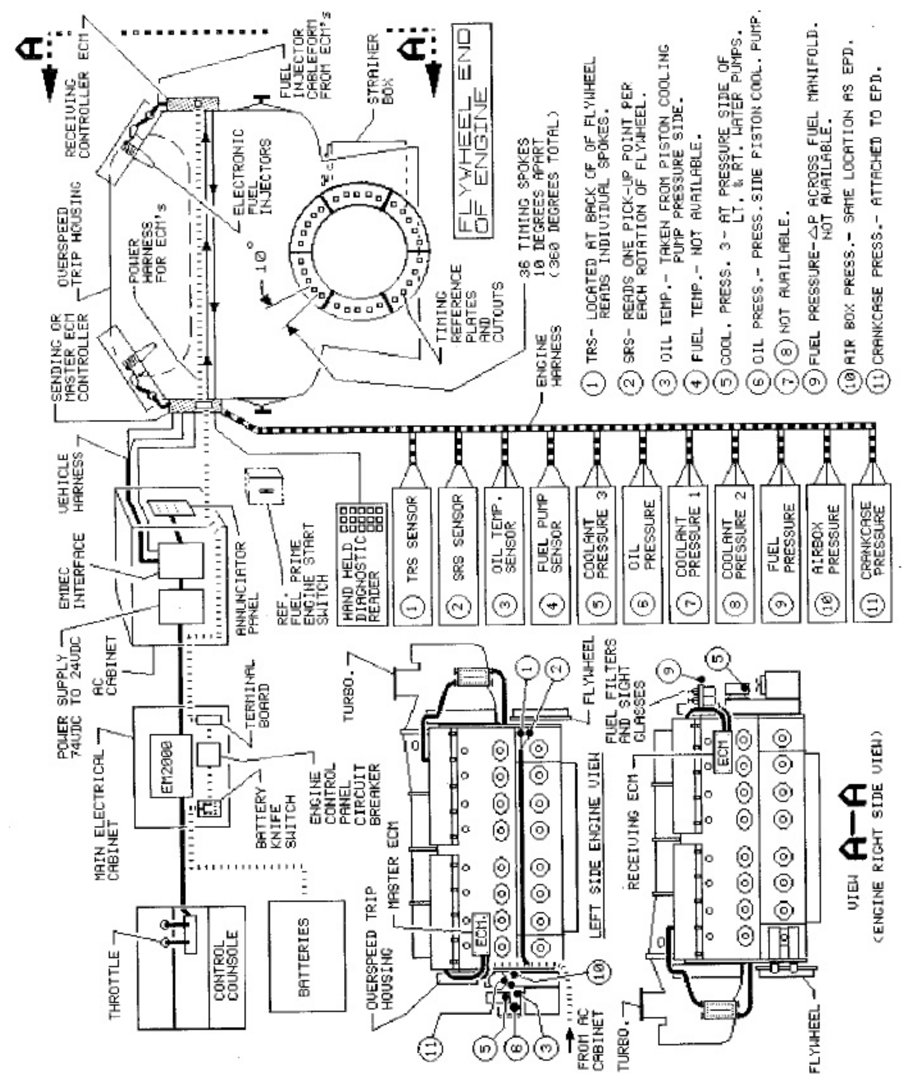


Figure C.3 *Overall EMDEC System (View 1).*

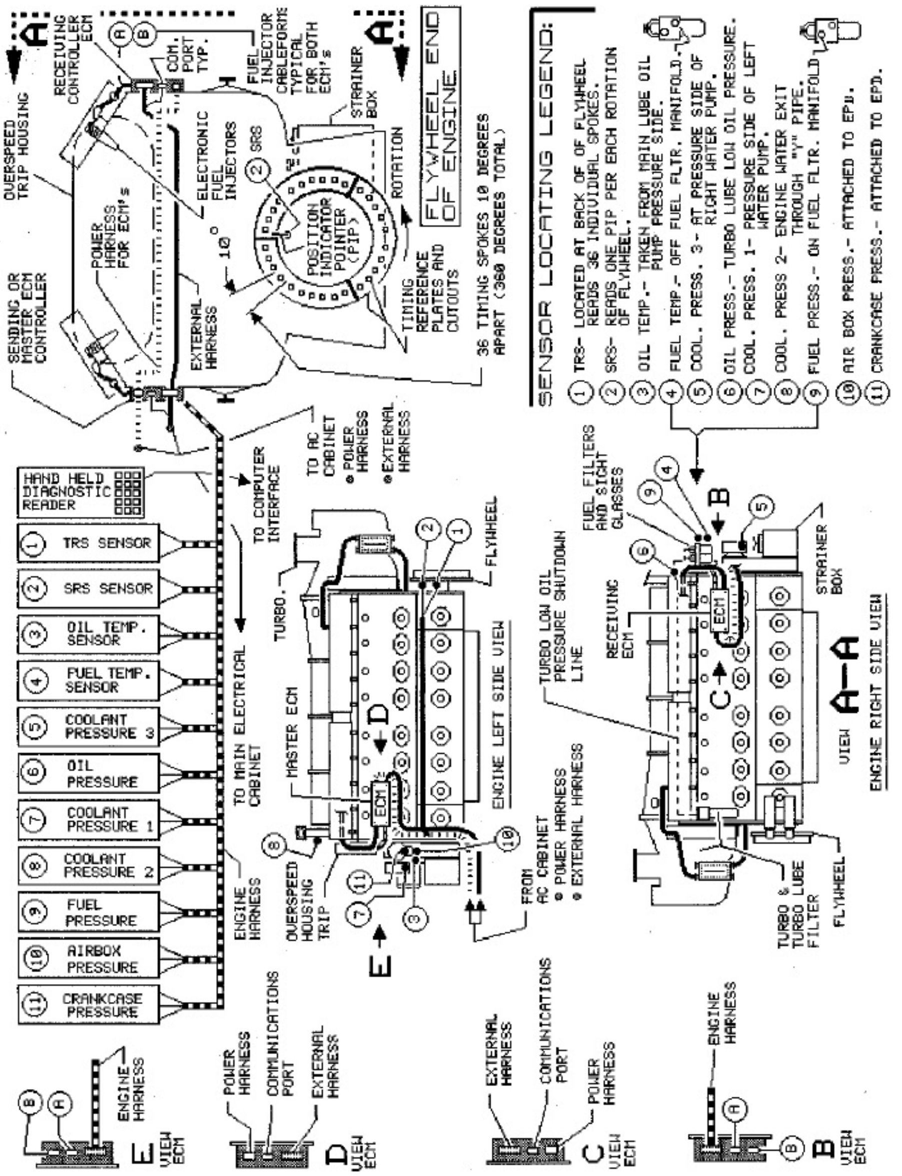


Figure C.4 *EMDEC Sensor Diagram (Part 1 Of 2).*

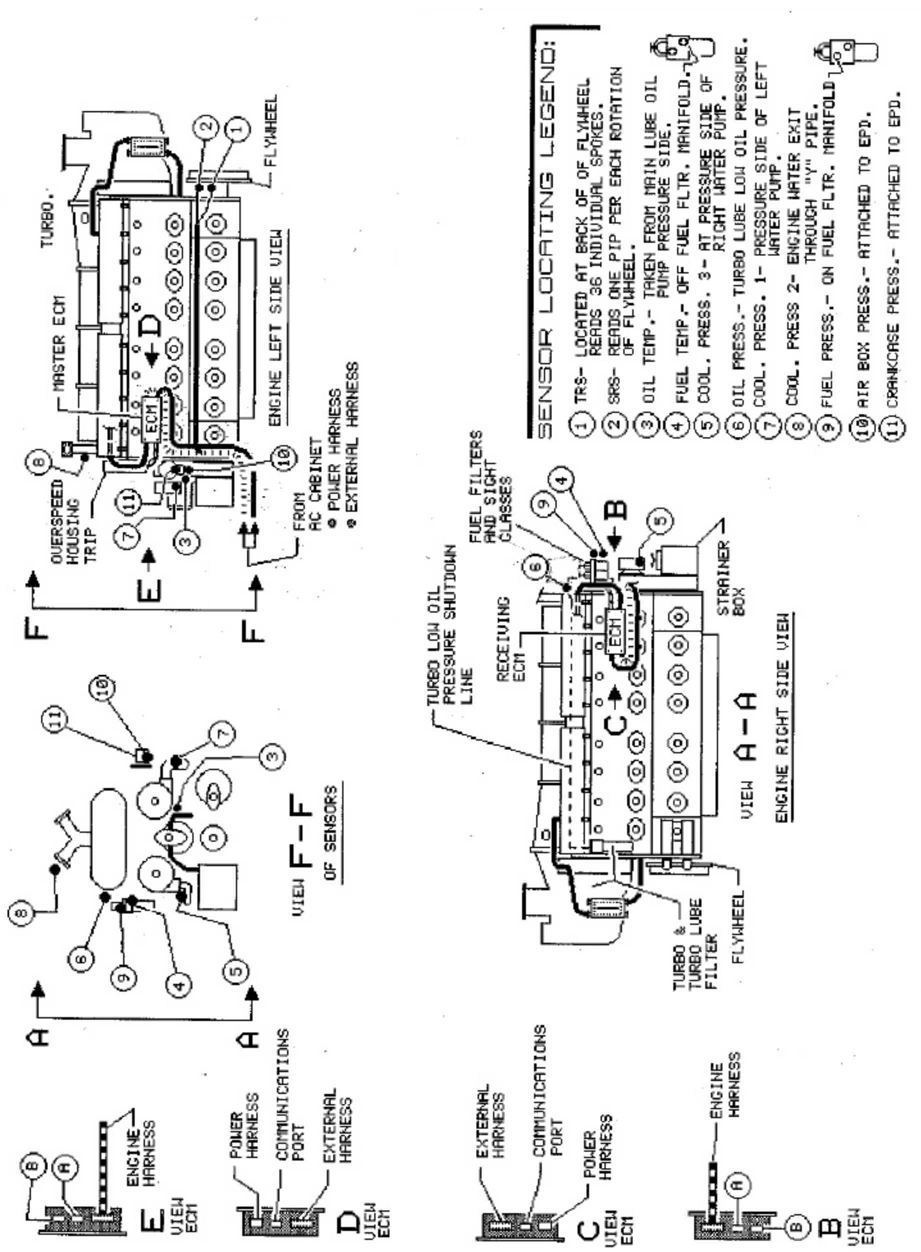


Figure C.5 *EMDEC Sensor Diagram (Part 2 Of 2).*

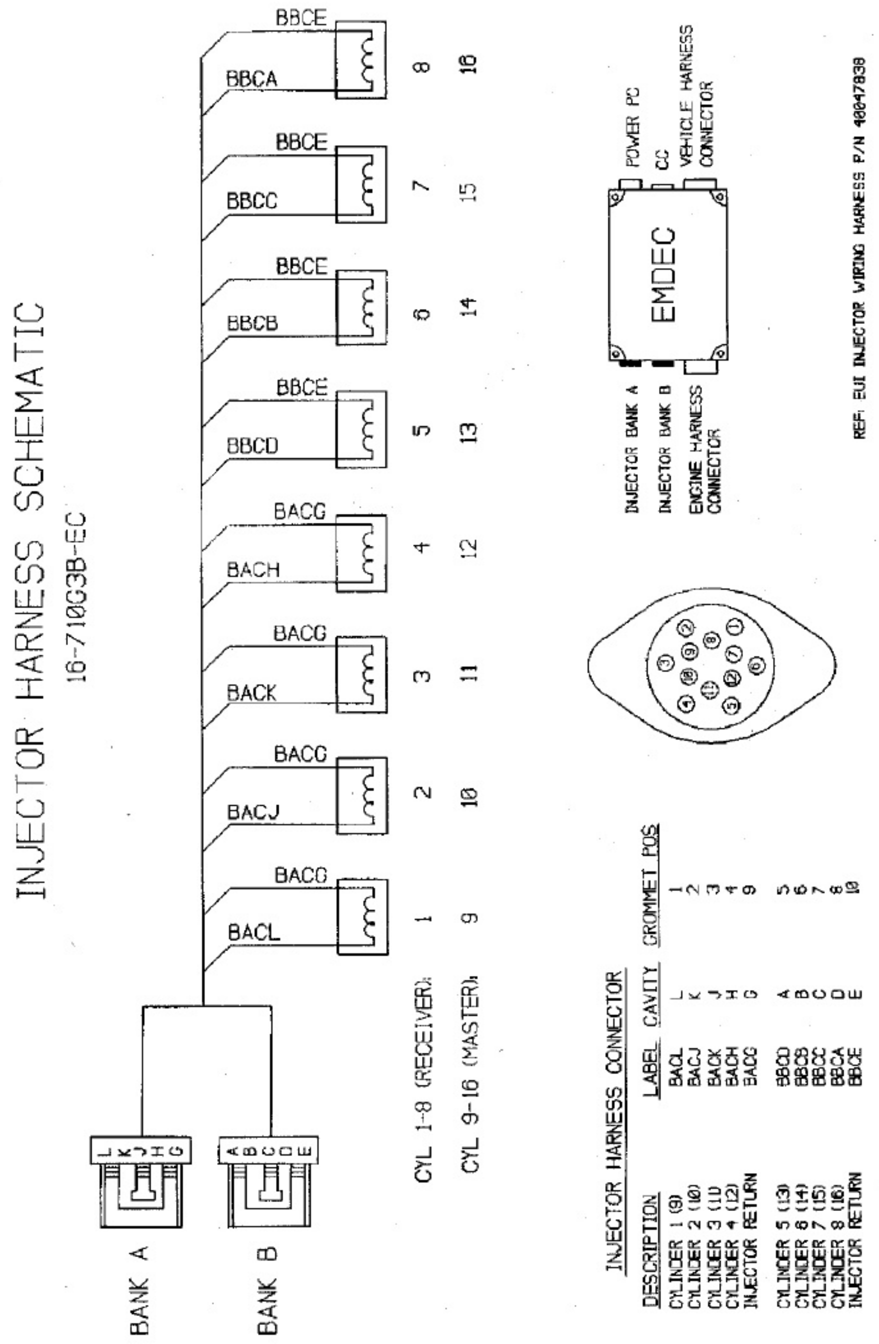


Figure C.6 *Injector Harness Schematic.*

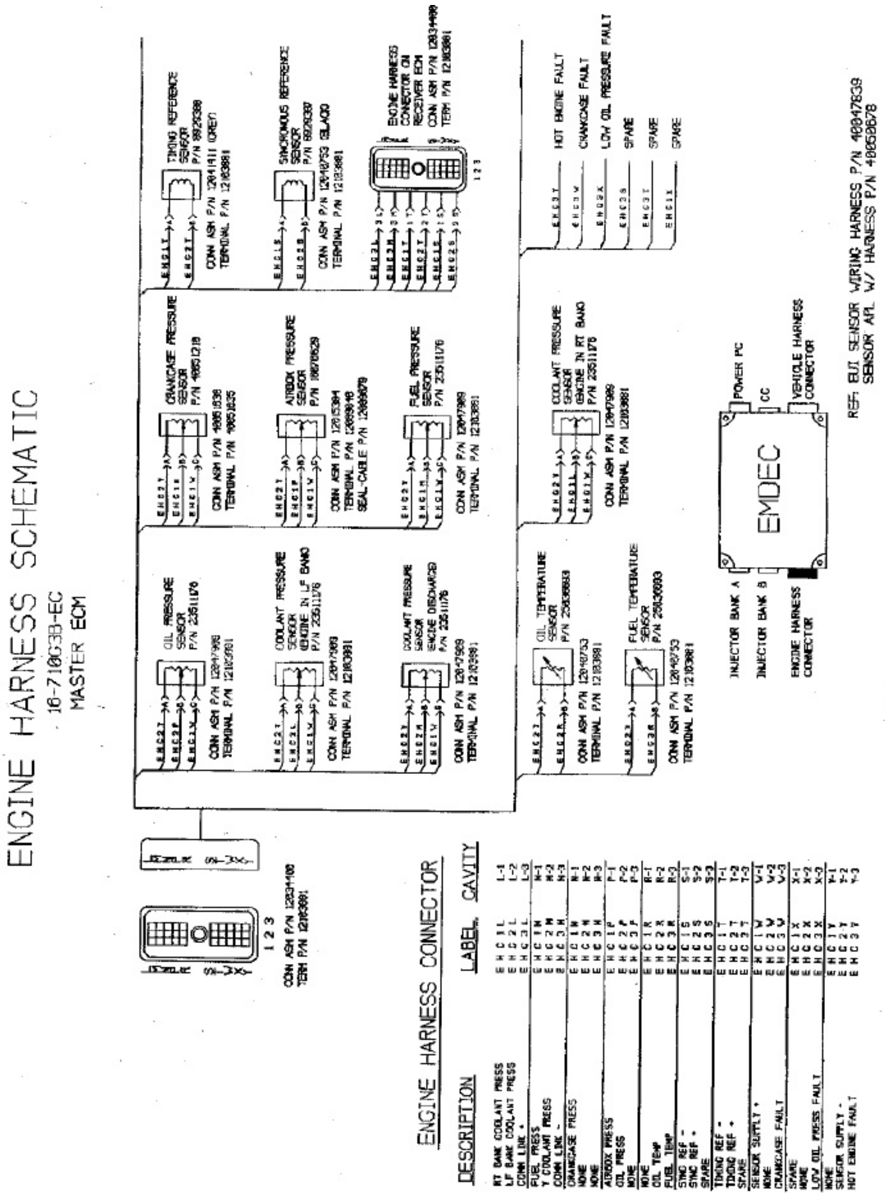
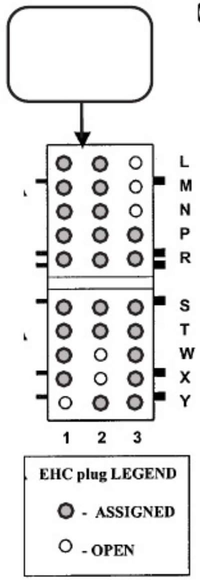


Figure C.7 *Engine Harness Schematic.*

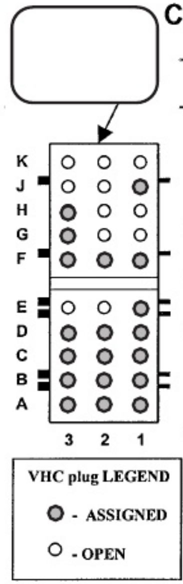
Cavity #	Functional Description	Wire #
L1	PSI sensor: fuel #2 (filter out)	EHC1L
L2	PSI sensor: cool #1 (RB pump)	EHC2L
L3	Comm: SAE J1939 '+'	N/A
M1	PSI sensor: fuel #1 (filter in)	EHC1M
M2	PSI sensor: cool #2 (eng. out)	EHC2M
M3	Comm: SAE J1939 '-'	N/A
N1	PSI sensor: eng. crankcase	EHC1N
N2	Temp. sensor:airbox temp.	EHC2N
N3	Shield: SAE J1939 comm.	N/A
P1	PSI sensor: engine airbox	EHC1P
P2	PSI sensor: oil #2 (turbo soakback)	EHC2P
P3	Temp. sensor: JWater out	EHC3P
R1	PSI sensor: oil #1-eng (turbo in)	EHC1R
R2	Temp. sensor:engine oil (in)	EHC2R
R3	Temp. sensor: Fuel in	EHC3R



Cavity #	Functional Description	Wire #
S1	SRS sensor (-)	EHC1S
S2	SRS sensor (+)	EHC2S
S3	Digital input:SPARE	EHC3S
T1	TRS sensor (-)	EHC1T
T2	TRS sensor (+)	EHC2T
T3	Digital input: SPARE	EHC3T
W1	Sensor supply (5VDC)	EHC1W
W2	PWM output signal #3	N/A
W3	Digital output: C'case PSI fault	EHC3W
X1	Timed input: SPARE	EHC1X
X2	PWM output signal #4	N/A
X3	Digital output: Low oil PSI fault	EHC3X
