N-VIROMOTIVE
Locomotive Service Manual
Manuscript Version 3.0

NATIONAL RAILWAY EQUIPMENT CO.

NATIONAL RAILWAY EQUIPMENT CO.
N-VIRO LOCOMOTIVE SERVICE MANUAL

CONTENTS

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GENERAL DATA

Model Designation _____ 1GS7B or 2GS14B or 3GS21B*
Locomotive Power (Gross) _____ 700 or1400 or 2100* hp
Wheel Arrangement (AAR Symbol) _____ B-B
Diesel Engines 2 or 3*
- Model _____ QSK19C
- Number of Cylinders _____ 6
- Compression Ratio _____ 16:1
- Fuel System _____ MCRS
- Emission Certification _____ U.S. EPA Tier 3, CARB Tier 3, EU Stage IIIA
- Displacement _____ 1,159 in^3 (19.0 L)
- Bore and Stroke _____ 6.25 in x 6.25 in (158.75 mm x 158.75 mm)
- Aspiration _____ Turbocharged and Charge Air Cooled
- Engine Speed (Rated) _____ 1,800 RPM
- Output Power (Rated) _____ 700 hp
- Minimum Low Idle Speed _____ 600 RPM

Alternators _____ 3 Phase 240 VAC (Rail Duty)
Generator Model _____ 572RDL
Supplies
- Lube Oil System Capacity per Genset _____ 78 gal
- Used Oil Reservoir Capacity _____ 200 gal
- Coolant Capacity per Genset (contains 50% Ethylene Glycol) _____ 45 gal
- Sand Capacity (Total) _____ 48 ft^3
- Fuel Capacity
- ___Basic _____ 2900 gal
- ___Retention Tank _____ 100 gal

Major Dimensions
- Height Over Horn _____ 194 (16’ 2)
- Width Over Handrail Supports _____ 126.5 (10’ 6-1/2)
- Length Over Coupler Pulling Faces _____ 536 (44’ 8)

Weight Fully Serviced _____ 268,000 lbs (121563 kg) **
Traction Motors
- Model _____ D77-78
- Number _____ 4
- Type _____ DC Series Wound, Axle Hung, Forced Air Ventilated

Maximum Locomotive Speed (Based on rated RPM of traction motors)
- Gear ratio _____ 62:15
- Wheel Dia. _____ 40”
- Max. Speed _____ 65 mph

* = Number of Gensets vary with the model.
** = 258,000 lbs for the 2GS14B on GP9 Frame.
** = 250,000 lbs for the 1GS7B Locomotive

*= IF EQUIPPED

Air Compressor

- Model: GAR37
- Type: Single-Stage, Oil-Injected
- Compressor Cooling: Air
- Lube Oil Capacity: 2.38 gal (9 L)
- Motor Shaft Speed: 3000 RPM
- Shaft Power Output: 40.5 hp (30.2 kW)

Air Brakes

- Model: 26L* or CCB26*

Storage Battery

- Lighting and Cab Equipment
  - Voltage: 64
  - Rating (8 Hour): 450
- Starting
  - Voltage: 64
  - Rating (8 Hour): 450

Minimum Curve Negotiation Capability

- Single Unit: 100 ft. Radius - 60° Curve
- Coupled to N-VIRO: 100 ft. Radius - 60° Curve
- Coupled to a standard 50ft. boxcar: 195 ft. Radius - 31° Curve

WEIGHTS

The weights as listed below are approximate and are intended as an aid in determining the handling procedure to be used.

	kg	lbs.
Genset	7861	17,330
Engine	2191	4830
Radiator Assembly	1170	2580
Generator	1588	3500
Exhaust Silencer	268	590
Equipment Blower	645	1422
Air Brake	239	526
Fuel Tank (Basic)	4627	10,200
Truck Assembly	17917	39,500
Traction Motor	2722	6,000
Axle	601	1325
Wheel 40”	485	1070
Gear	186	409
Bearing – Inner Race	15	33
Air Compressor	500	1100
Storage Battery	134	296
Air Conditioner	40	88

* = If 3rd Genset Equipped

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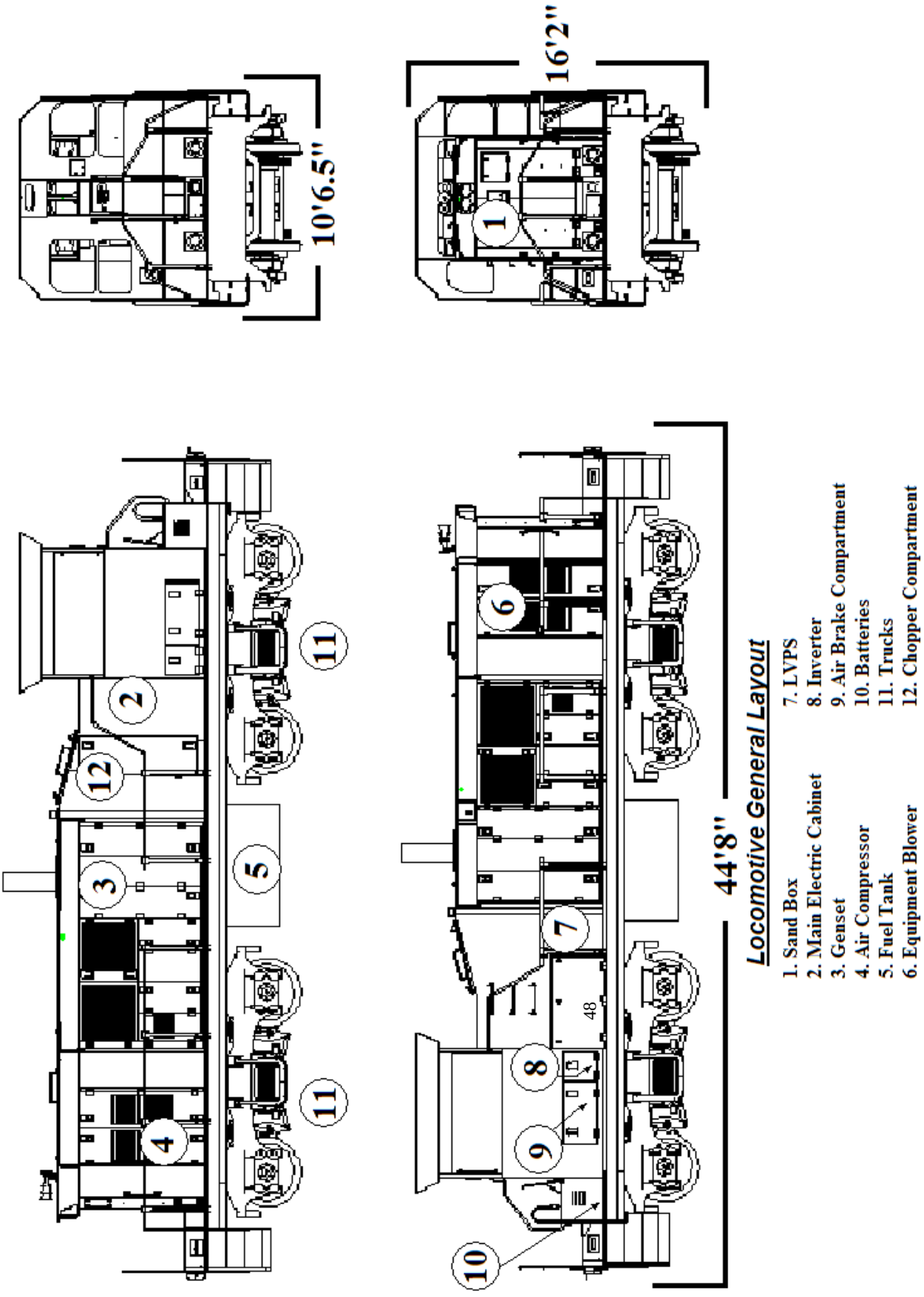

* 3rd Genset may not be installed in all models.

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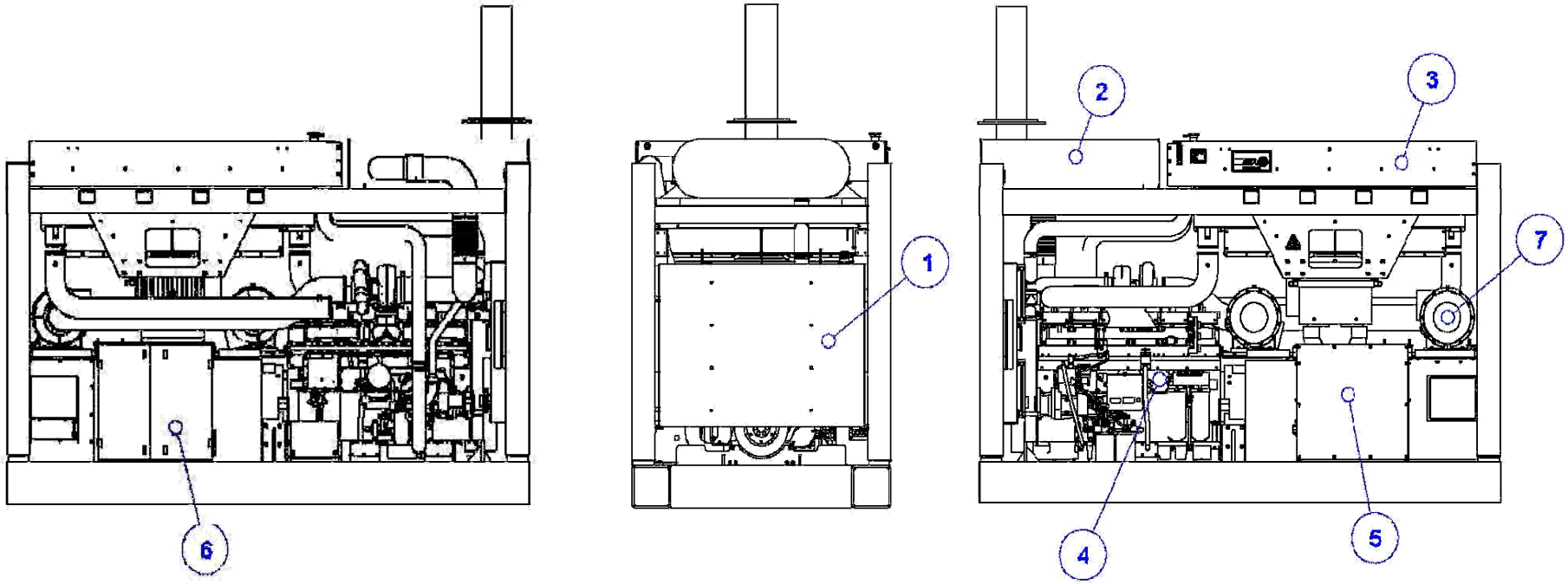

1. New Engine Oil Tank
2. Exhaust Silencer
3. Radiator Assembly
4. Engine
5. DC Rectifier Cabinet
6. Main Circuit Breaker Cabinet
7. Engine Air Filter

*= IF EQUIPPED

GENSET GENERAL ARRANGEMENT

GENERAL DESCRIPTION

INTRODUCTION

The National Railway Equipment Co. multiple engine/generator assemblies (genset), diesel-electric locomotives, illustrated in the introduction, are equipped with multiple Cummins QSK19 model diesel engines that each drive a main generator. Electrical power from the main generators is distributed to the traction motors from a common DC buss through a DC Chopper control system.

The locomotive is arranged and equipped so that the short hood or cab end is considered the front.

The locomotive is designed for single unit or multiple unit operation. When coupled together for multiple unit operation, all units are controlled simultaneously, through jumper cables, from the control stand in the cab of the lead unit.

LOCOMOTIVE OPERATION

The main sources of power for the locomotive are the diesel engines. A separate 24volt DC power system is arranged to provide necessary battery power for starting the diesel engines. This 24 volt battery is isolated and separate from all other control system circuitry including the 64 volt battery system. This allows the 64 volt battery system to provide necessary battery power for control system, lighting, air conditioning, and heating without draining the starting battery.

Once the first engine is started, the engine supplies the power to drive its own main generator. This main generator then provides necessary electrical power to drive the air compressor, equipment blower, cooling fan, and provides 3-phase AC power for battery charging and other control system functionality.

The air compressor is a rotary screw type compressor driven by a multi-stage three phase AC electric motor.

The equipment blower provides cooling air for the traction motors, DC Choppers, low voltage power supply, air conditioning inverter, and electric cabinet pressurization and is driven by a variable speed 3-phase AC electric motor.

Each Genset is equipped with its own cooling fan driven by a variable speed three phase AC motor.

A Low Voltage Power Supply (LVPS) is provided to convert power from the main generator to 74 volts DC for the 64 volt battery charging and 27 volts DC for the 24 volt battery charging.

A DC to AC inverter is provided to convert battery power to 115 volt AC power to operate the heating, ventilation, and air conditioning (HVAC) units in the operator's cab.

Each main generator rotates at engine speed and provides AC to a rectifier assembly which then delivers high voltage DC power to the common buss. DC Choppers provide power from the DC buss to each traction motor that's directly geared to an axle and a pair of driving wheels. The trucks, which house the motor and wheel arrangements, support all of the locomotive weight, and provide for flexibility to turn the locomotive and absorb many of the shocks while maintaining maximum traction for the wheels.

*= IF EQUIPPED

DESCRIPTION

Each Genset is equipped with one electric starting motor. The starting motor engages the ring gear to supply rotation necessary to start the engine.

For the starter motor to engage, the locomotive electrical system must be properly set up. Both the 24VDC and 64VDC battery switches must be closed. In the gensets, the MCB and 24VDC circuit breakers must be in the ON position. In the electric cabinet the control, local control, and electronic control circuit breakers must be in the ON position. The isolation switch must be in the START/STOP position. On the control stand, the control and fuel pump switch must be in the ON position.

When the Engine Start pushbutton is depressed and held in, the NForce system will initiate the genset starting process. The NForce system will activate the idle limiting buzzers to indicate the starting sequence has commenced and the Engine Start pushbutton should be released. The NForce system will then energize the ECMP relay in each Genset. After a short period of time it will energize the EE relay and then the ST relay, which will engage the starting motor.

Once the first genset is running, the NForce system will determine the appropriate time to start the second and third gensets. Pressing the start button will only start the first genset.

STARTING THE LOCOMOTIVE

Perform the following Prestart Inspections before attempting to start each Genset.

PRESTART INSPECTIONS

GENSET INSPECTION

The engine room equipment of each genset can be inspected by opening the access doors along the sides.

1. Check for visible fresh oil in each Genset's oil tank sight glass.
2. Observe for leakage of fuel oil, lube oil, water, or air.

AIR COMPRESSOR INSPECTION

The air compressor should be inspected before starting the engine.

1. Check air compressor for proper oil supply.
2. Check for oil leaks.
3. Check the air intake filter clamps are secure.

ENGINE STARTING PROCEDURE

After the preceding inspections have been completed, the diesel engine may be started. After engine starts, close all Genset access doors.

1. Ensure that all circuit breakers are in the UP or ON position.
2. At the operator's control stand, make certain that the generator field switch is off (down). Verify that the control/fuel pump switch and engine run switch is on (up).

NOTE

When starting trailing unit diesel engines and control cables have been connected between units, the control and fuel pump switch should remain off.

3. At the engine control panel, verify that the isolation switch is in the START position.
4. At the operator's control stand depress the engine start pushbutton and hold for 2 seconds. An engine starting warning buzzer will sound for 5 seconds and the engine with the least hours of service will start.
5. To start a specific Genset push in and hold the Air Conditioner Reset Pushbutton and the Engine Start Pushbutton simultaneously. A series of beeps will sound.

   One beep for Genset 1.

   Two beeps for Genset 2.

   Three beeps for Genset 3.

*= IF EQUIPPED

When the desired Genset tone is heard, release the Air Conditioner Reset Pushbutton while continuing to hold in the Engine Start Pushbutton. Release the Engine Start button when the engine start alarm sounds.

NOTE

If any problems with the starting of the diesel engines occur, refer to Diagnostic Mode in sect. 11 of this manual.

TRAILING UNIT CAB INSPECTION

Switches, circuit breakers, and controls located in the cab of a trailing unit should be checked for proper positioning as follows:

CIRCUIT BREAKER AND BATTERY SWITCH COMPARTMENT

1. Main battery knife switch closed.
2. All circuit breakers are in UP or ON position.

CIRCUIT BREAKER PANEL

1. All circuit breakers should be in the UP or ON position.
2. Verify that the ground relay cutout switch is closed.

ENGINE CONTROL PANEL

1. Isolation switch in START position.
2. Headlight switch in proper position to correspond with unit position in the consist.
3. Miscellaneous light switches positioned as required.
4. Load test switch in OFF position.
5. Traction motor cutout switches are in ON position.

NOTE

The electrical cabinet is pressurized with filtered air. Cabinet doors must be securely closed during locomotive operation.

OPERATOR'S CONTROL STAND

Switches and operating handles on the control stand should be positioned as follows:

1. Control and fuel pump switch, generator field switch, and engine run switch must be off.
2. Move throttle to IDLE.
3. Position reverser handle to neutral and remove to lock other handles.
4. Light and miscellaneous switches positioned as desired.

AIR BRAKE EQUIPMENT

1. Set CCB26 brake valve (EBV) to TRAIL CUTOUT position.
2. Place automatic brake handle in HANDLE OFF position.
3. Move independent brake handle to RELEASE position.

STARTING TRAILING UNIT DIESEL ENGINES

Engines in trailing units are started in the same manner as the engine in the lead unit. Refer to the STARTING THE LOCOMOTIVE paragraph of this section.

NOTE

If control jumper cables are already connected between units, ensure that the control and fuel pump, generator field, and engine run switches are off. This will allow these systems to be controlled from the lead unit.

FUEL TANK

DESCRIPTION

Each Genset contains its own fuel system located on the diesel engine (Fig. 2-4). Refer to Cummins Operation and Maintenance Manual for QSK19 Series Engine for details. This section describes the fuel tank and its components. See Figure 2-1.

Each Genset diesel engine is connected to the fuel tank. A Fuel Return and Fuel Suction line is provided for each engine. A Fuel Filler and Fuel Level Sight Glass is located on each side of the tank and an Electronic Fuel Gauge is located on the right side of the tank. Also included on the tank are Retention Tank Lines and a Fuel Tank Water Drain. Emergency Fuel Cutoff Switches are located on both sides of the locomotive frame in the vicinity of the fuel fillers. See Figure 2-2.

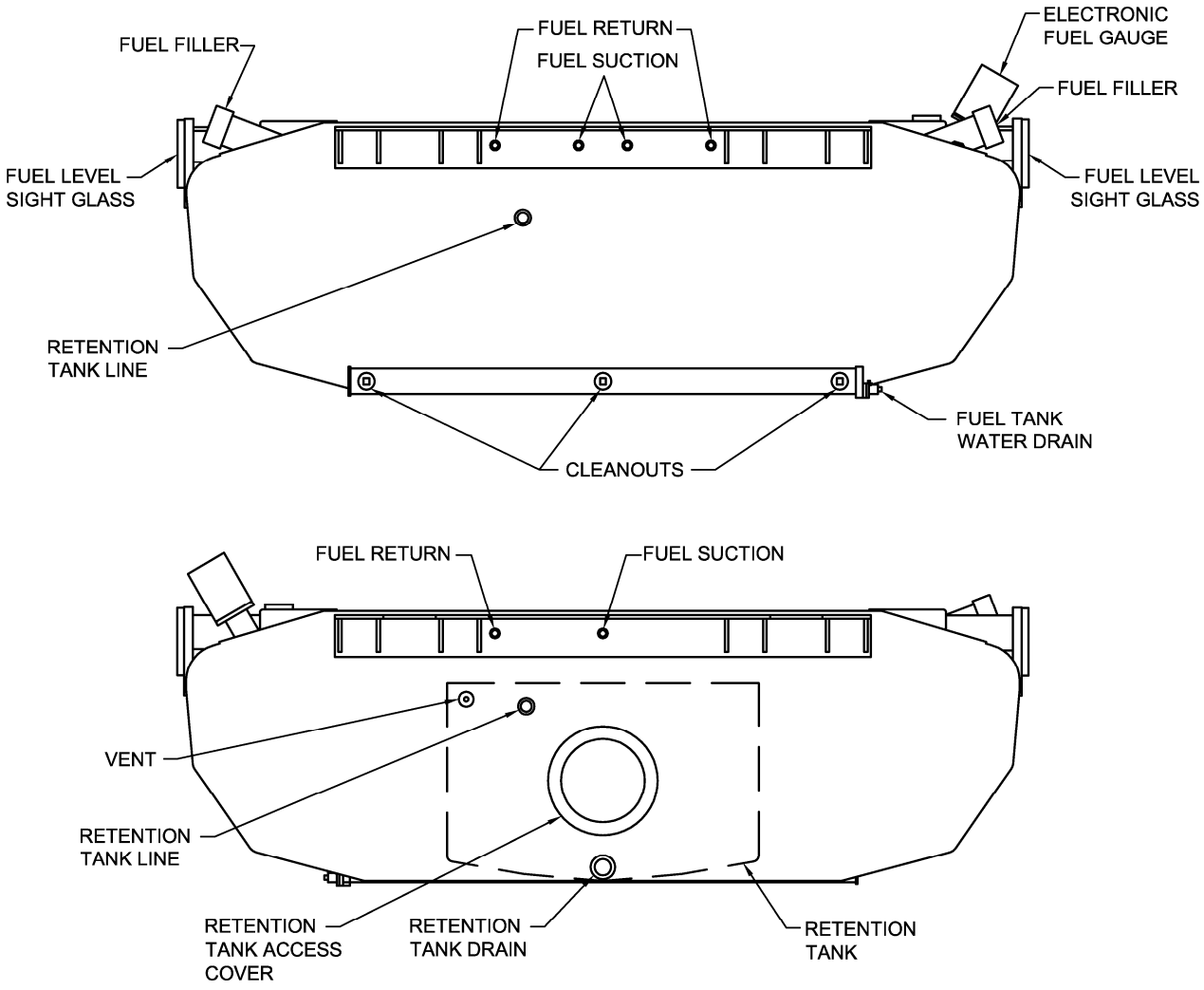

Figure 2-1– Fuel Tank End Views: Rear (top) & Front (bottom)

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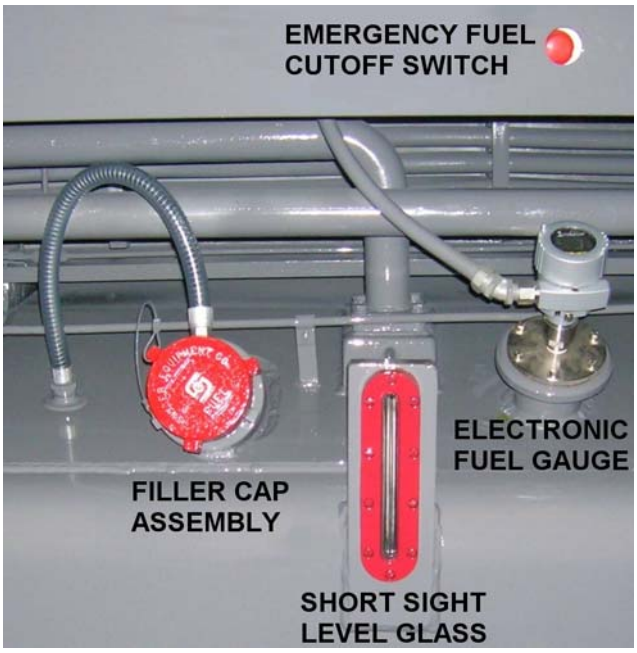

Figure 2-2 – Fuel Tank Components

EMERGENCY FUEL CUTOFF SWITCHES

In the event of an emergency, the fuel supply to the engine can be stopped by pressing any one of the three emergency fuel cutoff switches. Two switches, one on each side of the locomotive, are located on the underframe in the vicinity of the fuel fillers, and the third switch is located on the engine control panel. The switches are connected in series with the fuel pump control relay (FPCR). Pressing any of the switch buttons will de-energize FPCR, stop the fuel pump, and shut down the engine. The buttons are spring loaded and do not need to be reset.

ELECTRONIC FUEL GAUGE CONTROL UNIT

The fuel monitoring system provides a reliable method to accurately measure and report the amount of fuel in the tank. It includes a Level Sensor, Interface and Power Module, and Digital Display.

LEVEL SENSOR

The Level Sensor is comprised of three main sections:

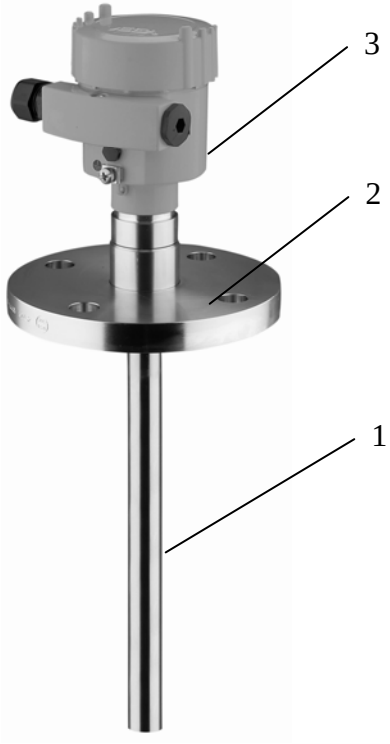

Figure 2-3 – Electronic Fuel Gauge

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1. **Probe** (Stainless Steel Waveguide) – this section of the Level Sensor is situated inside the tank.

2. **Mounting Plate** with insulating gasket

3. **Sensor Base** – the head of the unit is a mil spec gray aluminum housing for control and measurement circuits and one (1) backlit Digital Display.

The sensor operates on the principle of sending a guided microwave pulse along the waveguide. The pulse is then reflected from the surface of the fuel and back to the sensor base of the unit. The travel time of the pulse is measured, and using the profile of the tank pre-programmed from the factory, converted to a volume of fuel. The volume is then transmitted to the digital display(s) and to the communication module.

Interface and Power Module

The Interface and Power module is located in the Air Brake Compartment on the right side of the locomotive. It contains an isolated DC/DC converter providing 24VDC to the Level Sensor and Digital Display. The DC/DC converter is powered from standard 74VDC Locomotive systems.

Additionally, a 4-20mA signal, proportional to the fuel level (4 mA = empty, 20mA = full tank), is provided to send fuel level data to the ARC system.

Digital Display

The level sensor comes with a single digital display. The display is mounted in the base of the sensor. The display provides a clear, 4 digit value of the tank volume in either gallons or liters. The display is also backlit for high visibility in low light conditions.

An optional, additional digital display can be mounted on the left side of the fuel tank near the fuel filler.

FUEL STORAGE FACILITIES

The presence of slime in fuel filters indicates that bacteria and fungi are present in troublesome quantities. Water in the fuel storage tanks should be kept at the lowest possible level. Contact fuel oil supplier for recommendations regarding antiseptic treatment of fuel storage facilities.

DRAINING CONDENSATE FROM THE FUEL TANK

Condensate should be drained from the locomotive fuel tank at intervals specified in the N-VIROMOTIVE Maintenance Schedule, or more frequently if conditions warrant. During draining, the locomotive should be placed on an incline with the drain end of the tank facing downhill to ensure condensate accumulation at the water drain valve and adequate drainage without loss of fuel.

FILLING THE FUEL TANK

The fuel tank can be filled from either side of the locomotive. A short sight level gauge is located next to each fuel filler. This gauge indicates the fuel level from the top of the tank to about 4-1/2” below the top and should be observed while filling the tank to prevent overfilling.

RETENTION TANK

A 100 gallon tank for retention of materials is included within the fuel tank. Drain the retention tank by means of the retention tank drain pipe assembly. First remove the plug from the end of the pipe assembly, attach the drain hose, if used, and then open the drain valve in the pipe assembly. Close the valve and replace the plug after draining the tank.

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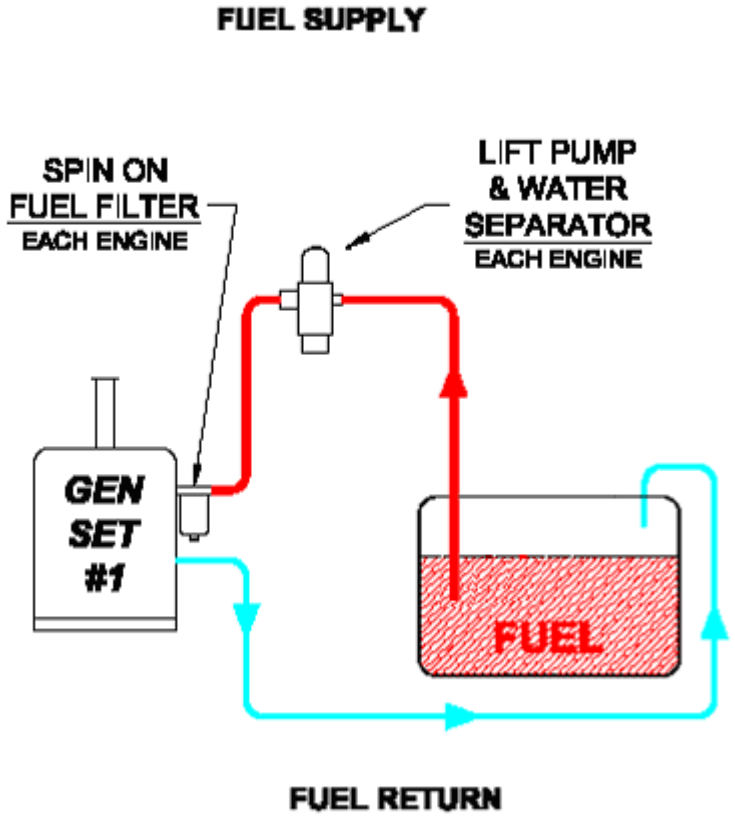

Fig. 2-4 Fuel Circuit

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DESCRIPTION

Air is taken into the carbody (equipment compartment) of the locomotive to supply air to separate systems.

1. Traction motors
2. Main electric cabinet
3. DC Choppers
4. Low Voltage Power Supply (LVPS)
5. Rectifiers
6. Inverter

Ambient air enters the equipment compartment through the filters that are located on each compartment door. There are two filters per door and four doors total per side (8 filters per locomotive). Outside air is drawn through the filters and into the blower. The blower distributes the air into the main duct located under the floor of the equipment compartment.

In addition to supplying air for cooling, air is supplied under pressure to help keep dirt from entering the main electric cabinet, the chopper compartment and the LVPS compartment.

NOTE

When the primary engine is at 1800 RPM (3rd notch and above), the blower is producing maximum air flow.

EQUIPMENT BLOWER

MAINTENANCE

1. Check the operation of the equipment blower every 3 months.

2. Foundation bolts and all set screws should be inspected for tightness.

3. Fans should be inspected for wear and dirt accumulation periodically. The fan wheel may have to be cleaned if dirt, grease, etc. has coated the wheel severely to hinder performance or operating requirements. Dirt piled in the housing should also be removed. Fan wheels having badly worn blades should be replaced. Wheels require careful balancing before being returned to service.

4. If excessive vibration or bearing temperature occurs above operating limits, corrective action must be taken immediately. It may be due to unbalance, misalignment, poor lubrication, or dirt build-up on the wheel, etc.

5. Repainting of exterior and interior parts of fans and ducts will extend the service life of the installation.

6. If the fan and/or housing require cleaning, steps must be taken to prevent cleaning materials and dirt/debris from entering the blower duct system.

Blower Assembly Troubles / Source

Capacity or Pressure Below Rating

1. Poor fan inlet or outlet conditions.
2. Air leaks in system.
3. Damaged wheel.
4. Incorrect direction of rotation.
5. Wheel mounted backwards on shaft.

Vibration and Noise

1. Bearings or wheel misaligned.
2. Unstable foundation.
3. Foreign material in fan or material build-up on the wheel causing unbalance.
4. Worn bearings.
5. Damaged wheel or motor.
6. Broken or loose bolts and set screws.
7. Bent shaft.
8. Fan wheel or drive unbalanced.
9. Speed too high or fan rotating in wrong direction.

Overheated Bearing

1. Too much grease in bearings.
2. Poor alignment.
3. Damaged wheel or drive.
4. Abnormal end thrust.
5. Dirt in bearing.

Overload on Motor

1. Wrong direction of rotation.
2. Poor alignment.
3. Wheel wedging or binding on inlet bell.
4. Motor improperly wired.

Fig. 3- 2 - Equipment Blower

AIR FILTERS

These air filters are mounted in the louvered doors of the equipment room (Fig. 3-1). These filters should be changed during the 92 day inspection.

In order for these filters to perform properly a secure fit is essential and must be checked frequently.

Fig. 3-1 - Air Filters

*= IF EQUIPPED

SERVICE DATA

CENTRAL AIR SYSTEM

FILTERS

Equipment Compartment door (30/30, 20 x 20 x 2) 155002003

Electrical Cabinet (6-1/2 x 29-3/8) 449001017

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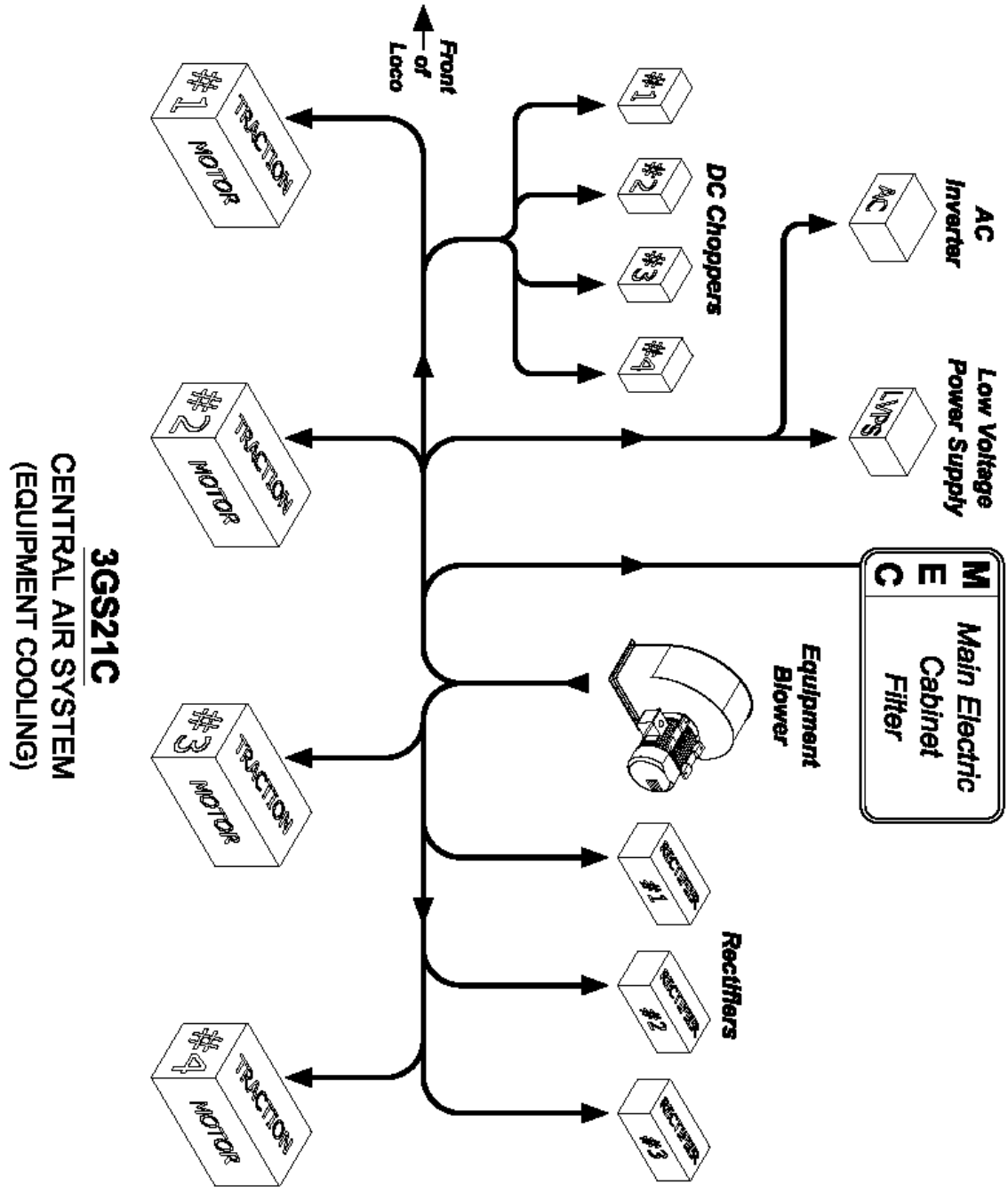

Fig. 3-3 - Air Flow

* Number of Rectifiers & Choppers May Vary Due to Model

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DESCRIPTION

Compressed air is used for operating the locomotive air brakes and auxiliary devices such as sanders, horn and windshield wipers.

AIR COMPRESSOR

Air is compressed by an air-cooled, single-stage, oil-injected screw compressor. The unit is comprised of the compressor element, an enclosed cooling fan, an oil separator, air and oil cooler, gearbox and flexible coupling. The compressor element houses two rotors mounted in a special bearing arrangement. The module is driven by a motor through the flexible coupling. Oil is injected to lubricate and seal the rotors as well as to absorb compressor heat.

AIR FLOW

Air drawn through filter (AF) and open inlet valve (IV) into compressor element (E) is compressed. Compressed air and oil flow through check valve (CV) into air receiver/oil separator (OT). The air is discharged through minimum pressure valve (Vp1) and air cooler (Ca).

Check valve (CV) prevents backflow of compressed air when the compressor is stopped.

Minimum pressure valve (Vp1) prevents the receiver pressure from dropping below a minimum pressure, needed for lubrication of compressor element (E). See Fig. 4-1.

OIL SYSTEM

In air receiver/oil separator (OT), most of the oil is removed from the air/oil mixture centrifugally. The balance is removed by oil separator element (OS). The lower part of the receiver serves as the oil tank.

Air pressure forces the oil from the oil tank through oil cooler (Co) and filter (OF) to compressor element (E).

The oil system is provided with a by-pass valve (BV1). When the oil temperature is below 75 degrees Celsius, by-pass valve (BV1) shuts off the oil supply from oil cooler (Co). Air pressure forces the oil from oil tank (OT) through oil filter (OF) and oil stop valve (Vs) to compressor element (E). Oil cooler (Co) is by-passed.

By-pass valve (BV1) starts opening the oil supply to cooler (Co) when the oil temperature has increased to the above mentioned value.

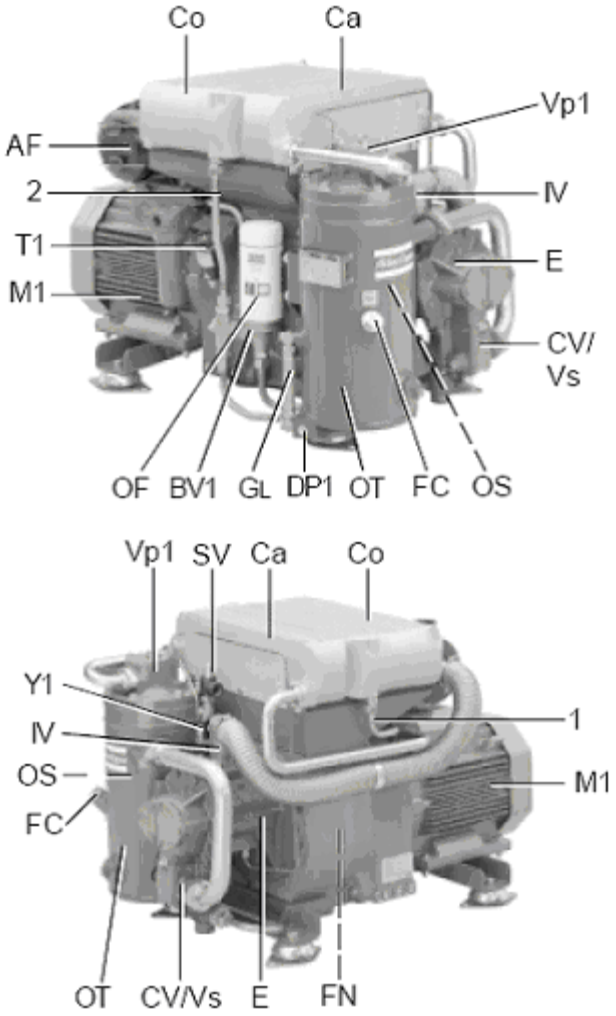
Oil stop valve (Vs) prevents the compressor element from flooding with oil when the compressor is stopped. The valve is opened by element outlet pressure when the compressor is started. See Fig. 4-1.

A heater (Hro) can be provided in the oil sump if operating in low ambient temperatures (below -25 degrees Celsius) or in high relative humidity conditions.

COOLING SYSTEM

The cooling system comprises air cooler (Ca) and oil cooler (Co). The cooling air flow is generated by the fan (FN). The cooling fan is mounted on the shaft of the motor. The cooling air is drawn in through the coolers and leaves the compressor unit via the bottom, left, or right side depending on the fan housing orientation.

* = IF EQUIPPED



AF	Air filter
BV1	Oil cooler by-pass valve
Ca*	Air cooler
Co	Oil cooler
CV	Check valve
DP1	Oil drain plug
E	Compressor element
FC	Oil filler plug
FN	Fan
Gl	Oil sight-glass
IV	Air intake valve
M1	Drive motor
OF	Oil filter
OS	Oil separator element
OT	Air receiver/oil separator
SV	Safety valve
Vp1	Minimum pressure valve
Vs	Oil stop valve
MVCC	Solenoid valve
1	Oil pipe
2	Oil pipe

Figure 4-1 - General View of Air Compressor

Operation of the Unloading/Loading System

Unloading

If the air consumption is less than the air output of the compressor, the net pressure increases. When the net pressure reaches the unloading pressure, solenoid valve (MVCC) is de-energized. The plunger of the valve returns by spring force:

1. The control pressure present in the chambers of loading plunger (LP) and unloading valve (UV) is vented to atmosphere via solenoid valve (MVCC).
2. Loading plunger (LP) moves by spring force causing inlet valve (IV) to close the air inlet opening.
3. Unloading valve (UV) is opened by receiver pressure. The pressure from air receiver/oil separator (OT) is released towards the unloader (UA).
4. The pressure is stabilized at a low value. A small amount of air is kept drawn in through valve (BV2) and is blown to the unloader.