Y1	PWM output signal #2	N/A
Y2	Sensor return (0VDC)	EHC2Y
Y3	Digital output: hot engine oil	EHC3Y

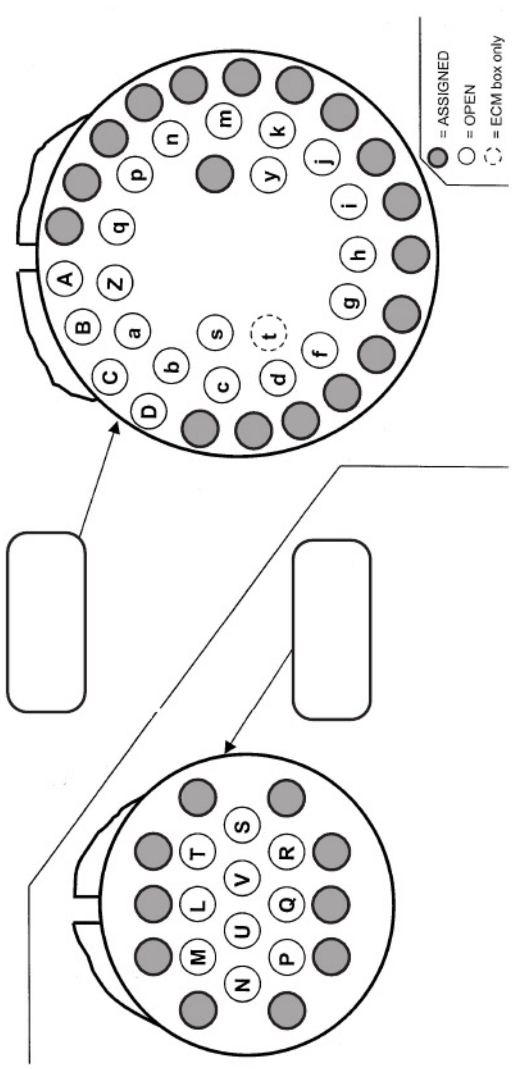
Figure C.8 *EHC Connector Plug Pin Assignment Cross Reference For Sender ECM.*

Cavity #	Functional Description	Wire #
A1	Digital output:cool temp.(alarm)	VHC1A
A2	Digital output: cool PSI (alarm)	VHC2A
A3	Sensor supply (5VDC)	VHC3A
B1	Check engine light	VHC1B
B2	Stop engine light	VHC2B
B3	Ignition	VHC3B
C1	Data link: SAE J1708/1587 '-'	VHC1C
C2	Data link: SAE J1708/1587 '+'	VHC2C
C3	Sensor return (0VDC)	VHC3C
D1	SPARE: PSI #2	VHC1D
D2	SPARE: PSI #1	VHC2D
D3	Variable Speed Governor	VHC3D
E1	Digital input: Alt. min. VSG	VHC1E
E2	Vehicle speed '+'	N/A
E3	Vehicle speed '-'	N/A



Cavity #	Functional Description	Wire #
F1	Digital input: SPARE	VHC1F
F2	PWM output signal #1: SPARE	VHCF2
F3	Digital output: SPARE	VHC3F
G1	Digital input:	N/A
G2	Digital input:	N/A
G3	Digital input: diagnostic request	VHC3G
H1	Digital input:	N/A
H2	Digital input:	N/A
H3	SPARE: PSI #3	VHC3H
J1	Digital input: SPARE	VHC1J
J2	Digital input	N/A
J3	Digital input:	N/A
K1	Tachometer drive	N/A
K2	Digital input:	N/A
K3	Digital input:	N/A

Figure C.9 *VHC Connector Plug Pin Assignment Cross Reference For Sender ECM.*



NOTE:

There are qty. two (2) female connector plugs that will come attached to the ME8G7C EMDEC engine.**Their plug arrangements are listed for reference only.** Connect these plugs directly to the ECM box (P/N 40100208).