Air output is stopped (0 %), the compressor runs unloaded.

* = IF EQUIPPED

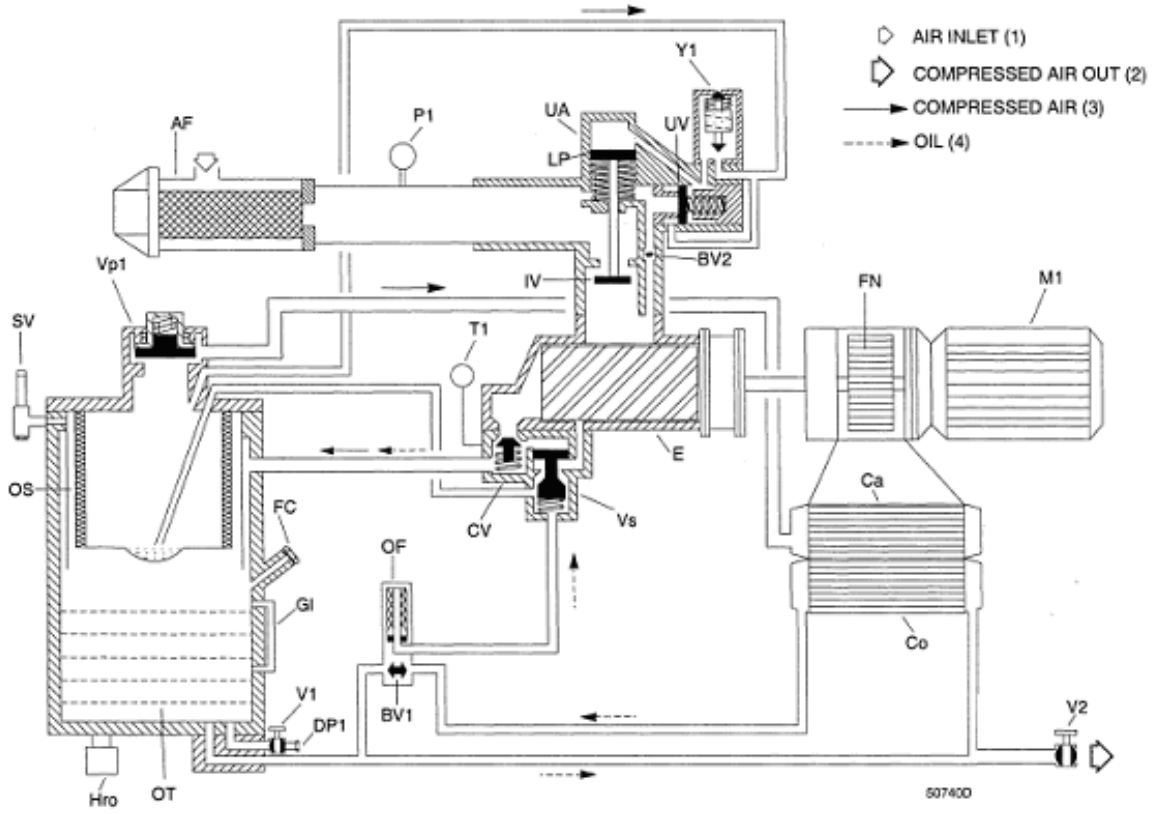
Loading

1. When the net pressure decreases to the loading pressure, solenoid valve (MVCC) is energized. The plunger of solenoid valve (MVCC) moves against spring force.

2. Control pressure is fed from air receiver/oil separator (OT) via solenoid valve (MVCC) to loading plunger (LP) and unloading valve (UV).

3. Unloading valve (UV) closes the air blow-off opening. Loading plunger (LP) moves against spring force causing inlet valve (IV) to open fully.

Air output is resumed (100 %), the compressor runs loaded.



AF	Air filter	FN	Fan	UA	Unloader
BV1	Oil cooler by-pass valve	Gl	Oil sight-glass	UV	Unloading valve
BV2	By-pass valve	IV	Air intake valve	Vp1	Minimum pressure valve
Ca	Air cooler*	LP	Loading Plunger	Vs	Oil stop valve
Co	Oil cooler	M1	Drive motor	V1	Oil drain valve
CV	Check valve	OF	Oil filter	V2	Air outlet valve
DP1	Oil drain plug	OS	Oil separator element	MVCC	Solenoid valve
E	Compressor element	OT	Air receiver/oil separator		
FC	Oil filler plug	SV	Safety valve		

Figure 4-2 - Unloading/loading system, compressor loaded

* = IF EQUIPPED

Operation of the Start/Stop System

The operation of the air compressor is regulated by the *NFORCE.* The *NFORCE* receives an electrical signal from the Main Reservoir Pressure Transducer (MRPT) proportional to the pressure of the main reservoir. When the pressure drops below 130 psi, the *NFORCE* closes contactors CC1 and CC2 to start the air compressor. After approximately 2 seconds of operation, the *NFORCE* opens contactor CC2 and approximately 50 milliseconds later closes contactor CC3. It then energizes the MVCC magnet valve to allow the air compressor to load. Once the air pressure in the main reservoir reaches 140 psi, the *NFORCE* de-energizes the MVCC magnet valve to unload the compressor. The compressor motor runs for 1 minute and if in that time period the main reservoir pressure does not drop below 135 psi, the compressor motor will shut down. If the pressure drops below 135 psi, the MVCC will be energized to allow the compressor to build main reservoir pressure to 140 psi.

Starting

After starting of the motor, air intake valve (IV) is opened fully by the pressure difference over the valve created by the rotating rotors. Air output is resumed (100 %), the compressor runs loaded.

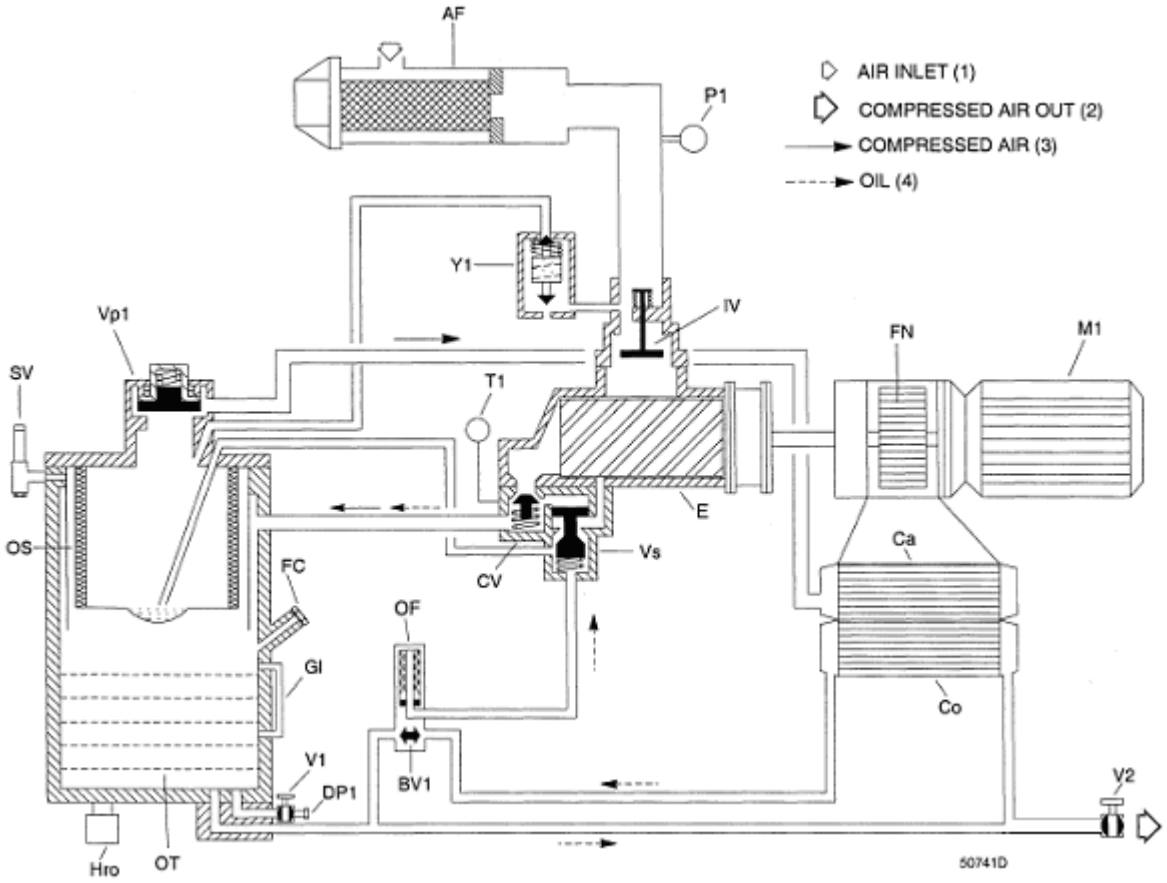
The plunger of the solenoid valve moves against spring force, closing the blow-off line.

Stopping

Air intake valve (IV) moves by spring force closing the air inlet opening. Air output is stopped (0 %).

The plunger of the solenoid valve returns by spring force, opening the blow-off line. The pressure from air receiver/oil separator (OT) is released through the solenoid valve into the housing of air intake valve (IV).

* = IF EQUIPPED



AF	Air filter	FC	Oil filler plug	OT	Air receiver/oil separator
BV1	Oil cooler by-pass valve	FN	Fan	SV	Safety valve
Ca	Air cooler*	Gl	Oil sight-glass	Vp1	Minimum pressure valve
Co	Oil cooler	IV	Air intake valve	Vs	Oil stop valve
CV	Check valve	M1	Drive motor	V1	Oil drain valve
DP1	Oil drain plug	OF	Oil filter	V2	Air outlet valve
E	Compressor element	OS	Oil separator element	MVCC	Solenoid valve

Figure 4-3 - Start/stop system, compressor loaded

* = IF EQUIPPED

MAINTENANCE

ATTENTION:

Before carrying out any maintenance or repair on the compressor, press an emergency fuel cutoff switch and open the 64VDC battery switch. Close the air outlet valve and depressurize the air system.

MAINTENANCE SCHEDULE

Consult the N-VIRO Maintenance Schedule for service intervals. The schedule comprises a summary of the maintenance instructions. Read the related section before taking maintenance measures.

OIL AND OIL FILTER CHANGE

1. Run the compressor until warm. Stop it and close the compressor outlet valve. Switch off the power. Wait a few minutes. Depressurize the oil system by opening oil filler plug (FC) one turn to permit any pressure to escape.

2. Remove plug (DP1). Drain the oil by opening drain valve (V1). Collect the oil in a collector and deliver it to the local oil collection service. Close the valve and reinstall the plug. Drain the cooler, if possible.

3. Remove the oil filter (OF).

4. Clean the filter seat on the manifold. Oil the gasket of the new element. Screw the element into place until the gasket contacts its seat, and then tighten by hand (approx. half a turn).

5. Remove plug (FC) and fill receiver/oil separator (OT) with oil until the level reaches the filler neck. Take care that no dirt drops into the system. Fit and tighten plug (FC).

6. Run the compressor for a few minutes. Stop the compressor and wait a few minutes to allow the oil to settle. Depressurize the system by opening oil filler plug (FC) one turn to permit any pressure to escape. Remove filler plug (FC) and fill with oil until the level reaches the filler neck. Reinstall and tighten plug (FC). Open the compressor outlet valve.

OIL SEPARATOR CHANGE

1. If the oil and oil filter are also to be changed, first carry out steps 1 up to 4 of the OIL AND OIL FILTER CHANGE section.

2. Stop the compressor, close the compressor outlet valve and depressurize the oil system by opening oil filler plug (FC) one turn to permit any pressure to escape. Switch off the power.

3. Remove the oil separator cover (6 bolts).

4. Remove oil separator element (OS).

5. Clean the oil separator compartment (if necessary).

   If the oil separator compartment is wet on the inside (moisture), the compressor element may be operating at too low temperatures. Consult NREC.

   If the bottom cup of the oil separator element is completely filled with oil, the oil scavenging line is clogged. Inspect the parts and replace, if necessary.

6. Fit a new oil separator element.

7. Refit the cover. Use two new O-rings.

8. If the oil and the oil filter are changed: carry out steps 5 and 6 of the OIL AND OIL FILTER CHANGE section. Check for leaks.

AIR FILTER

Inspecting

If the cartridge is excessively dirty, the change interval should be adapted. Always replace dirty or damaged elements.

Replacing

1. Stop the compressor. Switch off the power. Release the clips and remove the cover.
2. Unscrew the nut and take out the filter element.
3. Remove the dust from the cover.
4. Fit the new filter element.
5. Refit the cover. Observe the indication “TOP” (if applicable).

COOLERS

Keep the coolers clean to maintain the cooling efficiency.

Remove any dirt from the coolers with a fibre brush. Never use a wire brush or metal objects. Then clean by air jet in reverse direction of normal flow. If it is necessary to wash the coolers with a cleansing agent, consult NREC.

SAFETY VALVE

Operating

Operate the safety valve by unscrewing the cap one turn and retightening it or by pulling the valve lifting lever, depending on the type of valve.

Testing

Safety valves can be tested in the workshop for correct opening pressure.

Important

No adjustments are allowed. Never run the compressor without safety valve.

1. Stop the compressor. Close the outlet valve and switch off the power. Open plug (FC-Figure 4-3) one turn to permit any pressure to escape.
2. Remove the safety valve and replace it by a tested one, so that the compressor may be restarted.
3. Fit the valve to a pipe to which an accurate pressure gauge is fitted.
4. Connect the pipe to a depressurized part of the compressed air net via a pressure regulator.
5. Pressurize the valve gradually while observing the pressure gauge.
6. The valve should not leak until the opening pressure is reached (maximum allowed tolerance is 7.25 psi or 0.5 bar).
7. If the valve does not open at a pressure of 167 psi (11.5 bar), consult NREC or replace the valve.

BY-PASS VALVE

When the oil temperature is below 50 degrees Celsius, start the compressor. Measure the temperature of pipe 1, Figure 4-1.

1. This pipe should remain more or less cold until the oil temperature reaches approx. 75 degrees Celsius.
2. Replace the by-pass valve if it opens too quickly. Observe the correct direction of mounting.

PROBLEM SOLVING

MECHANICAL FAULTS AND SUGGESTED REMEDIES

1. Compressor starts running, but does not deliver air
   a. Solenoid valve (MVCC) out of order
      - Have valve inspected
   b. Air intake valve (IV) stuck
      - Consult NREC

* = IF EQUIPPED

c. Minimum pressure valve (Vp1) leaking (when net is depressurized)
   - Have valve checked

2. Compressor air output or pressure below normal
   a. Air consumption exceeds air output of compressor
      - Check equipment connected
   b. Choked air inlet filter element (AF)
      - Replace filter element
   c. Air intake valve (IV) does not fully open
      - Have valve checked
   d. Oil separator element (OS) clogged
      - Have element replaced
   e. Air leakage
      - Check and correct as necessary
   f. Safety valve (SV) leaking
      - Have valve replaced
3. Safety valve (SV) blows
   a. Minimum pressure valve (Vp1) malfunctioning
      - Have valve checked
   b. Oil separator element (OS) clogged
      - Have element replaced
   c. Safety valve (SV) out of order
      - Have valve replaced
   d. Pressure switch not functioning
      - Check and replace if necessary
   e. Discharge line clogged
      - Clear debris from line
4. Element outlet or air outlet temperature above normal
   a. Insufficient cooling air or cooling air temperature too high
      - Check for cooling air restriction or improve ventilation of compressor compartment. Avoid recirculation of cooling air. If installed, check capacity of compressor room fan
   b. Oil level too low
      - Check and correct as necessary
   c. Coolers (Co/Ca) clogged
      - Clean cooler block
   d. By-pass valve (BV1) malfunctioning
      - Have valve tested
5. Excessive oil consumption; oil carry-over through discharge line
   a. Oil level (Gl) too high
      - Check for overfilling. Release pressure and drain oil to correct level
   b. Incorrect oil causing foam
      - Change to correct oil
   c. Oil separator element (OS) defective
      - Have element checked. Replace, if necessary
6. Compressor does not blow off and cannot restart
   a. Solenoid valve (MVCC) stuck in closed position
      - Check solenoid valve, replace if necessary. Also check control pipe to valve for leakage

MAIN RESERVOIR AIR FILTERS

DESCRIPTION

The compressed air system has two centrifugal type filters, the main reservoir and auxiliary main reservoir filters. Both the main reservoir and auxiliary main reservoir filters are equipped with an automatic electric drain valve which operates on a signal from the *NFORCE*.

MAINTENANCE

The auxiliary main reservoir centrifugal filter contains a replaceable type filter element which should be changed at intervals stated in the applicable N-VIRO Maintenance Schedule. See Service Data for correct filter element.

Before removing the sump bowl on the bottom of the filter, be sure the cutout located between the main reservoir and the filter is shut off. Once the sump bowl is removed, the element can be removed by unscrewing the wing nut that holds the element in place.

The sump bowl on both the centrifugal filters may be cleaned out if necessary by removing the bowl. The drain valves should be cleaned and inspected when maintenance is performed on the filters as stated in the N-VIRO Maintenance Schedule.

MAIN RESERVOIR DRAIN VALVES

DESCRIPTION

The No. 1 & No. 2 main reservoirs are equipped with a combination automatic/manual drain valve. When set on automatic, it operates as the compressor loads or unloads to allow moisture to be drained from the reservoir before it is carried into the air system.

MAINTENANCE

The seat of each drain valve needs to be checked regularly to ensure there are no air leaks. Both the seals and the pistons must be greased periodically.

DRAINING THE AIR SYSTEM

It is recommended that both the MR filters and drains be operated manually once a day to make certain of the operation of the automatic function.

AIR BRAKE EQUIPMENT

CCB26 AIR BRAKE SYSTEM*

The N-Viro locomotives can be equipped with type CCB26 air brake equipment (Fig 4-9). The system is a microprocessor based electro-pneumatic brake control system. Equalizing Reservoir, Brake Pipe Control and Independent Application and Release Pipe control are managed by computer electronics. Brake Cylinder control is fully pneumatic and Actuating Pipe control is electro-pneumatic. The system does not include Passenger mode (graduated release) functionality.

The CCB26 system controls Lead/Trail functions and brake pipe cut-in and cut-out through the use of rotary selector knobs mounted on the Driver's Brake Valve (EBV).

The system includes standard penalty pipe logic for 3-pipe suppressible penalty requests, 10-pipe non-suppressible penalty requests and 26-pipe suppression functionality.

EPCU

The CCB26 system is comprised of distributed electronics that are linked via a network. The electro-pneumatic control unit (EPCU), Figure 4-4, consists of modularized line replaceable units (LRU's) that control the development of all pneumatic control pressures.

Four of the LRU's are 'intelligent' and communicate via the network. They are:

Brake Pipe Control Portion (BPCP) - The primary function of the brake pipe control portion is supply, exhaust, maintaining and cut-off of trainline brake pipe. The BPCP includes the brake pipe relay valve, emergency magnet valve and vent valve, and brake pipe cut-out function as well as break-in-two detection and brake pipe pressure sensing.

Equalizing Reservoir Control Portion (ERCP) – The primary function of the ERCP is control of the brake pipe relay. The ERCP controls equalizing reservoir pressure. The pneumatic and electrical control portions of the ERCP include emulation of the #3, #10, and #26 pipes. Optional penalty magnet valves can be piped to the manifold #3 pipe port for suppressible penalties, and to the #10 pipe port for non-suppressible penalties. In this manner, the penalty interface is identical to a 26L pneumatic braking system.

20 Control Portion (20CP) – The 20CP provides independent application and release pipe pressure.

Relay Control Portion (RCP) – Mounted on the EPCU, the RCP contains the systems relays, and provides discrete signal interface to Locomotive controls and sanding equipment.

* = IF EQUIPPED

The EPCU also contains:

Brake Cylinder Control Portion (BCCP) - The brake cylinder control portion provides brake cylinder pressure based upon the level of pipe 16 and pipe 20 pressures. Various BCCP portions are available depending upon the required brake ratio of the applied locomotive. The example in Table 4-1 lists typical BCCP applications and pressures for reference only.

Table 4-1 - Typical BCCP applications and pressures for reference only

Brake Application	Single Shoe (psi)
Min Brake	10-16
Full Service BC Pressure	58-64
**Emergency BC Pressure	70-82
Full Independent BC pressure	68-74
20 pipe pressure	42-48

Pressures indicated above are for reference only
***- Emergency BC pressure determined by ELV setting*

DB Triple Valve Portion (DBTV) – The DBTV develops brake cylinder pilot pressure during service brake applications, sensed by reduction of brake pipe pressure.

Power Supply Junction Box (PSJB) – Contains the EPCU power supply.

13 Control Portion (13CP) – Provides Bail Off (Actuating) pipe pressure.

Penalty Control Portion (PCP) – Used on Single Pipe Systems instead of a 13CP. Provides Split Penalty Functions.

16 Control Portion (16CP) – Provides brake cylinder limiting and brake cylinder assurance in emergency.

Figure 4-4 - EPCU

EBV

The operator commands the computer through the Electronic Brake Valve Controller (EBV, Driver's Brake Valve) Fig. 4-5. The EBV is also on the network and signals the handle position for Automatic and Independent

* = IF EQUIPPED

braking. An exception is the initiation of an emergency brake application which is propagated mechanically through a vent valve by placing the automatic handle into the Emergency position.

Equalizing Reservoir (ER) pressure is set via a normally centered switch with momentary positions on each side of center located at the top of the EBV.

Lead/Trail Mode and Cut-In and Cut-Out functions are provided on the EBV via a 3 position selector switch located at the bottom of the EBV.

Figure 4-5 - Vertical (Bulkhead) EBV

The CCB26 system performs several diagnostic functions.

Faults are enunciated to the operator via an LCD screen mounted on the Driver's Brake Valve (EBV). This screen is also used for routine advisory instructions such as penalty reset and emergency reset.

Emergency Brake Valve

The emergency brake valve is located in the left side of the cab by the entry door. When operated, this valve will initiate an emergency brake application.

Setting up the CCB26 Brake System

The CCB26 brake system may be set-up in Lead (brake pipe cut-in or cut-out) or in Trail (brake pipe cut-out). The system is set-up via the EBV's 3 position selector switch.

There are five modes of operation for the CCB26 Electronic Air Brake (EAB) system. They are:

- LEAD CUT-IN or SINGLE UNIT - Independent brake control is available via the electronic brake valve (EBV) Independent handle. Equalizing reservoir (ER) control is available via the EBV Automatic handle. The brake pipe pressure is 'Cut-In' and follows equalizing reservoir pressure. When the Auto handle is moved to Release (REL), ER and brake pipe (BP) will charge to the ER release pressure determined during Air Brake setup.

- LEAD CUT-OUT - Independent brake control is available via the EBV Independent handle. ER control is available via the EBV Automatic handle. The brake pipe pressure is 'Cut-Out' and is not controlled by equalizing reservoir pressure. Automatic brakes apply and release in response to trainline brake pipe pressure reductions and increases.

- TRAIL CUT-OUT - Equalizing reservoir is exhausted. The brake pipe pres sure is 'Cut-Out' and is not controlled by equalizing reservoir pressure. Independent brakes apply only in response to pressure in the Independent Application and Release (IA&R) pipe. The EBV will not respond to handle movement except to create an emergency application when the Auto handle is moved to 'EMER'. Automatic brakes apply and release in response to trainline brake pipe pressure reductions and increases.

- DEAD-IN-TRAIN - The EAB system is unpowered and the locomotive is being towed in a train (away from a controlling consist). Brakes will apply same as a freight car.

- DEAD-IN-CONSIST - The EAB system is unpowered and the locomotive is within the controlling consist. Brakes will apply same as a freight car. Independent brakes will also apply via IA&R pipe. Auto brakes may be bailed off.

LEAD CUT-IN OR SINGLE UNIT

NOTE

If Lead locomotive is in MU with other locomotives, ensure all trailing units are in 'TRAIL' and not in 'Emergency' before attempting to set lead locomotive up in 'LEAD' operation.

1. Place Auto handle in Release 'REL' (this will ensure that an EMERGENCY application does not occur) and Independent handle in 'FULL' application.

2. Place Reverser handle in 'Neutral'.

3. Turn Mode switch on EBV to indicate Lead.

4. The EBV screen displays the following message: "MODE CHANGE; MODE =LEAD CUT-IN".

5. Check for proper Equalizing Reservoir pressure on EBV screen display (ER psi should equal specified railroad operating pressure). If it doesn't, turn knob on EBV to raise or lower the ER pressure as needed.

NOTE

Pushing the knob momentarily to the "Inc." position will increase the ER set pressure by 1 psi. Holding the knob in the "Inc." position continuously will cause a higher rate of increase until the knob is released. The "Dec." position causes ER to decrease in a similar manner.

6. Observe Brake Pipe has charged to ER pressure (BP should be within ± 2 psi of ER).

7. Independent and Automatic brakes are now 'Cut-In'. Auto 'Service' brake, 'Emergency' application, and Independent handle operation is now available.

LEAD CUT-OUT OR HELPER UNIT

NOTE

Ensure all units are in 'TRAIL' and not in 'Emergency' before attempting to set up in LEAD CUT-OUT. Make sure BP, MR, A&R, and Actuating hoses are connected between Lead Cut-Out unit and trailing units.

1. Place Auto handle in 'CS/HO (Continuous Service/Handle Off)' and Independent handle in FULL' application.

2. Place Reverser handle in 'Neutral'.

3. Turn Mode switch on EBV to indicate Lead Cut-Out.

4. The EBV screen displays the following message: "MODE CHANGE; MODE = LEAD CUT-OUT".

5. Independent brakes are now 'Cut-In' and Automatic Brakes are 'Cut-Out'. Auto 'Service' brake is disconnected but an 'Emergency' application and Independent handle operation are still available.

TRAIL CUT-OUT

1. Ensure Throttle handle is in 'IDLE' and Reverser handle is in 'Neutral'. Remove Reverser handle.

2. Place Independent handle in 'REL' and Auto handle in 'Handle Off (HO)' position.

3. Turn Mode switch on EBV to indicate Trail.

4. The EBV screen displays the following message: "MODE CHANGE; MODE =TRAIL CUT-OUT".

5. Observe ER pressure reduces to zero psi.

6. Auto and Independent brakes are now Cut-Out.

NOTE

'EMERGENCY' is the only handle position that is functional on the EBV. Brakes will apply same as a freight car.

7. Ensure BP, MR, A&R and Actuating hoses are connected.

8. Open BP, MR, A&R, and Actuating ball valves starting at the head unit and continuing on down the consist until all remaining ball valves are open.

DEAD IN TRAIN

1. Ensure Throttle handle is in 'IDLE' and Reverser handle is in 'Neutral'. Remove Reverser handle.

2. Place Independent handle in Release 'REL'and Auto handle in 'Handle Off (HO)'.

3. Set handbrake, turn AB circuit breaker off and make sure that Brake Pipe is connected to preceding unit.

WARNING:

ANGLE COCKS ON INDEPENDENT APPLICATION AND RELEASE (20 PIPE) AND ACTUATING (13 PIPE) MUST BE OPEN TO PREVENT TRAPPING AIR PRESSURE THAT CAN CAUSE AN UNDESIRED BRAKE APPLICATION.

NOTE

At this point, engine should be run as a 'Dead' locomotive per railroad guidelines.

4. Drain MR air pressure.

5. Open brake bay door and drain all quick disconnect nipples on all control portions.

6. Cut wire or release locking mechanism on ERCP dead engine fixture handle, and switch it to 'IN/OPEN' position.

7. Slowly open BP angle cock to prevent a 'Emergency' application. MR will charge (approximately 15-20 minutes) to a preset pressure determined by the railroad.

8. Release handbrake.

NOTE

'EMERGENCY' is the only handle position that is functional on the EBV. Brakes will apply same as a freight car.

DEAD IN CONSIST

1. Ensure Throttle handle is in 'IDLE' and Reverser handle is in 'Neutral'. Remove Reverser handle.

2. Turn AB circuit breaker off and make sure that brake pipe is connected to preceding unit.

3. Ensure BP, MR, A&R and Actuating hoses are connected.

EQUALIZING RESERVOIR SETUP

Equalizing Reservoir (ER) setup is accomplished via the EBV-mounted normally centered switch with momentary positions on each side of center. When the switch is held in either the increase or decrease position, the set pressure will change in 1 psi increments at an initial rate of 1 psi per second. If the switch is held in the same position for longer than 5 seconds, the rate will increase to 5 psi per second, with incremental changes occurring at multiples of 5 psi. ER operating range is 60 - 110 psi; the system will ignore increment/decrement requests outside this range. Position changes of this switch in trail or when the automatic handle is not in release will be ignored.

CALIBRATING THE CCB26 BRAKE SYSTEM

The following instructions are intended to familiarize the user with the calibration procedures for CCB26 EAB (Electronic Air Brake) System. They include: Flow calibration, Gauge calibration, and Electronic Brake Valve (EBV) Controller calibration instructions.

EQUIPMENT REQUIRED

1. Wheel Chocks.
2. Calibrated Air Gauge (Digital, 1-200 psi ‘or’ Analog, 0-160 psi w/1 psi increments)
3. Calibrated Flow Orifice (0.220" - 0.228")

SETUP OF THE SYSTEM

1. Set the hand brake and chock the locomotive’s wheels.

2. Ensure that the Air Brake (AB) Circuit Breaker is in the ‘ON’ position.

3. Isolate the locomotive by removing Trainline Multiple Unit (MU) Cable and closing all MU Train end cocks. Set locomotive to ‘Lead \ Cut-In’ operation.

4. Make sure the Throttle handle is in the ‘IDLE' position and the Reverser handle is in the ‘Neutral’ position.

5. Ensure the locomotive compressor is operative, Main Reservoir is charged (130 psi, minimum) and brake pipe (BP) is charged to 90 psi (this may require feed valve to be set above 90 psi).

Flow Calibration

1. Verify flow orifice serial number and install calibration flow orifice onto the brake pipe hose glad hand on short hood end of locomotive. Set Independent EBV controller handle to ‘FULL’ and Auto handle to ‘REL’.

2. Secure BP hose and slowly open brake pipe angle cock (open cock slowly to prevent an emergency application). If an Emergency application does occur, place the Automatic brake handle in ‘Emergency’. Recover Emergency by waiting for the Emergency message to ‘timeout’ on the Main Operating screen and then place the Auto brake handle to ‘Release’.

NOTE:

While brake pipe angle cock is open, make sure that BP pressure is set to 90 psi on the BP gauge. If it is not, make necessary adjustment to feed valve setting in order to achieve BP pressure of exactly 90 psi (see Chapter 2, section F).

3. Observe flow indication on the flowrator. If flow reads 5 psid at 130 psi main reservoir no recalibration is required. If flow meter does not indicate 5 psid, calibrate flowmeter per manufacturer’s instructions.

Gauge Calibration

1. Install reference digital gauge on ERTP fitting on ERCP.

2. Place Automatic handle in REL.

3. Compare digital gauge to operator gauge. Recalibrate as necessary per standard railroad operational procedure.

4. Repeat comparing BPTP to BP operator gauge and BCTP to BC operator gauge.

Maintaining the CCB26 Brake System

The CCB26 Brake system requires little periodic maintenance. To keep the system performing optimally, refer to the N-VIRO Maintenance Schedule. Refer to the Service Data for the replacement filters.

TROUBLESHOOTING CCB26 ELECTRONIC AIR BRAKE SYSTEM

The following table identifies locomotive trouble symptoms related to Electronic Air Brake (EAB) operation. Troubleshooting steps are listed for each symptom and should be followed in numbered sequence.

Table 4-2 – Troubleshooting CCB26 Electronic Air Brake System

Symptom	Troubleshooting Steps
An 'Air Brake Fault' is posted on the EBV's LCD display screen.	The crew message fault display will include a three digit failure code (immediately following text). Note the three digit failure code and refer to CCB26 EBV CREW MESSAGES for corrective actions.
Power cutoff switch (PCS) does not clear. Or Cannot release brakes.	1) Place Automatic brake handle in Suppression (SUP) and wait for penalty to clear. If a 'Fault XX Active' message appears, it will be necessary to reset the source of the penalty (cab signal, ATP, alerter, etc.). Check Main Reservoir Gauge to insure air is being supplied to the brake system. After any penalties are reset, move the Automatic brake handle to Release (REL). Check to see if both ER and BP pressures rise. If ER rises and BP does not, see symptom 'Cannot charge brake pipe'. If ER and BP rise, but PCS still does not reset, go to step 2. 2) Ensure throttle handle is in 'IDLE' position and reverser handle is centered. Place the Automatic handle in Suppression (SUP). Power cycle the Electro-Pneumatic Control Unit (EPCU). If problem persists, an 'Emergency' or 'Penalty' source is active and must be cleared. If BP can be charged but PCS can not reset, replace the RCP. If problem persists, replace BPCP.
Cannot charge brake pipe.	1) Ensure locomotive set-up is 'Lead Cut-In' (see Chapter 2 for Set-Up instructions), and isolated from other locomotives and cars. Move Automatic brake handle to release (REL). Ensure ER charges to release setting (60 - 110 psi). If ER does not charge, see symptom 'Power cutoff switch (PCS) does not clear'. 2) Isolate locomotive (close end angle cocks) and repeat step 1. If BP charges now but wouldn't before, check train for leakage or de-coupling. 3) Place Electronic Brake Valve (EBV) Automatic handle 'sharply' into and out of emergency 'EMER' position at least ten times. Reset emergency and move Automatic brake handle to release (REL). If BP pressure rises, the problem was a stuck 21 vent valve on the EBV. 4) If BP rises partially toward ER but fails to reach ER (and a blow of air is heard at EPCU), replace BPCP (there may be contamination in the relay or emergency valve). If problem persists, replace locomotive vent valves.
Automatic brake cannot be bailed off on the locomotive.	1) Ensure Actuating pipe angle cocks are closed. 2) Ensure EBV's mode selector switch is set to "Lead Cut-In". 3) Replace 13CP. If problem persists, replace 20CP.
Automatic brake doesn't bail off when dynamic braking is achieved.	1) Put locomotive in dynamic brake position 1 and ensure voltage is present at power supply junction box (PSJB). Measure voltage at cable connector to J102, pins 'C' and 'E'. If no voltage is present, problem is outside of air brake system. If voltage is present, replace the LRU with the DBI magnet valve mounted on it. (BCCP or DBTV, depending on the system) 2) If problem persists, replace PSJB (MOV failure) or LON cable.

* = IF EQUIPPED

CCB26 EBV Crew Messages

The following messages are transmitted to the EBV display. These crew messages are provided to assist the operator in operating the brake system. They are not intended to be maintenance instructions.

Table 4-3 – CCB26 EBV Crew Messages

Line 1	Line 2	Meaning
WAIT	Powering Up	The system is booting up.
Set Hand Brake	PTU is ON	PTU disabled the brakes
Unable to Boot	Service xxCP	During power-up a problem was detected with the xxCP. Perform maintenance.
Unable to Boot	S/W Mismatch	Display when software version check fails on power-up
Fireman Emer	Put Auto in Emer	Display if emer and handle < emer
Operator Emer	Put Auto in Emer	Display if emer and handle < emer
Trainline Emer	Put Auto in Emer	Display if emer and handle < emer
Fireman Emer	Wait	Display if in emergency and handle in Emer., and timer < 60 sec.
Operator Emer	Wait	Display if in emergency and handle in Emer., and timer < 60 sec.
Trainline Emer	Wait	Display if in emergency and handle in Emer., and timer < 60 sec.
Faulty Penalty	Put Auto in Supp	Display if penalty and auto is < Supp
Safety Penalty	Put Auto in Supp	Display if penalty and auto is < Supp
Faulty Penalty	Keep in Supp	Display if in penalty and handle in Supp., and timer < 10 seconds
Safety Penalty	Keep in Supp	Display if in penalty and handle in Supp., and timer < 10 seconds
Fault xx Active	Shut AB Off	
Fault xx Active	Check BC Gauge	Display when fault 23 is active.
Fault xx Active	Trail Use Only	Display when a disabling fault is active.
Fault xx Active	Ind Full or Rel	Display when fault 20 is active.
Okay to Run	Service Soon - xx	Display when a non-critical fault is active.
WAIT - recharging	Reservoirs	Display until auxiliary reservoir is 98% charged, based on a formula developed from actual hardware performance. Only displayed while auto = REL.
Okay to Run	ER Target = xx psi	This is the default screen.
Flow = xxx SCFM	ER Target = xx psi	Alternate (optional) default screen for systems w/o pneumatic flowmeter.

CCB26 EBV Crew Message Fault Code Diagnostics

CCB26 diagnostic fault codes are reported to the operator on the EBV's LCD display screen. The three digit fault codes will be displayed as part of an air brake crew message. Fault codes are displayed at the end of a crew message. For example: the following crew message:

Would indicate fault code '001'. Refer to Table 4-4 for corrective actions.

NOTE

Only one 'Fault' can be displayed in an EBV crew message at any given time, even though multiple faults may be active. The user can access the 'LRU Fault Summary' list from the PTU Tool.

Diagnostics will be incorporated in accordance with the table below. Crew messaging will be limited to those listed in Table 4-3.

* = IF EQUIPPED

Table 4-4 – EBV Crew Message Fault Codes

Fault Code	Description	Detected By	Reason for Fault	Corrective Action	If Still Bad, Try:
001	ERCN Fault	RCP, BP	Loss of ERCN heartbeat for 4 seconds	Insure LON Cable is positively seated at ERCP. Cycle AB circuit breaker.	If not corrected, must be used in Trail Mode until repair. Replace ERCP at shop.
002	ERCP AW4 Fault	ERCP	ER > 120 or pressure not within +/- 5 psi in 10 seconds.	Place mode switch in TRAIL, Automatic handle in EMER, and Independent handle in FULL to clear fault.	If not corrected, must be used in Trail Mode until repair. Replace ERCP at shop.
005	MVER De-energized Closed	ERCP	Output feedback indicates de-energized	Must be used in Trail Mode until repair. Replace ERCP.	
010	BPT Fault	BRCP	Transducer output voltage > 4.5 or < 0.5.	If fault remains after power cycling AB circuit breaker, replace BPCP at next shopping. Set power off and us e in pneumatic backup until repair.	
016	BPCN Fault (BP Comm Loss)	EBV, ER	Loss of BPCN heartbeat for 4 seconds.	Inspect LON cable connection to BPCP on the EPCU and tighten as needed. Cycle AB circuit breaker.	Check for yellow light on BP control node. If steady or blinking, reprogram or replace BPCP. If red light remains on after power cycle, replace BPCP. Must be used in Trail Mode until repair.
055	20CP AW4 FAULT	20CP	Pressure not within +/- 5 psi in 10 seconds.	Place Mode switch to TRAIL, Automatic handle in EMER, and Independent handle in FULL to clear fault.	If fault remains use in Trail Mode until repair. Replace 20CP.
062	20CN Fault (20 Comm Loss Fault)	EBV	Loss of 20CN heartbeat for 10 seconds.	Insure LON cable is positively seated at 20CP. Cycle AB circuit breaker. If fault remains, set ABCB off and use in trail on pneumatic backup.	Check for yellow light on 20 control node. If steady or blinking, reprogram or replace 20CP. If red light remains on after power cycle, replace 20CP.
075	Automatic Handle Open	EBV	Potentiometer output voltage < min.	Set to trail. Replace EBV	
076	Ind Handle Open	EBV	Potentiometer output voltage < min.	Set to trail. Replace EBV	
085	EBVCN Fault	ER, BP	Loss of EBVCN heartbeat for 6 seconds.	Insure LON cable is positively seated at EBV connector and PSJB J100. Cycle AB circuit breaker.	Check for yellow light on EBV control node. If steady or blinking, reprogram or replace EBV. If red light remains on after power cycle, replace EBV.

* = IF EQUIPPED

26L AIR BRAKE EQUIPMENT*

The 26L brake equipment (Fig. 4-10) when used on a road switcher type locomotives consist primarily of the automatic and independent brake valves, the brake valve cutoff valve, control air valve, and the MU-2 valve. Details of this equipment vary on different railroads to meet specific operating requirements.

A dead engine feature is also part of the 26L air brake equipment. The dead engine cutout cock and pressure regulator are accessible from outside the locomotive through side doors provided. The pressure regulator is set by maintenance personnel and is not to be set by the operator.

AUTOMATIC BRAKE VALVE HANDLE

The automatic brake valve has six positions: RELEASE, MINIMUM REDUCTION, SERVICE, SUPPRESSION, HANDLE OFF, and EMERGENCY.

RELEASE POSITION

The RELEASE position is located to the extreme left and causes the brake valve to charge the brake pipe at the control air valve setting without the liability of overcharge.

MINIMUM REDUCTION POSITION

The MINIMUM REDUCTION position provides a reduction of approx. 6-8 psi pressure in the equalizing reservoir which also causes the same reduction in the brake pipe pressure. This position is located with the handle against the first raised portion on the quadrant to the right of release position.

SERVICE ZONE

SERVICE position is the area of movement starting at the MINIMUM REDUCTION position and continues till it ends at the FULL APPLICATION position. Brake application is increased as the handle is moved to the right through this area.

SUPPRESSION POSITION

The SUPRESSION position is located to the right of RELEASE position against the second raised portion of the valve and provides full braking effort as well as suppression of the overspeed and safety controls.

HANDLE OFF POSITION

The HANDLE OFF position is located to the right of SUPPRESSION position against the third raised portion of the valve. This position is used for the trailing units in a consist or for hauling a locomotive DEAD in train.

EMERGENCY POSITION

The EMERGENCY position is the extreme right position of the brake valve handle in which the brake pipe is vented as rapidly as possible to induce an emergency brake application.

INDEPENDENT BRAKE VALVE HANDLE

The independent brake valve is the self-lapping type with 2 positions: RELEASE and APPLICATION. This is located directly underneath the automatic brake valve.

RELEASE POSITION

The RELEASE position is located to the left and will release the locomotive’s brakes as long as the automatic brake handle is also in the RELEASE position.