Figure C.10 *Injector & Sensor Harness Plugs To ECM Box.*

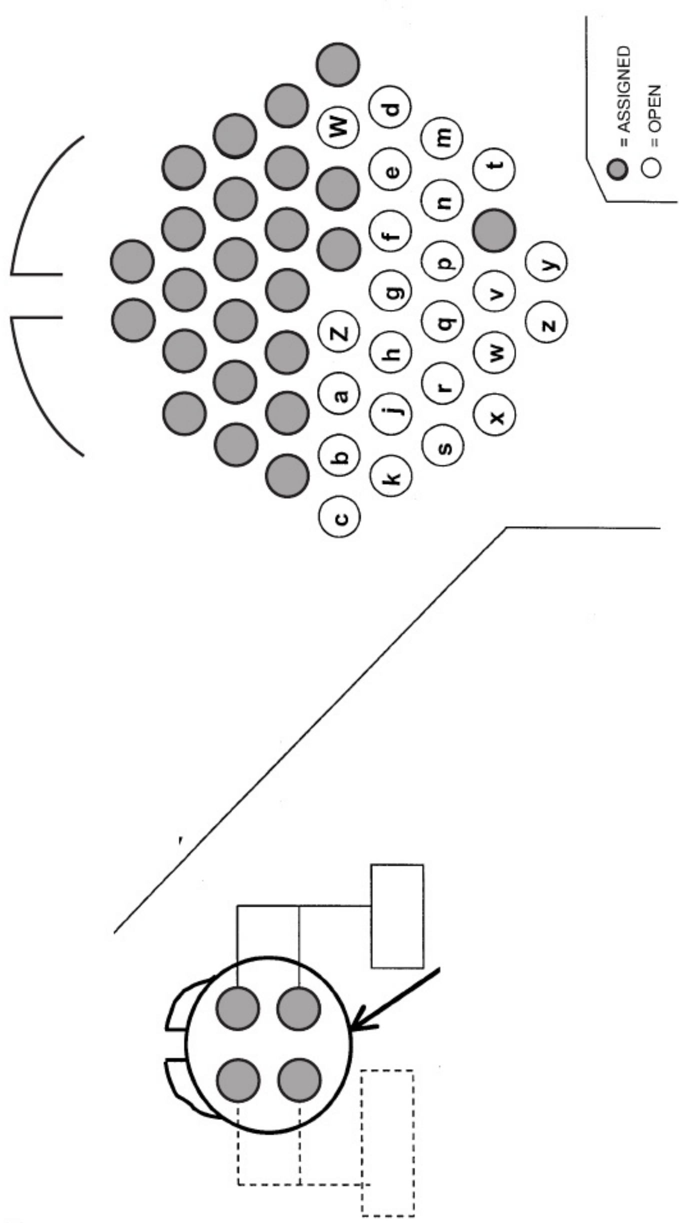


Figure C.11 *Control System Connections To ECM Box.*

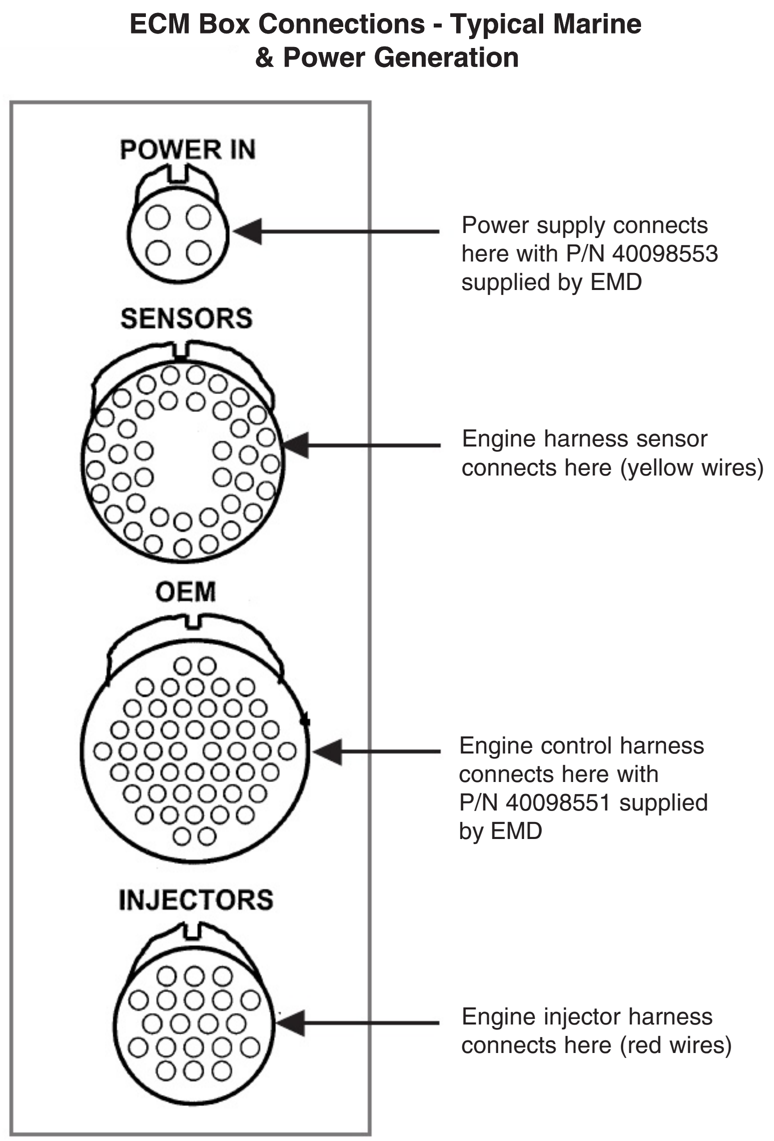


Figure C.12 *ECM Box Connections.*

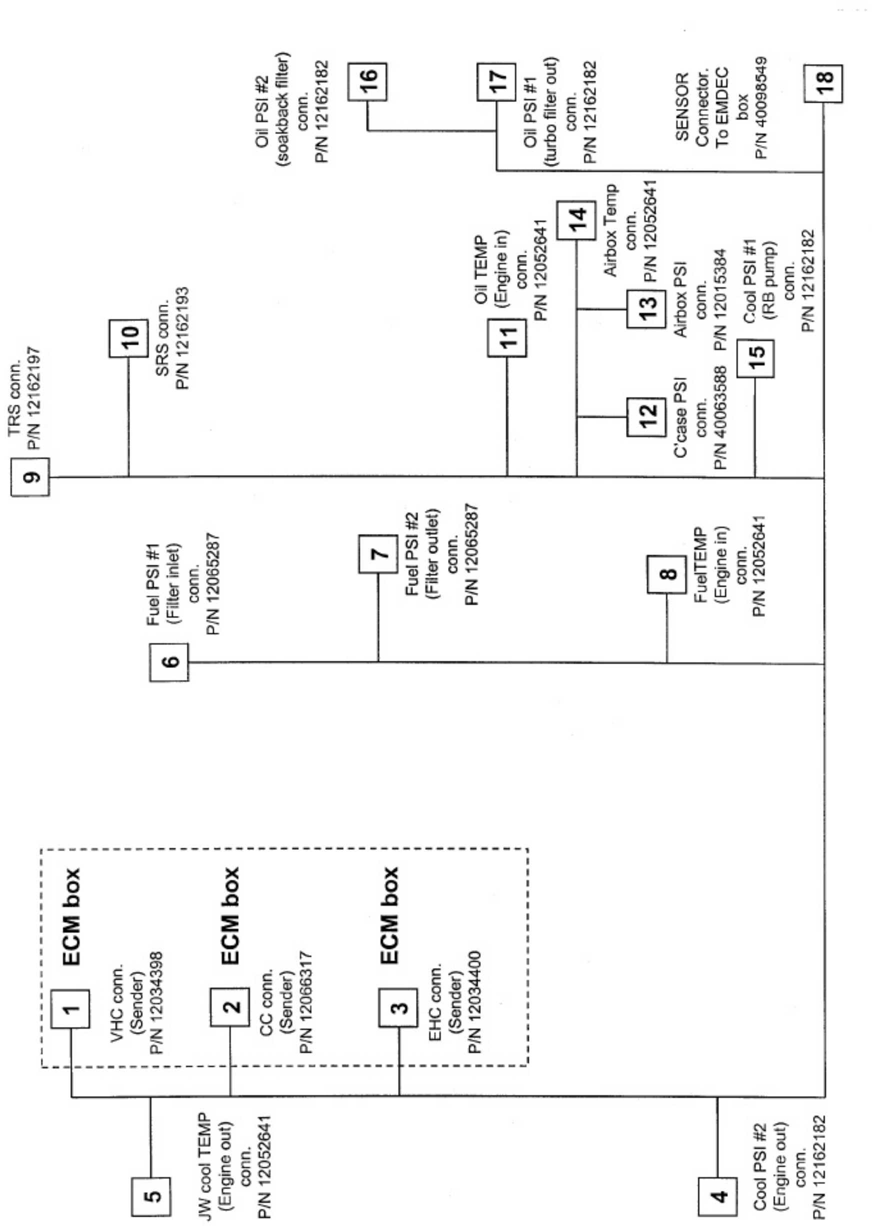


Figure C.13 *8G7C Sensor Wire Harness P/N 40098852.*

PIN #	Wire I.D. - Description - Wire diagram slide # Reference
E	EHC2T - TRS sensor (+) - Slide #4
F	EHC1T - TRS sensor (-) - Slide #6
H	EHC2S - SRS sensor (+) - Slide #4
J	EHC1S - SRS sensor (-) - Slide #6
K	EHC1W - Sensor supply (5VDC) - Slide #6
L	EHC1P - PSI sensor: engine airbox - Slide #6
M	EHC2L - PSI sensor: cool #1 (RB pump) - Slide #5
N	EHC2M - PSI sensor: cool #2 (eng. out) - Slide #5
P	EHC1R - PSI sensor: oil #1 - engine (turbo in) - Slide #5
R	EHC1N - PSI sensor: eng. crankcase - Slide #7
S	EHC2P - PSI sensor: oil #2 (turbo soakback) - Slide #7
T	EHC1M - PSI sensor: fuel #1 (filter in) - Slide #7
U	EHC3P - Temp. sensor: JWater out - Slide #3
V	EHC2R - Temp. sensor:engine oil (in) - Slide #5
W	EHC3R - Temp. sensor: Fuel in - Slide #3
X	EHC2N - Temp. sensor:airbox temp. - Slide #5
w	EHC1L - PSI sensor: fuel #2 (filter out) - Slide #7
Y	EHC2Y - Sensor return (0VDC) - Slide #4

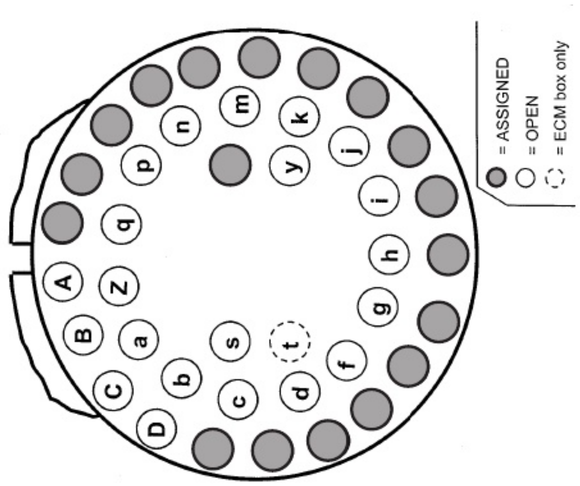


Figure C.14 *Sensor Harness Connector Plug Pin Assignment Cross Reference.*

PIN #	Wire I.D. - Description - Wire diagram slide # Reference
A	EHC3S - **Digital input:** SPARE**- Slide #4**
B	EHC3T - **Digital input:** SPARE**- Slide #4**
C	**EHC3W - Digital output: C'case PSI fault - Slide #3**
D	**EHC3X - Digital output: Low oil PSI fault - Slide #3**
E	**EHC3Y - Digital output: hot engine oil- Slide #3**
F	**VHC3A - Sensor supply (5VDC) - Slide #10**
G	**VHC3D - Variable Speed Governor - Slide #10**
H	VHC2D - SPARE: **PSI #1 - Slide #11**
J	VHC1D - SPARE: **PSI #2 - Slide #11**
K	VHC3H - SPARE: **PSI #3 - Slide #12**
L	**VHC3C - Sensor return (0VDC) - Slide #10**
M	**VHC2B - Stop engine light - Slide #9**
N	**VHC1B - Check engine light- Slide #9**
O	VHC3F - Digital output: SPARE **- Slide #11**
P	**VHC2A - Digital output: cool PSI (alarm) - Slide #9**
Q	**VHC1A - Digital output:cool temp.(alarm) - Slide #12**
R	VHC1J - **Digital input:** SPARE**- Slide #12**

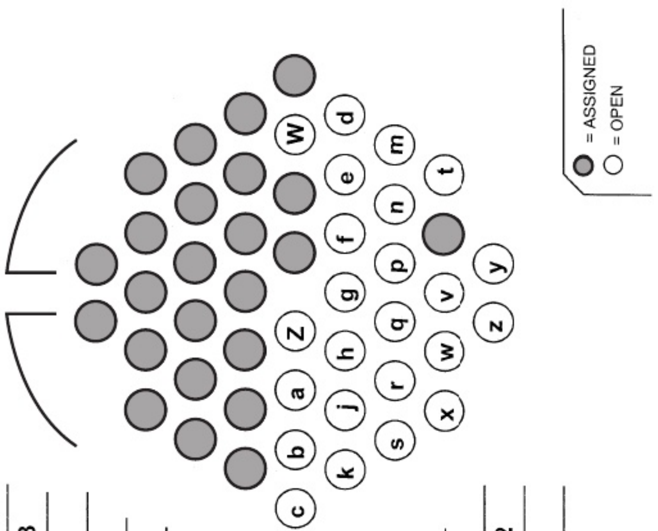


Figure C.15 *OEM Connector Pin Plug Assignment Cross Reference.*

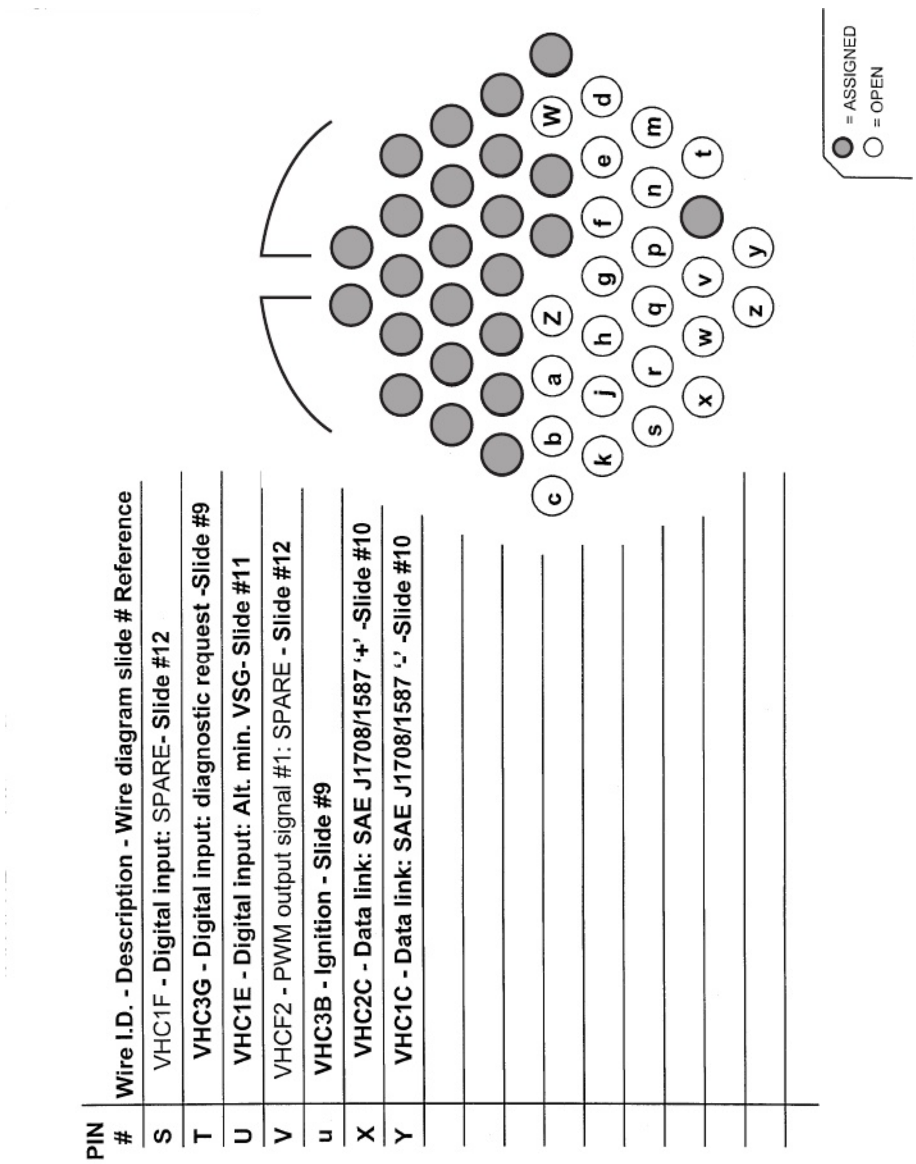


Figure C.16 *OEM Connector Plug Pin Assignment Cross Reference.*

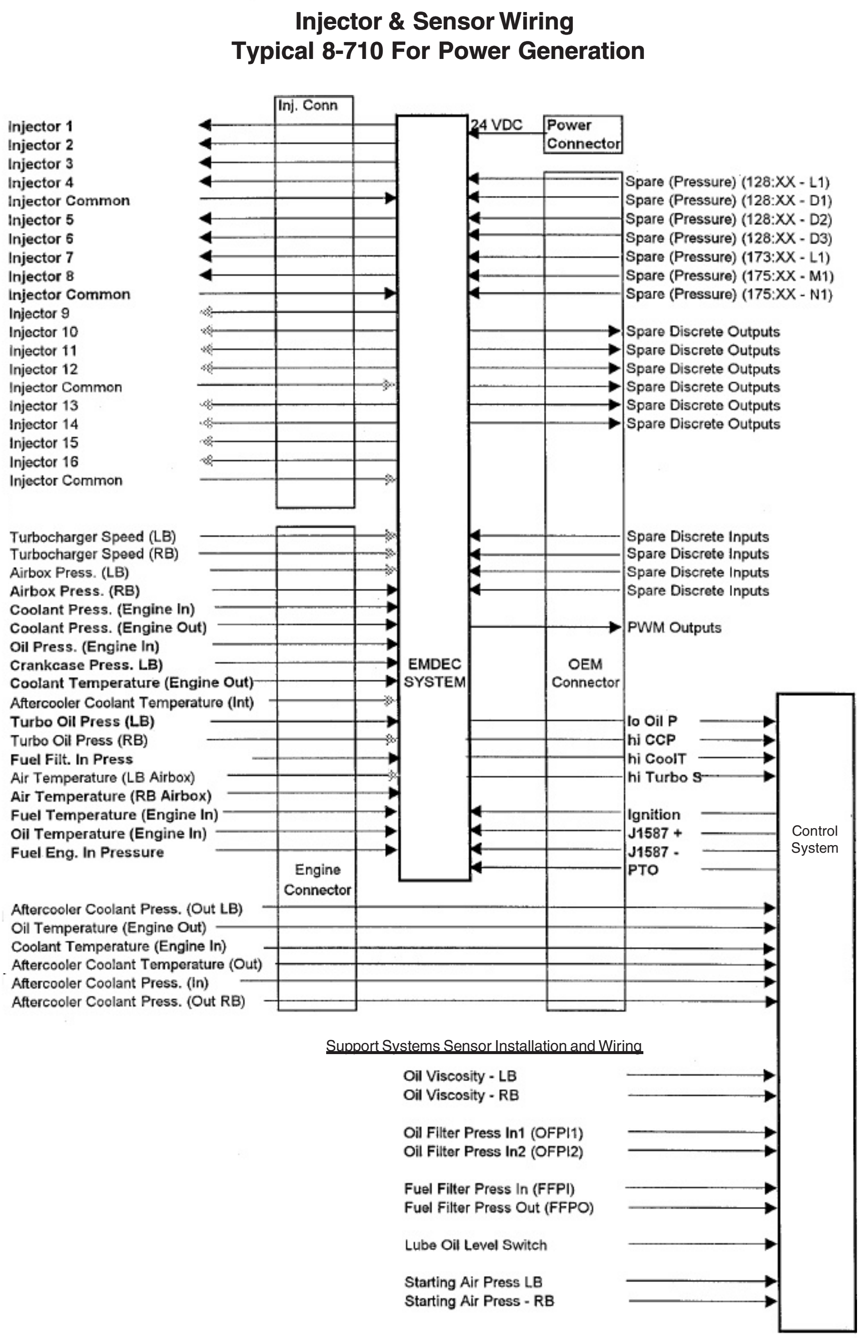


Figure C.17 *Injector & Sensor Wiring.*

Typical 8-710 For Power Generation

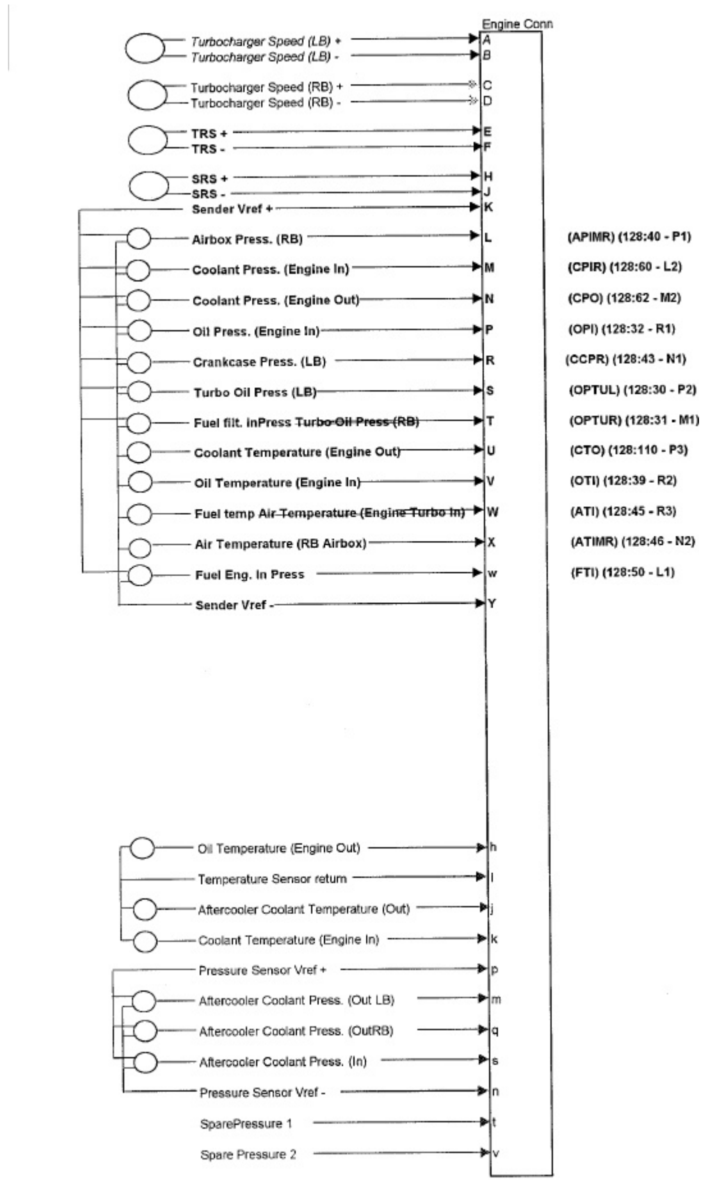


Figure C.18 *Typical 8-710 For Power Generation.*

Typical 8-710 For Power Generation

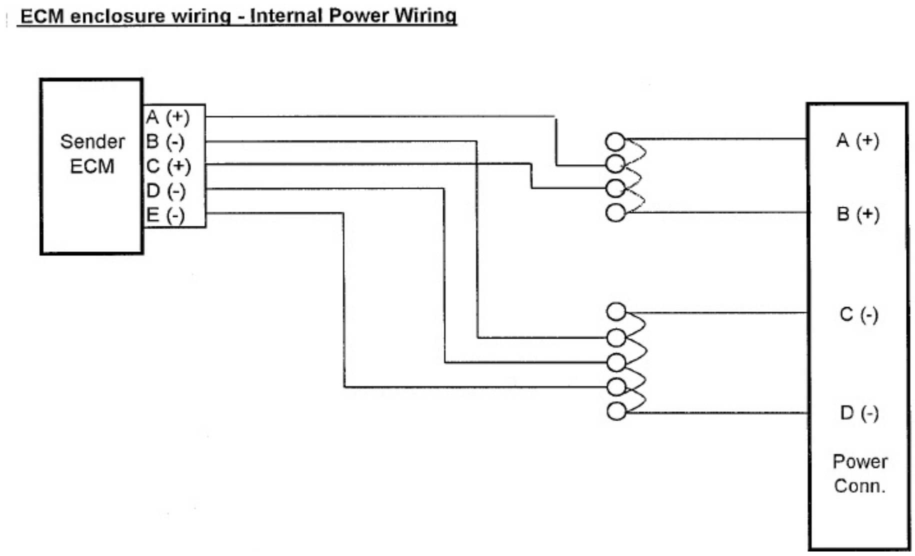


Figure C.19 *ECM Enclosure Wiring - Internal Power Wiring.*

Typical 8-710 For Power Generation

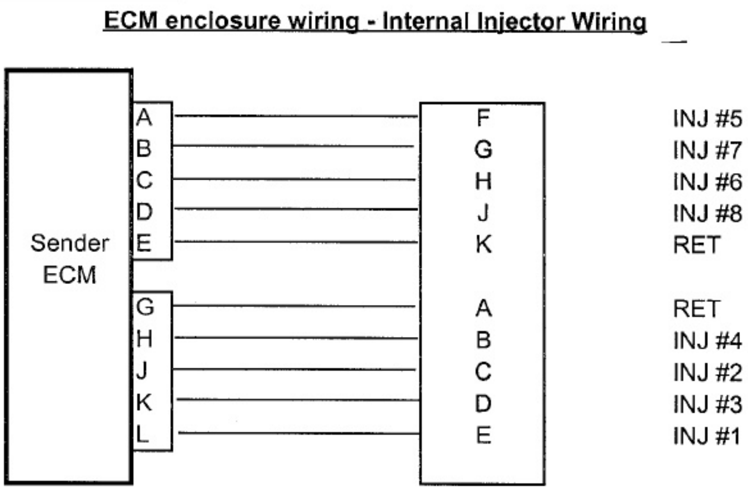


Figure C.20 *ECM Enclosure Wiring - Internal Injector Wiring.*

Typical 8-710 For Power Generation