If the handle is pushed downward while in this position, the any automatic brake application existing on the locomotive will be released.

* = IF EQUIPPED

FULL APPLICATION POSITION

The FULL APPLICATION position is located by moving the handle from left to right through the service zone. As the handle is moved further to the right, the locomotive brake application increases until maximum effort is obtained.

If the handle is pushed downward while in the service zone, brake application will be released by the amount indicated by the position of the independent brake handle.

MULTIPLE UNIT VALVE

There are three different types of multiple unit valves, but all allow the air brake equipment to be controlled by that of another unit.

The two position valve type has a “LEAD or DEAD” and a “TRAIL 26 or 24” positions.

The three position multiple unit valves have two variations identified by the color of the text on the nameplate.

The black lettered nameplate valve has the “LEAD or DEAD”, “TRAIL 6 or 26”, and “TRAIL 24” positions.

The red lettered nameplate valve has the “LEAD or DEAD”, “TRAIL 6”, and “TRAIL 26 or 24” positions.

CUT-OFF PILOT VALVE

The cut-off pilot valve is located directly underneath the automatic brake handle and has an OUT position used for hauling the locomotive “DEAD” in a consist and IN position for using the locomotive as a controlling unit.

There is a variation of the cut-off pilot valve that has an OUT, FRT (freight), and PASS (passenger) position.

It is still operated by pushing in and turning the indicator to the desired setting.

TRAINLINE AIR PRESSURE ADJUSTMENT VALVE

The trainline air pressure adjustment valve is used to obtain the desired brake pipe pressure and is maintained against overcharging or leaking by the automatic brake valve.

BEING CUT OUT

1. The automatic brake handle should be moved to SERVICE position and a 20 lb reduction of brake pipe pressure should be completed.
2. Once the brake pipe exhaust ceases, the cut-off valve needs to be moved to the OUT position..
3. Place independent handle in REL and auto handle in HANDLE OFF (HO) position.
4. Place the multiple unit valve in the necessary TRAIL position.
5. The throttle must be placed into the IDLE position while the reverser handle is put into NEUTRAL and removed to lock the controls.
6. Place all switches in the off position. Be absolutely certain that the control and fuel pump switch, generator field switch, and engine run switch are in the off position.
7. At the engine control panel, place headlight control switch in proper position for trailing unit operation. Place other switches on as needed.
8. After completing the operations outlined in the proceeding steps, move to the cab of the new lead unit.

BEING CUT IN

1. The generator field switch must be in the OFF position.
2. The reverser handle must be inserted, but remain in the NEUTRAL position.
3. Place auto handle in REL (this ensures that an EMERGENCY application does not occur) and independent handle in FULL application.

* = IF EQUIPPED

4. Put the cut-off valve into the IN position (if the unit has a three position valve, it must be in either the FRT or PASS depending on the consist).
5. The multiple unit valve must be placed into the LEAD position.
6. All circuit breakers in the black areas on the circuit breaker panel need to be in the ON position.
7. At the engine control panel, place the headlight control switch in proper position and other switches on as needed.
8. Place the engine run, control and fuel pump, and generator field switch in on position. Other switches may be placed on as needed.
9. Release all handbrakes.

SANDING SYSTEM

DESCRIPTION

The sanding system of the locomotive is provided to improve wheel/rail adhesion.

MANUAL SANDING

The operator may apply sand to the rails manually, by using either the SANDING LEAD TRUCK toggle switch, or the MANUAL SAND switch, both of which are located on the operator's control stand.

The following manual sand switches are located on the operator's control stand.

SAND LEAD TRUCK TOGGLE SWITCH

The switch provides sand to both the lead truck and *intermediate sanders in the direction of travel as indicated by the position of the reverser handle. The Sand indicator light will illuminate if this switch is engaged. The locomotive microprocessor control system, N-Force, will only allow for 10 second sanding with no speed.

MANUAL SAND SWITCH

When operated, this lever supplies a signal to the trainline and to the N-Force. The N-Force determines which direction the locomotive is moving and directs the signal to the appropriate sanding magnet valves. The basic switch is non-latching and may be operated in any direction for correct sanding. The NFORCE will only allow for 15 seconds of sanding at all times with this switch activated.

AUTOMATIC SANDING

The *NFORCE* system provides automatic sanding based on wheel slip conditions. Automatic sanding for wheel slip control can occur at any speed. The direction of the reverser handle determines the direction of sanding. Automatic sanding is done on the front truck in Forward, and the rear truck in Reverse. If the locomotive is equipped with intermediate sanders, these will also function in the direction of the reverser handle during automatic sanding. Automatic sanding is applied for the duration of the wheel slip detection, and is continued for 2 seconds after the wheel slip is corrected.

EMERGENCY SANDING

When the emergency sand switch is activated by the air brake system, the *NFORCE* activates all sanding magnet valves. The circuits from the switch are arranged so that emergency sanding from all traps will continue even though the reverser handle may be placed in the opposite direction of travel. The *NFORCE* monitors for zero locomotive speed for twenty seconds. If zero speed is established, the *NFORCE* will pick up the No Speed Relay (NSR), which will interrupt the feed from the emergency sand switch to the sanding magnet valves.

MAINTENANCE

Before any operation of the locomotive occurs the sanding equipment should be checked to ensure all of the components are functioning properly. Complete the following steps while the locomotive is set up for power operation

with the engine at idle.

1. Select which sanders to check first by placing the reverser handle in either the forward or reverse position.

2. Use the MANUAL SAND switch to trigger the sanding function the sanders designated by the position of the reverser handle. The SAND light should indicate sanding. Once proper sanding has been confirmed, move the reverser handle to check the sanders at the opposite end of the locomotive.

3. Once the sanding function has been confirmed, release the MANUAL SAND switch and make sure the sanding stops and the SAND light goes out.

4. Use the SANDING LEAD TRUCK switch to test the lead truck sanding function. Sand should coat the rails in front of the lead truck only as the SAND light comes on. The lead truck is determined by the position of the reverser handle. Once the sanding is confirmed, move the reverser handle and check for sanding at the opposite end of the locomotive.

NOTE

If the locomotive is equipped with intermediate sanders, the rails in front of the lead axle of the trailing truck will also be coated with sand as the SAND light indicates.

5. Release the SANDING LEAD TRUCK switch and confirm the sanding function has ceased and the SAND light has gone out on the control stand.

SANDER CONTROL VALVE

DESCRIPTION

In both the shortnose and endhood there is a sander control valve that, when energized electrically, will open allowing main reservoir air to be introduced to the sand traps.

NOTE

The electrical stimulation will be provided from the MANUAL SAND switch, SANDING LEAD TRUCK switch, or the NFORCE.

MAINTENANCE

If the sand control valve's functionality is in question, check the following areas:

1. Check all electrical connections

2. Check the condition of the wires leading to the connections.

3. Push in the plunger on the side of the valve. This will engage the clean-out jets.

NOTE

The jets clean out the orifice and will automatically reset at the beginning of the next sanding cycle.

If the valve continues to function improperly, remove and replace the valve with qualified equipment.

SAND TRAP

DESCRIPTION

The sand trap is a gravity fed valve. As the sand enters the top of the valve air is introduced proportionately to provide an even distribution of sand to the rail through the trap outlet.

A sand shutoff assembly is mounted to the top of the trap. It is normally open but can be used to shut off the flow of sand to the trap for maintenance purposes. See Fig 4-6.

MAINTENANCE

If the sander fails to operate, close the rotary sand shutoff valve, which is mounted to the top of the trap. For ease in closing, a handle is provided on both sides of sand shutoff. Using

the sliding T handle wrench provided in the bottom plug and quick flange disconnect, remove as indicated in Figure 4-9. Clean the various areas as indicated. After replacing the bottom plug and quick flange disconnect, turn the shutoff valve to the vertical (OPEN) position.

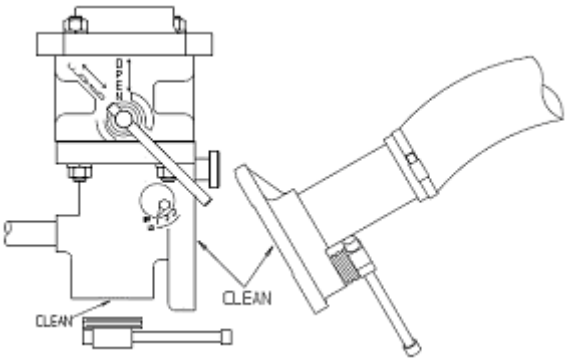


Figure 4-6 - Sand Trap Cleaning

The Sand Trap is adjustable. See Figure 4-7. Positioning the adjustable paddle determines the amount of sand delivered to the rail. To adjust the paddle, insert a 7/32" hex key wrench in the end of the paddle and turn the indicator toward "3" to increase or toward "LO" to decrease sand flow. Stamped numbers 1-2-3 merely indicate a guide for setting sand flow. When the indicator points between 1 and 2, the sander will deliver approximately 1 lb. of sand per minute.

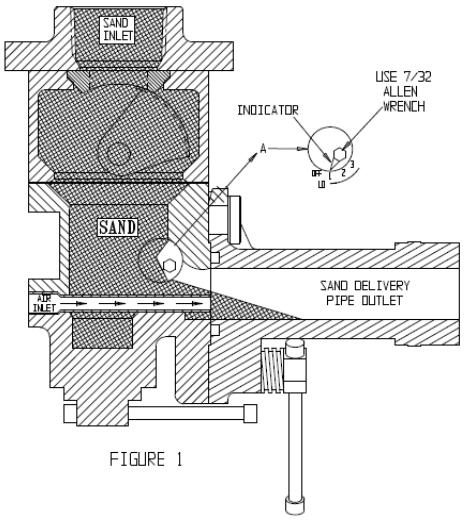


Figure 4-7 - Sand Trap Adjusting

AIR SYSTEM ACCESSORY EQUIPMENT

WINDSHIELD WIPER ASSEMBLY

DESCRIPTION

On each cab door and the opposite cab corner window is a separate, yet identical, wiper motor assembly. The motor of each assembly has a lever that can be used to manually operate the assembly in case of emergency or maintenance situations.

The wiper control valves for each motor are located directly above the sliding window units on the side of the cab.

MAINTENANCE

If the wiper motor is not functioning properly, trouble shoot by following these procedures:

1. Check all the air fittings and connections to ensure there are no leaks.

2. Utilizing the lever on the wiper motor, manually operate the assembly with the air on.

3. The line could be obstructed. Turn off the air at the control valve above the sliding window and use the lever to operate the motor assembly manually.

4. Remove the exhaust fitting and check that the valve is free of dirt and obstructions.

5. Remove the ball housing and check that the spring is in good working condition.

6. The valve could be obstructed. Remove the end caps and thoroughly flush the valve with air to remove any unwanted material.

7. Check that the exhaust hole is free from any obstructions.

If the motor is still not functioning properly, remove and replace the item with a qualified motor.

To remove the wiper connecting arm, do the following procedures:

1. Remove the acorn nut.

2. Pull the connecting arm from the splined shaft.

3. Slide new wiper arm onto the shaft being sure to line up the spline on the shaft.

4. Replace the acorn nut onto the shaft being careful not to over tighten.

The wiper assembly is designed to operate at 60-65 cycles per minute. The number of cycles per minute can be adjusted as follows:

1. A piece of paper underneath the wiper blade to simulate wet glass will help provide an accurate count of cycles.

2. With the wiper valve fully open, check to make sure the main reservoir pressure is at 130-140 psi.

3. Use the adjuster screw located on the exhaust restrictor to reach and maintain the desired number of cycles per minute.

AIR HORN

DESCRIPTION

The air horn system consists of horn switch, the control circuitry, front and rear horn magnet valves, and two three-chime horns, Figure 4-8. The Air Horn Pushbutton is a momentary switch that, when depressed, energizes the appropriate horn magnet valve and supplies compressed air to the locomotive air horn. The reverser handle position will indicate whether the forward or rear horn will sound. In the event that the reverser handle isn't in the forward or reverse position, then the forward horn will sound. The electronic bell is also energized when the air horn pushbutton is depressed and can only be de-energized by depressing the electronic bell operator button.

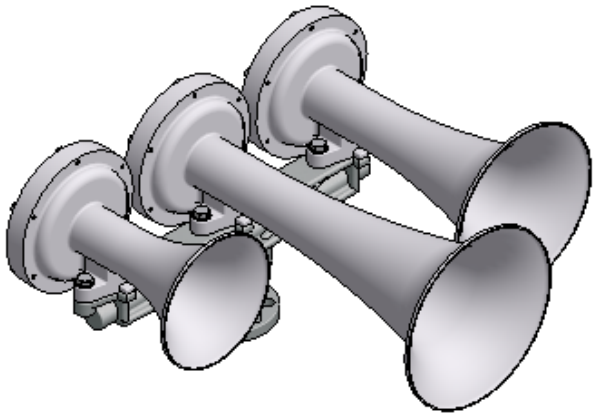


Figure 4-8 - Air Horn

MAINTENANCE

It is good practice to clean and inspect the horn diaphragm regularly. To do so utilize the following procedures:

1. Remove the bolts and rear horn cover to gain access to the diaphragm and ring.

2. Remove the diaphragm ring screws.

3. Carefully remove the ring and diaphragm. Open the air horn

operating valve with full reservoir pressure on the line to blow out the lines and clean the orifice dowel pin.

4. After cleaning the diaphragm and ring, re-install the components and secure with the ring screws.

5. Re-install the back cover with the bolts. Tighten to the appropriate torque specifications.

SERVICE DATA

COMPRESSED AIR SYSTEM

SPECIFICATIONS

AIR COMPRESSOR

Model	GAR30
Type	Single-Stage, Oil-Injected
Compressor Cooling	Air
Lube Oil Capacity	2.38 gal (9 L)
Motor Shaft Speed	3000 RPM
Shaft Power Output	40.5 hp (30.2 kW)

Compressor Oil

Compressor lube oil must be Atlas-Copco Roto-H Fluid only. **

***No approved equivalent lubricant or oil has been established for use in the air compressor.*

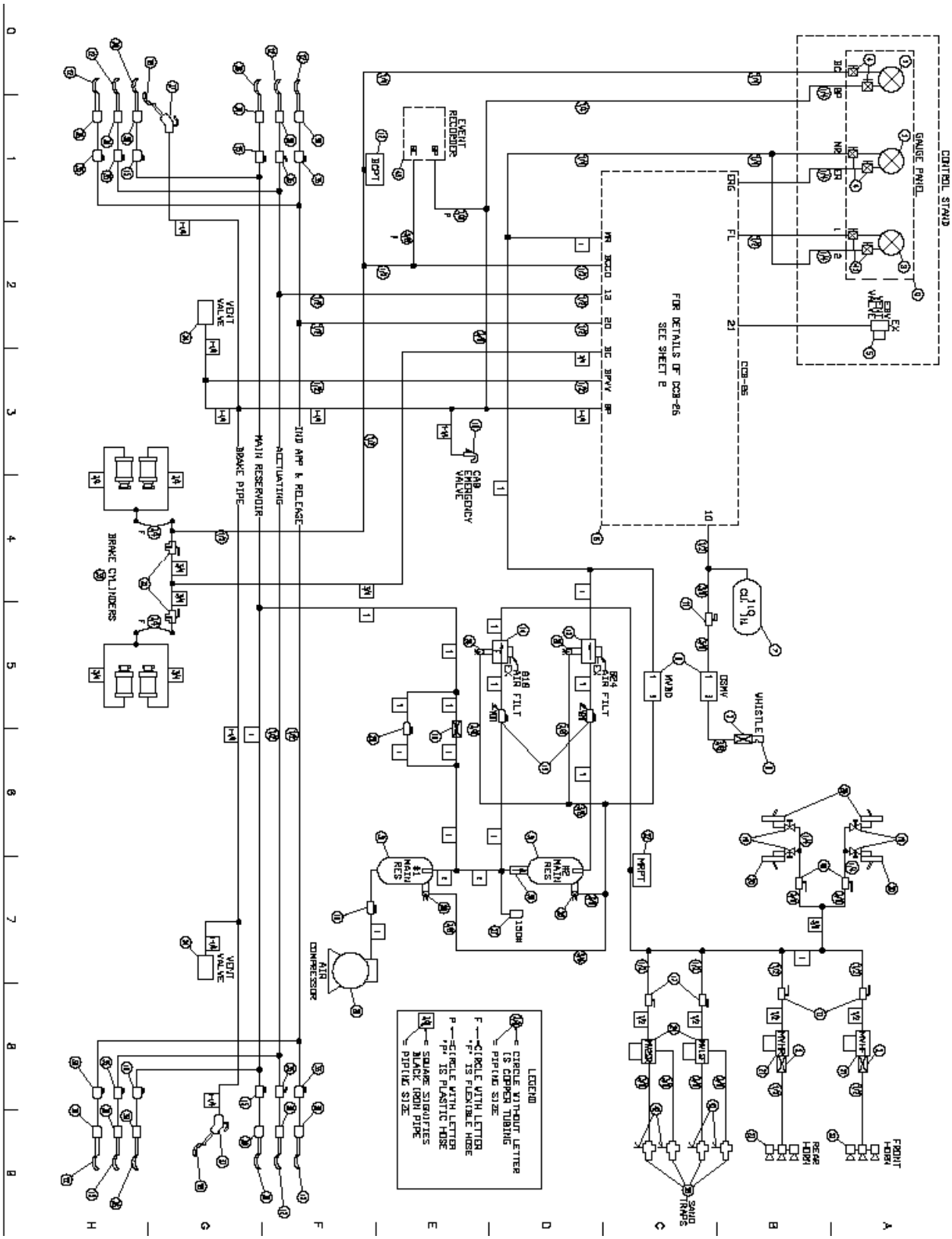


Fig 4-9 Typical CCB26 Schematic*

* = IF EQUIPPED

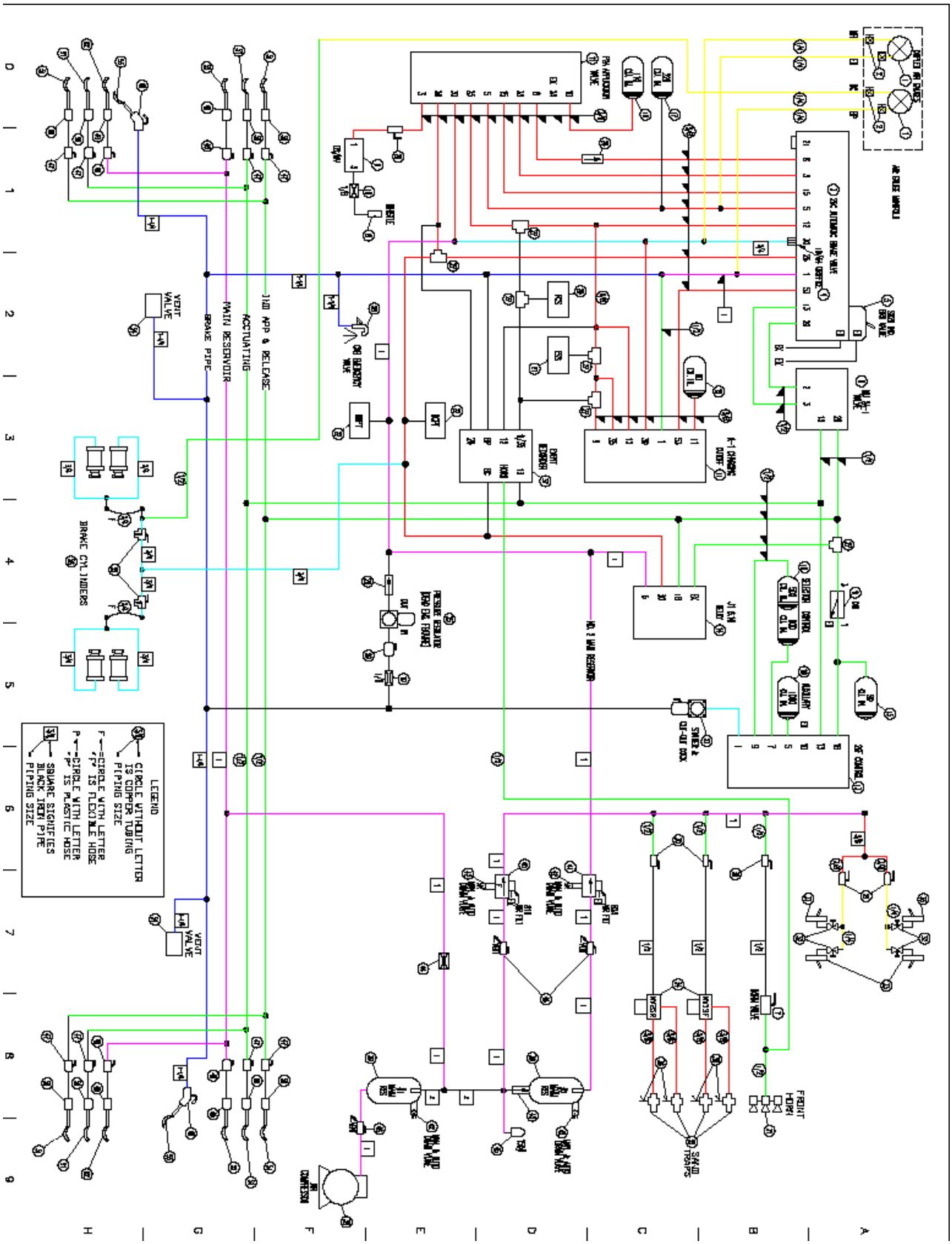


Fig 4-10 26L Air Brake Schematic*

* = IF EQUIPPED

INTRODUCTION

The intent of this section is to describe all electrical components of the locomotive that are not exclusive to each Genset. Refer to the Genset section of this manual for information on any component that is included as a component of the Genset Assembly.

There are different models of the genset locomotives. Any item that is subject to change will be notified by a (*).

GENERAL MAINTENANCE

All devices should be kept free of dust, dirt, or any foreign material. The Main Electric Cabinet is pressurized to keep the interior of the cabinet from collecting dust and dirt. Therefore, all doors must be latched and all covers must be bolted during locomotive operation.

DIGITAL TELEMETRY SYSTEM*

The DIGITAL TELEMETRY (DT) system is an optional system. Examples of some standard components are listed below.

NOTE

The DT system is customer specific and no maintenance or service information pertaining to that system is included in this manual.

- 802.11 Antenna
- ER; Event Recorder (Accuspeed UPRR Template)
- ERF; Engine Run In-line Fuse
- FLF; Fuel Monitor In-line Fuse
- GPS Antenna
- MAR; Control Device
- MCP; Communication Device
- Power Supply
- RIU; System Interface Device
- SDM1200 Antenna
- SPEC 200 Antenna

TRACTION MOTORS

Electrical power from the genset generators is distributed to traction motors mounted in the trucks, designated TM1, TM2, TM3 and TM4. Each motor is geared to a pair of wheels, with a 62:15 gear ratio. The motors are cooled by means of an external blower.

The motor fields and armatures are connected in series to provide the high starting torque required for locomotive service.

Motor rotation is changed by reversing the flow of the current through the field windings. This is accomplished by switchgear in the main electric cabinet.

The brush holder assembly is formed with a heavy cross section to minimize flexing and fatigue damage and to enable the assembly to withstand motor operating conditions. Brush holder cabling is arranged and clamped for increased mechanical strength.

The maximum continuous current rating is controlled by the *NFORCE* so that maximum tractive effort can be achieved.

Inspection and maintenance should be performed on a systematic basis as outlined in the N-VIRO Maintenance Schedule (Section 12).

Air Conditioner*

The dual roof mounted heating and air conditioning units (HVAC1 and HVAC2) provide fresh air heating/cooling to the cab. In addition, the unit will also filter and dehumidify the cab's air.

The single roof mounted air conditioning unit provides fresh air cooling to the cab. No heat application is available, but provided by the cab heaters. The unit will also filter and dehumidify the cab's air.

Operating Instructions for the Dual Roof Mounted A/C's*

The HVAC units are equipped with an Automatic Thermostat Control, Air Sweep Control, and Master Control (See figure below). Descriptions of each function are listed below.

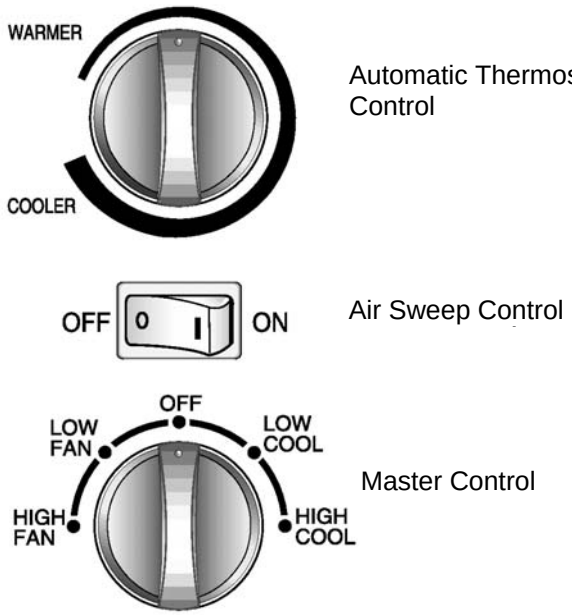


Figure 5-4 – HVAC Control Symbols

OFF

When the dial is turned to the OFF position the unit will NOT operate.

LOW FAN

LOW FAN will circulate small quantities of air WITHOUT cooling. Choose the LOW FAN setting by rotating the dial to this position

HIGH FAN

HIGH FAN will circulate large quantities of air WITHOUT cooling. Choose the HIGH FAN setting by rotating the dial to this position.

LOW COOL

LOW COOL will provide light cooling. Choose the LOW COOL setting by rotating the dial to this position.

HIGH COOL

HIGH COOL provides maximum cooling. Choose HIGH COOL by rotating the dial to this position. Once the cab is cooled, switch to a lower setting.

THERMOSTAT CONTROL

The thermostat maintains the room temperature automatically. Turn the thermostat toward COOLER for lower temperature control, or toward WARMER if a higher temperature setting is desired. The cooling operation automatically starts when the room temperature rises above your desired thermostat setting and stops when the room temperature reached your desired setting. (NOTE: The fan will operate continuously to maintain optimum temperature control.)

AIR SWEEP CONTROL

The units provide an automatic air sweep to cool the room more efficiently. When the air sweep is set on (|), the horizontal blade moves slowly up and down and distributes the air around the room. The direction of the vertical blades can be adjusted manually (make sure the air sweep is off). With the air sweep in the off position, the horizontal blade can be closed by pushing the PUSH mark on the blade, and can be opened again by pushing it again.

OPERATING INSTRUCTIONS FOR A SINGLE ROOF MOUNTED A/C*

The controls for the single roof mounted air conditioner unit are very similar and essentially function in the same manner as the dual unit.

MAINTENANCE

Refer to the N-VIRO Maintenance Schedule for normal maintenance procedures on the HVAC units.

* = IF EQUIPPED

TROUBLESHOOTING

Refer to the following table for basic troubleshooting of the HVAC units.

Table 5-1 HVAC Troubleshooting Guide

TROUBLE	POSSIBLE CAUSES	SOLUTION
The unit does not start	The unit may not be connected to the power supply correctly.	Check the inverter output.
The unit is not cooling the cab	There could be blockage of unit's air output.	Make sure that there are no obstacles restricting or blocking the unit's output.
	The temperature setting is too high.	Reset the Air V to a lower temperature setting.
	The air filter is dirty.	Remove and clean the filter.
	The cab was already very hot before the unit was turned on.	Allow a sufficient amount of time for unit to cool the cab.
	The unit is clicking and gurgling.	These noises are normal during the operation of the unit.
The unit is making noises	The basepan gasket has not been evenly compressed to about 60%.	Mounting bolts should be tightened evenly by compressing the basepan gasket to the sixty percent requirement.
The unit has water dripping inside	The temperature is low inside.	Adjust the thermostat control knob to a warmer setting. Should frosting continue, operate on LOW or HIGH FAN setting until the cooling coil is free of frost.
The unit has ice or frost on the coils	The filter is dirty.	Remove and clean the filter.

* = IF EQUIPPED

Refrigerator*

This optional, electrically operated unit is located in the cab. The fridge inverter (FINV) converts 64VDC battery voltage to 110VAC to operate the refrigerator.

FINV; Fridge Inverter*

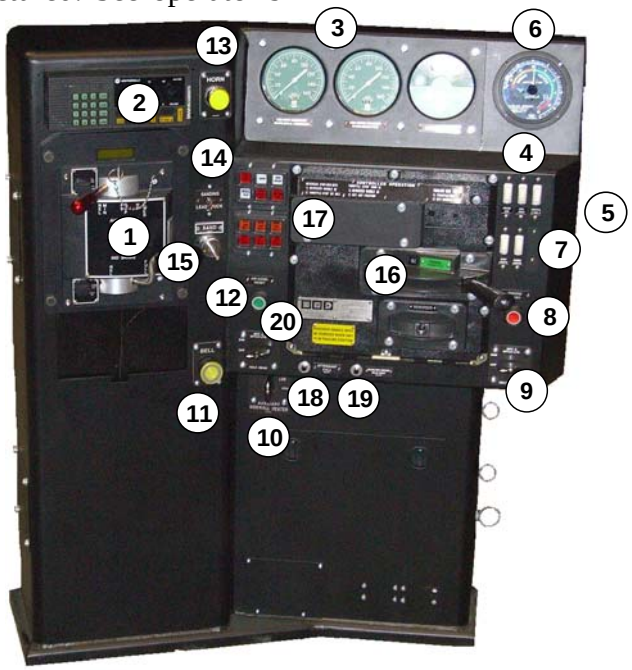
This inverter converts 64VDC battery voltage to 110VAC to operate the refrigerator unit.

Operator's Control Stand

The Operator's Control Stand, Figure 5-2 (Standard control stand pictured. See operator's manual for specific type.), contains operating handles, switches, gauges, and indicating lights used by the operator of the locomotive. The air brake valves and handles are on the left side of the stand, with the controller assembly to the right. Various gauges and indicating lights are located above the controller, and various operating switches are adjacent to it or below.

NOTE

Air Brake controls and gauges are described under the COMPRESSED AIR SYSTEM – Section 4 of this manual.



1. EBV (Driver's Brake Valve)	11. Electronic Bell Operator Button
2. Operator's Radio	12. Air Conditioner Reset Switch
3. Air Gauges	13. Air Horn Pushbutton
4. Control & Operating Switches	14. Lead Truck Sand Switch
5. Gauge Light Dimmer	15. Manual Sand Switch
6. Load Current Indicating Meter	16. Controller Assembly
7. Step & Gauge Light Switches	17. Indicator Light Panels
8. Engine Start Pushbutton	18. Attendant Call Button
9. Front Headlight Switch	19. Ground Reset Switch
10. Sidewall Heater Switch - Engineer	20. Rear Headlight Switch

Figure 5-2 – Operator's Control Stand

* = IF EQUIPPED

CONTROLLER ASSEMBLY

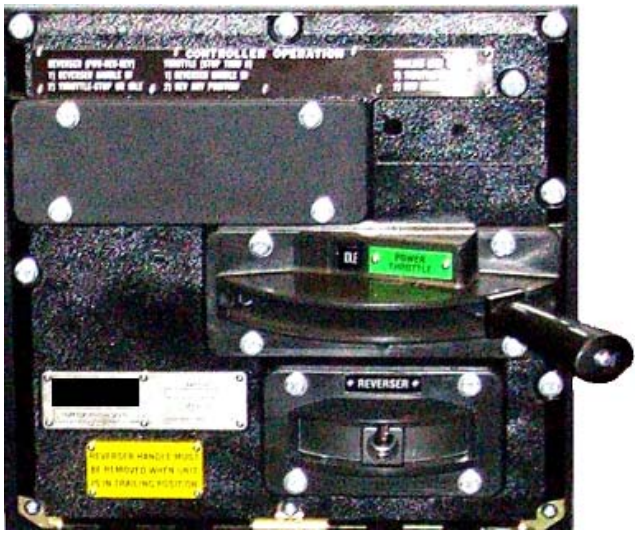


Figure 5-3 – Controller Assembly

The Controller, Figure 5-3, contains the two main operating handles: Throttle and Reverser. Nameplates identify each handle, and the position of the throttle is indicated in an illuminated window located directly above the handle. The controller assembly is hinged to the control stand, and can be swung down for maintenance and troubleshooting.

THROTTLE HANDLE

The throttle handle, which controls the engine speed, has an IDLE position, eight running notches, and a STOP position.

The IDLE position is as far as the handle can go to the right without pulling the handle out toward the operator.

The throttle handle can only be moved from IDLE position with the reverser handle installed in the reverser switch.

Immediately to the left of the IDLE position are the throttle positions starting with notch 1 and progressing left through to notch 8. As the handle is sequentially advanced through the notches, the horsepower and RPM's will increase with each movement.

The STOP position is obtained by pulling out on the handle and pushing right, past the IDLE position. This position will shut down all engines in a consist and should be used for emergency purposes only.

REVERSER HANDLE

CAUTION:

The reverser direction should ONLY be changed when the locomotive is completely stopped. If the direction is changed while the locomotive is moving, serious damage to the traction motors and/or choppers may occur.

The reverser handle determines the direction of locomotive movement and has three positions:

1. NEUTRAL is located in the center.
2. FORWARD is located to the right of NEUTRAL.
3. REVERSE is located to the left of NEUTRAL.

The handle can be installed or removed from the reverser switch only in OFF position and the throttle handle is in IDLE position.

The reverser handle can only be move to designate locomotive direction when the throttle handle is in IDLE or STOP.

The reverser handle is centered and removed to lock the throttle handle in IDLE.

NOTE

When the unit is in IDLE limiting shutdown mode, moving the reverser to forward or reverse will initiate engine starting.

MECHANICAL INTERLOCKS ON THE CONTROLLER

The handles on the controller are interlocked to limit the use of both handles. By being interlocked, they limit the use of both to protect against improper operation.

If the reverser handle is in the neutral position and the handle is installed, the throttle handle can be moved throughout positions freely. If the

handle is removed, however, the throttle is locked in IDLE position.

The reverser handle can be moved freely from NEUTRAL to FORWARD or REVERSE with the throttle handle in IDLE. But if the throttle handle is advanced into 1-8 positions the reverser is locked in whatever position it was in when the throttle was advanced.

LOAD CURRENT INDICATING METER

This meter reports pulling force of the locomotive and is graduated to read a maximum of 1500 amperes. The reading on the gauge will relay the average electrical current in the traction motors. Fig. 5-5.

Traction motor protection is provided by the *NFORCE* so the load current indicating meter does not indicate short-term current ratings or continuous current rating.

Figure 5-5 – Load Current Indicating Meter

NOTE

The wheel slip control system functions to correct slips by instantaneous reduction of power in small increments and by application of sand. The cumulative effect of a large number of power reductions in rapid succession is to cause the locomotive to maintain power at a level where adhesion can be maintained. Do not misinterpret this loss of power as a defect in the control system.

INDICATING LIGHTS PANEL

There are two Indicating Lights Panels (ILP1, ILP2) on the operators control stand, Figure 5-6. The indicating lights alert the locomotive operator of various operating conditions.

Figure 5-6 – Indicating Lights Panel

NOTE

The following indicating lights have a press-to-test feature which allows testing of the lamp circuit alone, isolated from its operation in the power control system. When the lens cap is depressed, the supply voltage is impressed across the lamp circuit. After a one second delay the light should go on.

PCS OPEN INDICATOR LIGHT

PCS OPEN light indicates when the pneumatic control device has cut power to the traction motors due to a emergency air brake or safety control application.

To reset the PCS the throttle must be placed in IDLE and control of the air brake must be regained. When this has been accomplished, power to the traction motors will be returned automatically.

SAND INDICATOR LIGHT

SAND indicator light shows when the Sanding Lead Truck Switch has been applied which provides sand to the lead truck only in the

direction specified by the position of the reverser handle. This light will not indicate any other sanding function such as manual, emergency, or wheel slip sanding.

GRD RELAY INDICATOR LIGHT

GRD RELAY light indicates that an electrical path to ground has occurred. The control system will automatically reset the ground relay two times without operator action. After the third occurrence of ground relay the operator must take action by depressing the ground reset pushbutton located on the control stand.

WHEEL SLIP INDICATOR LIGHT

WHEEL SLIP light indicates moderate to severe wheel slip, locked sliding wheels, or circuit difficulty. An intermittent indication by the wheel slip light simply means the control system is operating correctly to regain traction on the rail. Minor slips will not trigger the light but will cause an automatic sanding and a possible momentary drop in power to the traction motors of the slipping wheels. This is normal and requires no action by the operator.

WARNING

Any persistent or continual indication by the wheel slip light could mean a serious problem and the locomotive should be stopped immediately. An inspection should be done to ensure all the wheels rotate freely.

AUX POWER FAULT INDICATOR LIGHT

AUX POWER FAULT light indicates that either the 24VDC or 64VDC batteries are not fully charged. If the light stays on continuously for more than 5 minutes, then that could be an indication that the LVPS is not providing charging power to either 24VDC or 64VDC batteries.

MOTOR FAIL INDICATOR LIGHT

MOTOR FAIL light indicates that a DC Chopper or traction motor is not operating properly. Use railroad approved procedures to cutout the traction motor to identify the problem.

GNST 1 FAULT, GNST 2 FAULT, AND GNST 3 FAULT* INDICATOR LIGHTS

GNST 1 FAULT, GNST 2 FAULT, AND GNST 3 FAULT* red lights will illuminate if the respective engine (1, 2, or 3*) has reported a fault condition which cannot be resolved without shutting the engine down and making repairs. It can only be reset by the control system after proper repairs have been made. Those conditions are as follows:

1. Hot Engine Coolant
2. Hot Engine Oil
3. Low Engine Oil Pressure
4. Low Engine Coolant
5. Insufficient Fuel Pressure

GNST 1 SRV ENG, GNST 2 SRV ENG, AND GNST 3 SRV ENG* INDICATOR LIGHTS

GNST 1 SRV ENG, GNST 2 SRV ENG, AND GNST 3 SRV ENG* amber lights will illuminate anytime a condition exists in the engine that, if not corrected soon, could cause a shutdown FAULT. If this light is illuminated, the engine should be serviced as soon as possible.

AIR GAUGES

Air gauges to indicate main reservoir air pressure as well as various pressures concerned with the air brakes are located along the top of the control stand.

OPERATOR'S RADIO

Provisions have been provided to mount an AAR standard radio into the control stand.

* = IF EQUIPPED

SIDEWALL HEATER SWITCH – Engineer*

The Engineer's Sidewall Heater Switch (ESHSW) is a three-position rotary snap switch located to the left and beneath the controller assembly. The switch includes OFF, LOW, HIGH settings to provide control of the Engineer's sidewall heater.

AIR HORN PUSHBUTTON

When the air horn pushbutton is depressed, compressed air is supplied to the front or rear locomotive air horn via a magnet valve in the direction of travel as indicated by reverser handle position. Also, the electronic bell is energized and can only be de-energized by depressing the electronic bell operator button.

SANDING SWITCHES

SANDING LEAD TRUCK Toggle Switch (LTSSW)

The signal from this switch is not trainlined. The switch provides sand to only the lead truck in the direction of travel as indicated by the position of the reverser handle. This method of sanding dresses the rail and is adequate for most conditions. The SAND light will come on when this switch is activated. The *NFORCE* will only allow for 15 second sanding with this switch activated.

SAND SWITCH (MSSW)

When operated, this switch supplies a signal to the trainline and to the *NFORCE*. The control system determines which direction the locomotive is moving and directs the signal to the appropriate (forward or reverse) sanding magnet valves. The basic switch is non-latching and may be operated in any direction for correct sanding. The *NFORCE* will allow sanding up to 5 MPH for 15 seconds with this switch activated.

ELECTRONIC BELL SWITCH

This mushroom type, multi-position operator button controls the locomotive electronic warning bell. The operator is a "PULL-ON" and "PUSH-OFF" type that is spring loaded to maintain a center position. The electronic bell is also energized when the horn pushbutton is depressed, and can only be de-energized by depressing the electronic bell operator button.

HEADLIGHT SWITCHES

Two three-position rotary snap switches are provided for independent control of the front (FHSW) and rear (RHSW) headlights. Each switch has OFF, DIM, and BRT & DITCH LTS positions. All positions of each switch are operative, but in a multiple unit consist, the headlight control switches on the engine control panels of each unit must be properly positioned, and only the lead unit controls the headlights.

OPERATING SWITCHES

The three operating switches at the upper right corner of the control stand are crucial in the starting and operation of the locomotive.
Fig 5-4.

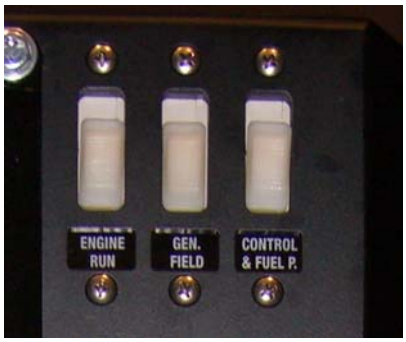


Figure 5-7 – Operating Switches

ENGINE RUN SWITCH (ERSW)

In order to obtain throttle control of the engines, the Engine Run Switch must be placed in the up or ON position. Otherwise the engines will remain at IDLE regardless of the Throttle Handle position.

* = IF EQUIPPED

GENERATOR FIELD SWITCH (GFSW)

In order for the generator to produce power the Generator Field Switch must be in the up or ON position. Otherwise the generator will not produce power even though the engines respond to the throttle.

CONTROL AND FUEL PUMP SWITCH (CFPSW)

In order to start and operate the engines this switch must be in the up or ON position. Otherwise there will be no power to the various low voltage control circuits.

LIGHT SWITCHES

Switches for the GAUGE LIGHTS (GASW) and STEP LIGHTS (SLSW) are located to the right of the controller assembly in the vicinity of the Operating Switches, and are placed ON as needed.

NOTE

The ground lights are controlled by the GASW if equipped.

ATTENDANT CALL PUSHBUTTON*

When the attendant call pushbutton (ATCSW) is depressed, in any unit coupled in consist, the alarm bell will ring in all units.