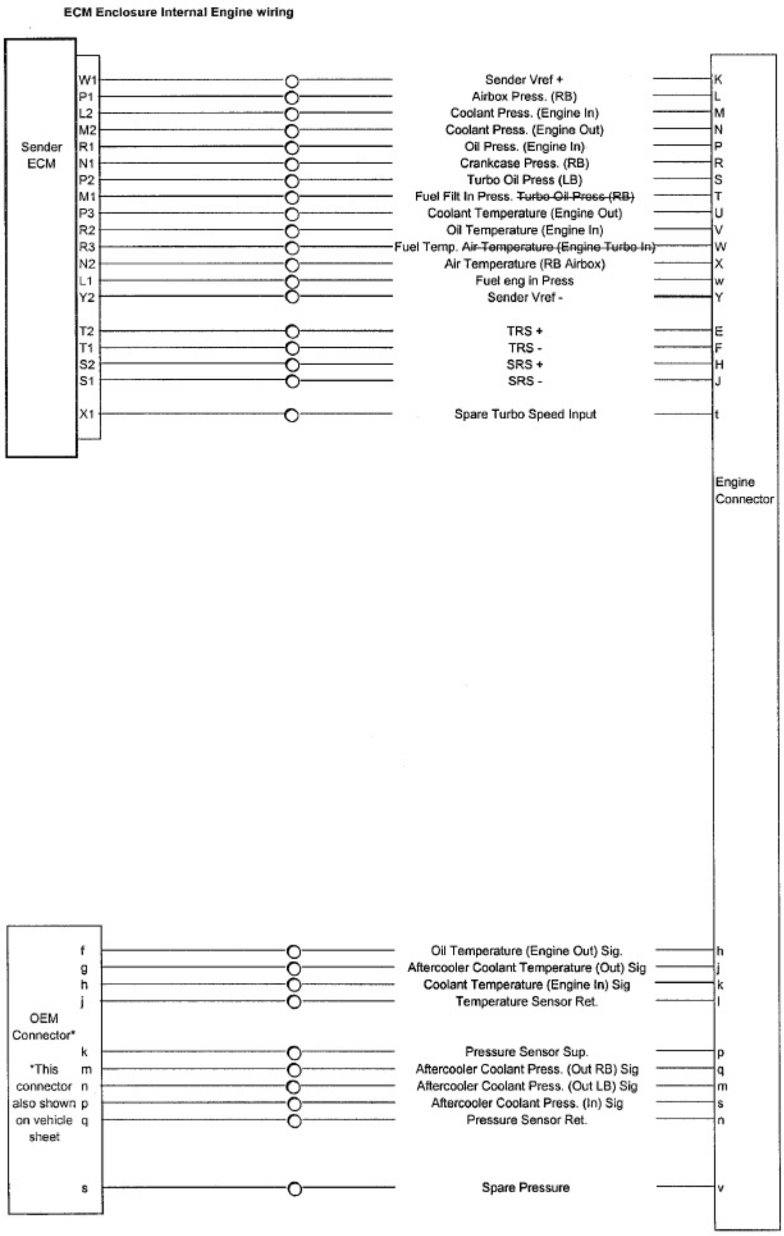


Figure C.21 *ECM Enclosure Wiring - Internal Engine Wiring.*

Typical 8-710 For Power Generation

ECM Enclosure Internal OEM wiring

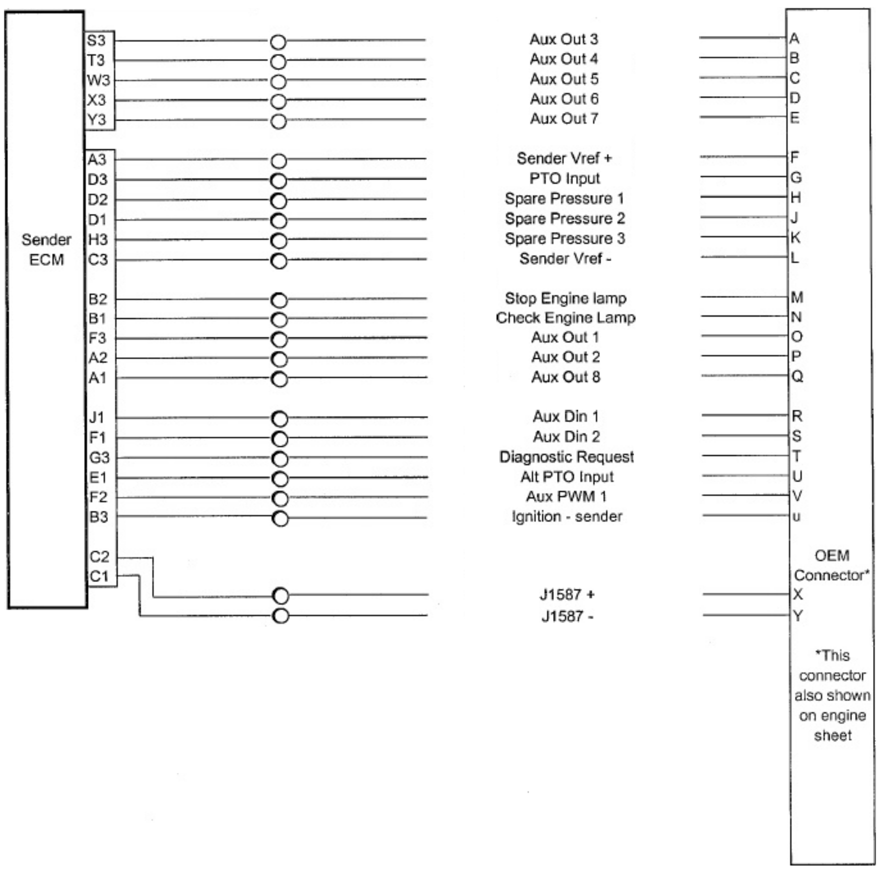


Figure C.22 *ECM Wiring - Internal OEM Wiring.*

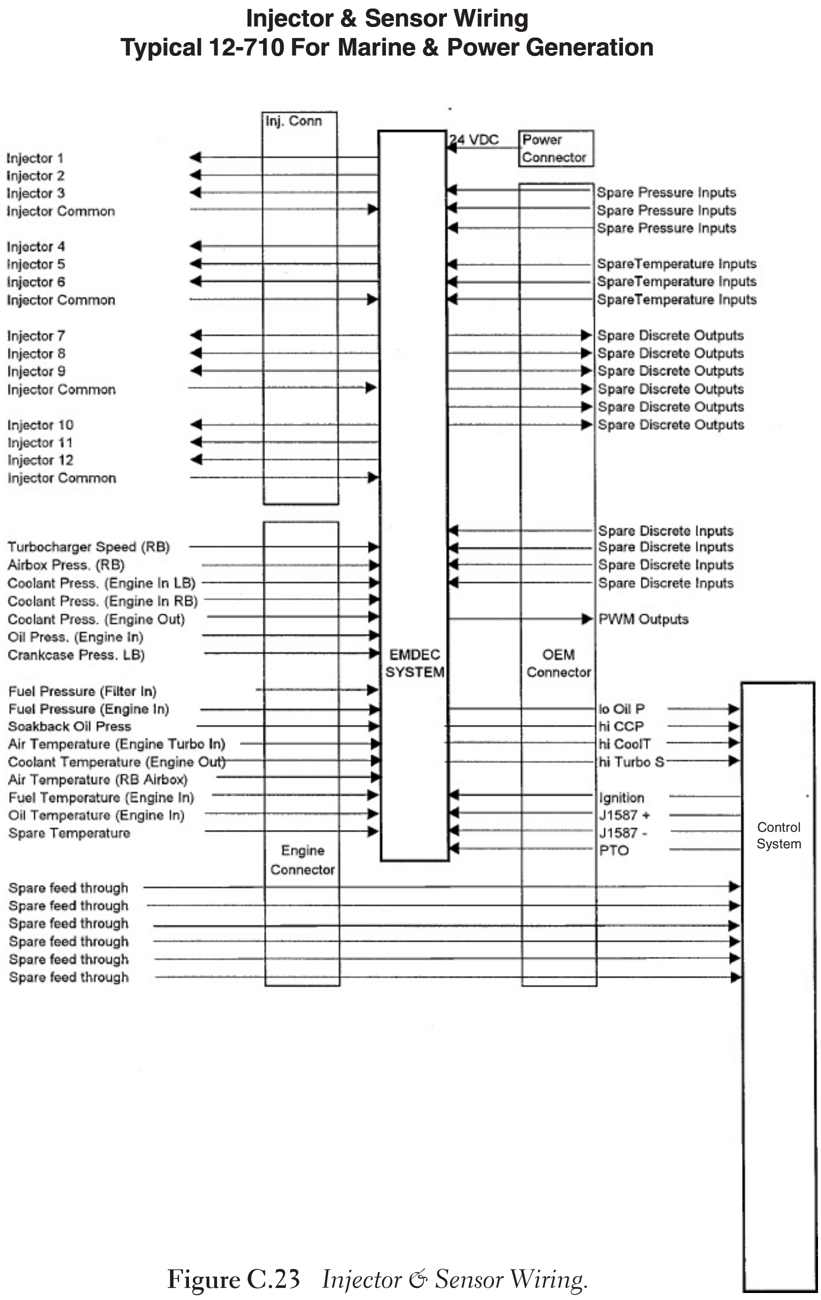


Figure C.23 *Injector & Sensor Wiring.*

Typical 12-710 For Marine & Power Generation

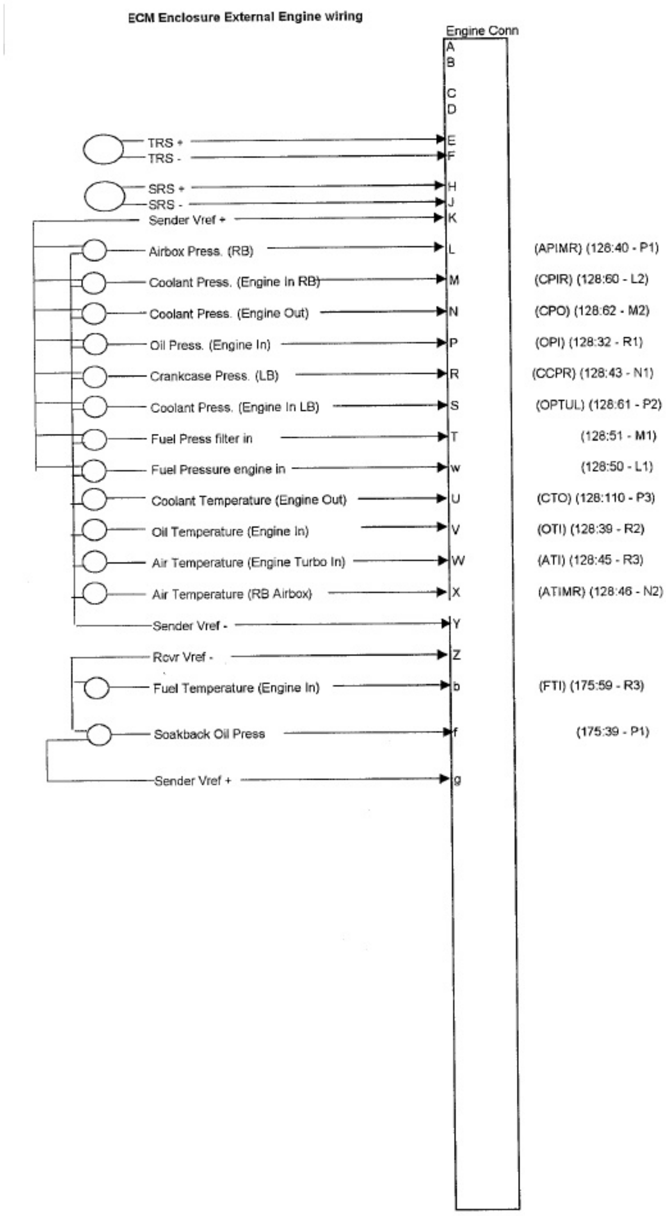


Figure C.24 *ECM Enclosure External Engine Wiring.*

Typical 12-710 For Marine & Power Generation

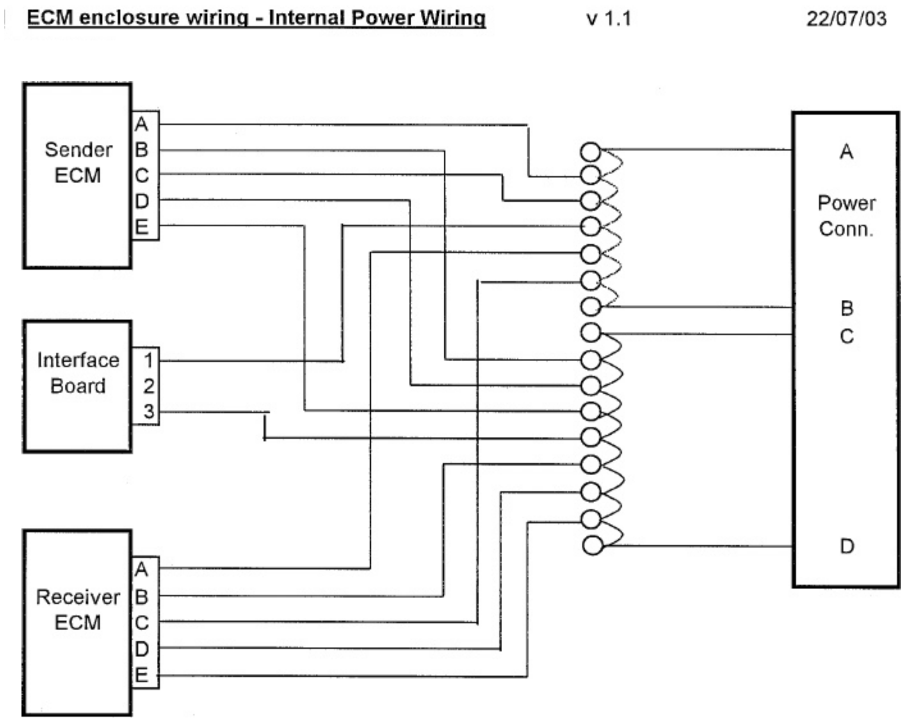


Figure C.25 *ECM Enclosure Wiring - Internal Power Wiring.*

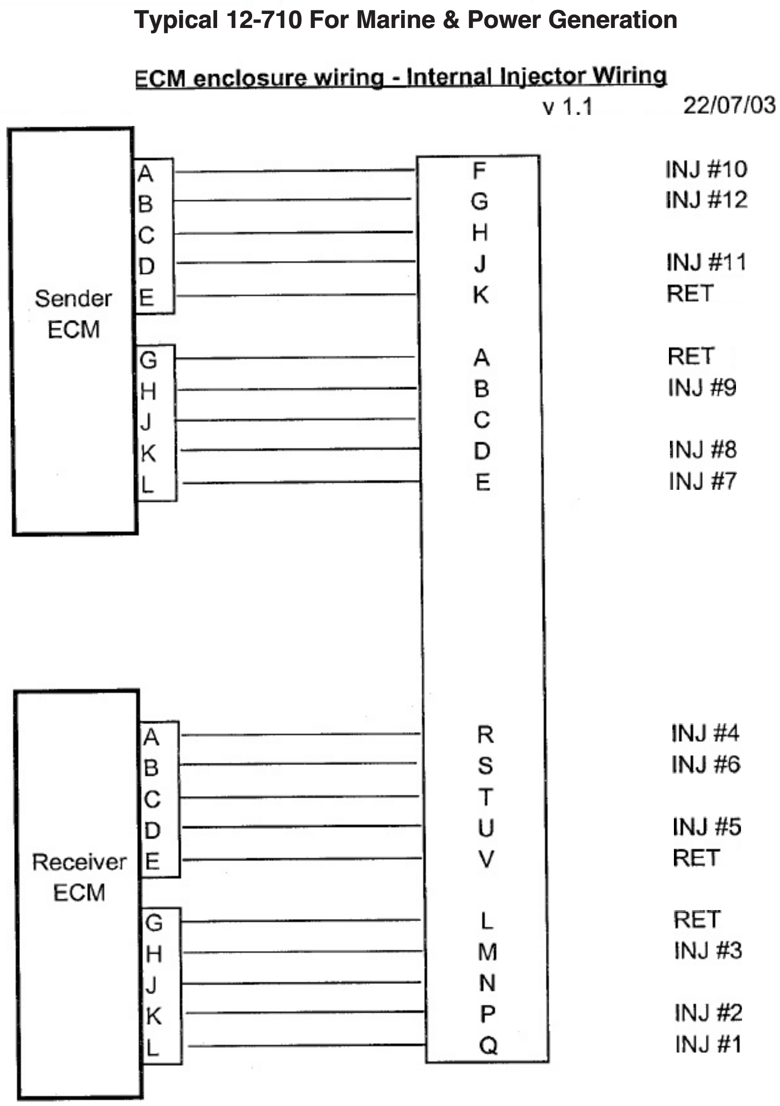


Figure C.26 *ECM Enclosure Wiring - Internal Injector Wiring.*

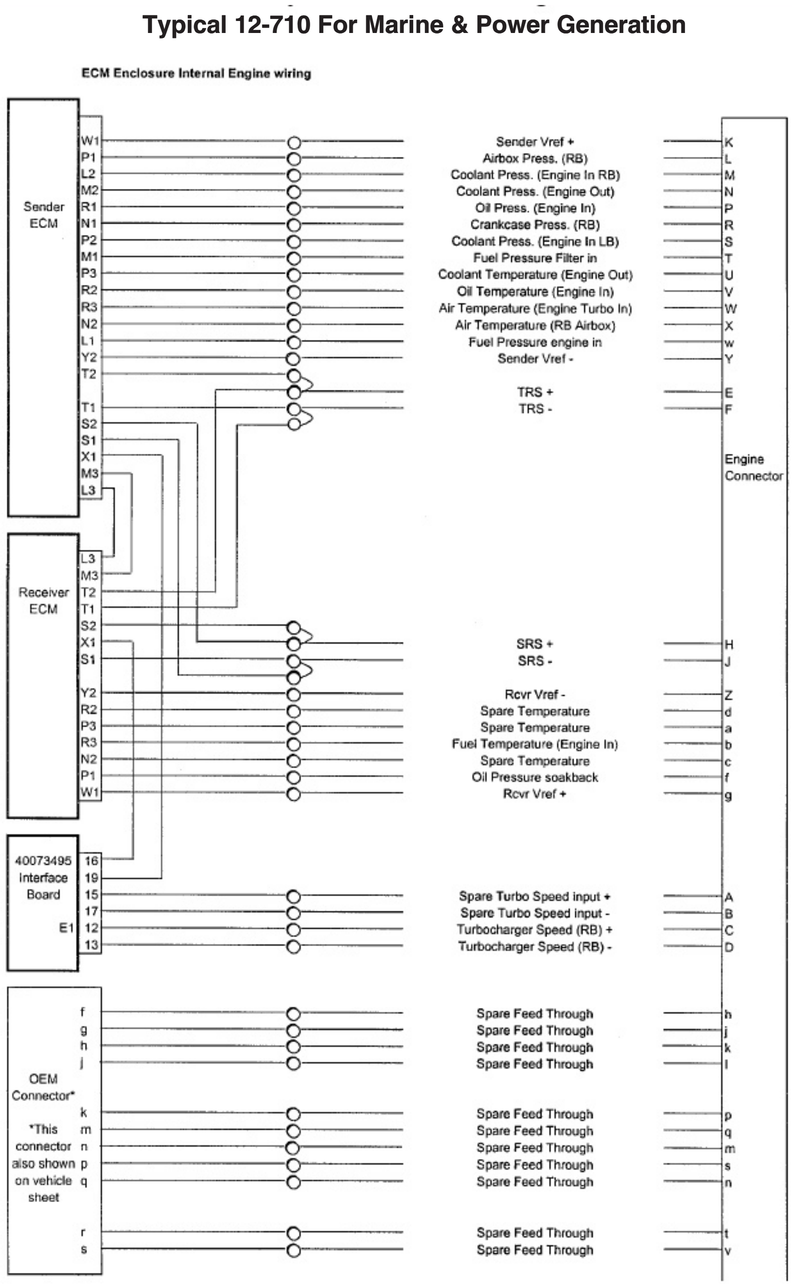