GROUND RELAY RESET PUSHBUTTON

The *NFORCE* monitors the Ground Relay Reset switch (GRRTSW). The operator can close the ground relay reset switch to reset the *NFORCE* fault counts, allowing the various ground relay limits and lockouts to be manually reset. This switch does not reset the ground relay coils. If the *NFORCE* detects this switch to be closed the fault counters are reset to two and a GR RESET alarm is set.

NOTE

This describes a standard GRRTSW. Refer to your Operator's Manual if there are any questions to the style on the locomotive.

ENGINE START PUSHBUTTON

CAUTION

Proper precaution should be made to ensure all personnel are in safe positions away from rotating and electrical equipment before engine starting is initiated.

When necessary to manually start an engine, the engine start pushbutton (EONSW) should be depressed until engine start warning buzzers are audible. The control system will then automatically start the engine that has the least amount of service hours.

The EONSW has additional functionality. It can be used to enter:

1. Diagnostic Mode
2. Selective Engine Starting Mode

DIAGNOSTIC MODE

In order to enter the Diagnostic Mode, the Engine Start and the Ground Relay Pushbuttons must be held for 5 seconds. The operators Interface Panel will indicate that the Diagnostic Mode has been entered.

On the top left side of each circuit breaker box mounted on the Gensets is a LED panel that will display any fault codes. See the Trouble Shooting Section at the end of this manual for the complete listing of the fault codes.

NOTE

Upon entering the Diagnostic Mode the lift pumps will run for 30 seconds.

* = IF EQUIPPED

SELECTIVE ENGINE STARTING MODE

In order to enter the Selective Engine Starting mode, the Engine Start and Air Conditioner Reset push buttons must be depressed together and held until an audible tone is heard. Every 5 seconds a series of beeps will sound. The number of beeps will correspond with the genset number.

When the desired genset is signified by the correct number of beeps, the A/C Reset pushbutton is released while maintaining the depression of the Engine Start button. An alert will sound to notify the starting of the genset.

AIR CONDITIONER RESET PUSHBUTTON

In the event that the locomotive has been in idle limiting mode for a length of time specified by the railroad, the control system will activate its load shedding strategy and discontinue the use of air conditioning and heating. The air conditioner reset pushbutton (ACRSW) should be depressed in order to cancel the load shedding mode.

RESISTORS

RE50, REGA1, REGA2, REGA3, REGB1, REGB2, REGB3

These resistors perform voltage dropping functions in the gauge lights.

GAUGE LIGHT RHEOSTAT

The gauge light rheostat (RH51) functions to adjust the intensity of the gauge lights.

Electric Hand Brake

DESCRIPTION

The locomotive parking brake (HNDBK) is an automated, electric motor driven system. The primary operator interface is a control panel incorporating two push buttons: SET & RELEASE. In the event electrical power is unavailable, the brake can be operated using a manual interface.

In the automatic mode, the force in the chain is initiated by the electric motor and delivered through a gear train to the output chain sprocket. The electric motor is coupled to the gear train through an electrically actuated clutch that allows the gear train to free wheel in the reverse direction. Electronic controls automatically stop the actuation sequence when the force in the chain has reached a pre-set level.

The force in the chain is maintained through the use of a mechanical pawl and ratchet type latch. In automatic operation, the detent mechanism is actuated and released with an electric solenoid. A manual lever release is also provided.

Safety Warnings

Always check to make sure personnel are clear of brake rigging prior to setting or releasing the hand brake.

Make sure the HAND BRAKE circuit breaker is in the off position before changing brake shoes on the truck equipped with parking brake rigging. To assure safety, the breaker must be turned off in the event the handbrake is wired to the hot side of the locomotive battery knife switch.

The parking brake chain should always be covered in an appropriate manner.

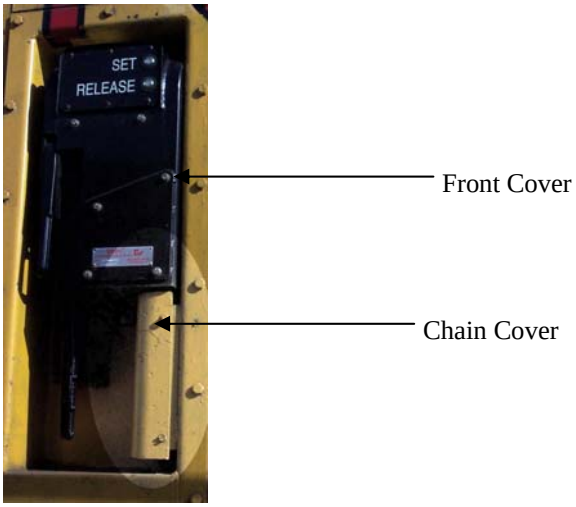
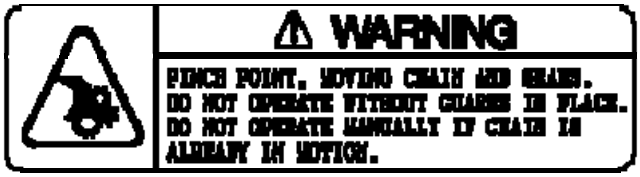


Fig. - 5-7- Hand Brake

* = IF EQUIPPED

Do not operate the handbrake with the front cover removed. The parking brake should never be set or released, either manually or by use of the push buttons, when the front cover is removed.



Do not attempt to operate the handbrake by holding onto or pulling either manual control lever once chain is in motion.

When using the manual release handle, pull the handle to release the brake and then let go of the handle. Do not push the handle back towards the brake. Allow the weight of the handle to return it to the "at rest" position.

When installing the brake chain, make sure the HAND BRAKE circuit breaker is in the off position.

Never use the automatic controls to install brake chain.

Use best shop practices when installing the handbrake. The parking brake weighs 210 lbs.

In the event the parking brake requires service while installed on the locomotive, make sure electrical power is disconnected.

Make sure parking brake chain load is released prior to performing any type of ON LOCOMOTIVE maintenance or service. The locomotive must be properly secured before releasing the parking brake chain load.

Turn the HAND BRAKE circuit breaker off before removing the front cover.

Turn the HAND BRAKE circuit breaker off before opening the control box.

Turn the HAND BRAKE circuit breaker off before opening the electrical box.

Maintenance

The design intent of the handbrake is for minimal end user maintenance.

On Locomotive

Review above section, SAFETY WARNINGS

During scheduled locomotive maintenance, the parking brake should be checked for normal operation, both manual and automatic.

During scheduled locomotive maintenance, all mounting bolts should be checked and tightened if necessary.

During scheduled locomotive maintenance, the parking brake chain should be checked for excessive wear (reference railroad maintenance standards). Excessive wear will cause binding of the parking brake. Catastrophic chain failure can lead to injury or locomotive rollaway.

It is recommended that the following components be lubricated at a minimum every 3 years or when necessary (based on service cycles): all spur gears, all ratchet gears, chain sprocket, and all moving pins. See Figure 5-8.

A. Make sure the parking brake circuit breaker is in the off position.

B. Use Loctite Super Lube Grease with PTFE, Loctite P/N 82328 (14 oz container).

C. Before lubricating, make sure to clean any dirt or debris from the gear teeth.

D. Apply 3 to 4 ounces of grease using a small applicator brush. Make sure to apply the grease evenly to all gear teeth.

E. Do not allow lubrication to contact the clutch assembly. In the event lubricant does contaminate the clutch, clean the clutch

plates using a fast drying, non-residue forming electrical contact cleaner.

F. Apply lubrication to the portion of the chain which makes contact with the chain sprocket during operation of the brake. This will help minimize chain wear.

G. Operate the brake several times (manually and automatically) to assure lubrication is evenly dispersed and to assure the clutch has not been contaminated.

H. Remove any lubrication that may have inadvertently come in contact with the manual set handle, the manual release handle, the locomotive walkway / platform, and any locomotive railing.

Off Locomotive

There is no maintenance activity which requires the parking brake to be removed from the locomotive.

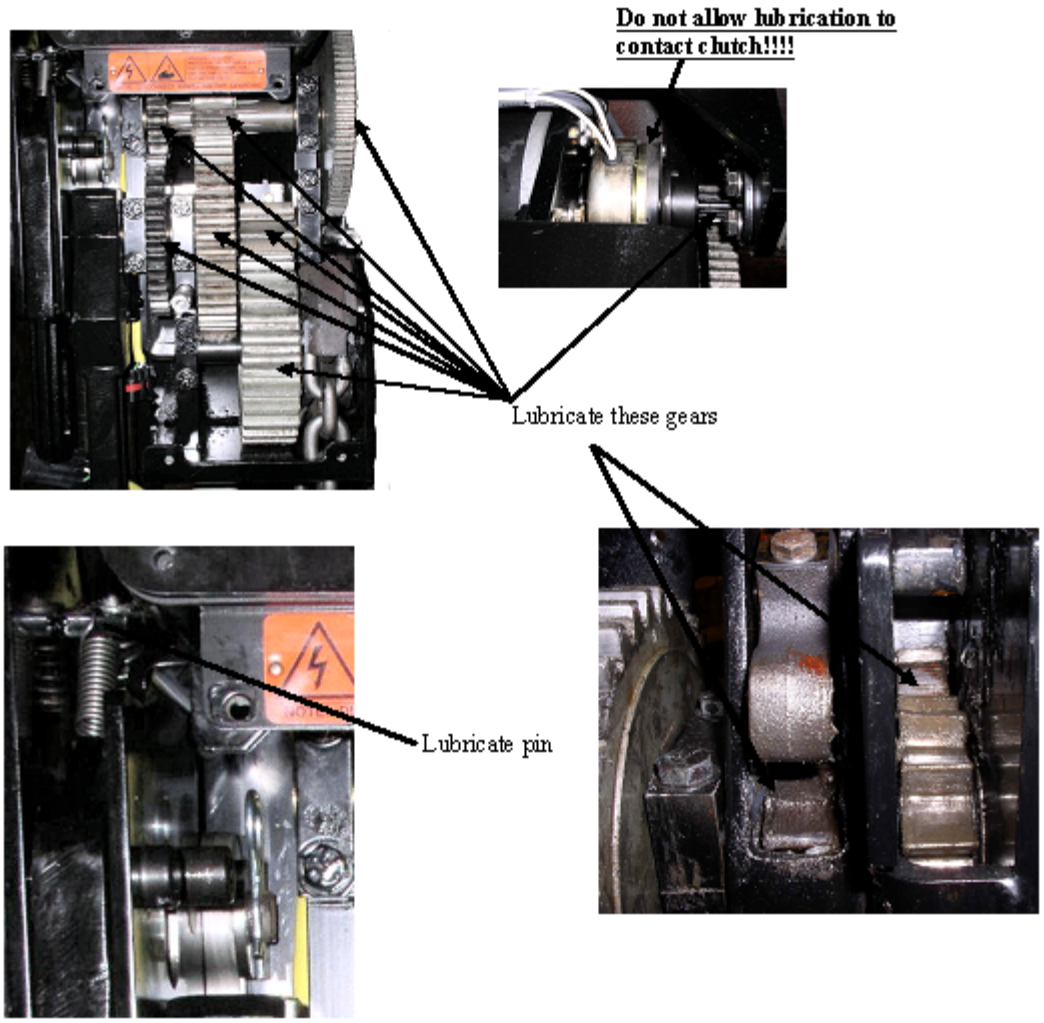


Figure 5-8 – Electric Hand Brake Lubrication

* = IF EQUIPPED

HAND BRAKE REMOTE PUSHBUTTON*

This optional switch (HNDBSW) is located on the left side of the locomotive underframe under the cab entry door. There are set and release buttons that operate the hand brake in the same manner as the controls mounted on the hand brake.

POWER ELECTRONIC EQUIPMENT

EQUIPMENT OVERVIEW

The GENSET locomotive has three variable speed diesel engines coupled to AC generators that are connected to three uncontrolled 3-phase rectifiers. The outputs of the rectifiers from each genset are connected in series to form a common DC bus for the four, 350kW, Chopper drives.

During periods of low traction effort, only one of the diesel engines will be running and its speed will increase, as more tractive effort is required. The second and third diesels will provide additional power during times of high tractive effort or higher locomotive speed. As the diesel engines may operate at a variable speed, the output of the generators may also vary both in terms of frequency and voltage.

Each of the four Chopper Drives is connected to the common DC bus via an external contactor such that in the event of a fault condition an individual chopper can be isolated allowing the remaining three choppers to operate. The chopper drive will provide a fixed frequency variable pulse width output in response to an external demand from the *NFORCE* to four DC series wound traction motors.

RECTIFIER MODULE (DC RECT)

A rectifier is used to convert alternating current (AC) from the generator, to direct current (DC), for the chopper modules.

Fig. 5-9 - Rectifier

There are three rectifier modules on the locomotive, one for each genset. The AC from the generators is then rectified, and the DC outputs from the three modules are connected in series to form the DC bus, DCP and 1DCP.

CHOPPER MODULE (DCH1, DCH2, DCH3, DCH4)

The DC Chopper converts the DC bus voltage, from the rectifier modules, to the required level to control the traction motor speed. The *NFORCE* interfaces to the chopper via a 4-20mA control loop, to set the chopper duty cycle to obtain the required traction motor speed.

Fig. 5-10 – DC Chopper

AIR CONDITIONER INVERTER (ACINV)

The inverter is used to convert DC voltage, from the 74VDC battery, to 115VAC voltage to

* = IF EQUIPPED

power the two HVAC units for cab heating and cooling.

LOW VOLTAGE POWER SUPPLY (LVPS)

The LVPS is comprised of a rectifier and two inverters. The ac output from the generators is firstly rectified to dc, changed to ac before being transformed and rectified down to a low voltage dc level for the purpose of battery charging. There are two controlled outputs from the module; one for the 74VDC battery and the other for the 27.2VDC battery.

THEORY OF OPERATION

BASIC TECHNICAL DESCRIPTION OF RECTIFIER AND CHOPPER

The output from each of the three generators is protected by a circuit breaker, and connected to the Rectifier Module. The rectifier module consists of two, six pulse rectifiers with two separate DC positive and two DC negative outputs.

The rectifier modules are connected in series on the vehicle to provide a DC bus for the chopper modules. The rectifier module has normally closed temperature switches mounted on the heat sink to provide a shutdown signal in the event of a high heat sink temperature.

The DC bus is fed to the four chopper drives via the P and M contactors, which can be opened in the event of a fault to enable vehicle operation to continue with the remaining choppers. These contactors MUST NOT be closed when the generator excitation is applied as this will cause an over voltage of the chopper capacitors.

The DC bus, via the contactors, is connected to the chopper drive and DC Film capacitors reduce the ripple content of the rectified supply. The input current to the chopper is monitored by a DC Current Transformer that provides a signal in the event of a major fault causing an over current on the output of the unit. This will enable the input P contactor to be opened and operation of the vehicle to resume until servicing.

The chopper drive interfaces with the external Vehicle control system via a 4 to 20mA ‘Duty Cycle Demand’ signal in response to the speed demand from the driver’s control. The chopper drive control card will alter the duty cycle of the series IGBT from 0 to 100% duty in response to the demand signal. The overall control of the chopper module is from the *NFORCE*.

The Chopper Control Card monitors the voltage and current to the traction motor and these feedback signals are transmitted over 4 to 20mA current loops to the *NFORCE*. The Chopper Control Card will provide electronic overload and short circuit protection in the event of a fault.

In the event of a major fault such as output over current or a loss of control of the chopper IGBT, that could result in damage to the equipment, the chopper drive ‘Fatal fault’ output is set high and latched in this position.

The *NFORCE* monitors this contact so that it can open the P contactor feeding the respective chopper module.

LVPS BASIC TECHNICAL DESCRIPTION

The Low Voltage Power Supply (LVPS) function is to charge the locomotive batteries and to provide low voltage DC power.

The LVPS is powered from the locomotive’s auxiliary 3-phase AC Supply; a circuit breaker provides protection. The AC input is rectified and a filtered DC link supply provides the input to two, high frequency IGBT H-bridges, provide a fixed pulse width modulated square wave supply to two LVPS isolation transformers.

The output of the transformers is rectified and filtered and the regulated 74VDC and 27.2VDC LVPS outputs provide both the low voltage power and battery charging requirements of the locomotive. The LVPS control circuit provides

current limit and short circuit protection and in the event of an over current type fault, the circuit shuts down for 10 seconds, then a restart is attempted. If the fault is no longer present then normal output is restored, if not, five attempts are made before the equipment shuts down permanently. To reset the module the input power should be removed for 30 seconds.

Protection is also provided against reverse battery connection before the output contactors are closed. LED Status indicators are fitted as standard to aid in troubleshooting.

INVERTER BASIC TECHNICAL DESCRIPTION

The 4kW single Phase Inverter Unit provides power for the two roof mounted HVAC units and a convenience outlet in the main electric cabinet. The input circuit, connected directly to the On-board Battery Supply (74VDC), incorporates an Input Contactor and a LC Filter providing protection against input transients. Link Capacitors feed a Heatsink Mounted H-Bridge to drive the Output Transformer. The Secondary Winding provides the required 115Vrms Output Voltage, to supply the HVAC units. The 115Vrms Output is protected by a 40A Circuit Breaker, located through the cut out in the front panel of the module.

INDICATIONS AND ALARMS

The following LED Indicators are mounted on the front of the Inverter Unit Enclosure in order to display the current status of the unit whilst also helping in fault analysis. These are as follows:

a. **Control Supply OK (Green)**: This LED will illuminate when the internal power supply is established

b. **Main Capacitor Live (Blue)**: This LED will illuminate when the input contactor has closed and the input filter capacitors are charged.

c. **Converter ON (Green)**: This LED will illuminate when the Inverter Unit is providing Output Voltage.

d. **115Vrms Output OK (Blue)**: This LED will illuminate when the Output Transformer is providing Output Voltage to Air Conditioning Units. The LED is connected across the 115Vrms output.

e. **Fault Condition (Amber)**: This LED will illuminate if the Driver / Control Card detects a fault condition. It is controlled via a digital output from the Driver / Control Card.

BASIC TROUBLESHOOTING

OVERVIEW

This section covers the basic troubleshooting" fault finding on the power electronic equipment and is designed to be used as a guide by the operator.

The operator is provided with a software package, "NRE – Portable Test Equipment" software.

The Portable Test Equipment (P.T.E.) is a diagnostic tool for viewing the running parameters and the fault conditions of the chopper drives, inverter and the LVPS. The equipment required is an IBM compatible Personal Computer with a serial port and Windows 98 operating system.

This P.C. along with the installed software will be referred to as the P.T.E. In addition, a communication lead is required which links the P.T.E. to the listed unit. This consists of a screened cable fitted with the appropriate "D" type and LEMO connector. The LEMO connector will be plugged into the following sockets located in the locomotive cab:

a. DCH1 – for Chopper 1 and the LVPS
b. DCH2 – for Chopper 2 and the Inverter
c. DCH3 – for Chopper 3
d. DCH4 – for Chopper 4

When the P.T.E. is connected to a functioning unit, the fault history can be viewed in the Fault Logs. The actual running parameters can be viewed and a snapshot can be taken of any time frame required in the Real Time Display.

This information can be stored on disk or transferred to other locations for further analysis.

To obtain the most effective use of the P.T.E., an understanding of the unit's circuitry configuration and operation will be required.

Please Note: The P.T.E. is a data logging system as such it is not possible to affect the operation of the listed units by the inadvertent operation of the P.T.E

RECTIFIER

The rectifier is designed to operate over an input voltage range of 120V 30Hz to 267V 67Hz, and give a DC voltage equivalent to the AC input voltage.

If input voltage is present from the generator / generators and no output voltage is present. Change the rectifier unit.

DC CHOPPER

If a chopper fault occurs an alarm bell will sound within the cab. The *NFORCE* will inform the operator which chopper drive has faulted.

An attempt should be made to reset the chopper drive and attempt to run the motor again. If the unit has persistent faults, cut out the motor. Replace the chopper drive at the earliest opportunity.

LVPS

The LVPS is designed to operate over an input voltage range of 160V 40Hz to 266V 66Hz and give two output voltages; 72VDC and 27VDC.

If the LVPS unit develops a fault, check the input voltage and ensure it is with in the listed range. If the input voltage is out of spec or not present, refer to Locomotive wiring schedules.

If the input voltage is correct, but there is no output voltage on either or both of the output terminals remove the power from the input wait 30 seconds and apply the power once more. If the fault persists then replace the LVPS unit.

INVERTER

The Inverter is designed to operate over an input voltage range of 55VDC to 80VDC and give an output voltage of 115V AC rms at 60Hz

If the HVAC or the AC receptacle fails to operate, the inverter may be at fault. The LED indication panel on the front of the enclosure can be used to help diagnosis the fault with the inverter.

a. **Control Supply OK (Green)**: If this LED is "out" ensure that the inverter environmental contact is closed, i.e. inverter is called for.

b. **Main Capacitor Live (Blue)**: If this LED is "out' ensure battery voltage is within specifications as detailed above

c. **Converter ON (Green)**: If this is "out" the inverter has developed and internal problem

d. **115Vrms Output OK (Blue)**: If this is "out" – there is no 115V output, check the circuit breaker located through the panel cutout is closed. Wait one minute before closing the breaker to allow the HVAC compressor to discharge.

e. **Fault Condition (Amber)**: if this LED is "on" the inverter has developed a fault.

If any of the LEDS are out as listed above and the Fault LED is illuminated, remove power from the inverter; check and reset the breaker, situated on the front of the enclosure. Wait one minute before powering up, power up and check LED and system performance.

If the inverter unit does not operate or indicates a fault, replace the inverter unit.

EVENT RECORDER

This optional recorder provides the ability to record the overall operation of the locomotive.

A minimum of 48 hours of recorded data is stored in non-volatile flash Random Access Memory (NVRAM). As the memory is filled to capacity, the oldest data is overwritten with newly acquired data. No batteries are required to retain recorded data in the event recorder.

The integrated alerter system controller assures that the locomotive Engineer is attentive to the operation of the train at all times. The alerter has been designed as a fully redundant system for maximum train protection and minimum line-of-road failures.

For more information, refer to the event recorder manual.

SPEED INDICATOR

The Speed Indicator (SPD IND) incorporates two digital displays for the Engineer and Conductor, an odometer, and an accelerometer. The Speed Indicator provides each crewmember with a speed indication directed toward their normal cab position.

The Speed Indicator automatically provides two speed display ranges. Speeds below 10 MPH are displayed in miles and tenths of miles, and speeds above 10 MPH are displayed in whole miles.

The Speed Indicator controls an overspeed circuit that provides an output to the Overspeed Magnet Valve (MVOS) when the speed of the locomotive matches or exceeds the overspeed setting of the Speed Indicator. Once the locomotive has reached the overspeed set point and has remained at or above that point for 5 seconds, the overspeed circuit will be de-energized. The overspeed point is adjustable from 5 MPH to 120 MPH.

The odometer will increment and decrement based on the direction of the locomotive. True net distance can be obtained from any locomotive movement. The four and a half digit odometer displays readings in the range +/- 19,999 feet in one-foot increments.

The accelerometer display will report positive or negative acceleration in the range 0.0 to +/-99.9 MPH/min, with changes in 1/10 MPH/min increments.

A four-position dimmer control is included on the speed indicator.

The wheel size is adjustable in ½ inch increments. The measurement of the wheel diameter is entered directly into the speed indicator.

CONFIGURATION

DISPLAY ILLUMINATION ADJUSTMENT

To change the brightness level of the display, depress the DIM button. The illumination adjustment works in a circular fashion: each press of the DIM button will reduce the brightness of all displays until the lowest setting is reached, and then the next press will return the brightness to the highest setting. Example: Bright -> High -> Med -> Low -> Bright -> etc.

OVERSPEED SET POINT ADJUSTMENT

To adjust the overspeed setting of the Speed Indicator:

- Ensure the locomotive speed is 0 MPH.
- Press and hold the DIM button for 10 seconds. The Engineer's display will show the current overspeed setting in MPH, and the odometer display will display "OSPd" to signify that the Speed Indicator is in the "overspeed set-point" display mode.
- While still keeping the DIM button depressed, turn the key in the key switch provided on the back of the Speed Indicator. Once the key switch has been turned, the Indicator is placed in the OVERSPEED SET mode. Release the DIM button.

- Pressing the DIM button will decrease the overspeed set-point, and pressing the COUNT button will increase the overspeed set-point. Changes to the overspeed set-point are made in 1 MPH increments with each press of DIM or COUNT.

NOTE

Holding the DIM or COUNT buttons depressed will result in the overspeed setting being scrolled quickly.

- Once the desired overspeed setting is shown on the display, return the key switch to the normal position and remove the key. The new overspeed setting is stored in non-volatile memory and will remain the overspeed setting until it is changed again by this procedure.

- To verify the new overspeed setting, confirm that the locomotive is still stopped. Push and hold the DIM button for 10 seconds. The Engineer's display will show the current overspeed setting in MPH.

Wheel size adjustment

Measurement Display

To check the wheel size stored in the Speed Indicator, turn the key in the key switch provided on the back of the Speed Indicator. The Engineer's display will report the wheel diameter setting.

Adjustment

- Ensure the locomotive is stopped.

- Measure the wheel diameter of the wheel connected to the axle drive that the Speed Indicator uses.

- Insert the key into the key switch provided on the back of the speed indicator and turn the key. The current wheel setting will be displayed in the Engineer's speed display. The odometer will display "dIA" to signify that the Speed Indicator is in the wheel size adjustment mode.

- Modify the wheel setting by pressing either the DIM or COUNT button. Each time the DIM button is pressed, the wheel diameter setting will decrement half of an inch. Each time the COUNT button is pressed, the wheel diameter setting will increment half of an inch.

NOTE

Holding the DIM or COUNT buttons depressed will result in the overspeed setting being scrolled quickly.

- When the desired wheel diameter is displayed, turn the key switch to the normal position and remove the key. The new wheel size setting is stored in non-volatile memory and will remain the wheel size setting until it is changed again by this procedure.

- The wheel size setting can be confirmed during the power-up self-test, found in the Functional Testing Section of this manual.

OPERATION

ACCELEROMETER

The normal operation of the accelerometer/odometer display is in the accelerometer mode. Any acceleration/deceleration of the locomotive will be shown on this display in 1/10th MPH/min increments. As an example, if the display shows -14.5 MPH/min, it indicates that the locomotive speed is decreasing by 14.5 miles per hour per minute. At this deceleration rate, if the locomotive were traveling 29 MPH, it would take two minutes for the locomotive to reach 0 MPH. Similarly, if the accelerometer read +12.0 MPH/min, it would take one minute for the locomotive to increase its speed by 12 miles per hour. Whenever the odometer is used, the accelerometer display will be replaced by the odometer reading.

ODOMETER

To use the odometer, perform the following operations:

- Place the locomotive reverser in either the forward or reverse position.

NOTE

If the locomotive is moved before selecting the direction of the locomotive with the reverser, the odometer display will automatically switch to the accelerometer mode.

- Press the COUNT-HOLD-DONE BUTTON once. The display will show the current state of the odometer (0 feet if not moving).

NOTE

Once movement commences, the elapsed distance will be displayed as a positive distance, **REGARDLESS OF THE REVERSER POSITION**. When a movement that is opposite to the START of movement is performed, the distance will decrement in a similar fashion.

- To freeze the odometer display, depress the COUNT-HOLD-DONE button once. The odometer will cease counting and will flash the display.

- To turn off the odometer from a frozen odometer display, press the COUNT-HOLD-DONE button once. If the odometer display is not currently frozen, press the COUNT-HOLD-DONE button twice to exit the odometer mode. The odometer/accelerometer display will return to its normal accelerometer function.

NOTE

After +/- 19,999 feet, the odometer display will blink, indicating an over-range condition.

FUNCTIONAL TESTING

Power-Up Self-Test Operations

During the Speed Indicator power-up, diagnostic checks are made of the electronics and the speed indicator program memory. The digital displays on the Speed Indicator are used to show the following information.

NOTE

The Conductor's speed display will not illuminate until the power-up self-test is complete.

Fig. 5-2 Display Information

Information Displayed	Display Location	Display Duration
Software Version (1-19)	Engineer’s Speed Display	3 Seconds
Axle Drive Type (20 or 60)	Accelerometer Display	3 Seconds
Wheel Size (1/2” increments)	Engineer’s Speed Display	3 Seconds
Overspeed Setting	Engineer’s Speed Display	See Note Below

NOTE

The Speed Indicator will "ramp" the speed display from 5 MPH below the overspeed setting up to the overspeed setting and then flash the overspeed setting for 30 seconds. While the overspeed setting is displayed, the user may press either of the buttons located on the front of the Speed Indicator. This will cause the Overspeed Magnet Valve (MVOS) to de-energize for 5 seconds to test the overspeed penalty brake application system. After 30 seconds has elapsed or one of the buttons has been pressed to test the MVOS, the Indicator enters the "run" mode of operation.

NOTE

If a speed signal is detected upon power-up, the speed indicator will immediately enter the run mode and bypass the power-up operations.

LED TEST MODE

To test all LED displays, turn power off to the Speed Indicator. Press and hold the DIM button and return power to the Speed Indicator. The Indicator will automatically step through a test of all display segments and then return to the normal operating mode when finished (approximately 30 seconds).

MAINTENANCE

The Speed Indicator does not require periodic maintenance for any internal components. There are no user-serviceable parts internal to the Speed Indicator housing. Periodic inspection of the overspeed setting/function and adjustment of the wheel diameter setting should be performed during scheduled locomotive maintenance intervals.

MAIN ELECTRICAL CABINET

The main electric cabinet is a portion of the back wall of the cab, and houses the Low and High Voltage electrical devices necessary for the operation of the locomotive.

WARNING

Never open any electric cabinet doors other than to gain access to the circuit breaker and switch panels. High voltage and current are present throughout the control cabinet.

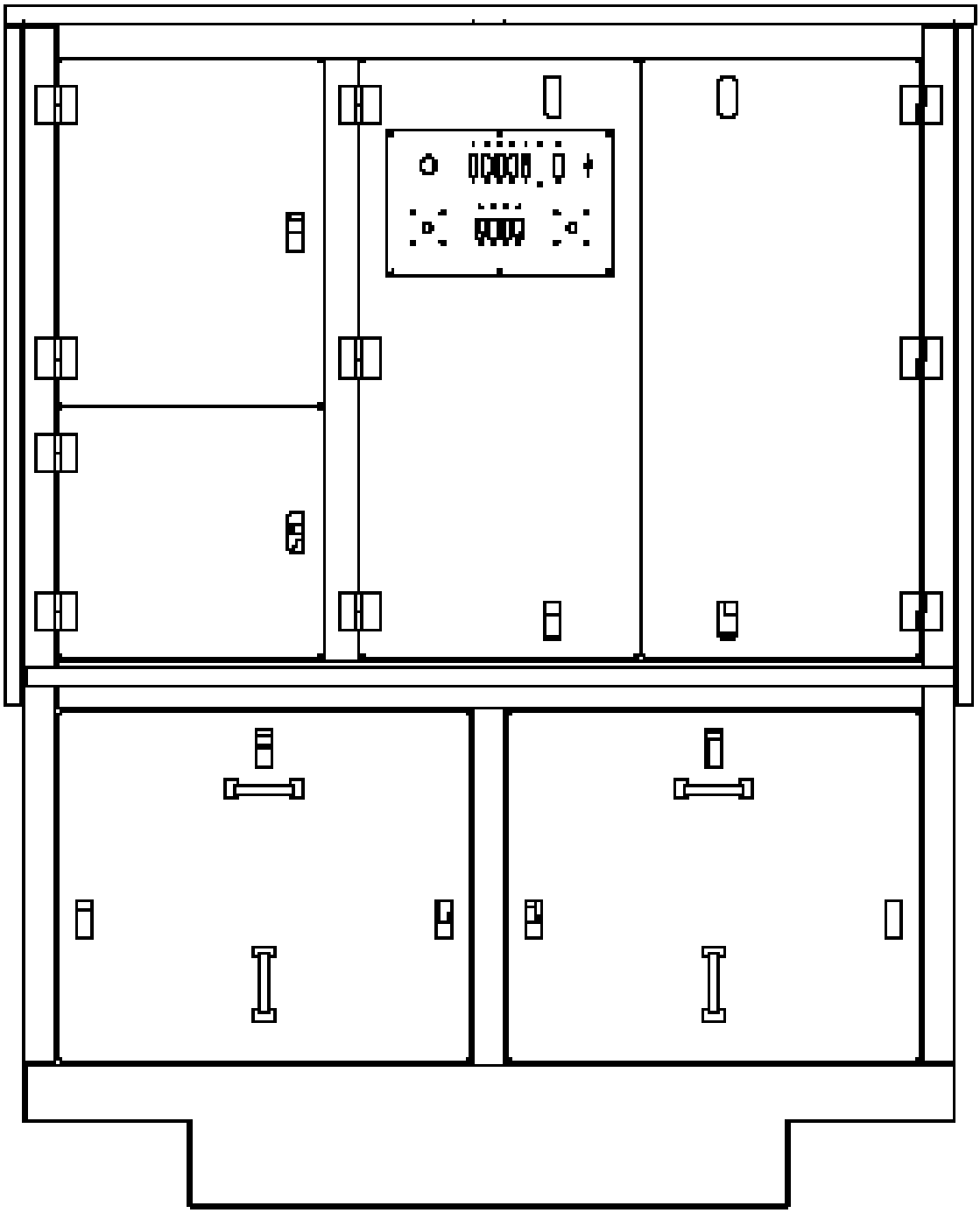


Figure 5-9 – Electrical Cabinet, Front View

* = IF EQUIPPED

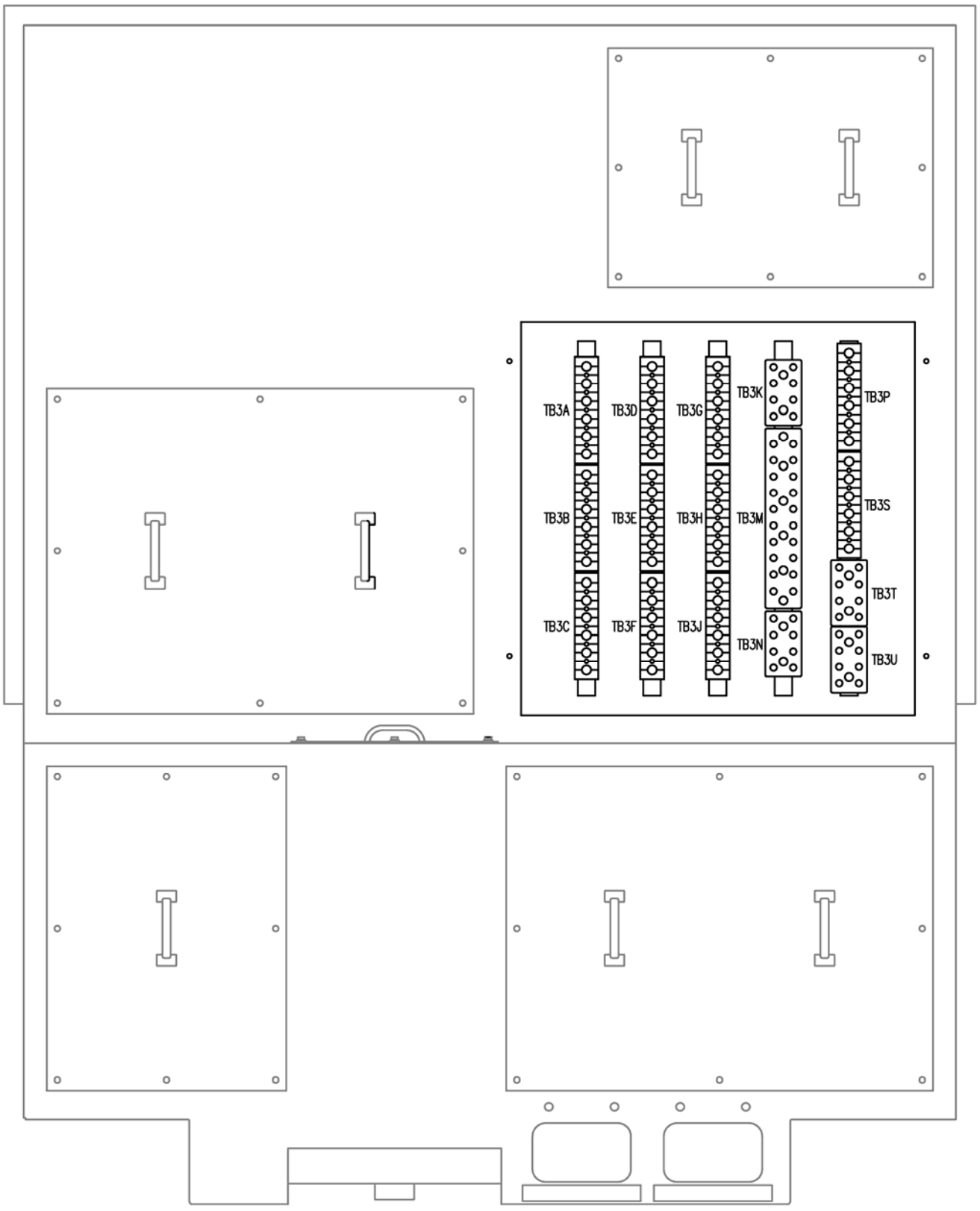


Figure 5-110 – Electrical Cabinet with Terminal Board Cover Removed, Rear View

* = IF EQUIPPED

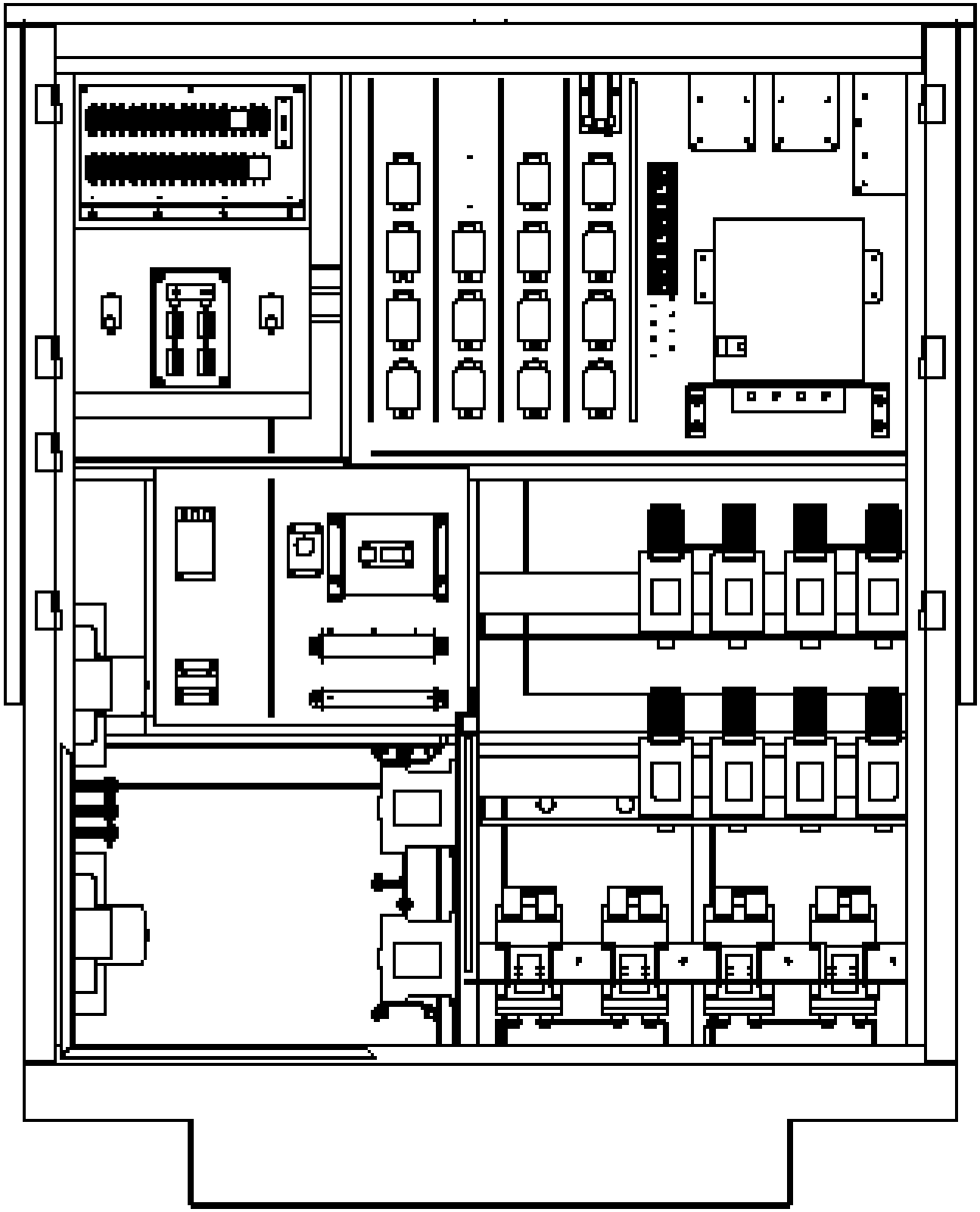
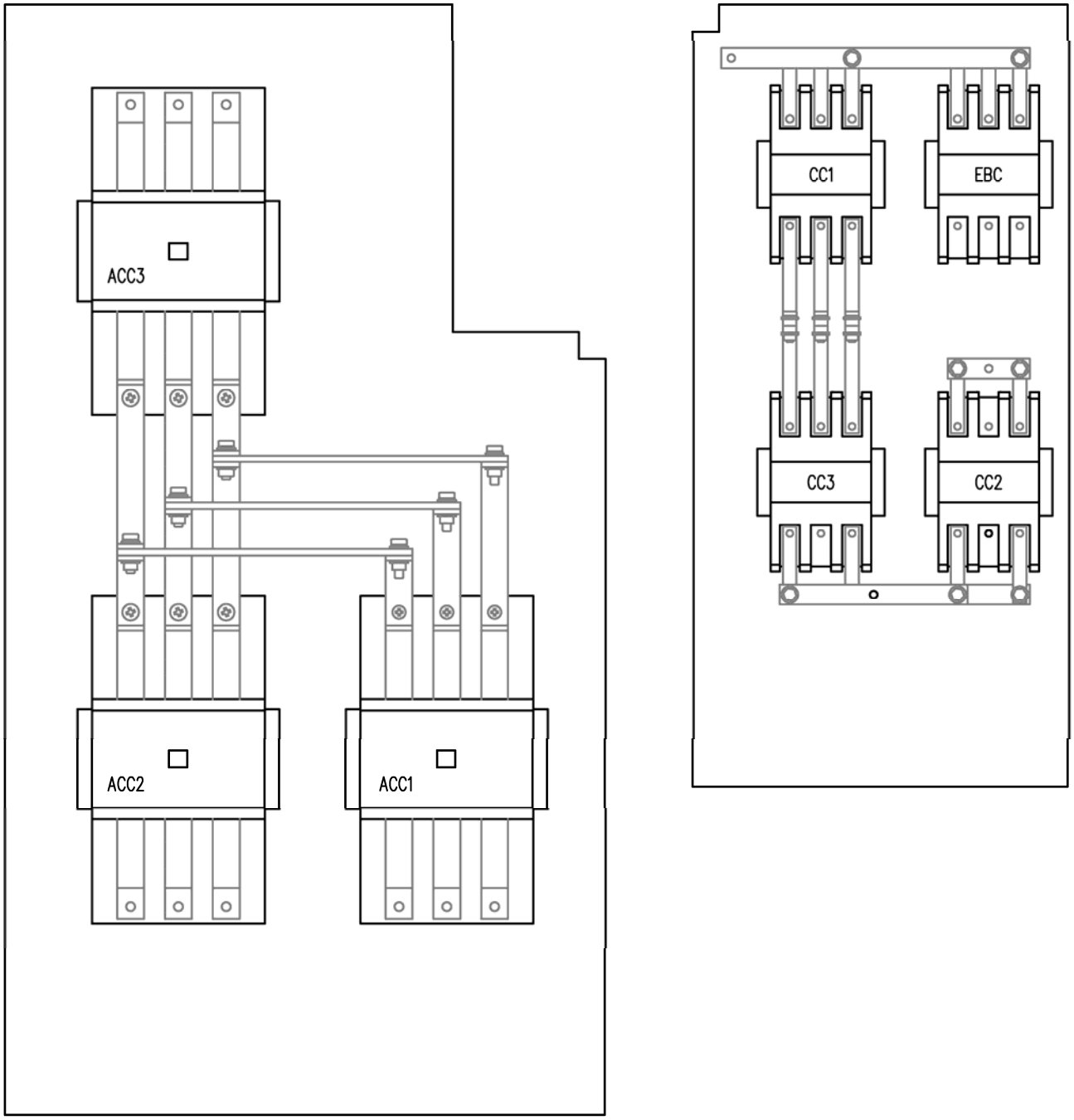


Figure 5-13 – Electrical Cabinet with Doors Removed, Front View

* = IF EQUIPPED



* = If ACC3 is Equipped

Figure 5-14 – AC Contactor Panel & Compressor Control / Equipment Blower Contactor Panel, Front View

* = IF EQUIPPED

ENGINE CONTROL PANEL

The engine control panel, Figure 5-15* and Figure 5-16*, contains various devices that are used in the operation of the locomotive. Following is a brief description of their individual functions. The locomotive will have either version 1 or version 2 of the engine control panel.

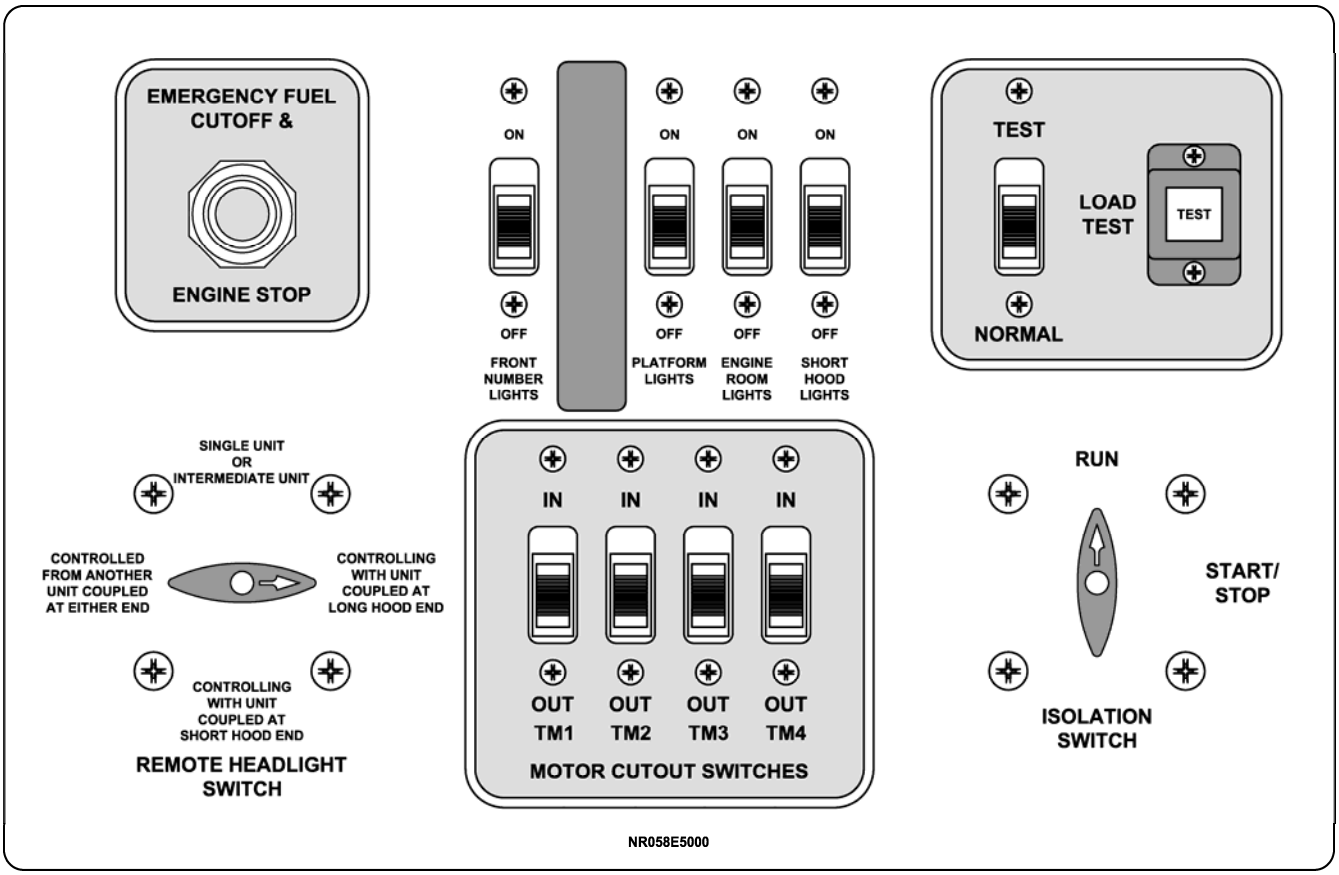


Figure 5-15 – Engine Control Panel version 1*

* = IF EQUIPPED

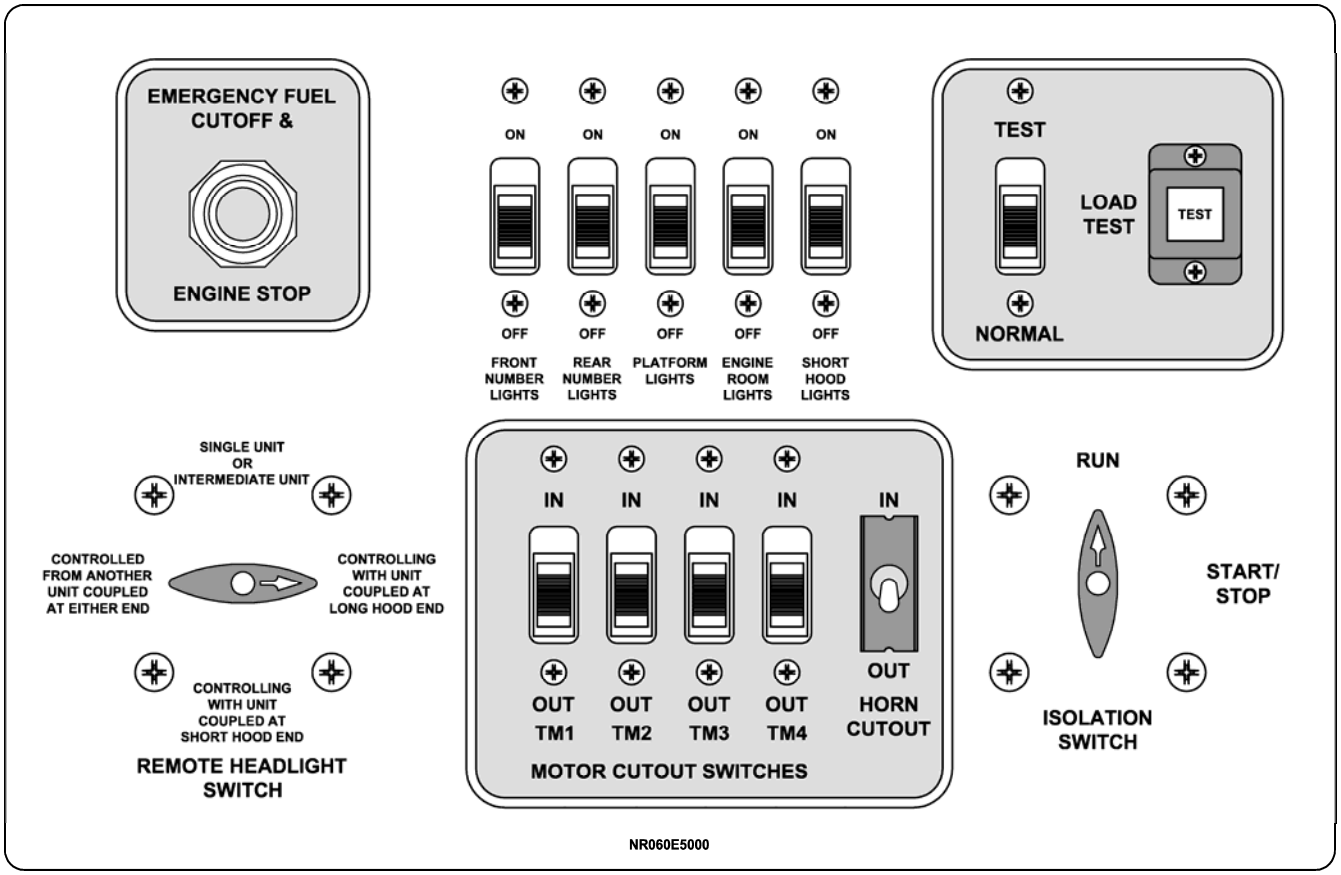


Figure 5-16 – Engine Control Panel version 2*

LOAD TEST SWITCH & INDICATOR LIGHT (LTSW, LTIL)

The load test indicator light will illuminate anytime the load test switch is placed in the Test position, with the isolation switch in START/STOP position and the reverser centered. This is an indication that the *NFORCE* indicates a load test mode and the unit will not apply power to the traction motors.

TRACTION MOTOR CUTOUT SWITCHES (MC1SW, MC2SW, MC3SW, MC4SW)

The traction motor cutout switches operate to electrically isolate a defective traction motor or it's associated DC Chopper. There is a cutout switch for each traction motor. When in the OUT position, the respective traction motor is electrically isolated permitting operation with the remaining good motors. The *NFORCE* will automatically limit power to prevent overloading the operative motors. The isolated motors will continue to rotate as the train moves.

The isolation switch must be placed in START/STOP position and the reverser in center position before operating a traction motor cutout switch.

WARNING

Make certain that all wheels freely rotate before operating the locomotive with a motor that has been cutout.

HORN CUTOUT SWITCH (HCSW)

This switch is exclusive to version 2. When placed in the OUT position, the horns on the locomotive will not sound regardless if the horn switch on the control stand is pressed. With the Horn Cutout Switch in the OUT position, the electronic bell will still sound.

* = IF EQUIPPED

ISOLATION SWITCH (ISSW)

This switch allows any unit in a locomotive consist to be "taken off the line" regardless of the control signals from the controlling unit. The switch has two positions.

START/STOP POSITION

In order to manually start any engine, the Isolation Switch must be placed in the START/STOP position.

This position is also used to isolate the unit. When isolated, the unit will not develop power and will run at IDLE. However, if a controlling unit of a multiple unit consist is isolated, all trailing units will still respond to the controls of the controlling unit.

The isolation switch must be placed in the START/STOP position before the *NFORCE* will respond to a traction motor cutout switch being placed in the OUT position.

RUN POSITION

The RUN position is used to remove the unit from isolation after the engines have been started. Once in this position, the unit will respond and operate at full capacity.

REMOTE HEADLIGHT SWITCH (HSSW)

The front and rear headlight switches, located on the control stand, operate the twin sealed-beam headlights. In order for these switches to operate properly, the headlight circuit breaker must be engaged.

The remote headlight control switch is mounted on the engine control panel and allows the lead unit to operate the headlight of the rear unit. This switch has three positions:

A. On lead unit

When locomotive is being used individually this switch should be in the SINGLE UNIT position.

If the locomotive is being used as the lead unit and the trailing units are coupled to the No. 2 or long hood end of the unit, this switch should be placed in the CONTROLLING – COUPLED AT LONG HOOD END position.

If the locomotive is being used as lead unit and the trailing units are coupled to the No. 1 or short hood end of the unit, this switch should be placed in CONTROLLING – COUPLED AT SHORT HOOD END position.

B. On Intermediate Units

When the locomotive is being used in a multiple consist, this switch should be placed in the INTERMEDIATE Unit position.

C. On Trailing Units

If the locomotive is placed in the last trailing unit in a multiple consist, this switch should be placed in the CONTROLLED – COUPLED AT EITHER END position.

The twin sealed-beam front and rear headlights are controlled by the front and rear headlight switches on the operator's control stand. Before these switches will function, the headlight circuit breaker must be placed on.

The remote headlight switch mounted on the engine control panel provides for operation of the rear unit headlight from the lead unit. The switch positions are set on each unit as follows:

ON LEAD UNIT

If only a single locomotive unit is being used, place the switch in SINGLE UNIT position.

In multiple unit service, if trailing units are coupled to the No. 2 or long hood end of the lead unit, place the switch in the CONTROLLING – COUPLED AT LONG HOOD END position.

In multiple unit service, if trailing units are coupled to the No. 1 or short hood end of the lead unit, place switch in CONTROLLING –

COUPLED AT SHORT HOOD END position.

ON INTERMEDIATE UNITS

On units operating in between other units in a multiple unit consist, place the switch in the INTERMEDIATE UNIT position.

ON TRAILING UNITS

The last unit in a multiple unit consist should have the headlight control switch placed on CONTROLLED – COUPLED AT EITHER END position.

EMERGENCY FUEL CUTOFF & ENGINE STOP Switch (EFCSW)

The EFCO pushbutton allows for immediate shut down of engines with the press of this button and can be locked out for unit maintenance purposes.

MISCELLANEOUS LIGHT SWITCHES (SHLSW, FNLSW, RNLSW, ERLSW, PFLSW)

Switches are included in circuits for various lights on the locomotive. The switches are closed as desired to operate the short hood lights (SHLSW), number lights (FNLSW and RNLSW), engine room lights (ERLSW), and platform lights (PFLSW).

NOTE

Rear Number Lights (RNLSW) are exclusive to version 2 of the panel.

CIRCUIT BREAKER PANEL

The circuit breaker panel is used to operate, isolate, and protect various systems on a locomotive. The breakers contained in the panel can be operated by the levers on the front of the panel. These breakers protect equipment and alert the operator of a problem by tripping when such an event occurs. If a breaker has a guard installed, it is meant to stay on at all times. Fig 5-17* and Fig 5-18*.

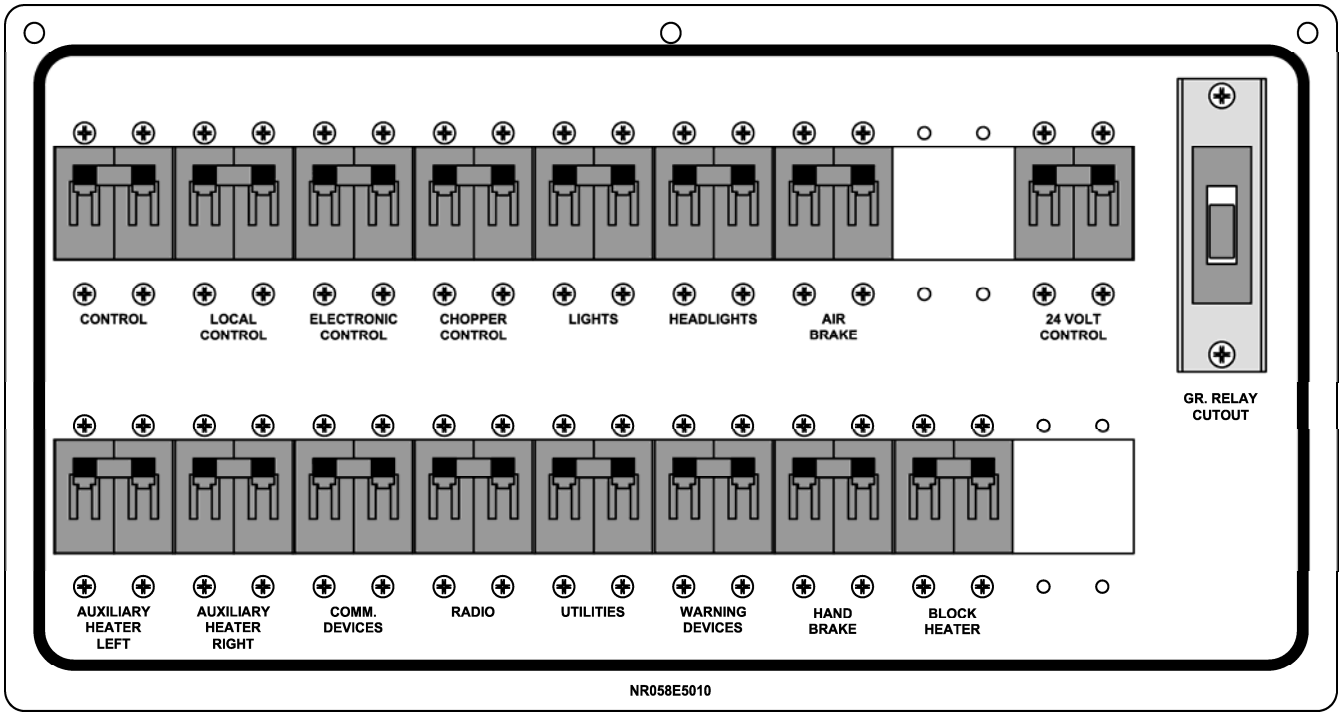


Figure 5-17 – Circuit Breaker Panel version 1*

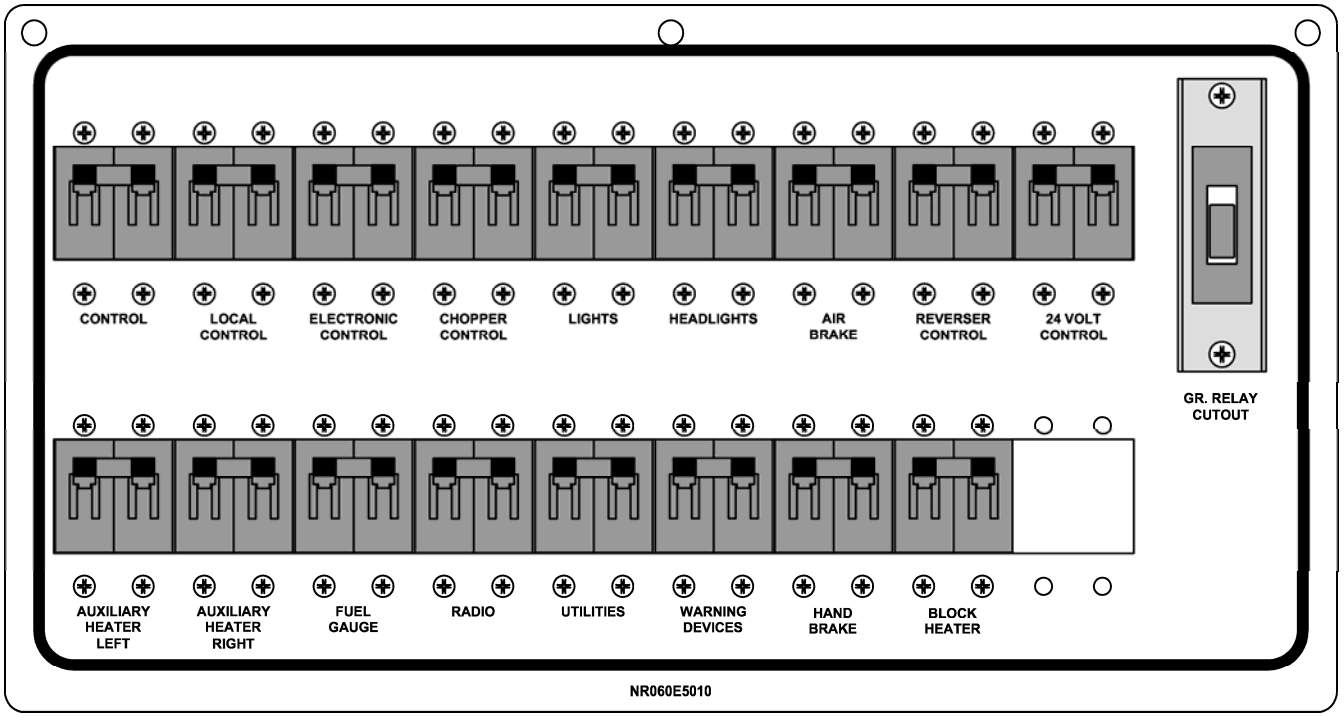


Figure 5-18 – Circuit Breaker Panel version 2*

* = IF EQUIPPED

AUXILIARY A/C CIRCUIT BREAKER (AACCB)

This 5amp circuit breaker controls the power to the AC Outlet in the main electrical cabinet.

CONTROL (CTCB)

This breaker sets up the control circuits for engine starting. Once the engine is running, power is supplied through this breaker from the LVPS to maintain operating control.

LOCAL CONTROL (LCCB)

This circuit breaker establishes “local” power from the LVPS to operate heavy duty switchgear and various control devices.

ELECTRONIC CONTROL (ECCB)

This circuit breaker supplies power to the *NFORCE* and event recorder and, if open, will not allow the locomotive to operate.

CHOPPER CONTROL (CHCB)

This circuit breaker supplies power to the DC Choppers. If open, power to the traction motors will be disabled.

LIGHTS (LTCB)

This breaker supplies power to the switches that control the lights and it must be on for the lights to function properly.

HEADLIGHTS (HLCB)

This breaker provides current to both headlights and ditch lights and provides power for headlight trainline control.

AIR BRAKE (ABCB)

This supplies power to the electronic air brake system and must remain on for proper operation of the electronic air brakes.

REVERSER CONTROL (RVCB)

This breaker is exclusive to version 2 (Fig 5-18). It supplies power to the reverser module (RV) and must remain ON for proper operation of the locomotive.

24 VOLT CONTROL (24vcb)

This breaker supplies power for the Genset control system and must remain on in order for the engines to start and operate properly.

AUXILIARY CAB HEATER LEFT & RIGHT (AHLCB & AHRCB)

The switches that operate the two auxiliary cab heaters are located on the control stand and the main electrical cabinet. These switches and heaters are protected by these breakers.

COMMUNICATION DEVICES (CDCB)

This breaker supplies power to the Digital Telemetry System equipment and Fuel Gauge system. It must remain on at all times for proper satellite communication.

ENGINEER SIDE CAB HEATER CIRCUIT BREAKER (ECHCB)

The ECHCB protects the engineer side cab heater from over current.

FIREMAN SIDE CAB HEATER CIRCUIT BREAKER (FCHCB)

The FCHCB protects the fireman’s side cab heater from over current.

Fuel Gauge (FGCB)

This breaker is exclusive to version 2 (Fig 5-18). It supplies power to the fuel gauge system.

* = IF EQUIPPED

RADIO (RACB)

This breaker protects circuits that supply the communication radio.

UTILITIES (UTCB)

This circuit breaker provides power for the auto drain valve heaters on the main reservoirs in the air system and also to the air compressor heater.

WARNING DEVICES (WNCB)

This breaker protects the horn and electronic bell circuits.

HAND BRAKE (HBCB)

This breaker supplies power to the electric operated hand brake.

BLOCK HEATER (BHCB)

This breaker supplies A/C power to each Genset's block heater used for preheating engine coolant in preparation for start. The locomotive will not operate if this breaker is open or OFF.

GROUND RELAY CUTOUT SWITCH (GCSW)

The ground relay cutout switch is used to isolate the locomotive from the ground relay for safety during locomotive maintenance procedures. When in down or CUTOUT position, this will keep the engines from responding to throttle and prevent the excitation of the gensets.

CIRCUIT BREAKER AND BATTERY SWITCH COMPARTMENT

The circuit breaker and battery switch compartment, Figure 5-19, is located beneath the circuit breaker panel. It contains the equipment described in the following paragraphs.

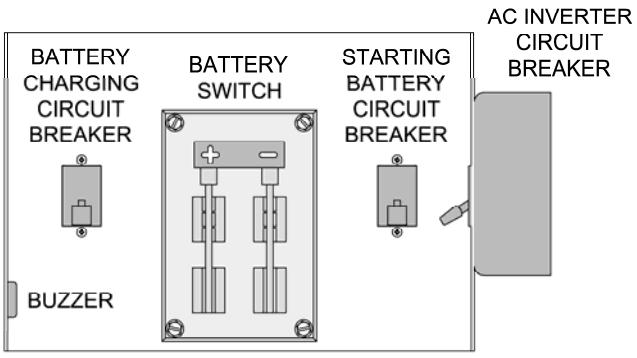


Figure 5-19 – Circuit Breaker and Battery Switch Compartment

BATTERY SWITCH (MBSW)

This switch is used to connect the 64VDC batteries to the locomotive low voltage electrical system and should be kept closed at all times during operation.

The 64VDC main battery knife switch may be opened during certain shop maintenance procedures and in instances where the engine is shut down and the locomotive taken out of service for an extended layover. This will prevent the battery from being discharged in the event the lights or other low voltage devices are inadvertently left operating during the layover.

BATTERY CHARGING CIRCUIT BREAKER (BCCB)

This circuit breaker protects the battery charging system from over current. It must remain closed during normal locomotive operation.

STARTING BATTERY CIRCUIT BREAKER (SBCB)

This circuit breaker protects the 24VDC starting battery charging from over current similar to the battery charging circuit breaker. This breaker should also remain closed during all normal locomotive operations.

* = IF EQUIPPED

AC INVERTER CIRCUIT BREAKER (INVCB)

This breaker protects the AC Inverter used to convert 64VDC battery power to AC power for the air conditioner operation. The air conditioners cannot be used if this breaker is in the open position.

BUZZER (BZZR)

The Buzzer is the physical buzzer portion of the Buzzer Panel.

OPERATOR INTERFACE PANEL

This optional panel is a visual display unit that provides information from the *NFORCE* for locomotive operators and locomotive maintenance personnel.

MAIN ELECTRICAL CABINET DEVICES

Devices not listed on the Engine Control Panel, Circuit Breaker Panel or Circuit Breaker and Battery Switch Compartment, and are located in the Main Electric Cabinet, are described in these paragraphs.

CONTACTORS

ACC1, ACC2, ACC3; AC CONTACTOR

The ACC1 Contactor connects the Genset 1 Auxiliary AC bus output to the BHCB Circuit Breaker, CC1 Contactor and EBC Contactor.

The ACC2 Contactor connects the Genset 2 Auxiliary AC bus output to the BHCB Circuit Breaker, CC1 Contactor and EBC Contactor.

The ACC3 * Contactor connects the Genset 3 Auxiliary AC bus output to the BHCB Circuit Breaker, CC1 Contactor and EBC Contactor.

BSC; BATTERY SHED CONTACTOR

This contactor disconnects all 64V DC loads from the 64V batteries by working in conjunction with the BATTERY VOLTAGE MONITOR (BVM) and the BATTERY TIME DELAY RELAY (BTD) to keep the batteries from being discharged.

CC1, CC2, CC3; COMPRESSOR CONTROL CONTACTOR

The CC1, CC2 and CC3 contactors are utilized to control the air compressor motor. The CC1 contactor supplies AC voltage to the compressor T1, T2 and T3 motor leads. The CC2 contactor closes to start the motor in slow speed. Approximately 2 seconds after the compressor starts, CC2 is de-energized and then the CC3 contactor is closed to bring the compressor motor to full speed operation.

EBC; EQUIPMENT BLOWER CONTACTOR

The EBC is controlled by the *NFORCE* and is used to turn on the equipment blower motor.

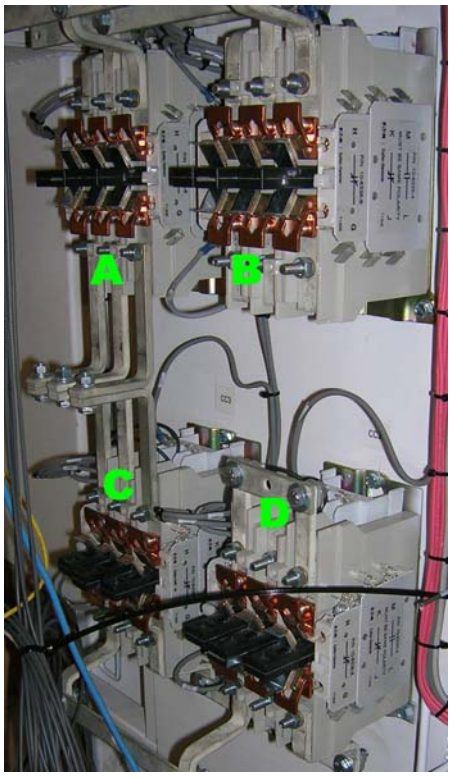


Fig. 5-20– Contactors (CC1, 2, 3, and EBC)

* = IF EQUIPPED

LSC; LOAD SHED CONTACTOR

The LSC is controlled by the *NFORCE* and turns off the AC inverter and/or the cab heater after a predetermined period of time to conserve energy in the 64VDC battery system.

Fig. 5-21 – Load Shed Contactor

M1, M2, M3, M4; MOTOR CONTACTORS

The M1, M2, M3, M4 contactors connect the output of the DC Choppers to the traction motors. M1 is connected in series with number 1 traction motor and only provides power to this motor. M2, M3, M4 contactors are connected in the same manner. See Fig. 5-23.

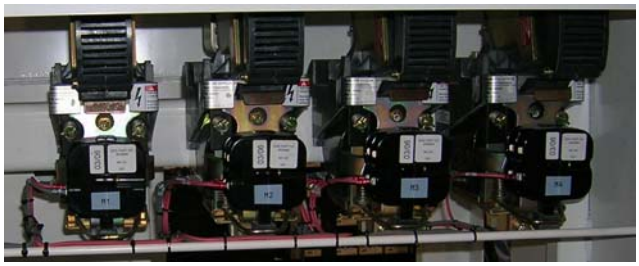


Fig. 5-23 – Motor Contactors

P1, P2, P3, P4; POWER CONTACTORS

P1, P2, P3, P4 power contactors are controlled by the *NFORCE* and supply high voltage to the DC Choppers. P1 is connected in series with DCH1 and only provides power to this chopper. P2, P3, P4 contactors are connected in the same manner.

RV1, RV2, RV3, RV4; REVERSING CONTACTOR

The N-VIRO locomotives are equipped with magnetically operated reversers. These reversing contactors are magnetically operated. RV1 is used to reverse the current flowing through number 1 traction motor thus providing directional control for the locomotive. RV2, RV3, and RV4 operate in the same manner. Each reverser is equipped with a Motor Cutout.

Fig. 5-22 – Reversing Contactors

RV1/L2, RV2/L1, RV3/R1, RV4/R2; REVERSING CONTACTORS*

The N-VIRO locomotives are equipped with motorized reversing contactors. These reversing contactors are operated by a motorized module RV. RV1/L2 is used to reverse the current flowing through number 1 traction motor thus providing directional control for the locomotive. RV2/L1, RV3/R1, and RV4/R2 operate in the same manner. Each reverser is equipped with a Motor Cutout.

RV; REVERSING MODULE*

The reversing module is operated by the RVR relay. The module has a motor that operates a cam arrangement that causes the motorized reversing contactors to change position.

* = IF EQUIPPED

Current Rectifiers

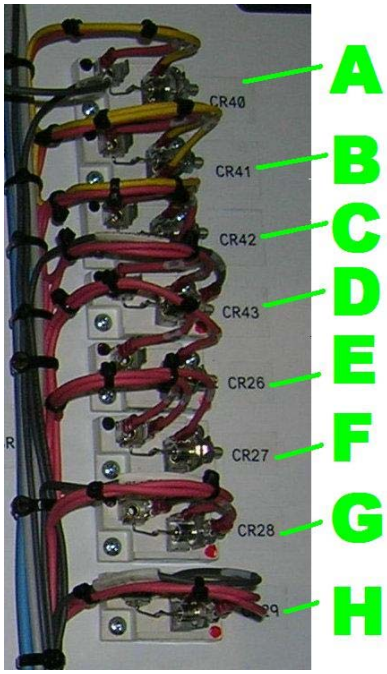


Fig. 5-24 – Current Rectifiers

CR26, CR27, CR28, CR29

These current rectifiers are used in the sanding control circuits. The rectifiers separate manual sand control circuits from emergency sand control circuits. See E – H on Fig. 5-24.

CR40, CR41, CR42, CR43

These current rectifiers are used to separate control power for the programming of DCH1, DCH2, DCH3, and DCH4. See A – D on Fig. 5-24.

CRBC; BATTERY CHARGING CURRENT RECTIFIER

This current rectifier is used to block the 64VDC battery voltage from supplying energy to the Engineer and Fireman sidewall heaters. Energy for the Engineer and Fireman sidewall heaters are supplied directly from the LVPS.

CURRENT TRANSDUCERS

CTA; AIR COMPRESSOR CURRENT TRANSDUCER

This current transducer provides 4-20mA to the *NFORCE* proportional to the current flowing to the air compressor motor.

CTB; EQUIPMENT BLOWER CURRENT TRANSDUCER

This current transducer provides 4-20mA to the *NFORCE* proportional to the current flowing to the equipment blower motor.

CTC; CHARGING CURRENT TRANSDUCER

This current transducer provides 4-20mA to the *NFORCE* proportional to the current flowing to the low voltage power supply (LVPS).

CTD; BATTERY CHARGING CURRENT TRANSDUCER

This current transducer provides 4-20mA to the *NFORCE* proportional to the currents flowing through the 64VDC battery charging system.

CTE; RECTIFIER DC OUT CURRENT TRANSDUCER

This current transducer provides 4-20mA to the *NFORCE* proportional to the currents flowing through the 24VDC battery charging system.

CTF; DC TRACTION CURRENT TRANSDUCER

This current transducer provides 4-20mA to the *NFORCE* proportional to the currents being produced in the high voltage system.

CTP; CURRENT TRANSDUCER PANEL

This panel provides an interface between the current transducers and the *NFORCE*. It provides the control voltage used by the current transducers to produce the 4-20mA outputs.

STEP DOWN TRANSDUCER

This transducer supplies power to the LVPS .It also provides 240 volts to the T1 transformer. It provides 480 a volts primarily & 240 volts secondarily.

RELAYS

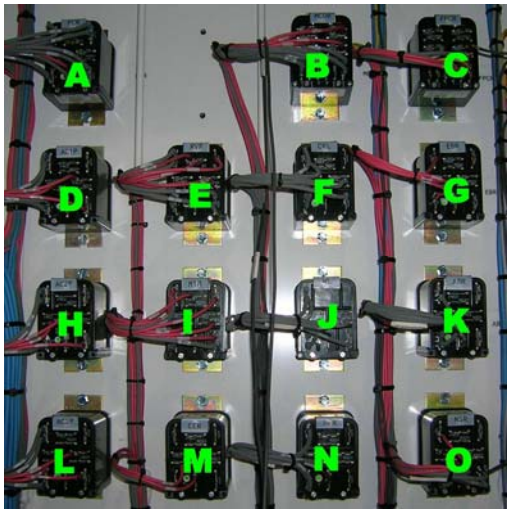


Fig. 5-26 - Relays

A. Pneumatic Control Relay
B. Motor Cutout Relay
C. Fuel Pump Control Relay
D. AC1P Relay
E. Reverser Forward Relay
F. Compressor Relay
G. Electronic Bell Relay
H. AC2P Relay
I. Motor Relay
J. Reverser Relay
K. Alarm Bell Relay
L. AC3P Relay
M. Chopper Enable Relay
N. Motor Fail Relay
O. No Speed Relay

ABR; ALARM BELL RELAY

This relay is operated by the *NFORCE* to sound the alarm bell in the locomotive cab.

AC1P, AC2P, AC3P; PILOT RELAYS

These relays are energized one at a time by the *NFORCE*. The AC1P relay energizes ACC1 and connects the ground relay circuit to Genset 1. The AC2P relay energizes ACC2 and connects the ground relay circuit to Genset 2. The AC3P relay energizes ACC3 and connects the ground relay circuit to Genset 3.

BTD; BATTERY TIME DELAY RELAY

This relay is provided to give a 5 minute time delay to the BATTERY SHED CONTACTOR (BSC).

CER; CHOPPER ENABLE RELAY

This relay supplies control power to DCH1, DCH2, DCH3, DCH4. The CER responds to generator field (ON) trainline six commands.

CR24, CR25 RELAYS

These relays are part of the No Heat Relay circuit that serves to block energy from the Engineer's Side Cab Heater circuit breaker and the Fireman's Side Cab Heater circuit breaker.

CRL; COMPRESSOR RELAY

This relay is controlled by the *NFORCE*. It applies a control voltage to the 22 trainline to activate compressors on other locomotives connected to the trainline.

EBR; ELECTRONIC BELL RELAY

This relay is activated by pulling the Electronic Bell Switch (EBSW) or by depressing the Horn Switch (HNSW). The EBR will remain energized until the EBSW is pushed in.

FPCR; FUEL PUMP CONTROL RELAY

This relay is energized by pressing the engine start switch (EONSW) on the control stand, and is held up by its own interlocks. There are three emergency fuel cutoff switches (EFCSW, EFCO1, EFCO2) connected in series with the FPCR coil. Pressing any one of these switches will shut the locomotive engine down.

GR; GROUND RELAY

This relay detects a ground fault in the AC and DC high voltage circuits.

MCOR; MOTOR CUTOUT RELAY

This optional relay is controlled by the *NFORCE* and causes the magnetic reversers to cycle so that the motor cutout mechanisms can

* = IF EQUIPPED

be locked out.

MFR; Motor Fail Relay

This relay is controlled by the *NFORCE* to indicate that a DC Chopper has failed. The MFR turns on the motor fail light located on the control stand.

MTR; Motor Relay

This relay is controlled by the *NFORCE* to control the M1, M2, M3, M4 motor contactors.

NHR; NO HEAT RELAY*

This relay is controlled by the engine and fireman cab heater circuit breakers. When energized, this relay opens the control circuit to the air conditioner to stop operation.

NSR; No Speed Relay

This relay is controlled by the *NFORCE* and turns off Emergency Sand operation when the locomotive speed is zero.

PCR; Pneumatic Control Relay

This relay is controlled by the air brake system and is de-energized with the initiation of a penalty or emergency brake application. Engine speed and power is reduced to idle when the PCR is de-energized.

RVF; Reverser Forward Relay*

This optional relay is controlled by the *NFORCE* to control the RV1, RV2, RV3, RV4 magnetic reversing contactors.

RVR; Reverser Relay

This optional relay is controlled by the *NFORCE* to control the motorized module RV.

WLR; Wheel Slip Light Relay

This relay is controlled by the *NFORCE* to turn on the wheel slip light on the control stand and supplies a signal to the wheel slip trainline (10T).

Resistors

RE2

This resistor is inserted in series with the load test light to provide proper voltage to the lamp.

RE31

This resistor is inserted in series with the Ground Relay (GR) operational coil to limit current flow through the coil.

RECAN

This resistor is used to terminate the J1939 communications bus.

REHLA & REHLB

THESE RESISTORS ARE USED TO DIM THE HEADLIGHTS.

Misc. Main Electric Cabinet Devices

AC OUTLET *

115VAC convenience outlet has been provided for charging of diagnostic equipment.

BZZRP; Buzzer Panel

The buzzer panel is controlled by the *NFORCE* and is used to provide an auditory warning that the locomotive is in Idle Limiting. The warning is sounded before the Genset engine is shut down by the *NFORCE*, while the Genset engines are shut down and prior to the Genset engine being automatically started by the *NFORCE*.

CCP1, CCP2, CCP3, CCP4; Chopper Download Port Assembly

The CCP1, CCP2, CCP3 and CCP4 Chopper Download Ports provide a computer access point to obtain data from the four propulsion system choppers, LVPS and Inverter. CCP1 provides access to the number 1 chopper and the LVPS. CCP2 provides access to the

* = IF EQUIPPED

number 2 chopper and the Inverter. CCP3 provides access to the number 3 chopper. CCP4 provides access to the number 4 chopper.

DCVP; DC Voltage Panel

The DCVP monitors the voltage contained in the high voltage system and provides a 4-20mA signal to the *NFORCE* proportional to the voltage of the DC buss.

ECM; Electronic Control Module

The ECM is referred to as the *NFORCE*. The *NFORCE* system is a computer control system that monitors and controls all functions of locomotive operation.

FSHSW; Sidewall Heater Switch – Assistant

This switch is a three-position rotary snap switch located outside the MEC on the assistant's side of the cab. The switch includes OFF, LOW, HIGH settings to provide control of the assistant's sidewall heater.

LTN & LTP; Bus Bar, Load Test Negative & Positive

These bus bars are provided to be the connection point between the locomotive and an external load box.