Figure C.27 *ECM Enclosure Internal Engine Wiring.*

Typical 12-710 For Marine & Power Generation

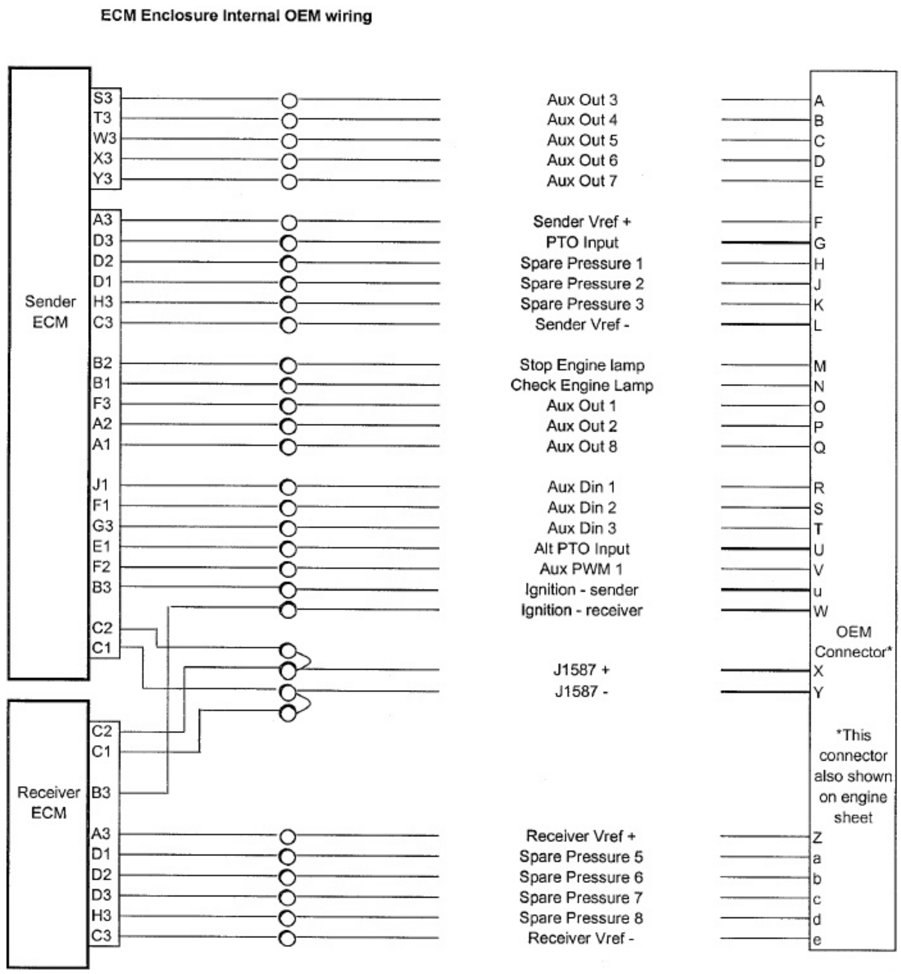


Figure C.28 *ECM Enclosure Internal OEM Wiring.*

Typical 12-710 For Marine & Power Generation

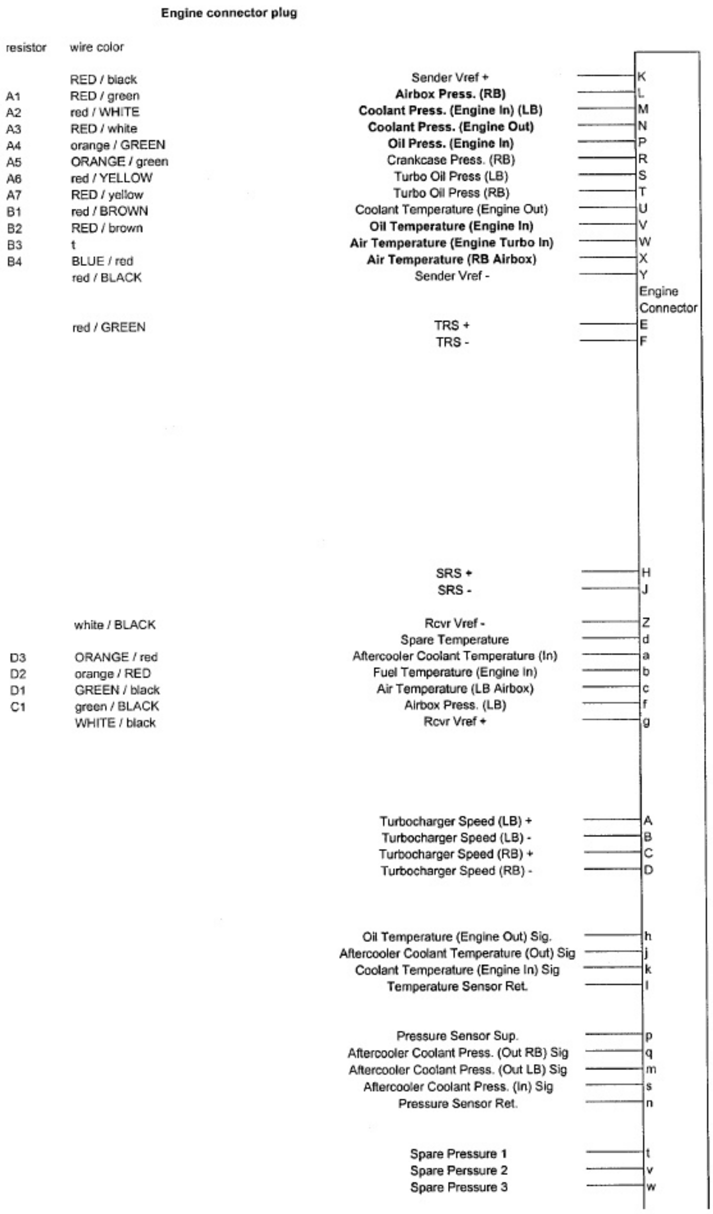


Figure C.29 *Engine Connector Plug.*

Notes:

Recommended Tools and Reference Material

Appendix D

PART NUMBER	ITEM	PURPOSE
40055368	PC Reader Kit	Interfaces EMDEC Computer
	Digital Multimeter	General Troubleshooting
15/16”	Crowsfoot	Apply Torque To Injector Fuel Lines
8237117	Snap Ring Pliers	Removing 70 Platform/ 80/90MAC Check Valves
9576512	Extraction Tool	For AMP Terminals
12085270	Crimp Tool	For Packard Terminals
12085271	Crimp Tool	For Packard Terminals
40003920	Insertion/Extraction	Tool For Engine Protector Terminals
40051636	Crimp Tool	For Barrel Type Terminals
40052278	Crimp Tool	For Barrel Type Terminals
40052279	Insertion/Extraction	Tool For 12 Cylinder Power/ Sensor Plugs
AMP91019-3	Extraction Tool	For 16 Cylinder Power Plugs
AMP69710-1	Crimp Tool	For 16 Cylinder Power Plugs
AMP90310-2	Crimp Tool	For AMP Terminals In AC Cabinet
	SRS/TRS Simulator	SRS/TRS Simulator Tool
	Sensor Pot Box	Sensor Potential Simulator
40094650	Speed Sensor Gap Gauge	For 710/256 H Series Engines
40103969	Sensor Box Simulator	For 710 Series Engines

REFERENCE MATERIALS

PART NUMBER	TITLE
N00008EP	Diesel Engine Troubleshooting Guide
	(For EMD 645 and 710 Engines)

Notes:

D

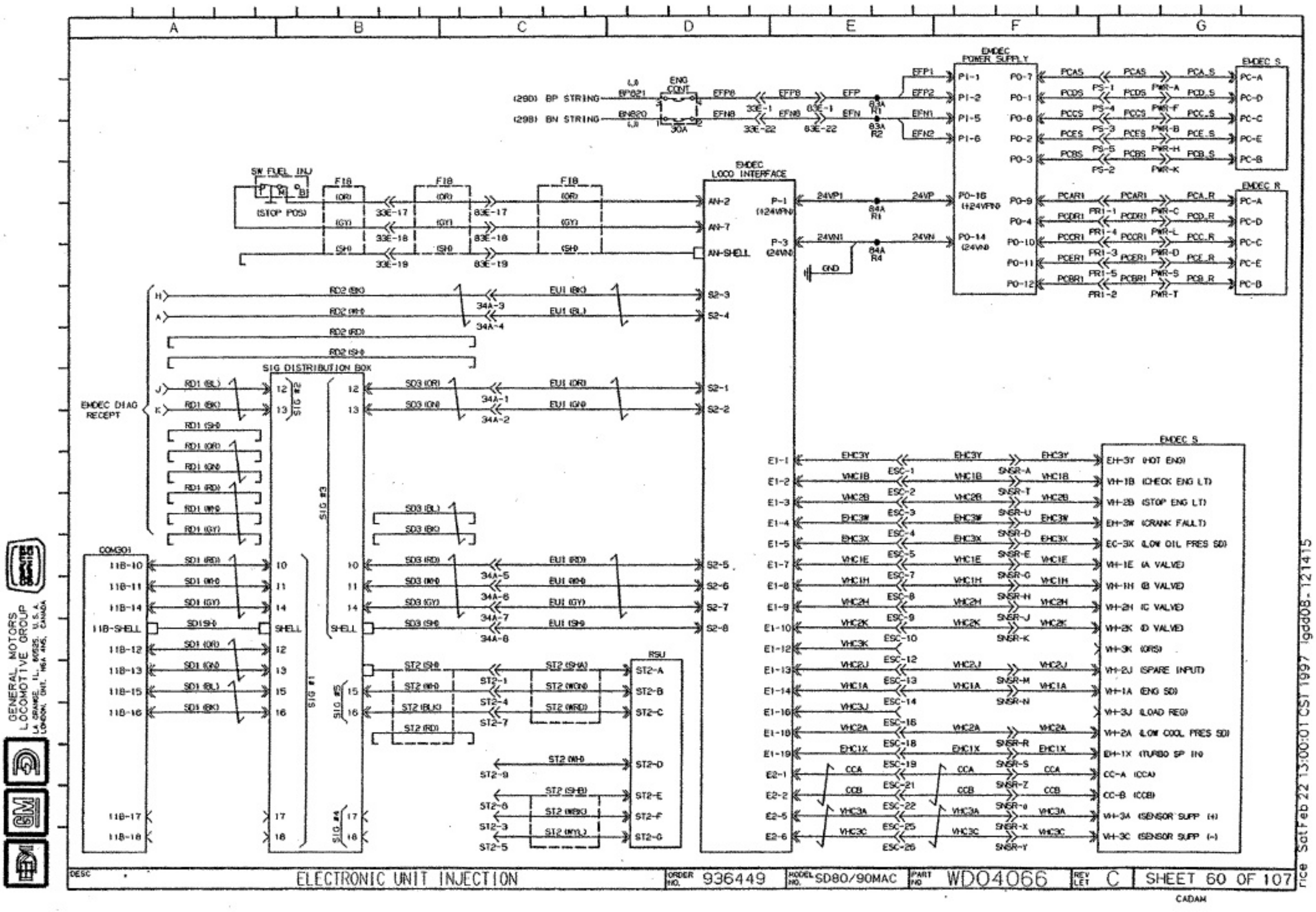
Notes:

Sensor Application Chart

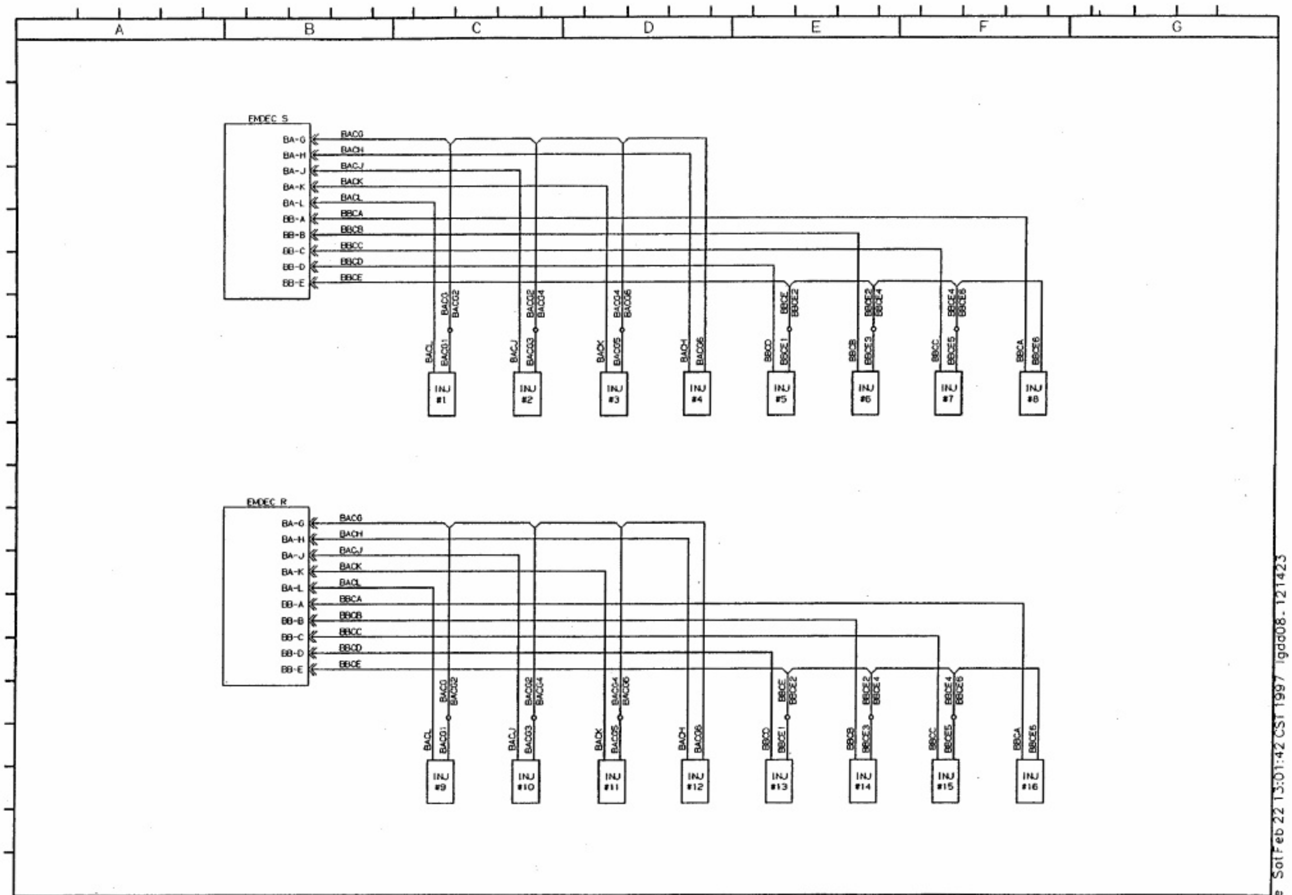
Appendix E

DEVICE	APPLICATION(S)	RANGE
40059731	Fuel Pressure	0-200 PSIA
40063567	Fuel, Oil, Engine Air Airbox Temperature	2.8K Ohms at 25˚C (Same transfer function as shown on page 59)
40079154	Crankcase Pressure	-0.5 to 0.5 PSIG
40086233	Engine Air, Airbox Temperature	3K Ohms at 25˚C
40087572	Coolant, Turbo Oil Pressure, Fuel Pressure	0-100 PSIG
40087573	Fuel Pressure Engine-In Fuel Pressure Primary Filter-In, Oil Pressure Engine-In, Oil Pressure Filter-In	0 - 200 PSIA
40089208	Airbox Pressure	0-87 PSIA

Notes:



A B C D E F G
EMDEC POWER SUPPLY
EMDEC S
EMDEC R
EMDEC LOCO INTERFACE
ENG CONT
30A
(290) BP STRING
(298) BN STRING
SW FUEL INJ
(STOP POS)
F18
EMDEC DIAG RECEPT
SIG DISTRIBUTION BOX
SIG #1
SIG #2
SIG #3
SIG #4
SIG #5
COMG01
RSU
GND
EH-3Y (HOT ENG)
VH-1B (CHECK ENG LT)
VH-2B (STOP ENG LT)
EH-3W (CRANK FAULT)
EC-3X (LOW OIL PRES SD)
VH-1E (A VALVE)
VH-1H (B VALVE)
VH-2H (C VALVE)
VH-2K (D VALVE)
VH-3K (ORS)
VH-2J (SPARE INPUT)
VH-1A (ENG SD)
VH-3J (LOAD REG)
VH-2A (LOW COOL PRES SD)
EH-1X (TURBO SP IN)
CC-A (CCA)
CC-B (CCB)
VH-3A (SENSOR SUPP (+)
VH-3C (SENSOR SUPP (-)
GENERAL MOTORS LOCOMOTIVE GROUP
LA GRANGE, IL. 60525, U.S.A.
LONDON, ONT. N6A 4N5, CANADA
DESC
ELECTRONIC UNIT INJECTION
ORDER NO. 936449
MODEL NO. SD80/90MAC
PART NO WD04066
REV LET C
SHEET 60 OF 107
CADAM
Sat Feb 22 13:00:01 CST 1997 igdd08-121415

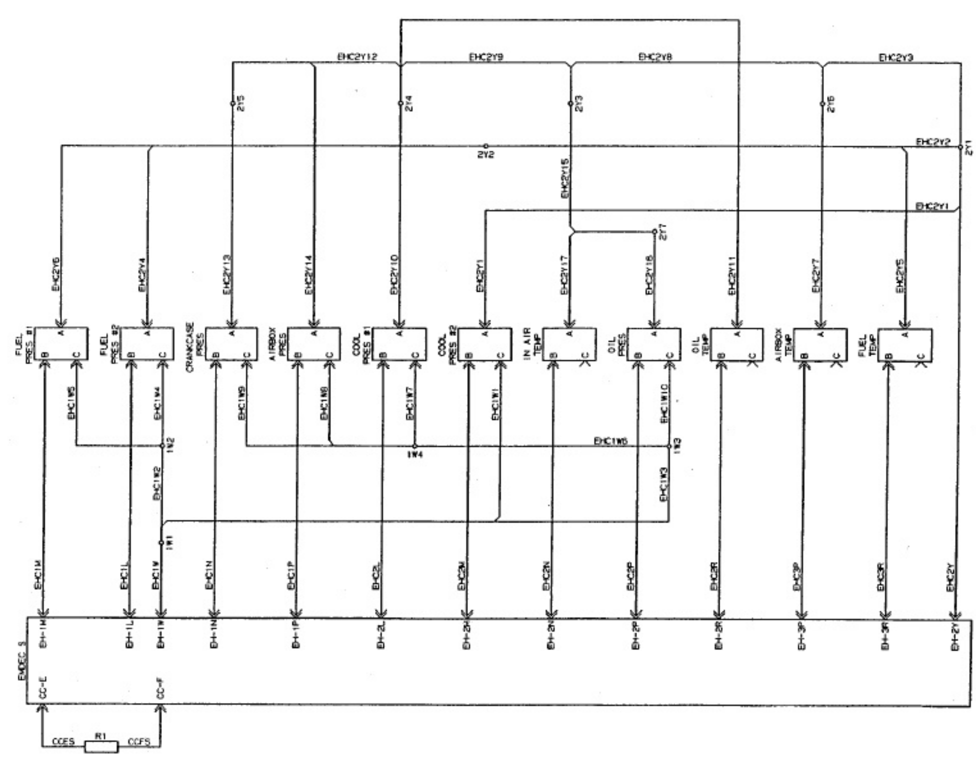


GENERAL MOTORS LOCOMOTIVE GROUP

DESC	ORDER NO.	MODEL NO.	PART NO	REV LET	
ELECTRONIC UNIT INJECTION	936449	SD80/90MAC	WD04066	A	SHEET 61 OF 107

CADAM

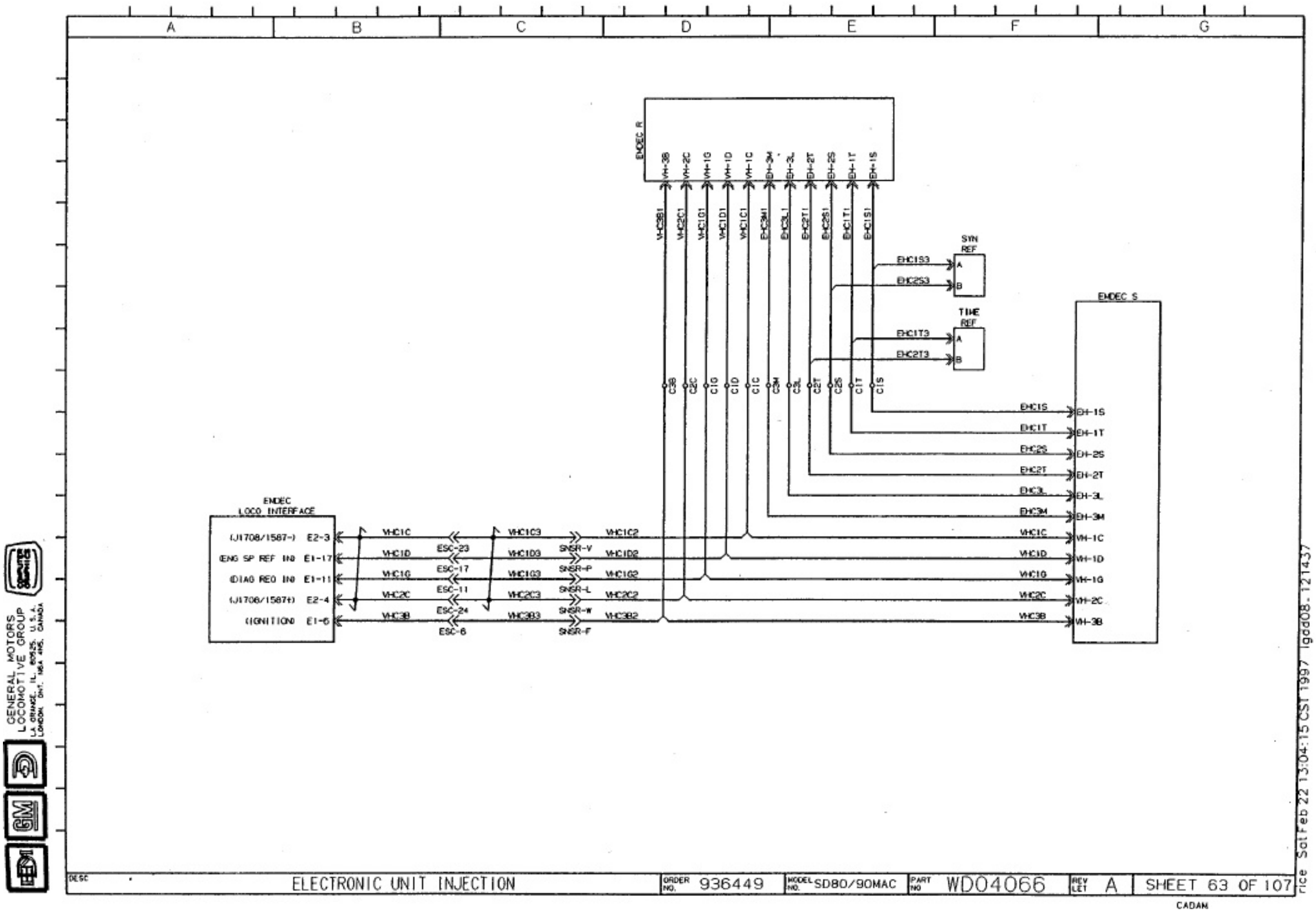
rice Sat Feb 22 13:01:42 CST 1997 lgdd08.121423



DESC	ELECTRONIC UNIT INJECTION	ORDER NO. 936449	MODEL NO. SD80/90MAC	PART NO. WD04066	REV LET —	SHEET 62 OF 110

CADAM

GENERAL MOTORS LOCOMOTIVE GROUP
LA GRANGE, IL 60525 U.S.A.
LONDON, ONT. N6A 4N5 CANADA



EMDEC R
EMDEC S
SYN REF
TIME REF
EMDEC LOCO INTERFACE
(J1708/1587-) E2-3
(ENG SP REF IN) E1-17
(DIAG REQ IN) E1-11
(J1708/1587+) E2-4
(IGNITION) E1-6
ESC-23
ESC-17
ESC-11
ESC-24
ESC-6
SNSR-V
SNSR-P
SNSR-L
SNSR-W
SNSR-F
GENERAL MOTORS
LOCOMOTIVE GROUP
LA GRANGE, IL. 60525, U.S.A.
LONDON, ONT. N5A 4N5, CANADA
ELECTRONIC UNIT INJECTION
ORDER NO. 936449
MODEL NO. SD80/90MAC
PART NO WD04066
REV LET A
SHEET 63 OF 107
CADAM