MCO1, MCO2, MCO3, MCO4; Traction Motor Cutouts

The MCO1 motor cutout locks RV1 in the center position to isolate number 1 traction motor. MCO2, MCO3, MCO4 perform the same function on the respective reversers; RV2, RV3, RV4.

T1; AC Voltage Transformer

The T1 AC voltage transformer provides an input signal to the *NFORCE* proportional to the AC voltage on the auxiliary bus.

TRP; Trainline Resistor Panel

This panel consists of a series of resistors connected to the trainline circuits to provide transient suppression.

MISC. ELECTRICAL DEVICES

AATS; Ambient Air Temperature Sensor

The ambient air temperature sensor provides a 4-20mA signal to the *NFORCE* proportional to ambient air temperature. The sensor is mounted in the LVPS compartment. The probe extends through the bottom of the compartment to read the ambient air temperature.

ACOMP; Air Compressor

The air compressor is provided to supply compressed air to the air brake and auxiliary systems on the locomotive.

ALARM BELL

The alarm bell is located in the control stand and is provided to produce an audible warning of a malfunctioning system on the locomotive. It also can be utilized for signaling between locomotive cabs.

Auxiliary Sidewall Heaters

ESH; Sidewall Heater - Engineer

This auxiliary heater is located on the Engineer's side of the cab and is operated by the sidewall heater switch (ESHSW) located on the control stand.

FSH; Sidewall Heater – Assistant

This auxiliary heater is located on the Assistant's side of the cab and is operated by the sidewall heater switch (FSHSW) located on the outside of the main electric cabinet.

AXDR; Axle Generator

The axle generator provides the *NFORCE* with a signal proportional to locomotive speed. The

axle generator is mounted on the R2 journal box and produces 500 pulses per revolution of the axle

Batteries

24BAT; 24VDC Starting Battery

The 24VDC battery system is used to provide control voltage and engine starting voltage for the Gensets.

64BAT; 64VDC Locomotive Batteries

The 64VDC battery system is used to provide control voltage for the trainline control systems, the *NFORCE* system and locomotive lighting.

CCB26; Air Brake System *

The CCB26 electronic air brake system controls the locomotive air brake system. See the COMPRESSED AIR SYSTEM section of this manual for more information.

BCPT; Brake Cylinder Pressure Transducer

This transducer provides a 4-20mA signal to the *NFORCE* proportional to the air pressure applied to the locomotive brake cylinders of the lead truck.

CMO3; Event Recorder Current Module

The current module converts the voltage applied to the load ammeter into an electronic signal. This signal is supplied to the event recorder.

DNHTR1, DNHTR2, DNHTR3, DNHTR4; Blowdown Heaters

These optional blowdown heaters are thermostatically controlled heating elements attached to the blowdown valves to prevent its respective valve from freezing.

EBELL; Electronic Bell

The electronic bell is located under the underframe on the left side of the locomotive. It is activated by either the horn switch or bell switch.

EBM; Equipment Blower motor

The equipment blower motor is used to supply air for cooling of various components of the locomotive. In addition, the air is used to provide positive pressure to the LVPS, Chopper and Main Electric compartments to prevent dirt and dust buildup in the compartments. See the CENTRAL AIR SYSTEM section of this manual for more information.

EFGC; Electronic Fuel Gauge Control Kit

The EFGC monitors and reports the amount of fuel in the fuel tank. It displays the fuel level on the digital display (REFG) located on the fuel tank.

EIM; Emergency Interface Module *

The emergency interface module provides a digital output to the LCU when the CCB26 air brake system initiates an emergency sand command.

LCU; Locomotive Control Unit

The LCU is the head-of-train unit.

Magnet Valves

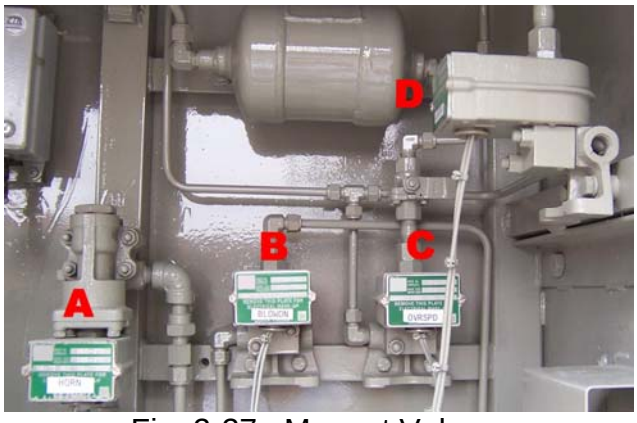


Fig. 2-27– Magnet Valves

* = IF EQUIPPED

A. Horn Mag. Valve (Front)
B. Main Blowdown Mag. Valve
C. Over Speed Mag. Valve
D. Alerter Mag Valve

MV1Sf; Front Sander Magnet Valve

This Magnet Valve is located in the short hood and is controlled by the *NFORCE* system. Refer to Section 4 for a complete description of sanding operations.

MV2SR; Rear Sander Magnet Valve

This Magnet Valve is located in the end hood and is controlled by the *NFORCE* system. Refer to Section 4 for a complete description of sanding operations. See Fig. 2-28.

MVHF, MVHR; Horn Magnet Valves

These Magnet Valves are energized by the Horn Switch, HNSW. When energized, air is supplied to the appropriate horn. Front Horn Magnet Valve, MVHF, is located in the Air Brake Compartment. Rear Horn Magnet Valve, MVHR, is located in the End Hood. See Fig.'s 2-27 and 2-28.

Fig. 2-28 – Rear Horn and Sander Magnet Valves

MVOS; Overspeed Magnet Valve

When an overspeed condition is detected, this Magnet Valve is energized by the Speed Indicator to initiate a penalty brake application. The MVOS is located in the Air Brake Compartment. See Fig. 2-27.

MVA; ALERTER MAGNET VALVE

If the locomotive engineer fails to respond to the Alertness Control System, the MVA will be de-energized by the event recorder to cause a penalty brake application.

MRPT; Main Reservoir Pressure Sensor

This sensor is located in the control stand and provides the *NFORCE* with a 4-20mA signal proportional to the air pressure contained in the main reservoir.

SBSW; 24VDC STARTING battery Knife Switch

This knife switch is provided to interrupt the 24VDC battery voltage used by the Gensets and the *NFORCE*. The switch should not be opened when the Gensets are in operation.

SBF; Starting Battery Fuse

This 900A fuse is located in the right side battery box behind the 24VDC battery switch.

The fuse protects locomotive wiring in the event of a short circuit in a genset starting motor.

* = IF EQUIPPED

Introduction

The electrical control system of the N-VIRO locomotive is handled by the electronic control module (ECM). The ECM is referred to as the *NFORCE*.

SCOPE

The *NFORCE* software will perform the following functions

- Read input information from the locomotive
- Drive digital and analog outputs for locomotive Power control
- Perform locomotive wheel slip control
- Locomotive equipment protection
- Store alarm information for retrieval
- All alarm information shall be time stamped
- Diagnostic download resolution will be 0.1 seconds
- Perform self-diagnostics on the system
- Communicate information via RS-232/USB or 9 pin D serial port of a personal computer
- Allow new software to be uploaded

Interface and Control Requirements

The *NFORCE* uses various software routines for monitoring and controlling the locomotive. These software routines, alarms, and messages are described in the following pages.

Alarm Bell Control

The alarm circuit alerts the operator to abnormal conditions or protective device activity. The alarm bell can be activated be either closing the Attended Call button or when the *NFORCE* energizes the ABR relay.

Events that will activate the alarm bell are as follows:

GROUND RELAY DETECTION

The alarm bell rings when the *NFORCE* detects that the Ground Relay is active. The alarm bell will continue to ring until the Ground Relay is reset.

AIR COMPRESSOR FAULT

The alarm bell rings 2 seconds on then off repeatedly when the *NFORCE* detects an Air Compressor alarm.

TM BLOWER FAILED

The alarm bell rings for 5 seconds when the *NFORCE* detects a TM BLOWER FAILED alarm.

OPEN TRACTION MOTOR & PINION SLIP FAULTS

The alarm bell rings when the *NFORCE* detects either an open traction motor or pinion slip alarm. The alarm bell will continue to ring until these alarm are cleared.

GEN SET FAULT

If the *NFORCE* senses that the Cummins Control System has activated the GEN SET “Fail” indication, the *NFORCE* will ring the alarm bell for five seconds.

GEN SET START FAILURE

If the *NFORCE* senses that the Cummins Control System has activated the GEN SET “NO ST” indicator the *NFORCE* will ring the alarm bell for five seconds.

LVPS FAULT or LVPS OVERTEMP

If the LVPS Fault indicator is on the *NFORCE* will set a LVPS FAULT alarm, and ring the alarm bell for 5 seconds.

* = IF EQUIPPED

DC RECTIFIER FAULT

If the DC Rectifier Fault indicator is on the *NFORCE* will ring the alarm bell for 5 seconds.

EXCITATION FAULT

If the *NFORCE* determines that it can not control any of the Traction Motor Current Choppers it will ring the alarm bell for five seconds.

24 VOLT SUPPLY FAULT

The alarm bell will ring continuously until the Isolate switch is placed in the isolate position when this alarm is active.

BATTERY VOLTS FAILED

If the *NFORCE* monitor a BATTERY VOLTS FAILED alarm the alarm bell will ring for 5 seconds.

ALARM NOT THIS LOCO

If another locomotive in the consist activates the Attendant Call and Alarm MU line (2T), this alarm is set

MU LINE FAILED 2T

When the *NFORCE* energizes ABR relay to drive a MU 2T line it checks to ensure the MU line becomes active. This alarm is set if the MU line fails to become active.

DC Rectifier Control

The DC Rectifier converts AC power supplied from the AC BUS to DC power for the traction motor circuits.

The DC Rectifier will supply a 74 volt digital output to the *NFORCE* to indicate that it has over heated. If this input is LOW the rectifier is operating as intended. If this digital should go HIGH the *NFORCE* will set a DC RECTIFIER FAULT alarm, shut down the engines, and turn on the AUX PWR Fault indicator light. The *NFORCE* will also ring the alarm bell for 5 seconds.

DC RECTIFIER OVERTEMP

If the DC Rectifier over temperature signal from the rectifier is off, the *NFORCE* will set a DC RECTIFIER OVERTEMP alarm, ring the alarm bell for 5 seconds, shut down the engines, and turn on the AUX PWR Fault indicator.

Directional Control (Magnetic)

The *NFORCE* will monitor the directional train lines 8T (forward) and 9T (reverse). If the Isolate switch is in the "RUN" position the *NFORCE* will determine the operating direction based on the status of these two train lines.

When 8T is high and 9T is low the *NFORCE* will pickup the RVF relay which will set the magnetic reversers in the forward direction. If 8T is low and 9T is high the *NFORCE* will de-energized the RVF relay setting the reversers in the reverse direction. Once the direction has been set, if both 8T and 9T are low the current direction will be held.

If both 8T and 9T are high at the same time the *NFORCE* will disable the traction motor chopper control and set a MU 8T AND 9T HIGH alarm.

No directional changes will be allowed unless the locomotive speed is zero.

The *NFORCE* will not control the reversers directly. In the case of magnetic configurations the *NFORCE* will control one standard general purpose EMD relay called RVF, which in turn will control the reversers. When the RVF relay is picked up the locomotive is set to operate in the forward direction.

CONTACTOR FAILED RV1
CONTACTOR FAILED RV2
CONTACTOR FAILED RV3
CONTACTOR FAILED RV4

If a contactor fails to pick up or drop out, a CONTACTOR FAILED RVF'*' alarm is set, where '*' is the contactor that failed. The *NFORCE* senses the auxiliary contacts on these contactors. When the *NFORCE* energizes or releases the coil through the RVF relay, it checks for the correct feedback from the auxiliary contacts on the reverser contactors. If the correct feedback is not received, one of these alarms is set.

MU 8T AND 9T HIGH

This alarm is set if the MU lines command both Forward (8T) and Reverse (9T) at the same time. The traction motor chopper control is disabled if this occurs. Loading is prevented until only one of these lines is high.

RELAY FAILED RVF

If the RVF relay is picked up and RV1, RV2, RV3, and RV4 do not pickup or if RVF is dropped and RVF1, RVF2, RVF3, and RVF4 do not drop out, a RELAY FAILED RVF alarm is set. The *NFORCE* senses the auxiliary contacts on RV1, RV2, RV3, and RV4. When the *NFORCE* energizes or releases the RVF relay coil, it checks for the correct feedback from the auxiliary contacts of the reverser contactors. If the correct feedback is not received, this alarm is set.

Excitation Control

For this application the *NFORCE* will not regulate the main generator output. Each Cummins engine provides 700 HP at maximum RPM. With all engines at maximum RPM the total brake horse power is 2100 HP.

While the engines are operating the *NFORCE* will verify that the AC voltage supplied to the AC bus is operating between 160-240 VAC.

The *NFORCE* will also monitor the auxiliary AC BUS load by means of the following:

- CTA – Air Compressor Motor Current Load Current Sensor.
- CTB – Traction motor Blower Motor Load Current Sensor.
- CTC – Low Voltage Power Supply Load Current Sensor.

The *NFORCE* calculates the total AC power used by the ancillary equipment in order to determine the available AC power used for traction power (AC BUS Power – [CTA+CTB+CTC] = Traction Power).

Excitation Enable Mode

The *NFORCE* will set the excitation control to the requested kilowatt reference as determined by throttle position once **ALL** of the following conditions are met.

- Isolate switch is in the "RUN" position.
- No fatal fault alarms reported by the Traction Motor Choppers.
- The power contactors are picked up.
- Direction is set.
- The PCR relay is picked up.
- The 6T MU is high and the throttle position 1-8.
- Ground Relay Cutout Switch is closed.
- The AC bus is operating between 160 - 240 VAC.

* = IF EQUIPPED

Excitation Output Regulation

Excitation will be based on the Throttle Schedule as outlined below (Table 6-1). This table outlines excitation output if the following conditions are true:

- All traction motors are cut in.
- All traction motors are operating within the traction motor protection parameters.

If locomotive speed is below 2.5 MPH, the second and third engines will not be started, as one GEN SET will be able to provide enough traction motor current to meet the maximum limits of the Traction Motor Choppers and Traction Motors.

Table 6-1– Throttle Schedule

Throttle Notch	Eng 1 BHP	Eng 1 THP	Eng 1 RPM	Eng 2 BHP	Eng 2 THP	Eng 2 RPM	Eng 3 BHP	Eng 3 THP	Eng 3 RPM	Loco BHP	Loco THP
Idle	67	0	1200							67	0
1	228	145	1500							228	145
2	388	305	1500							388	305
3	685	585	1800							685	585
4	547	447	1800	390	373	1500				937	820
5	661	651	1800	485	469	1500				1146	1030
6	594	494	1800	514	494	1800	429	412	1500	1537	1400
7	667	567	1800	587	567	1800	587	567	1800	1841	1701
8	697	597	1800	686	664	2000	686	664	2000	2069	1925

LOW AC BUS VOLTAGE

If AC bus voltage is less than 100 VAC while the engines are operating for 30 seconds, and the *NFORCE* has not nullified AC excitation the *NFORCE* will set this alarm.

EXCESSIVE PHASE I GS

If the average phase current for any operational Genset (1, 2, or 3*) exceeds 1750A for 2 seconds continuously or 1950A for 200 milliseconds the *NFORCE* will set this alarm and shut down the offending Genset.

PHASE I IMBALANCE GS

If the phase currents for any operational Genset (1, 2, or 3*) differ from one another by more than 250A for at least one second continuously the NFORCE will set this alarm and shut down the offending Genset.

Ground Relay Control

The purpose of the Ground Relay (GR) protection system is to protect the main generators, traction motors, and high voltage wiring, and reduce the possibility of electrical fires by removing excitation when a ground faults occur in the high voltage system.

The ground fault detection circuit is connected the same as a conventional locomotive. If a high voltage ground is detected by this circuit, the GR picks up and latches and the *NFORCE* will then set a GR TRIPPED alarm. The reset coil of this relay is connected to the *NFORCE*, allowing for automatic reset as required.

* = IF EQUIPPED

The *NFORCE* monitors the GR Reset switch. The operator can close the GR Reset switch to reset the *NFORCE* fault counts allowing the various ground relay limits and lockouts to be manually reset. This switch does not reset the ground relay coils. If the *NFORCE* detects this switch to be closed the fault counter are reset to two and a GR RESET alarm is set.

A Ground Relay Cutout Switch (GRCO) is provided to disable the ground relay protection circuit during certain shop maintenance procedures. If the *NFORCE* detects this switch to be open, excitation will be disabled and a NO LOAD GR CUT OUT alarm is set.

If the ground relay circuit trips the *NFORCE* will set the traction motor current chopper control to zero, nullify AC generator excitation, idle the engines, and ring the alarm bell. The *NFORCE* will then automatically reset the ground relay up to two times and restore the locomotive back to normal operation. Each time the ground relay trips, the GR fault counter increases by one.

If the GR fault counter reaches three with no more than one hour between ground faults, the *NFORCE* will lock out automatic ground relay reset, ring the alarm bell, set the alarm NO POWER GR, and not allow motoring operation.

If the GR fault counter reaches three, the fault counter can be reset to two by the operator activating the GR Reset switch. The *NFORCE* monitors the position of the switch, and will automatically reset the counters if the switch is activated.

GR RESET

This alarm is set if the *NFORCE* senses the GR Reset switch is closed. Activating the GR Reset reverts the fault counters back to two.

GR TRIPPED

When the *NFORCE* senses a Ground Relay picked up a GR TRIPPED alarm is set. When this alarm is set the *NFORCE* will set the traction motor current chopper control to zero, nullify AC generator excitation, idle the engines, and ring the alarm bell.

NO LOADING GR CUT OUT

If the *NFORCE* senses the Ground Relay Cutout switch is open, this alarm is set and prevents loading. Throttle is limited to the Idle position.

NO POWER DUE TO GR

If the GR fault counter reaches three with no more than one hour between ground faults, the *NFORCE* locks out the automatic ground relay reset and sets this alarm. The traction motor chopper control is disabled preventing loading to regain normal operation use the GR Reset switch.

Idle Limiting Control

The *NFORCE* reduces fuel consumption and exhaust emissions by monitoring locomotive operating parameters and automatically shutting down and restarting the engines during locomotive idle times.

Before the *NFORCE* will shut down the engines, the engines must idle for at least 15 minutes, regardless of any other system condition. After this idling period has elapsed, the following parameters must be met before the engines will be shut down:

- Battery charging current is less than 25 amps.
- Battery voltage is greater than 69V.
- Ambient Air temperature is greater than 10ºF.
- Reverser handle is centered (no direction).
- BC Pressure above 22psi

When all of these conditions are met, the following shutdown sequence occurs:

The locomotive Warning Buzzers sound for one second on, and one second off for 30 seconds,

warning the operator that the engines are about to shutdown. If any of the shut down parameters becomes invalid during this 30-second period, the engine shutdown is aborted. After the engines have shut down, the Warning Buzzers sound intermittently at 30-second intervals to indicate the locomotive is in Idle Limiting mode.

One of the engines will restart when any ONE of the following conditions exist:

- Battery voltage is less than 60V.
- Ambient Air temperature is less than 0ºF.
- Reverser handle is in Forward or Reverse.
- BC Pressure below 18.5psi.
- The Engine Start button has been closed.

If one or more of the engine restart requirements exist, the Warning Buzzers will ring for 30 seconds (one second on/one second off), and then begin standard engine startup sequence. During the startup sequence the Warning Buzzers will sound continuously. Following the engine restart, loading is disabled for 60 seconds to allow the locomotive to stabilize before continuing with normal operations.

The *NFORCE* will also load shed the air conditioning during Idle Limiting if the locomotive remains at idle and no direction has been set for 60 minutes. If this is the case the *NFORCE* will drop the LSC contactor shutting down the air conditioning. The operator can reactivate the air conditioning by pressing the AC Reset Button.

ENG UNEXPECTED SHUTDOWN

This alarm is set if the engine has been shut down for a reason that the *NFORCE* is unable to determine. This will occur when the GEN SET READY output drops while the FPCR and *NFORCE* Start/Run outputs are high. This alarm will clear once the engine has successfully started.

ENG STOP BY CONTROL STND

This alarm is set if an engine shutdown has been requested from the throttle handle on the control stand. This is detected by observing that the 3T MU line is high while the 15T, 12T, and 7T MU lines remain low for a period of at least 1 second. This alarm clears once the throttle control handle is moved back to Idle, and the FPCR has been dropped by pressing the EFCO button.

TRANSDUCER FAILED CTD

When the *NFORCE* detects the signal from CTD is less than 4mA a TRANSDUCER FAILED CTD alarm is set.

AMBIENT AIR TEMP FAIL

When the *NFORCE* detects the signal from the temperature sensor is less than 4mA an AMBIENT AIR TEMP FAIL alarm is set.

BC PRESSURE SENSOR FAIL

When the *NFORCE* detects the signal from the pressure sensor is less than 4mA a MR PRESSURE SENSOR FAILED alarm is set.

CONTACTOR FAILED LSC

If the LSC contactor fails to pick up or drop out, a CONTACTOR FAILED LSC alarm is set. The *NFORCE* senses the auxiliary contacts on these contactors. When the *NFORCE* energizes or releases the coil, it checks for the correct feedback from the auxiliary contacts. If the correct feedback is not received, this alarm is set.

LOAD METER CONTROL

The *NFORCE* provides an analog output to drive a standard GM load meter located on the control stand. The output is an average of all the traction motors measured by the *NFORCE* current transducer sensors. If a traction motor is cutout, the average current is taken from the remaining motors

LOW VOLTAGE POWER SUPPLY (LVPS 12KW) CONTROL

While the engines are operating, the *NFORCE* will verify that the AC voltage is operating between 160 and 240 VAC.

The Low Voltage Power Supply will convert power from the AC BUS in order to supply 74 VDC to the low voltage circuits. The *NFORCE* will monitor the current loading for the LVPS using current transducer CTC. If the current rises above 40 amps the *NFORCE* will set a LVPS FAULT alarm. Additionally the *NFORCE* will monitor the locomotive battery voltage. If the voltage drops below 65 volts while the AC BUS is above 160 VAC a LVPS FAULT alarm will also be set. When a LVPS FAULT is set, the *NFORCE* will turn on the AUX PWR Fault indicator and ring the alarm bell for 5 seconds. This alarm is cleared when the current monitored by CTC drops below the current limit and/or the battery voltage is above 70 volts. If the AC voltage is below 160 volts this alarm is disabled.

If the *NFORCE* monitors the battery voltage below 55 volts, while the engines are running a BATTERY VOLTS FAILED alarm is set. The *NFORCE* will disable loading, return the engines to idle, turn on the alarm bell for 5 seconds, and turn on the AUX PWR Fault indicator. This alarm is cleared when the battery voltage is above 60 volts.

The LVPS also supplies 24 VDC for the Cummins engines. The *NFORCE* will use one digital input to verify the status of the 24 volt supply. If this input is low, the *NFORCE* will disable engine starting and sets a NO 24 VOLTS alarm. If the 24 VDC digital goes low while the engines are running the *NFORCE* will shut down the engines.

The LVPS will supply a 74 volt digital output to the *NFORCE* to indicate that it has over heated. If this input is high the *NFORCE* will also set a LVPS OVERTEMP alarm.

NO 24 VOLTS

If the digital input used to monitor the 24 volt supply from the LVPS is low, engine starting will be disabled and this alarm will be set.

BATTERY VOLTAGE TOO LOW

If the *NFORCE* monitors the battery voltage below 50 volts a BATTERY VOLTAGE TOO LOW alarm is set. Any operating Genset will be shutdown and engine starting will be inhibited. This alarm is cleared when the battery voltage is above 55 volts.

BATTERY NO CHARGE

If the *NFORCE* monitors the battery voltage below 69 volts while the engines are running for 15 seconds a BATTERY NO CHARGE alarm is set. The *NFORCE* will turn on the AUX PWR Fault indicator. This alarm is cleared when the battery voltage is above 70 volts.

LVPS FAULT

If the *NFORCE* monitor the LVPS current load monitored by current transducer CTC above 40 amps, and/or battery voltage below 65 volts while the engines are running a LVPS FAULT alarm is set. The *NFORCE* will ring the alarm bell for 5 seconds and turn on the AUX PWR Fault indicator. This alarm is cleared when the current drops below the current limit amps and/or the battery voltage is above 70 volts.

TRANSDUCER FAILED CTC

When the *NFORCE* detects the signal from CTC is less than 4mA a TRANSDUCER FAILED CTC alarm is set.

MAIN RESERVOIR COMPRESSOR CONTROL

Compressed air is used for operating the locomotive air brakes and auxiliary devices such as sanders. The air compressor on most locomotives is mechanically driven by the diesel

engine. However this locomotive air compressor will be driven by an AC motor. Once one of the engines is operating and there is 160 - 240 VAC supplied to the AC bus, the *NFORCE* will enable the compressor.

The air compressor is not always building air pressure when turning. An un-loader piston cuts out the compressing action and is controlled by a magnet valve call MV-CC. When MV-CC is energized the air compressor begins to build pressure. The MV-CC will be energized if the main reservoir pressure drops below a low pressure set point of 130 psi and re-energized at a maximum pressure set point of 140psi.

This locomotive is also equipped with Compressor Synchronizing which allows the compressor on each unit in the consist to help build main reservoir pressure if any other compressor in the consist is active. This is done by using a general purpose relay (CRL) to apply 74 volts to trainline 22T when any of the air compressors are building pressure.

Using a 200 PSI pressure sensor the *NFORCE* monitors and maintains main reservoir air pressure. The *NFORCE* also monitors the Air Compressor Synchronizing MU line (22T). If any of the locomotives in the consist activate their air compressor this train line is driven high. If 22T is high all of the locomotives will activate their air compressors allowing each locomotive to help maintain main reservoir pressure. When this MU is high the *NFORCE* will activate the air compressor by energizing MV-CC. If the *NFORCE* activates the air compressor and 22T is low the *NFORCE* will also pickup a relay called CRL which will apply 74 volts to 22T. Regardless of the status of 22T if the main reservoir pressure has reached 145psi MV-CC will be de-energized.

When the main reservoir pressure drops below 130 PSI or train line 22T is driven high the *NFORCE* will first verify that contactors CC1, CC2, and CC3 are open and MV-CC is de-energized. The *NFORCE* monitors the current loading from the air compressor motor using current transducer CTA. With CC1, CC2, and CC3 open the current should be zero amps. The *NFORCE* will then close contactor CC1, followed by CC2. Monitoring CTA the *NFORCE* will wait for the current loading to stabilize. Once the current has stabilized the *NFORCE* will drop CC2 and pickup CC3. The *NFORCE* again waits for the current loading to stabilize. Once the current loading has stabilized the *NFORCE* will pick up CRL, which will drive 22T high. The *NFORCE* will also pickup MV-CC, which allows the air compressor to build pressure.

If the current monitored by CTA rises above 200 amps the *NFORCE* will drop CC1/CC2/CC3, and drop MV-CC. The *NFORCE* will then try to reactivate the air compressor as described above up to two additional times. If the current is still above 200 amps on the third attempt the *NFORCE* will drop the CC1/CC2/CC3 contactors, set an AIR COMPRESSOR FAULT alarm, ring the alarm bell for 5 seconds, disable the traction motor choppers, and flashes the AUX PWR Fault indicator. This alarm can only be cleared by shutting down the engines.

AIR COMPRESSOR FAULT

If the current monitored by CTA rises above 200 amps the *NFORCE* will drop CC1/CC2/CC3, and pick up MV-CC. The *NFORCE* will then try to reactivate the air compressor as described above up to two additional times. If the current is still above 200 amps on the third attempt the *NFORCE* will drop the CC1/CC2/CC3 contactors, set an AIR COMPRESSOR FAULT alarm, ring the alarm bell for 2 seconds on and off, disable the traction motor choppers, and flashes the AUX PWR Fault indicator. This alarm can only be cleared by shutting down the engines. This will also be set if a compressor contactor faults (CC1, CC2, and CC3). This fault is also set during COMPRESSOR MOTOR OVERLOAD and COMPRESSOR MOTOR UNDERLOAD conditions. Once set the alarm bell will ring 2 seconds on and off and flash the AUX PWR fault indicator.

CONTACTOR FAILED CC1
CONTACTOR FAILED CC2
CONTACTOR FAILED CC3

If a contactor fails to pick up or drop out, a CONTACTOR FAILED CC'*' alarm is set, where '*' is the contactor that failed to pick up or drop out. The *NFORCE* senses the auxiliary contacts on these contactors. When the *NFORCE* energizes or releases the coil, it checks for the correct feedback from the auxiliary contacts. If the correct feedback is not received, one of these alarms is set and can only be cleared by shutting down the engine. This alarm also sets the AIR COMPRESSOR FAULT alarm.

MR PRESSURE SENSOR FAIL

When the *NFORCE* detects the signal from a pressure sensor is less than 4mA a MR PRESSURE SENSOR FAILED alarm is set.

MU LINE FAILED 22T (CRL)

When the *NFORCE* energizes the CRL relay to drive the 22T MU line it checks to ensure the MU line becomes active. This alarm is set if the MU line status does not match the status of the CRL relay.

COMPRESSOR MOTOR OVERLOAD

When the *NFORCE* detects air compressor motor load current on CTA in excess of 65 A for 10 seconds continuously this fault is set. If the NFORCE detects CTA current in excess of 120A for 500 ms continuously this fault is set. Once this fault is set the air compressor is disabled and removed from the auxiliary bus. If excessive current persists once the compressor is disabled engines will be shutdown. Note that once this fault is latched it will not be cleared until the next manual engine start attempt.

COMPRESSOR MOTOR UNDERLOAD

When the NFORCE detects air compressor motor load current on CTA less than 15 A for 10 seconds continuously this fault is set. Once this fault is set the air compressor is disabled and removed from the auxiliary bus. Note that once this fault is latched it will not be cleared until the next manual engine start attempt

TRANSDUCER FAILED CTA

When CC1, CC2, and CC3 are dropped and there is no AC power supplied to the air compressor motor the *NFORCE* checks for near zero current on current transducer CTA. If CTA indicates more than 10 amps or less than -5 amps, a TRANSDUCER FAILED CTA alarm is set.

User-Initiated Locomotive Tests

The operator can initiate one of the preprogrammed locomotive tests by using the laptop interface. The TEST Screen available are Input/Output Test and Load Test. To enter the Input Output test enter "FSD" in capital letters. To enter Load Test enter "FSE." in capital letters.

The mode, displayed at the bottom right of the screen, indicates which mode is active and/or the status of the locomotive. The mode changes to display the current state of the locomotive after the test is complete.

The mode information consists of one of the following:

- Input/Output Test
- Load Test
- Motoring

Input/Output Test

This test cycles the locomotive contactors, light indicators, relays, and sanders which are controlled by the *NFORCE*. The load meter will

also be tested at the end of this test. The *NFORCE* analysis software will display on the laptop screen instructions on setting up the locomotive to start the testing. If any of the contactors or relays fail to pick up, or if the feedback to the *NFORCE* fails, an alarm will be displayed indicating the failure. The test can be paused when a contactor or relay alarm is displayed, to ensure that the problem is corrected before continuing, and to keep the *NFORCE* output active to allow for troubleshooting.

For all sanders, indicator lights, and the load meter, the operator will need to visually verify that the device is operating as intended.

The test will be cancelled if the operator interrupts the test by pressing E to end, or if any of the locomotive setup conditions change.

To access the Input/Output test screen enter FSD.

Field value descriptions include:

High refers to the device being on. Low refers to the device being off.

LOAD METER: ##### is displayed during testing of the load meter, the Load Meter is driven from 0–1500 amps in 300-amp increments.

To set up and start the test:

1. Ensure the locomotive is in Isolate.
2. Ensure the locomotive engines are shut down.
3. Center the reverser handle.
4. Ensure the locomotive is at a standstill and the air brakes are applied.
5. Wait for the pressure cutout switch (PCS) to reset, if it hasn't already (the control stand PCS OPEN light must be off). The PCS resets if the Throttle handle is in Idle and if the air brake control has recovered.
6. Press B to begin the test.

The test can be left to complete itself, or you can interrupt it by pressing P to pause or E to end. The test typically allows 5 seconds between each step to verify proper operation. During the test, the *NFORCE* will pick up and drop out each relay, contactor, and indicator one by one.

The following will be tested and verified using feedbacks:

P1, P2, P3, P4, ACC1, ACC2, ACC3, RVF {RV1, RV2, RV3, RV4}, EBC, CC1, CC2, CC3, ABR, CRL, NSR, MTR, LSC, MFR, WARNING BUZZERS

The following will be tested and verified visually:

GEN SET1 FAULT, GEN SET2 FAULT, GEN SET3 FAULT, GEN1 SERVICE, GEN2 SERVICE, GEN3 SERVICE, WL, AUX PWR FAULT, LOAD METER (0 – 1500 AMPS), SPEED (10MPH)

Messages which can appear on the screen during the test include:

- **ALL CONTACTORS MUST BE DROPPED OUT** appears if one or more of the contactors are not dropped prior to initializing this test.
- **CONTACTOR TEST INITIALIZING** replaces **PRESS B TO BEGIN TEST** when the test is activated. This message is displayed momentarily and then is replaced by **TESTING: XXXX, PRESS P TO PAUSE, E TO STOP** where 'XXXX' is the signal being tested.
- **SHUT DOWN ENGINES** appears if any of the engines are still running when you try to initialize this test.
- **LOCOMOTIVE IS MOVING** appears if speed is not zero.

- **PCS NOT READY** appears if the PCS has not been reset.

- **PLACE REVERSER IN FORWARD** appears if the Reverser handle is not in the forward position when you try to initialize this tests.

- **PRESS B TO BEGIN TEST** appears when all of the conditions to start the test are met.

- **PRESS E TO END PAUSE** appears when the test is paused during testing.

- **PRESS P TO PAUSE** appears while the test is in progress.

- **LOAD TEST SWITCH MUST BE TURNED ON** appears when the load test switch is in the off position.

- **PUT ISOLATION SWITCH IN ISOLATE POSITION** appears if this switch is not in the Isolate position.

- **TESTING: COMPLETE** appears when the test is finished. This message appears momentarily and then is replaced by PRESS B TO START TEST.

- **Testing XXXX: PRESS P TO PAUSE, E TO STOP** appears when the test is in progress, where 'XXXX' is the item being tested.

Load Box Operation

The *NFORCE* monitors the status of the Load Test Switch. If the digital monitoring this switch goes high the *NFORCE* will set the mode of operation to Load Test.

When selecting this test mode the traction motor current choppers are connected manually across an external load box.

The *NFORCE* will not enter load test mode unless the following conditions are met:

- M Contactors are dropped
- 8T and 9T are low
- Engine(s) are running and are at idle
- 6T is low
- The Isolate switch is in the "Run" position.
- Locomotive speed is zero

If a laptop is connected to the *NFORCE* during this test, Figure shows what will be displayed on screen FSE:

1. Current and voltage from each chopper
2. Total Current and Voltage
3. Current BHP, THP and AHP

* = IF EQUIPPED

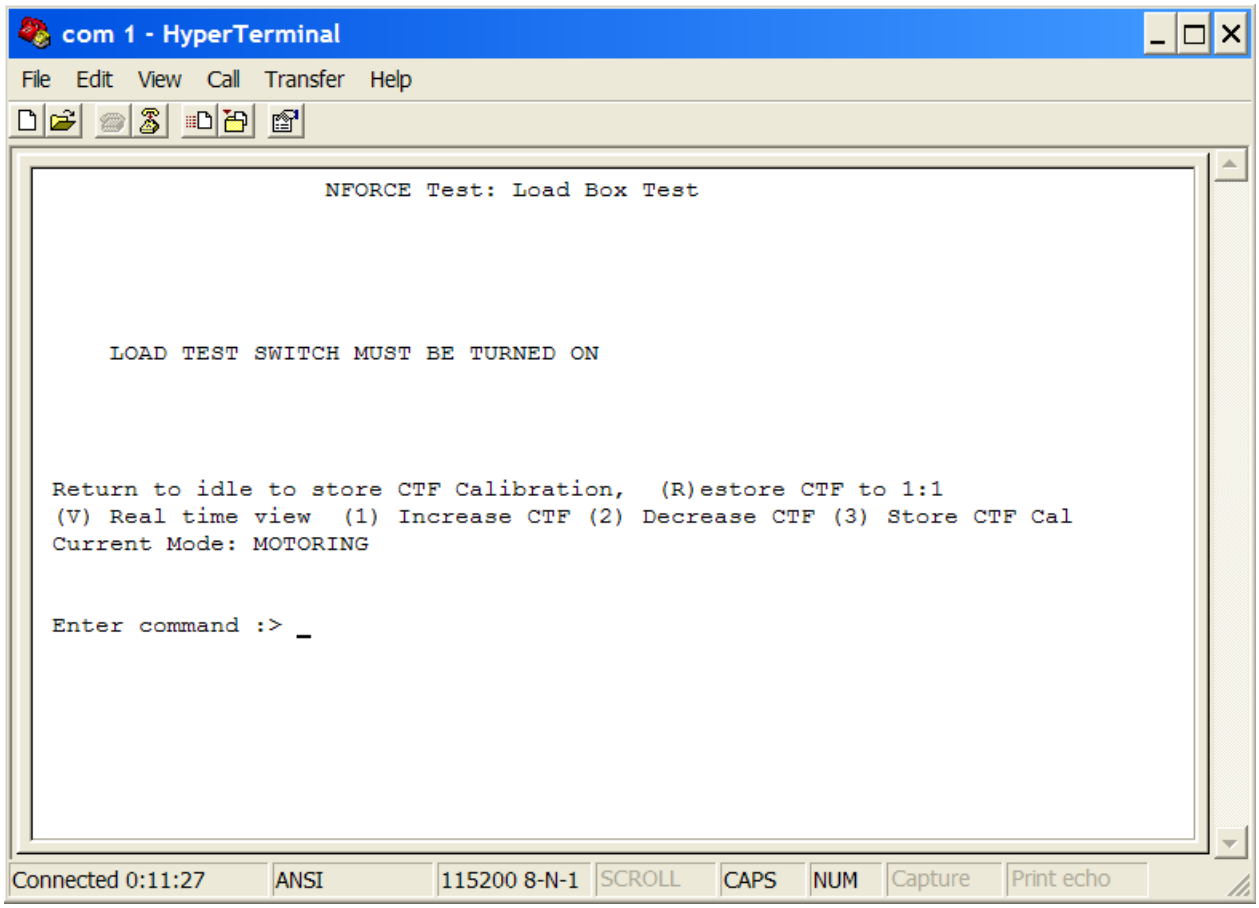


Figure 6-1 – FSE screen during load test

If a laptop is connected to the *NFORCE* while the test switch is closed, instructions on setting up the locomotive to start the testing will be displayed.

To set up and start the Load Test:

1. Ensure the locomotive is at a standstill and the air brakes are applied.

2. Disconnect the MU jumper cables from both ends of the locomotive.

3. Move the Throttle handle to Idle and the Reverser handle to Neutral.

4. Run the diesel engine and ensure it is warm enough to provide full power.

5. Set all other locomotive operator controls for Power control (Isolation switch in run, generator field switch up).

6. Set the Test Switch to “Test Mode.”

7. After the test switch has been closed move the throttle as required to perform the Load Test.

8. Note that the DC bus current transducer CTF may be calibrated to an external source using this interface.

IMPORTANT

NOTE THAT THE LOAD TEST WILL NOT END AUTOMATICALLY. To stop loading during this test, move the throttle to Idle and set the test switch to “Normal” operation.

Messages which can appear if using a laptop during the test include:

ENGINE MUST BE RUNNING appears if the engine is off when you try to initialize this test.

LOCOMOTIVE IS MOVING appears if the locomotive is moving. The Load Test aborts if this occurs.

LOCOMOTIVE NOT IN IDLE appears if the locomotive is not in Idle when you attempt to start the test.

PLACE REVERSER IN NEUTRAL appears if the Reverser handle is not in Neutral.

POWER MODE CONTROL

The *NFORCE* will monitor the MU 6T (Motoring Excitation) and Isolate switch. If the Isolate switch is in the "RUN" position, the direction is set, and 6T is high, the mode of operation will be set to Motoring. Once Motoring has been enabled the *NFORCE* will pickup the MTR Relay, which will pickup the motoring contactor M1 through M2.

The *NFORCE* will pick up those power contactors that are not associated with traction motors that are cut out as soon as the *NFORCE* has been powered. The only time a power contactor will be dropped is in association with a motor that has been cutout.

RELAY FAILED MTR

If the MTR Relay fails to pick up or drop out, a RELAY FAILED MTR alarm is set. The *NFORCE* senses the auxiliary contacts on this relay. When the *NFORCE* energizes or releases the coil, it checks for the correct feedback from the auxiliary contacts. If the correct feedback is not received, this alarm is set.

CONTACTOR FAILED P1
CONTACTOR FAILED P2
CONTACTOR FAILED P3
CONTACTOR FAILED P4

If a contactor fails to pick up or drop out, a CONTACTOR FAILED P'*' alarm is set, where '*' is the contactor that failed to pick up or drop out. The *NFORCE* senses the auxiliary contacts on these contactors. When the *NFORCE* energizes or releases the coil, it checks for the correct feedback from the auxiliary contacts. If the correct feedback is not received, one of these alarms is set.

SANDING CONTROL

The *NFORCE* will monitor and control the locomotive sanders directly based on the status of the Manual Sand MU (23T) and the Lead Truck Sand switches. This system provides Automatic Sanding based on wheel slip condition when operating in motoring.

This system also monitors the Emergency Sand MU (5T). When the Emergency Sand switch is closed, 13T is supplied to all of the sanding magnet valves. The *NFORCE* monitors for zero locomotive speed for twenty seconds. If zero speed is established the *NFORCE* will pick up the No Speed Relay (NSR), which will interrupt the 13T feed from the Emergency Sand switch to the sanding magnet valves.

The Manual Sand switch (23T MU) allows sanding up to 5 MPH for 15 seconds. Depending on locomotive direction, sanding control enables the leading sanders on all trucks.

The Lead Truck Sand Switch allows sanding at all times for 15 seconds. Depending on locomotive direction, sanding control enables sanding on the leading sander of the leading truck only.

Automatic sanding for wheel slip control can occur at any speed. Automatic sanding is done on the front truck in Forward, and the rear truck in Reverse. Automatic sanding is applied for the duration of the wheel slip detection, and is continued for 2 seconds after the wheel slip is corrected.

RELAY FAILED NSR

If the No Speed Relay fails to pick up or drop out, a RELAY FAILED NSR alarm is set. The *NFORCE* senses the auxiliary contacts on this relay. When the *NFORCE* energizes or releases

the coil, it checks for the correct feedback from the auxiliary contacts. If the correct feedback is not received, this alarms is set.

TRACTION MOTOR CURRENT CHOPPER CONTROL

This application is equipped with three Cummins engine/AC Generator sets. This AC power is rectified and placed on a common DC BUS. Each traction motor circuit is equipped with a current chopper that will provide DC power to the traction motor based on a 4-20mA current loop signal supplied by the *NFORCE*.

The following is a description of the signals used to control the Traction Motor Choppers:

- Traction Motor Current – This 4-20mA current loop output signal is provided by the chopper to allow the *NFORCE* to monitor the current supplied to the traction motors. (4mA = 0 amps, 20ma = 1666 amps)
- Traction Motor Voltage – This 4-20mA current loop output signal is provided by the chopper to allow the *NFORCE* to monitor the voltage supplied to the traction motors. (4mA = 0 volts, 20ma = 1000 volts)
- Fatal Fault – The Chopper will turn on this 74 volt digital output if it determines that it can NOT regulate the current and voltage as requested from the *NFORCE* (Chopper output shorted indication).
- Chopper Failed – The Chopper will turn on this 74 volt digital output if it determines that it has over heated.
- Duty Cycle – This 4-20mA current loop output signal from the *NFORCE* supplied to the chopper determines how much current is allowed to flow from the chopper. (4mA = 0% Duty Cycle, 20mA = 100% Duty Cycle)
- Chopper Enable – The Chopper requires 74 volts to enable the Chopper output. These 74 volts will be supplied by the 6T train line.

The *NFORCE* will enable the 4-20mA duty cycle control outputs to each of the Traction Motor Current Chopper inputs once **ALL** of the following conditions are met.

- Confirm the status power & motoring contactors are picked up.
- Confirm that the appropriate reversers contactors are picked based on the status of 8T and 9T.
- Ensure that the locomotive is not in emergency by verifying that the PCR relay is picked up.
- If the 6T MU is high, Generator Field Switch up, and the throttle handle in position 1-8. The *NFORCE* will drive the throttle to the requested RPM.
- AC BUS is operating between 160-240 volt..
- Ground Relay Cutout Switch is closed, which is monitored by an *NFORCE* digital input.
- There are no active Traction Motor Chopper Fatal Faults outputs.
- There are no active Traction Motor Chopper Failed outputs.
- There are not active traction motor current or voltage sensor failures.

If any of these conditions are not met for any of the Traction Motor Current Choppers that chopper will not be enabled.

If the *NFORCE* determines that it can not control the Traction Motor Choppers, it will nullify the AC power, ring the alarm bell for five seconds, and set an EXCITATION FAULT alarm. To continue operation any traction motor circuits with active Traction Motor Current Chopper fatal faults must be cut out.

The Traction Motor Choppers are designed to meet the following short term load ratings:

- 1050 to 1095 24hrs - 1hr
- 1070 to 1095 1hr - 30mins
- 1095 to 1145 30mins - 15mins
- 1145 to 1275 15mins - 62sec
- 1275 to 1400 62sec - 30sec

The *NFORCE* will limit the current supplied by the Traction Motor Choppers as outlined above. If one of these current limit ratings is reached the *NFORCE* will reduce loading for that chopper to 1050 amps for 30 minutes.

AMB AIR TEMP FAILED

When the *NFORCE* detects the temperature sensor signal is less than 4mA an AIR TEMP FAILED alarm is set. If this sensor fails the *NFORCE* sets ambient air temperature to 110°F.

CHOPPER 1 ACT FAILED
CHOPPER 2 ACT FAILED*
CHOPPER 3 ACT FAILED*
CHOPPER 4 ACT FAILED*

When the choppers are shut down and there is no DC power supplied to the Traction Motors the *NFORCE* checks for near zero current on current signals supplied by the chopper. If signal indicates more than 10 amps or less than -5 amps, a CHOPPER '*' ACT FAILED alarm is set, where '*' is the chopper that has failed. The Motor Fault Indicator is also turned on.

CHOPPER 1 FAULT
CHOPPER 2 FAULT*
CHOPPER 3 FAULT*
CHOPPER 4 FAULT*

If a Traction Motor Chopper turns on its' "Fatal Fault" indicator the *NFORCE* will set a CHOPPER '*' FAULT, where '*' is the chopper that failed. When this alarm is set the *NFORCE* will ring the alarm bell for 5 seconds. The Motor Fault Indicator is also turned on.

CHOPPER 1 FAILED
CHOPPER 2 FAILED*
CHOPPER 3 FAILED*
CHOPPER 4 FAILED*

If a Traction Motor Chopper turns on its' "Failed" indicator the *NFORCE* will set a CHOPPER '*' FAILED, where '*' is the chopper that failed. While this alarm is active the *NFORCE* will disable the failed chopper. When this alarm is set the *NFORCE* will ring the alarm bell for 5 seconds. The Motor Fault Indicator is also turned on.

CHOPPER 1 VOLTS FAILED
CHOPPER 2 VOLTS FAILED*
CHOPPER 3 VOLTS FAILED*
CHOPPER 4 VOLTS FAILED*

When the choppers are shut down and there is no DC power supplied to the Traction Motors, the *NFORCE* checks for near zero voltage on voltage signals supplied by the chopper. If signal indicates more than 10 volts or less than -5 volts, a CHOPPER '*' VOLTS FAILED alarm is set, where '*' is the chopper that failed. The Motor Fault Indicator is also turned on.

CHOPPER 1 NOT RESPONDING
CHOPPER 2 NOT RESPONDING*
CHOPPER 3 NOT RESPONDING*
CHOPPER 4 NOT RESPONDING*

When the *NFORCE* has applied a 5% control duty cycle or greater to a chopper, and the output excitation is monitored to be less than 25 amps after 5 seconds, a CHOPPER'*' NOT RESPONDING fault is set, where '*' is the chopper that has failed.

Traction Motor Cutout Control

Traction Motors can be cut out if there is a failure on a specific motor while the locomotive is isolated. There is one motor cutout switch for each of the four traction motors (MCOS1, MCOS2, MCOS3, and MCOS4). If one of these

* = IF EQUIPPED

switches is closed while the locomotive is isolated the *NFORCE* will drop the power contactor associated with the traction motor to be cutout, pick up the corresponding MCO coil and cycle MCR, which will cycle all of the magnetic reversers allowing the selected contacts to be centered, cutting out the motor. Additionally if any motor is cut out the *NFORCE* will also pick up the MFR relay turning on the Motor Failed Indicator. When cutting a traction motor back in, the *NFORCE* will nullify AC power during the process.

The *NFORCE* will only pick up the power contactors for those motors that are cut in. The *NFORCE* will also disable traction motor chopper control for the traction motors that are cut out.

The *NFORCE* will limit the current output from the traction motor choppers when traction motors are cut out to allow full use of the remaining traction motors. This limit is calculated as the number of motors cut in multiplied by the current limit of each traction motor, or the maximum power available on the DC bus, whichever is less.

When a traction motor is cutout the *NFORCE* will still monitor the corresponding traction motor armature current transducer. If the current is sensed from the cutout traction motor a TM CUTOUT FAULT alarm is set and traction motor chopper control for all traction motors is disabled. The alarm is reset 3 seconds after the average current drops below 100 amps.

SOLENOID FAILED MCO1
SOLENOID FAILED MCO2
SOLENOID FAILED MCO3
SOLENOID FAILED MCO4

When the *NFORCE* energizes a solenoid, it checks for the correct feedback from the coil sense inputs. If the correct feedback is not received a SOLENOID FAILED MCO‘*’ alarm is set, where ‘*’ is the solenoid that failed.

TM 1 CUT OUT
TM 2 CUT OUT
TM 3 CUT OUT
TM 4 CUT OUT

The *NFORCE* determines traction motor cutout status based on the status from the Cutout switches and motor cutout solenoids. If a traction motor is cutout, a TM ‘*’ CUT OUT alarm is set, where ‘*’ is the specific traction motor that is cutout. The Motor Fault Indicator is also turned on.

TRACTION MOTOR PROTECTION CONTROL

The *NFORCE* continually monitors traction motor current and voltage. This is accomplished with the use of 4-20mA signals provided by each Traction Motor Chopper. The *NFORCE* will regulate the current to not be more than 1400 amps. Additionally the voltage will be regulated to be less than 600 volts. If a traction motor current and/or voltage exceeds these safe levels, a TM CURRENT EXCEEDED or TM VOLTAGE EXCEEDED alarm will be set.

The *NFORCE* will compare the currents through each of the traction motors, and if the average traction motor current is greater than 100 amps, and any traction motor current is lower than 50 amps, loading to that traction motor is dropped and a OPEN TM alarm will be set. The alarm is reset 3 seconds after the average current drops below 100 amps. If this alarm occurs three times on the same traction motor within five minutes the Traction Motor Current Chopper associated with that traction motor will be disabled and a CHOPPER DISABLED OPEN TM alarm will be set. This alarm can be reset by placing the Isolate switch in the isolate position.

Normally the *NFORCE* calculates traction motor temperature based on traction motor cooling air temperature, amount of cooling air (calculated), traction motor current & voltage, and locomotive speed. However for this application the Traction Motor Current Choppers not able to

withstand as much current as the traction motors, and therefore will be the limiting factor. This application is equipped with axle speed sensing equipment installed on axle two. The *NFORCE* will limit wheel speed in order to limit the locomotive speed. The default setting is 73 MPH, which is typically the maximum speed specification for the traction motors. If this speed is exceeded the *NFORCE* sets an OVER SPEED alarm, and will decrease excitation until the over speed is corrected. The excitation is reapplied if the speed drops below the set speed.

The *NFORCE* controls traction motor cooling by controlling the AC contactor called EBC, which connects the TM Blower motor to the AC bus. The *NFORCE* will not pickup the EBC two seconds after one of the ACC contactors is confirmed as closed. The *NFORCE* will then pickup VRO allowing the AC bus voltage to build to between 160 and 240 VAC.

The *NFORCE* also monitors the current loading from the TM Blower Motor using current transducer CTB. If the current is operating above 199 amps for 4 seconds the *NFORCE* will drop the EBC contactor. The *NFORCE* will attempt to re-engage the TM Blower up to three times, if the loading current is still operating above this limit the *NFORCE* will disable the TM Blower and set an TM BLOWER FAILED alarm. If this alarm is active, the traction current will be limited to a maximum of 525 amps. This alarm can be reset by shutting down the engines.

CHOPPER DISABLED OPEN TM1
CHOPPER DISABLED OPEN TM2*
CHOPPER DISABLED OPEN TM3*
CHOPPER DISABLED OPEN TM4*

If an open traction motor alarm occurs three times on the same traction motor within five minutes the Traction Motor Current Chopper associated with that traction motor will be disabled and a CHOPPER DISABLED OPEN TM‘*’ alarm will be set, where ‘*’ is the specific traction motor that failed. This alarm can be reset by placing the Isolate switch in the isolate position.

CONTACTOR FAILED EBC

If the EBC contactor fails to pick up or drop out, a CONTACTOR FAILED EBC alarm is set. The *NFORCE* senses the auxiliary contacts on these contactors. When the *NFORCE* energizes or releases the coil, it checks for the correct feedback from the auxiliary contacts. If the correct feedback is not received, one of these alarms is set. This alarm also sets TM BLOWER FAILED alarm.

TM BLOWER OVERLOAD

If the *NFORCE* monitors the TM Blower Motor loading current is operating above expected levels with respect to primary engine RPM this alarm will be set after 10 consecutive seconds. If the current exceeds 165A for 200 ms the alarm will be set before the 10 second timer expires. This alarm sets the TM BLOWER FAILED alarm. This fault is latched until the next engine start attempt is made. The following list shows the overload current levels with respect to primary engine rpm:

- 65A @ 1200 RPM
- 100A @ 1500 RPM
- 140A @ 1800 RPM

TM BLOWER UNDERLOAD

If the *NFORCE* monitors the TM Blower Motor loading current is operating below expected levels with respect to primary engine RPM this alarm will be set after 10 consecutive seconds. This alarm sets the TM BLOWER FAILED alarm. This fault is latched until the next engine start attempt is made. The following list shows the underload current levels with respect to primary engine rpm:

- 15A @ 1200 RPM
- 45A @ 1500 RPM
- 63A @ 1800 RPM

* = IF EQUIPPED

TM BLOWER FAILED

When this alarm is set the *NFORCE* will ring the alarm bell for 5 seconds, turn on the AUX PWR Fault indicator light and drop the EBC contactor to disconnect the blower motor from the auxiliary bus. This alarm can be reset by shutting down the engines. This alarm is also set when CONTACTOR FAILED EBC is set. Once this alarm is set and the EBC contactor is dropped the system checks that blower motor load current has fallen below acceptable levels. If the current has not dropped below 165A within 1 second of the EBC contactor opening all engines are shutdown.

TRANSDUCER FAILED CTB

When EBC is dropped and there is no AC power supplied to the Traction Motor Blower motor the *NFORCE* checks for near zero current on current transducer CTB. If CTB indicates more than 10 amps or less than -5 amps, a TRANSDUCER FAILED CTB alarm is set.

THROTTLE & ENGINE CONTROL

The *NFORCE* will monitor & control the engines by use of J1939 CAN BUS protocol.

The engines cannot start if the Control and Fuel Pump (13T) and Local Control (PA) circuit breakers are open. The *NFORCE* monitors both of these breakers with 74 volt digital inputs, and will set an alarm if either of these breakers are open.

The *NFORCE* also monitors the 24 VDC for the Cummins engines supplied by the Low Voltage Power Supply (LVPS). If the 24 VDC supply is not present, the engine starting is disabled. If the 24 VDC supply fails while the engines are running, the *NFORCE* will turn off all RPM outputs returning the engines to idle. In either case the alarm bell will be activated until the Isolate switch is placed in the Isolate position.

The *NFORCE* monitors the loading time for each engine and regulates the engine start up sequence to maintain equal loading between the two engines.

STARTING PRIMARY ENGINE

The *NFORCE* monitors the START switch to determine when to start the first engine. The switch is a normally open momentarily closed switch. If the START switch is closed the *NFORCE* will verify the following:

- Isolate switch is in the isolate position
- 8T, 9T, and 6T are low
- FPCR is picked up.
- 24 volt breaker is closed

If all of the above conditions are met the *NFORCE* will turn on the Warning Buzzer and ECMP (Engine Control Module Power). Then the *NFORCE* will pickup EE (Engine Enable). The *NFORCE* will then pickup the ST relay associated with that engine. This will start the engine cranking. The *NFORCE* will allow cranking for 6 seconds. If the engine RPM rises above 400 within this time period the *NFORCE* will drop the ST relay. The *NFORCE* will pickup the ACC contactor associated with that engine after the engine RPM has reached 1200 RPM (IDLE). The EBC is picked up after the ACC contactor, then VRO (Voltage Regulator Output) allowing the AC generator to operate. Following the engine startup loading is disabled for 5 seconds to allow the locomotive to stabilize before continuing with normal operations.

NOTE

ACC1, ACC2, and ACC3 contactors are used to connect the auxiliary power loads to the AC BUS

The engine should now be running at 1200 RPM, and 160 VAC should be available from the generator. This can be verified using the AC Bus input included as part of the Excitation control.

If the engine does not start during the first 8 second period the *NFORCE* will drop the starters and wait 18 seconds before retying to

start. The *NFORCE* will try up to three times to start the engine. If the engine fails to start on the third attempt the *NFORCE* will lock out that engine.

Once the engine(s) are running, if the FPCR should drop, the *NFORCE* will automatically shut down the engines all engines.

If the *NFORCE* should want to shut down the engines for fuel savings, it would drop the EE output to each engine. If the Cummins Control Systems monitors this input go low it will shut down the engine independently of the status of FPCR.

Starting Secondary Engine

When notch 4 or higher is requested the seconded engine is required provided the first engine is developing motor currents of 600A or more. Starting is the same as described for the first engine start up. However the START switch is not required to close. Additionally the Warning Buzzers will not sound when starting the second engine. Once the NFORCE has verified that the requested RPM has been reached it will pickup VRO allowing that generator to produce power.

When the throttle demand has been reduced to notch 4 or lower the second engine will be returned to idle for 5 minutes. If no request loading request are made for notch 4 or higher the engine is shut down by dropping the EE output to that engine.

Tertiary Engine

When notch 6 or higher is requested and locomotive track speed is above 4.5 MPH the third engine is required provided the first & second engines are developing full power. Starting is the same as described for the first engine start up. Again the START switch is not required to close. Additionally the Warning Buzzers will not sound when starting the second engine. Once the *NFORCE* has verified that the requested RPM has been reached it will pickup VRO allowing that generator to produce power.

When the throttle demand has been reduced to notch 6 or lower, the third engine will be returned to idle for 1 minute. If no loading requests are made for notch 6 or higher, the engine is shut down by dropping the EE output to that engine.

RPM Control

As with most of the locomotive controls, the throttle handle switches (THS) operate in the 74 VDC system. When one of the throttle switches is closed 74 volts is applied to a *NFORCE* digital input.

For throttle control, the *NFORCE* senses the following:

- Isolate Switch
- AV throttle (15T)
- BV throttle (12T)
- CV throttle (7T)
- DV throttle (3T)
- Engine Run Relay (16T).
- Generator Field (GF) Control (6T)

The following table (Table 6-1) shows trainline verses throttle position, and engine running verses Throttle.

Table 6-1 – Trainline vs. Throttle Position & Engine Running vs. Throttle

Throttle Notch	Eng 1 BHP	Eng 1 THP	Eng 1 RPM	Eng 2 BHP	Eng 2 THP	Eng 2 RPM	Eng 3 BHP	Eng 3 THP	Eng 3 RPM	Loco BHP	Loco THP
Idle	67	0	1200							67	0
1	228	145	1500							228	145
2	388	305	1500							388	305
3	685	585	1800							685	585
4	547	447	1800	390	373	1500				937	820
5	661	651	1800	485	469	1500				1146	1030
6	594	494	1800	514	494	1800	429	412	1500	1537	1400
7	667	567	1800	587	567	1800	587	567	1800	1841	1701
8	697	597	1800	686	664	2000	686	664	2000	2069	1925

The notch position, determined from the throttle trainlines, is then passed on to the Rate Control module which is used as a reference for maximum loading for that throttle position. For Notch 1 through 4, the *NFORCE* will run one engine. For notches 4 through 5 two engines, and for notches 6 through 8 the *NFORCE* will run all engines.

If any of the following conditions are true, the engines are returned to idle:

- Engine Run switch (16T) – If 15T 12T, 7T, or 3T are high and 16T remains low, the *NFORCE* will determine that the Engine Run switch is open, the throttle will be limited to idle.

- Generator Field (6T) – If 15T 12T, 7T, or 3T are high and 6T remains low, and the Isolate switch is in the "RUN" position the *NFORCE* will determine that the GEN FLD switch is open, the throttle will be limited to idle. NOTE – If the Isolate switch is in the "ISOLATE" position the *NFORCE* will allow engine RPM without loading.

- PCS switch – If the Pneumatic Control switch drops out with the loss of locomotive air pressure, the PCR relay will drop out. This will interrupt the positive feed to the throttle handle, and force the engine to idle. The *NFORCE* monitors the status of the PCR relay with a digital input, and will display a PCS alarm when this occurs.

- The *NFORCE* also monitors the ground relay circuits, if a ground fault has occurred on the locomotive the *NFORCE* will reduce the engine RPM to idle.

- The *NFORCE* monitors the status of the GRCO. If this input is low the *NFORCE* will limit throttle to idle.

Locomotive track speed limiting engines running to one is disabled during Load Test.

If 3T is high while 6T, 15T, 12T, and 7T are low all engines will be shut down by dropping the EE signals to all engines.

ENGINE SHUT DOWN BY FPCR

This message is set if the *NFORCE* senses that the FPCR goes low while the engines are running.

ENGINE RUN SWITCH DOWN

The ENG RUN switch (ER) is down. The engine will not be allowed above Idle and will not load.

GEN FLD SWITCH DOWN.

This message is set when the *NFORCE* senses that the throttle has been moved from the idle position causing some of the governor solenoids to pickup while the 6T MU remains low.

LOCAL BREAKER OFF

This message indicates that the Local Control

Breaker is Off.

NO CONTROL AND FUEL PUMP

The *NFORCE* senses that the Positive Control and Fuel Pump on the 13T string is not energized. When this occurs, the train lined control functions won't operate and the engine won't load. After a short delay, the engine shuts down because the fuel pump is Off.

PCS

The Pneumatic Control Relay (PCR) has dropped out. If it is the lead locomotive, the feed to the throttle handle switches is dropped out. This prevents the throttle MU lines (6T, 3T,7T, 12T, 15T) from picking up, effectively preventing loading on all locomotives in the consist. This occurs after an emergency brake application. The *NFORCE* only displays the status of the PCR; loading is prevented by loss of GF (through open PCR interlocks).

NO LOAD GR CUT OUT

If the *NFORCE* senses the Ground Relay Cutout switch is open, this alarm is set and prevents loading. Throttle is limited to the Idle position.

GEN SET #1 FAULT
GEN SET #2 FAULT*
GEN SET #3 FAULT*

If the Cummins Control system turns on the "FAULT" output the *NFORCE* will set a GEN SET'*' FAULT, where '*' is the GEN SET that failed. While this alarm is active the *NFORCE* will not allow the failed GEN SET to start. When this alarm is set, the *NFORCE* will ring the alarm bell for 5 seconds.

GEN SET #1 SERVICE ENGINE
GEN SET #2 SERVICE ENGINE*
GEN SET #3 SERVICE ENGINE*

If the Cummins Control system turns on the "WARN" output the *NFORCE* will set a GEN SET'*' SERV ENG, where '*' is the GEN SET that requires service.

GEN SET #1 START FAILURE
GEN SET #2 START FAILURE*
GEN SET #3 START FAILURE*

If the Cummins Control system turns on the "NO ST" output, the *NFORCE* will set a GEN SET'*' START FAILURE, where '*' is the GEN SET that failed to start. While this alarm is active the *NFORCE* will not allow the failed GEN SET to start. When this alarm is set the *NFORCE* will ring the alarm bell for 5 seconds.

CONTACTOR FAILED ACC1
CONTACTOR FAILED ACC2
CONTACTOR FAILED ACC2

If a contactor fails to pick up or drop out, a CONTACTOR FAILED ACC'*' alarm is set, where '*' is the contactor that failed to pick up or drop out. The *NFORCE* senses the auxiliary contacts on these contactors. When the *NFORCE* energizes or releases the coil, it checks for the correct feedback from the auxiliary contacts. If the correct feedback is not received, one of these alarms is set.

GEN SET #1 MAINTENANCE
GEN SET #2 MAINTENANCE*
GEN SET #3 MAINTENANCE*

If the Cummins Control system turns on the "MAINT" output the *NFORCE* will set a GEN SET'*' MAINTENANCE, where '*' is the GEN SET that requires maintenance.

WHEEL SLIP/CREEP CONTROL

Wheel-rail studies have shown that after the initial slip of a powered wheel there is still a considerable amount of frictional force between the wheel and the rail. In fact, if the wheel slip is allowed to increase, the force on the rail will increase to some peak value then decrease. This increased frictional force can be utilized for increased tractive effort, and is known as wheel creep.

* = IF EQUIPPED

The *NFORCE* allows the wheels to creep at 1–2 mph above track speed. As wheel slip increases, TM chopper power is decreases. Power to the Traction Motors is cut quickly and then reapplied to just below the level at which the wheel slip occurred. The controlled power levels result in continuous wheel creep.

By allowing Wheel Creep, the system provides an increase in adhesion above conventionally equipped locomotives under poor rail conditions, resulting in more pulling power. Excitation reduction is proportional to the severity of the wheel slip, thereby minimizing loss of tractive effort.

There are two types of wheel slip conditions that may be encountered: simultaneous and differential. Simultaneous wheel slips conditions are wheel slips that occur at the same rate on all axles. Differential wheel slip conditions are wheel slips that occur on different axles at different rates.

The *NFORCE* monitors single, pulses per wheel revolution (PPR) speed signal from axle two traction motor current, and traction voltage from each axle. After comparing each signal, the *NFORCE* system adjusts system power to the traction motors if a wheel slip or wheel slide is detected.

To protect against synchronous wheel slip, the *NFORCE* calculates average traction motor current 100 times per second, and maintains a filtered average traction motor current and voltage signal. If the actual traction motor current or voltage varies from the averaged signal by more than ±100, the *NFORCE* reduces excitation proportional to the excess signal in order to regain control of the wheel slip, providing as much tractive effort as rail conditions permit.

During normal locomotive operation all traction motor armature currents & voltages are approximately equal. During a differential wheel slip the traction motor armature currents & voltages are unbalanced. The *NFORCE* also monitors current & voltage differences. If there is sudden change in current or voltage, the *NFORCE* applies correction based on wheel slip severity. Reducing excitation output proportional to the amount of the initial current drop and activates the sanders until control is regained.

The *NFORCE* breaks wheel slips into three categories. Stage #1 is a slight wheel slip requiring a slight power reduction of 2% to correct. Stage #2 is a minor wheel slip requiring a minor power reduction that is proportional to the severity of the wheel slip, and sanding. Stage #3 is a major wheel slip requiring a further proportional power reduction and sanding. The WS relay is picked up for Stage #3 wheel slips only. The relay interlocks will turn on the wheel slip light on the locomotive control stand and energize the 10T trainline.

While the traction motors are cutout, wheel slip control is limited to those sensors that correspond to the traction motors still cut in.

A single speed sensor has been applied to monitor locomotive track speed. This sensor is applied to axle 2. The wheel diameter can be set using a laptop to maintain speed signal accuracy.

MU LINE FAILED 10T

When the *NFORCE* energizes a relay to drive a MU line it checks to ensure the MU line becomes active. This alarm is displayed if the MU line fails to become active. The fault could be with the *NFORCE* ECM, on the driver board, the wiring to the relay coil, the relay coil, the wiring from the MU line, or the Digital I/O board.

WHEEL SLIP

If there is an active wheel slip for more than 1 second this alarm is set. The *NFORCE* picks up the WS relay, which drives the Wheel Slip

Alarm MU line (10T).

WHEEL SLIP NOT THIS LOCO

Another locomotive in the consist activated the Wheel Slip Alarm MU line (10T).

PC Communications & Analysis Software

The analysis software allows communication via RS-232 serial link to the *NFORCE* system.

The *NFORCE* System has an integrated recording function which is continually operating while the system is functional. The *NFORCE* system records information and stores it in three types of log (Alarm, Diagnostic, & Statistics Logs). This information can be viewed using the analysis software program. The *NFORCE* system scans all inputs and outputs – digitals and analogs – 10 times each second, and updates each log as required.

Connecting To the *NFORCE* Using Hyper Terminal

The *NFORCE* system uses RS 232 serial communications to transfer information to and from the PC. A standard VT100 terminal emulation is employed allowing common, easy to operate Windows programs such as Hyper Terminal to communicate with the *NFORCE*. Any Windows based serial terminal program may be used to talk to the *NFORCE* system.

These instructions will describe how to use Hyper Terminal to transfer log data from the *NFORCE* to a laptop PC running Microsoft ® Windows ®.

- Connect the communications cable from the front connector of the *NFORCE* CPU board to the serial port of your laptop computer.
- Run Hyper Terminal from your laptop computer. This is commonly found by going to *Start -> Programs -> Accessories -> Communications*. If your laptop does not have Hyper Terminal, you must install it before continuing.
- If this is the first time you have connected to the *NFORCE* with Hyper Terminal, create a new connection. Give the connection the name *NFORCE* as shown in Figure 6-2. Click OK when you have entered the name and chosen an icon.

* = IF EQUIPPED

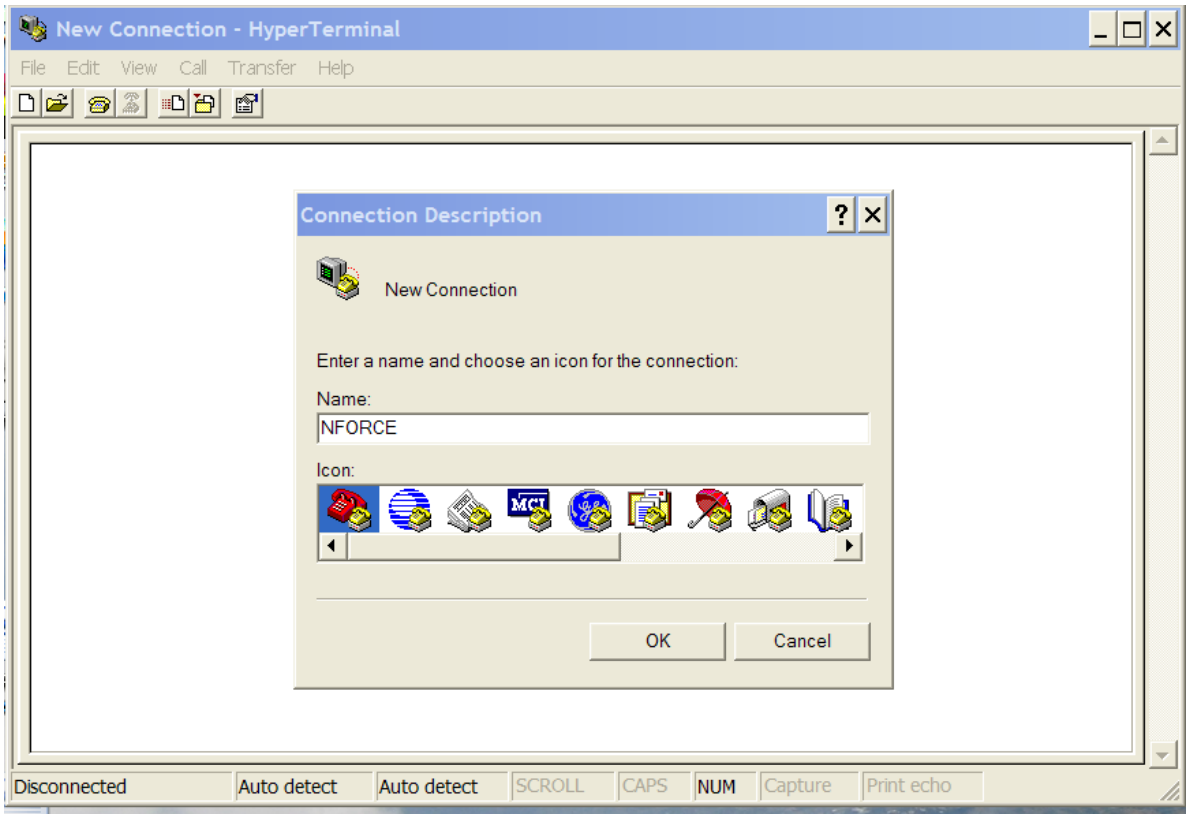


Figure 6-2 – Naming the *NFORCE* HyperTerminal Connection

- Hyper Terminal must now be configured with the correct communications settings to talk to the *NFORCE*. Hyper Terminal should now be showing the *Connect To* window (Figure 6-3). Using the drop down box provided for *Connect Using* select the COM port you have connected the *NFORCE* cable to. This is commonly COM1. Click OK when ready.

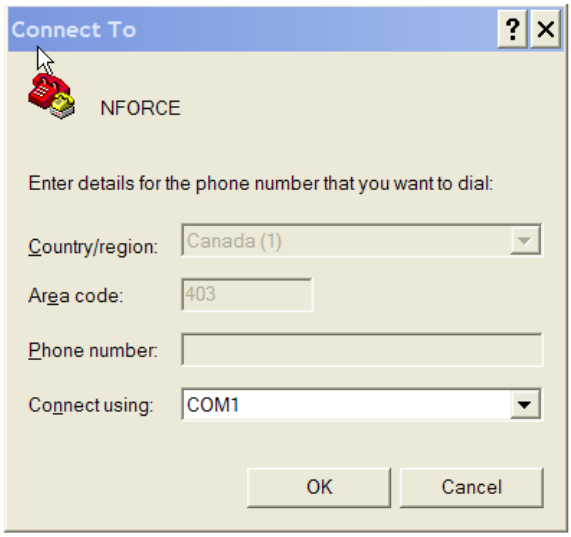


Figure 6-3 – HyperTerminal Communications Settings

* = IF EQUIPPED

- Hyper Terminal should now be displaying the COM Properties window (Figure 6-4) which contains the configurable port settings. Set the fields to the following:

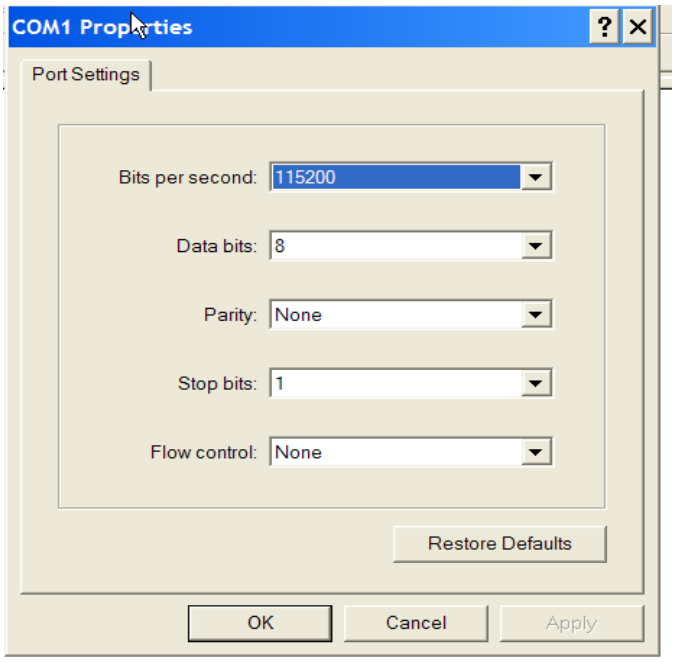


Figure 6-4 – COM Properties window

NOTE

It is very important that these settings are correct to ensure successful communications with the *NFORCE* system.

Click OK when ready.

Communicating With the *NFORCE* & *NFORCE* Help Menu

- Starting if the *NFORCE* is powered down:

  Now that the PC is configured to talk to the *NFORCE*, power up the *NFORCE* system if it is not already powered. You should see some messages on the Hyper Terminal screen as the *NFORCE* performs system checks (Fig. 6-5). This is normal. **If you do not see anything on the screen, you should check your physical cable connection and your COM port settings.**

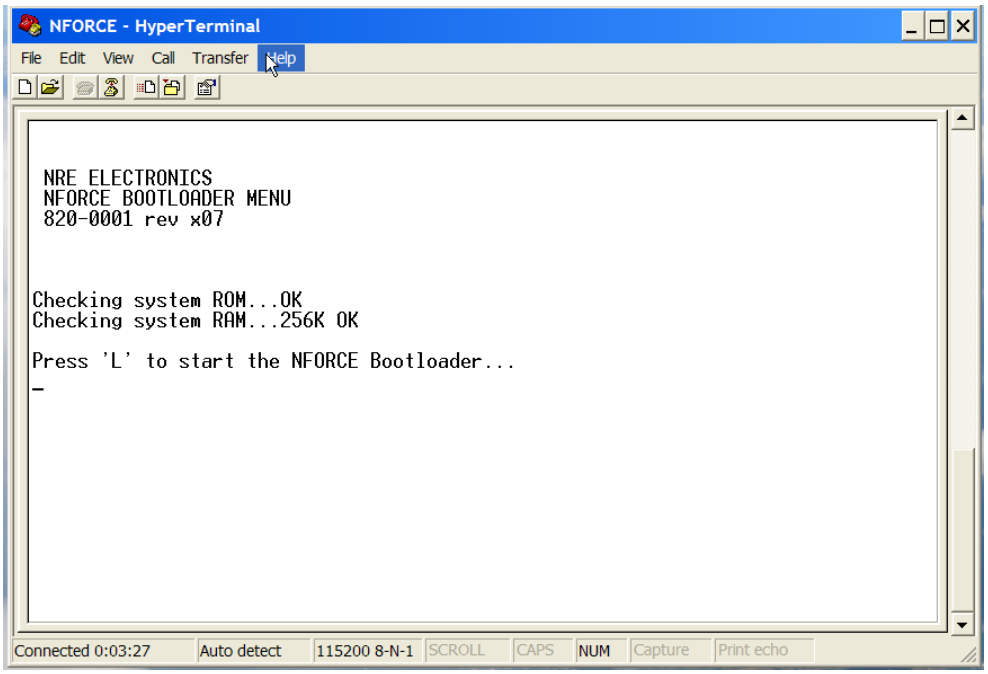


Figure 6-5 – Startup System Checks

When the *NFORCE* has finished its system checks it will run the terminal interface automatically. See below (Figure 6-5):

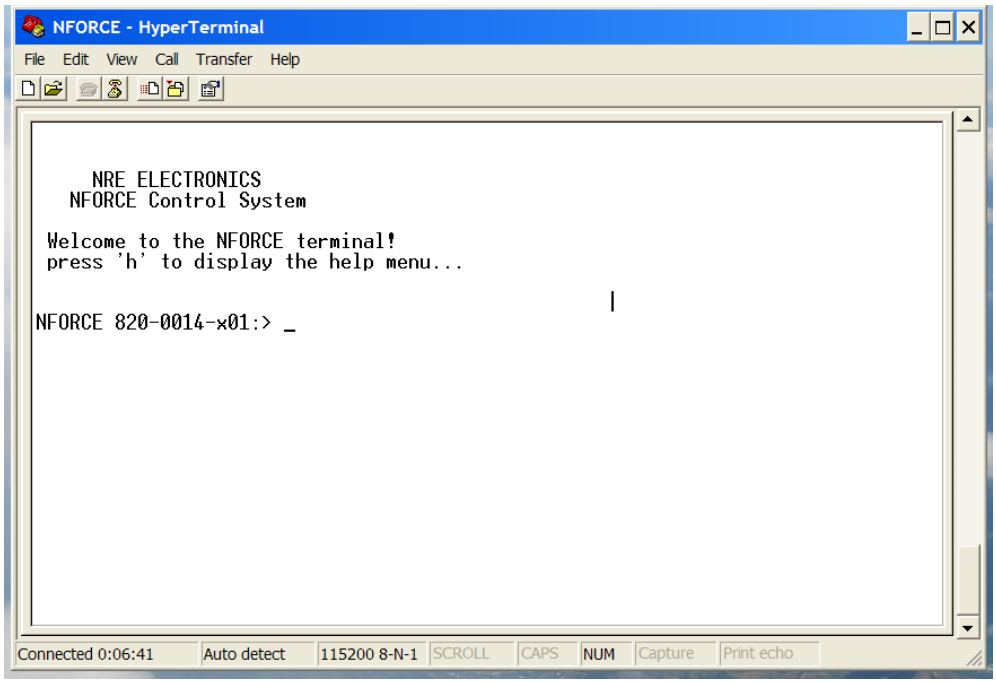


Figure 6-6 –Terminal Interface

* = IF EQUIPPED

- The *NFORCE* is now running and is ready for user input. Press the 'h' key on your laptop keyboard to launch the Help Menu. Note that not all *NFORCE* systems have identical help menu contents as some items are specific to certain locomotive types. If you do not see anything on the screen, you should check your physical cable connection and your COM port settings.

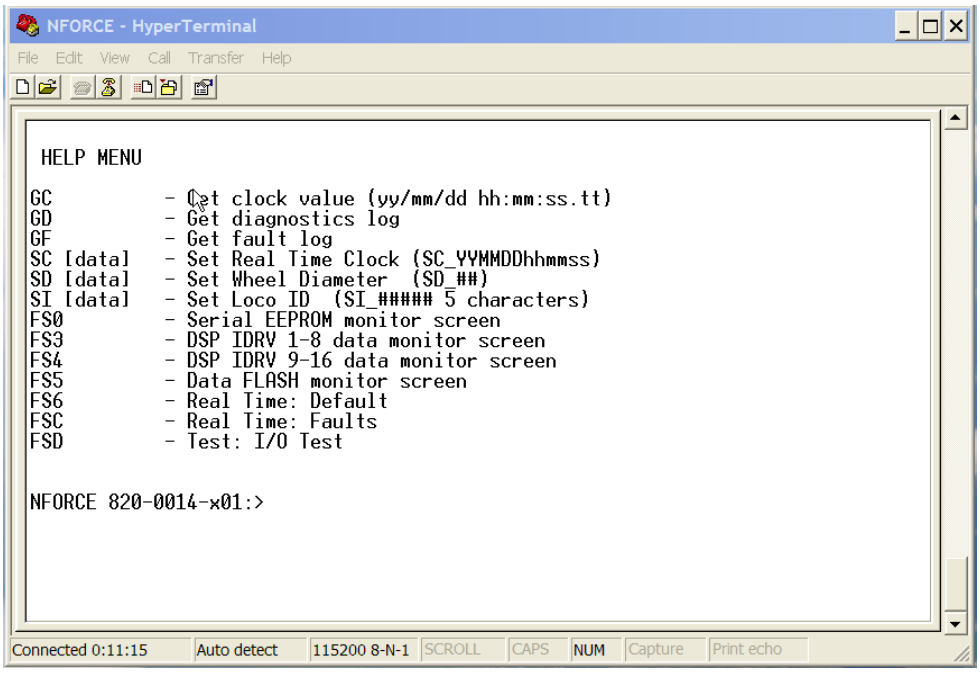


Figure 6-7 – Help Menu

All of the commands are listed in the help menu. Note the commands for transferring log information.

Downloading the *NFORCE* Fault Log to the PC

The *NFORCE* system is capable of sending comma delimited ASCII text file fault logs via the RS 232 serial port. These logs must be captured and saved by the terminal program in use to be viewed following the completion of the download.

- Choose a file name and save location for the Fault Download.

  In Hyper Terminal, select *Transfer->Capture Text*. The *Capture Text* window should appear:

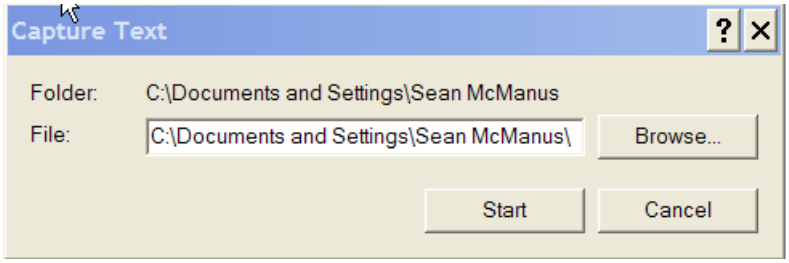


Figure 6-8 – *Capture Text* Window

  Click *Browse* to select the location on the computer you wish to save the file. Choose a unique name for the file to distinguish it from other previous downloads and files. Click *Save* when done selecting a file name and save location (Figure 6-8). Click *Start* when ready to download.

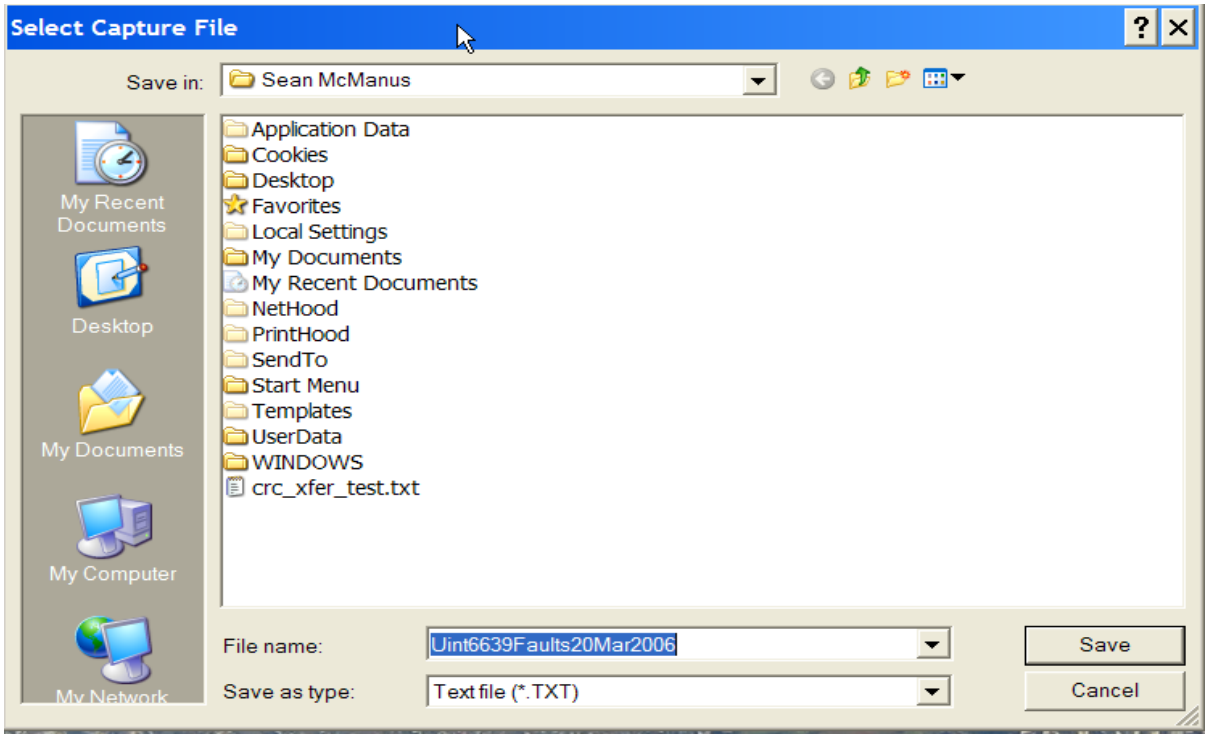


Figure 6-9 – *Capture File* Save Location

- Ensure that the locomotive is isolated and is not loading. Initiate the file transfer by entering the GF command. The *NFORCE* will immediately begin downloading the Fault Log to the PC. Note that this can take several minutes to complete. Also note that the terminal window will be very

rapidly updating seemingly meaningless information. This is simply the fault data passing into the file and is normal.

- Upon completion, the *NFORCE* will display the message **`Transfer Complete!!`** and the command prompt:

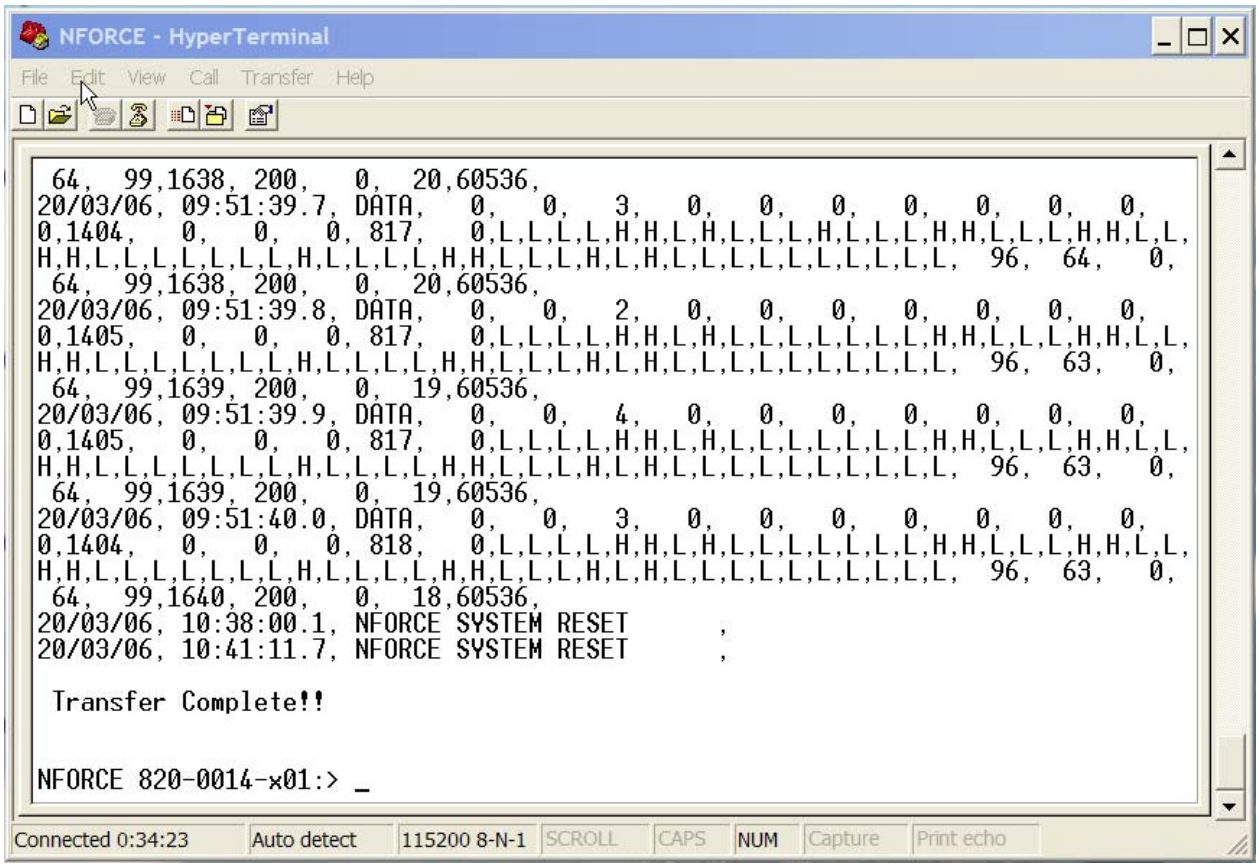


Figure 6-10 – Transfer Complete

The Fault Log download is now finished. Stop the file capture in Hyper Terminal by selecting *Transfer->Capture Text->stop.*

* = IF EQUIPPED

Downloading the *NFORCE* Diagnostic Log to the PC

The *NFORCE* system is capable of sending comma delimited ASCII text file diagnostics logs via the RS 232 serial port. These logs must be captured and saved by the terminal program in use to be viewed following the completion of the download.

- Choose a file name and save location for the Fault Download.

  In Hyper Terminal, select *Transfer->Capture Text*. The *Capture Text* window should appear:

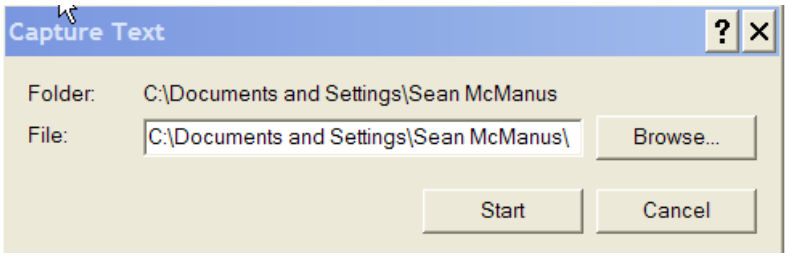


Figure 6-11– *Capture Text* Window

Click *Browse* to select the location on the computer you wish to save the file. Choose a unique name for the file to distinguish it from other previous downloads and files. Click *Save* when done selecting a file name and save location. Click *Start* when ready to download.

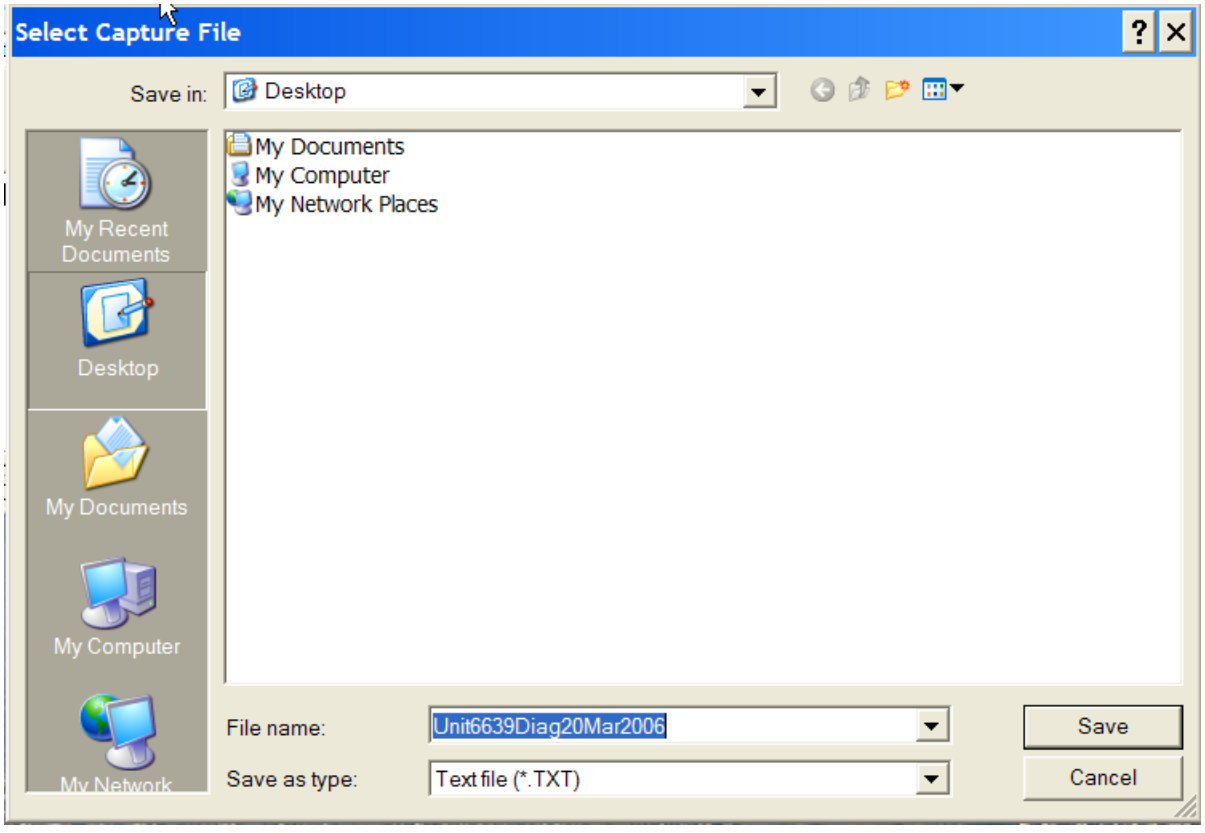


Figure 6-12 – *Capture File* Save Location

- Ensure that the locomotive is isolated and is not loading. Initiate the file transfer by entering the GF command.

  The *NFORCE* will immediately begin downloading the Diagnostic Log to the PC. Note that the terminal window will be very rapidly updating seemingly meaningless information. This is simply the data passing into the file and is normal.

- Upon completion, the *NFORCE* will display the message **`Transfer Complete!!`** and the command prompt:

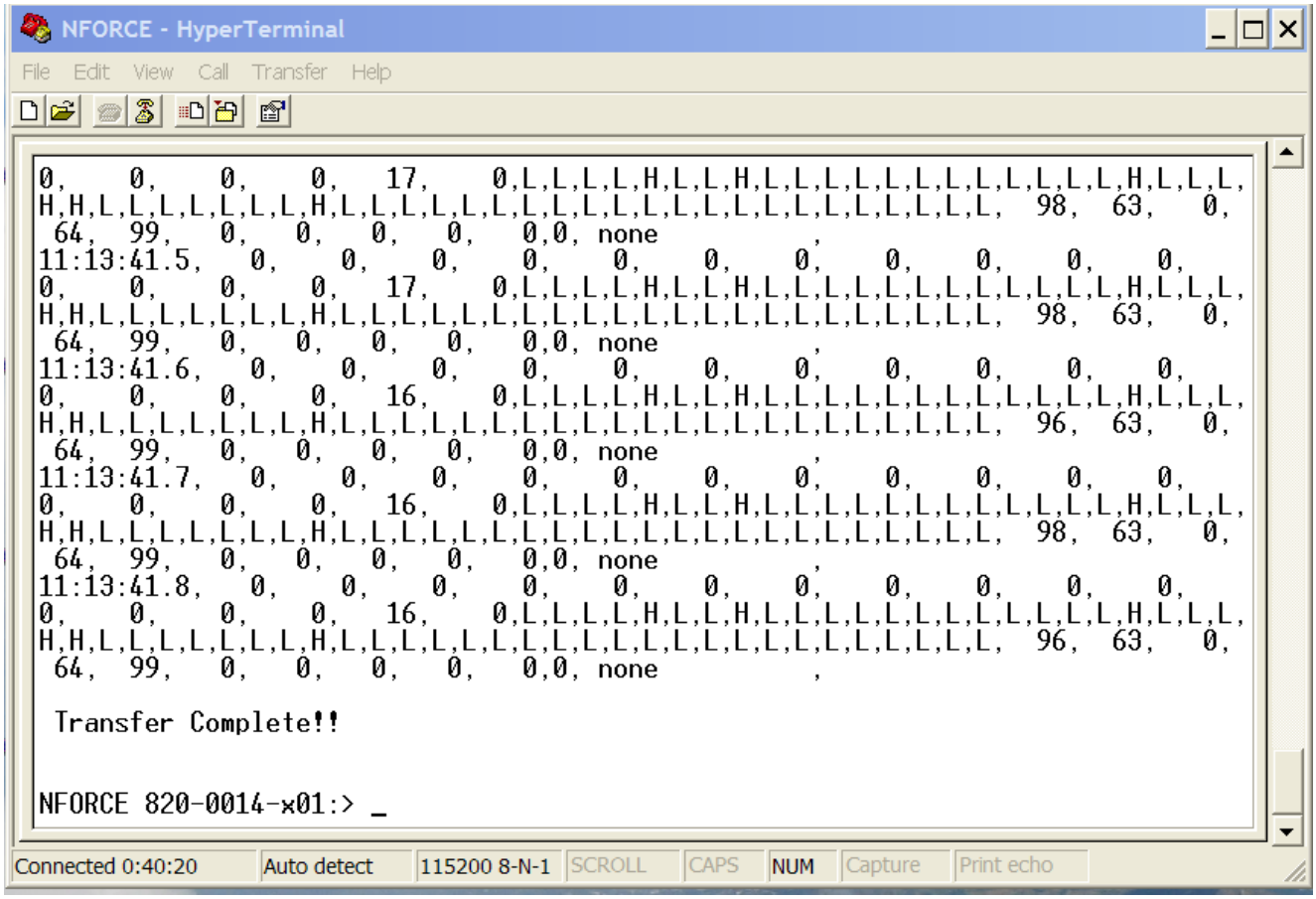


Figure 6-13 – Transfer Complete

The Diagnostics Log download is now finished. Stop the file capture in Hyper Terminal by selecting *Transfer->Capture Text->stop.*

* = IF EQUIPPED

DOWNLOADING THE *NFORCE* STATISTICS LOG TO THE PC

The *NFORCE* system is capable of sending comma delimited ASCII text file diagnostics logs via the RS 232 serial port. These logs must be captured and saved by the terminal program in use to be viewed following the completion of the download.

- Choose a file name and save location for the Statistics Download.

  In Hyper Terminal, select *Transfer->Capture Text*. The *Capture Text* window should appear:

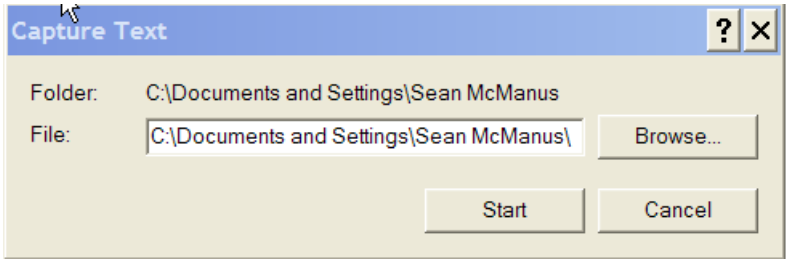


Figure 6-14 – *Capture Text* Window

Click *Browse* to select the location on the computer you wish to save the file. Choose a unique name for the file to distinguish it from other previous downloads and files. Click *Save* when done selecting a file name and save location. Click *Start* when ready to download.

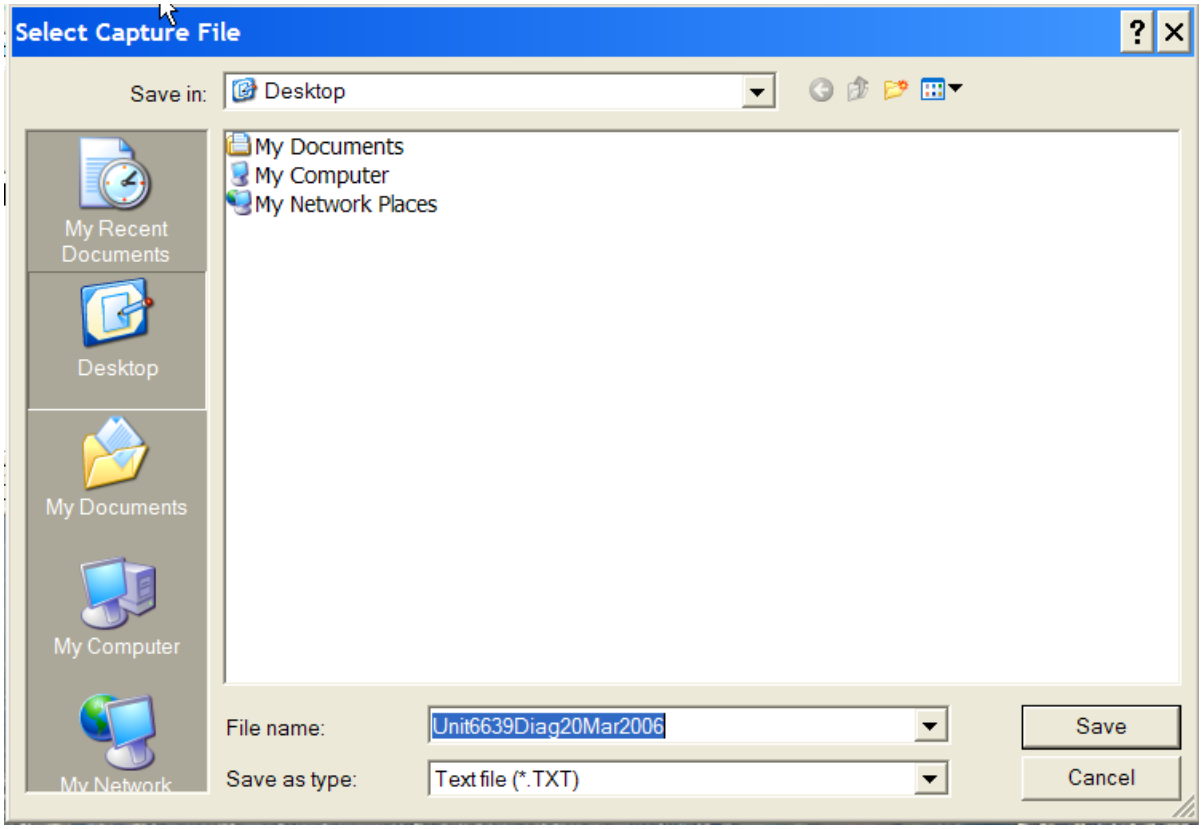


Figure 6-15 – *Capture File* Save Location

* = IF EQUIPPED

- Ensure that the locomotive is isolated and is not loading. Initiate the file transfer by entering the GS command.

  The *NFORCE* will immediately begin downloading the Statistics Log to the PC. Note that the terminal window will be very rapidly updating seemingly meaningless information. This is simply the data passing into the file and is normal.

- Upon completion, the *NFORCE* will display the message **`Transfer Complete!!`** and the command prompt:

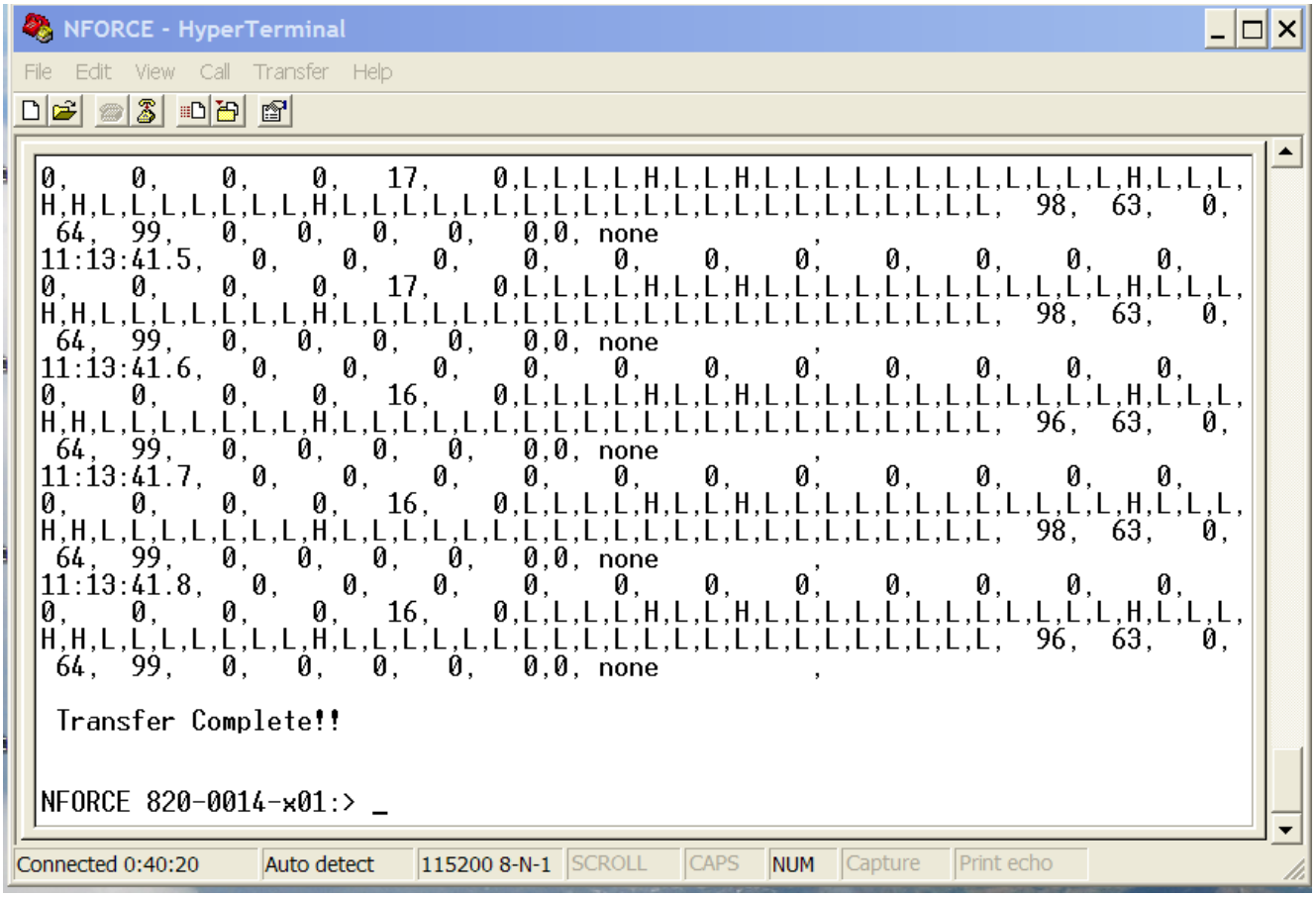


Figure 6-16 – Transfer Complete

The Statistics Log download is now finished. Stop the file capture in Hyper Terminal by selecting *Transfer->Capture Text->stop.*

* = IF EQUIPPED

VIEWING *NFORCE* LOG DOWNLOAD FILES WITH A PC

The *NFORCE* formats all downloads into ASCII comma delimited text files for easy import into popular spreadsheet programs such as Microsoft ® Excel ®.

Most spread sheet programs are capable of importing delimited text files. These instructions will describe how to import and view *NFORCE* comma delimited text files using Microsoft ® Excel ®. NRE Electronics recommends using Microsoft ® Excel ®.

- Launch Excel and open the saved log file (.txt extension) captured by Hyper Terminal. Excel will post a warning window indicating that the file is not in the standard Excel format.

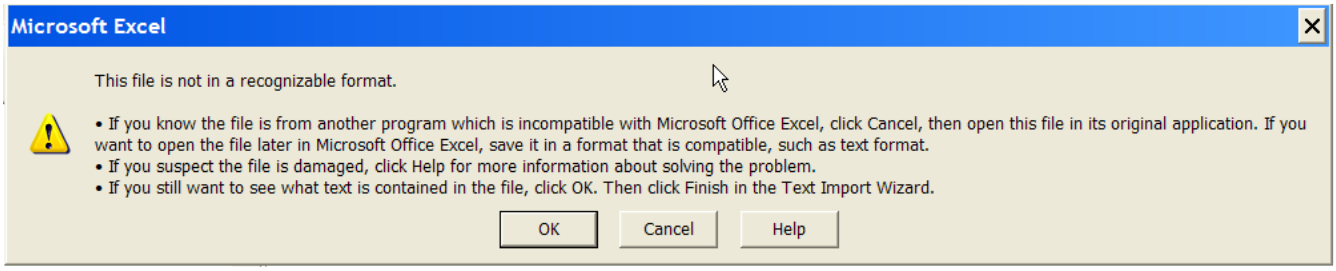


Figure 6-17 – Excel File Warning Window

Click OK to start the import wizard:

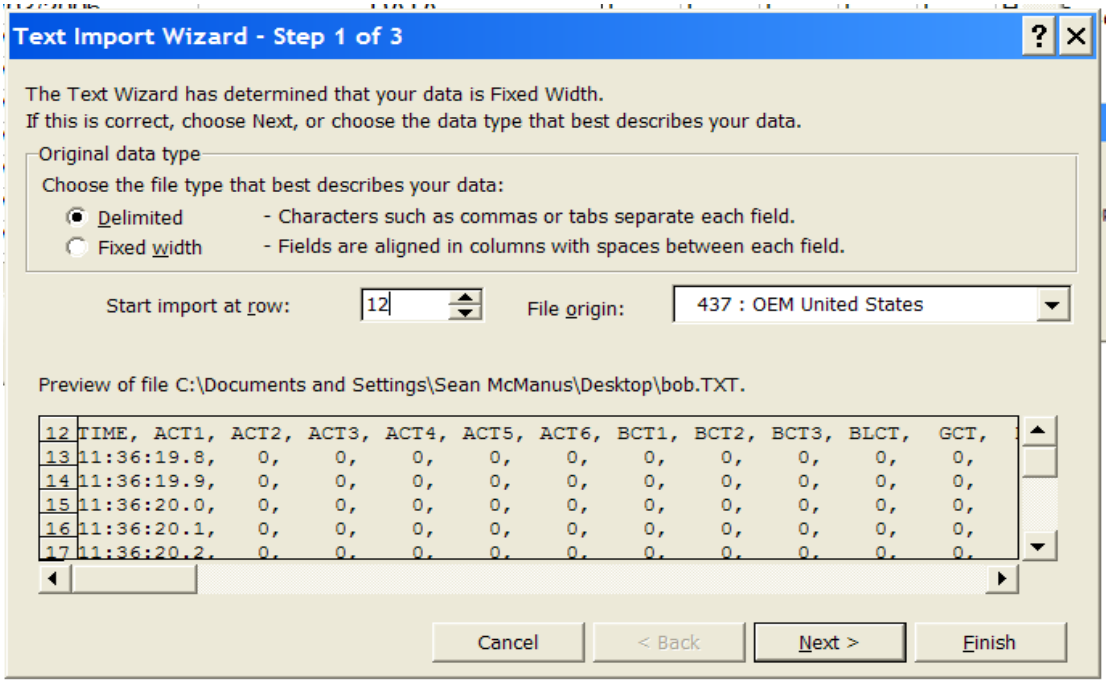


Figure 6-18 – Excel Text Import Wizard (Step 1)

Set the Original Data Type radio button to *Delimited* as above. Adjust the 'Start import at row' to the labels row, typically this is row 12. Use the slide bar provided to find the label row number if you are not sure.

Click *Next* > when ready.

- Set the comma delimiter to allow Excel to prepare the data columns. Note the vertical bars that are inserted to distinguish the data fields.

  Click *Finish* when ready.

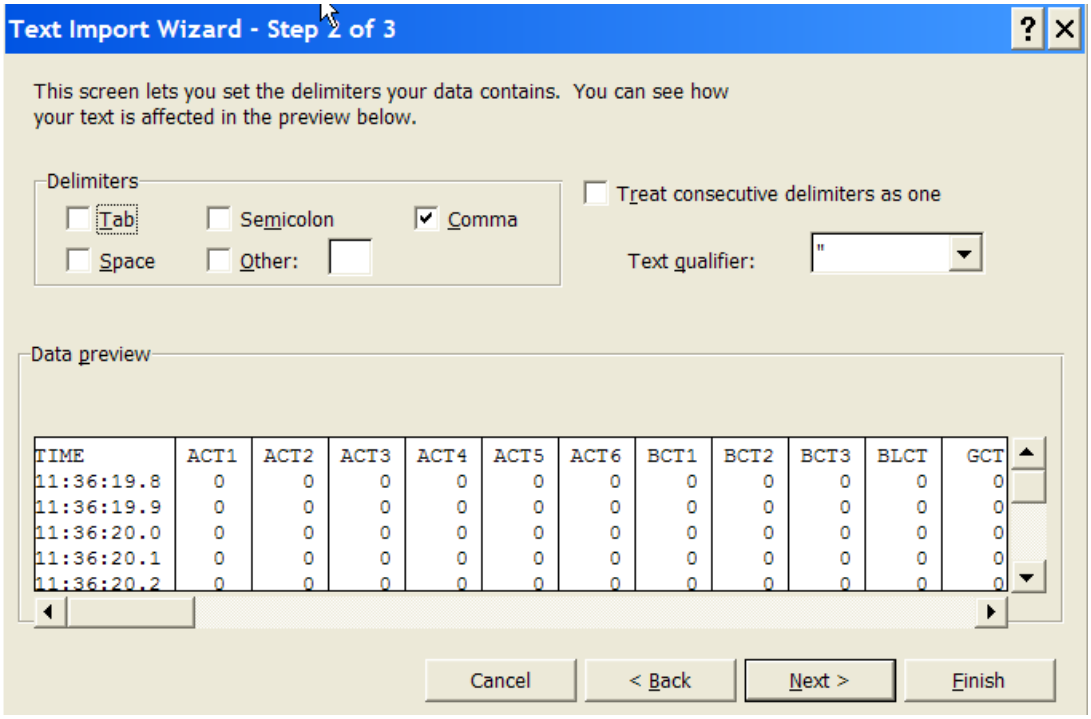
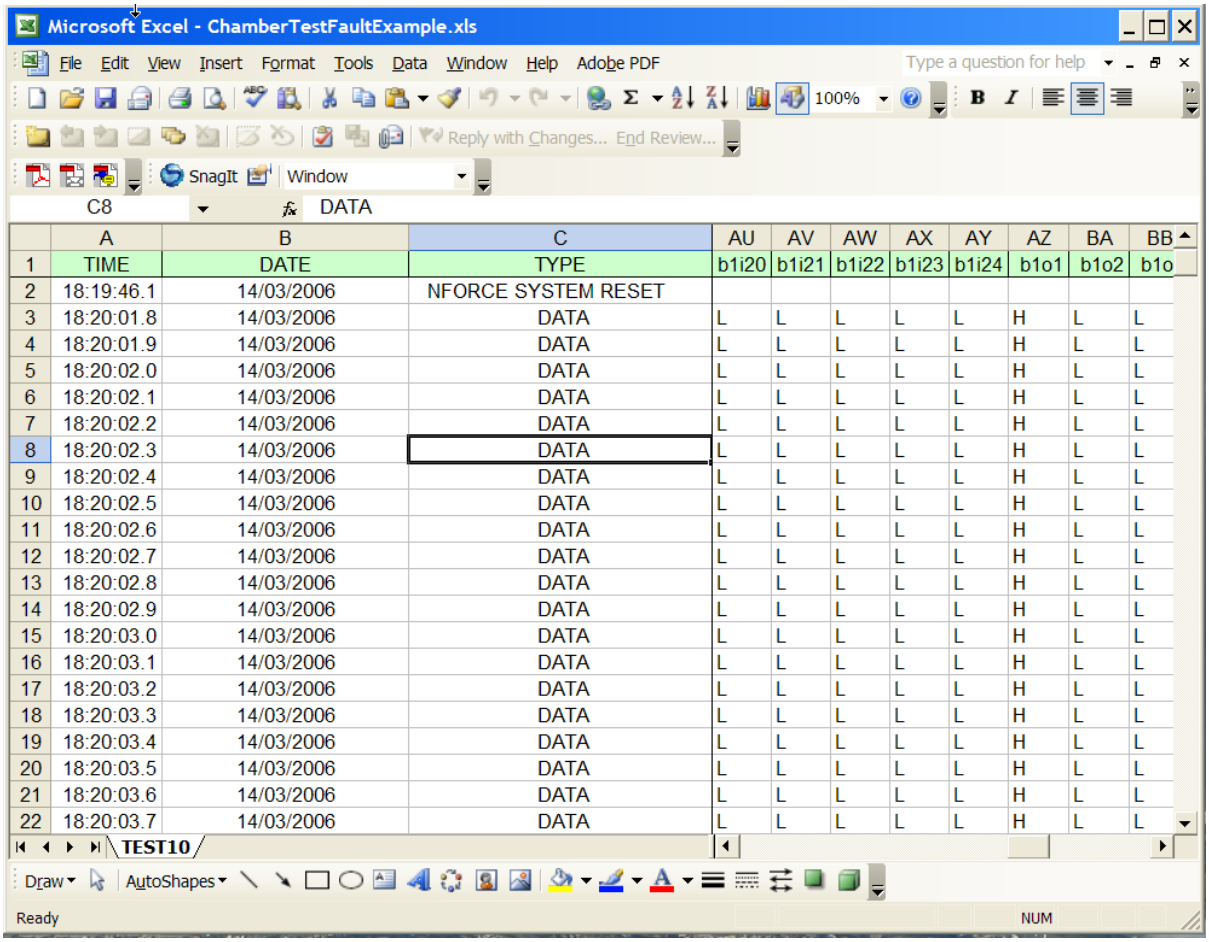


Figure 6-19 – Excel Text Import Wizard (Step 2)

- The file is now ready for viewing! The data is unsorted. Excel may be used to sort the data to your liking. Users typically sort the data set using the time stamp in the first column then sort according to the data of interest. Macros may be constructed to assist with repetitive sorts. Please refer to Excel help material for more information regarding sorting and macros.

- An example of an imported fault log is below. The diagnostic log file is identical with the exception of the DATE and TYPE columns are removed as all diagnostic data records are the same type (DATA) and all diagnostic data records occur on the same date over a span of several minutes.



	A	B	C	AU	AV	AW	AX	AY	AZ	BA	BB
1	TIME	DATE	TYPE	b1i20	b1i21	b1i22	b1i23	b1i24	b1o1	b1o2	b1o
2	18:19:46.1	14/03/2006	NFORCE SYSTEM RESET								
3	18:20:01.8	14/03/2006	DATA	L	L	L	L	L	H	L	L
4	18:20:01.9	14/03/2006	DATA	L	L	L	L	L	H	L	L
5	18:20:02.0	14/03/2006	DATA	L	L	L	L	L	H	L	L
6	18:20:02.1	14/03/2006	DATA	L	L	L	L	L	H	L	L
7	18:20:02.2	14/03/2006	DATA	L	L	L	L	L	H	L	L
8	18:20:02.3	14/03/2006	DATA	L	L	L	L	L	H	L	L
9	18:20:02.4	14/03/2006	DATA	L	L	L	L	L	H	L	L
10	18:20:02.5	14/03/2006	DATA	L	L	L	L	L	H	L	L
11	18:20:02.6	14/03/2006	DATA	L	L	L	L	L	H	L	L
12	18:20:02.7	14/03/2006	DATA	L	L	L	L	L	H	L	L
13	18:20:02.8	14/03/2006	DATA	L	L	L	L	L	H	L	L
14	18:20:02.9	14/03/2006	DATA	L	L	L	L	L	H	L	L
15	18:20:03.0	14/03/2006	DATA	L	L	L	L	L	H	L	L
16	18:20:03.1	14/03/2006	DATA	L	L	L	L	L	H	L	L
17	18:20:03.2	14/03/2006	DATA	L	L	L	L	L	H	L	L
18	18:20:03.3	14/03/2006	DATA	L	L	L	L	L	H	L	L
19	18:20:03.4	14/03/2006	DATA	L	L	L	L	L	H	L	L
20	18:20:03.5	14/03/2006	DATA	L	L	L	L	L	H	L	L
21	18:20:03.6	14/03/2006	DATA	L	L	L	L	L	H	L	L
22	18:20:03.7	14/03/2006	DATA	L	L	L	L	L	H	L	L

Figure 6-20 – Imported Fault Log Example

STATISTICS LOG CONTENT

The Statistics Log records various information that relates to the locomotive and its operation. Most of this information is accumulative and is referred to as statistics, while some information defines the parameters of the locomotive and the *NFORCE* System. All Lifetime Statistics are also stored in an external, non-volatile memory device which remains on the locomotive at all times.

The Statistics Report contains the following information:

- **Date/Time** (settable parameter) is the time and date of the download computer when data was downloaded from the *NFORCE*.
- **Firmware Version** indicates the version and revision of the *NFORCE* internal operating software.
- **Loco ID** (settable parameter) is the ID number of the locomotive from which data was removed. The ID number is composed of 5 alpha-numeric characters. Acceptable characters include numbers 0-9, letters a-z and letters A-Z. Space is used for blanks in the event the ID number is less than 5 characters in length.
- **Wheel Diameter** (settable parameter) is the diameter of the locomotive wheel in inches.
- **Axle Gen PPR** (settable parameter) is the pulses per revolution (PPR) of the incoming speed signal from the installed speed pick-up equipment.
- **Idle Parked** indicates the number of hours that the locomotive has spent with the engine at idle and the reverser in neutral.
- **Idle Working** indicates the number of hours the locomotive has spent with the engine at idle and the reverser set in either forward or reverse.

* = IF EQUIPPED

- **Idle Limit Shutdown** indicates the total hours the engine spent in *NFORCE* Shutdown mode.
- **Isolated** indicates the total hours the locomotive spent with the isolate/run switch in the isolate position.
- **Running** indicates the total engine run hours.
- **Shutdown** indicates the total engine shutdown hours (manual and automatic.)
- **Stop, Notch 1-8** displays the time in hours spent at various throttle positions.
- **Engine Run Times** displays hours and minutes spent at each RPM setting.
- **Distance** displays miles traveled in forward, reverse and neutral.
- **Energy** displays total energy consumed in kWh.
- ***RESTART COUNTS (ENGINE RESTART COUNTS)*** displays the *Reason* for each engine *NFORCE*, each recorded for the *Lifetime* the *Trip*.
- ***SHUTDOWN TIMES (UNABLE TO SHUTDOWN TIMES)*** displays the *Reason* for each engine shutdown failure and the associated number of hours accumulated.

* = IF EQUIPPED

VIEWING & SETTING *NFORCE* LOCOMOTIVE PARAMETERS

There are several settable parameters that the *NFORCE* system uses to operate. These parameters (with the exception of the real time clock) are stored in a memory unit that is permanently installed on the locomotive external to the *NFORCE* module in the *NFORCE* wire harness. This allows the operating parameters to remain with the locomotive in the event that the *NFORCE* module is changed or replaced.

WARNING

It is very important that all of the parameters be set before the locomotive is put into service!

The following parameters are settable:

- Locomotive ID
- Wheel diameter
- Time and Date

The parameters may be viewed by launching the 'FS0' Serial EEPROM monitor screen: Figure 6-21.

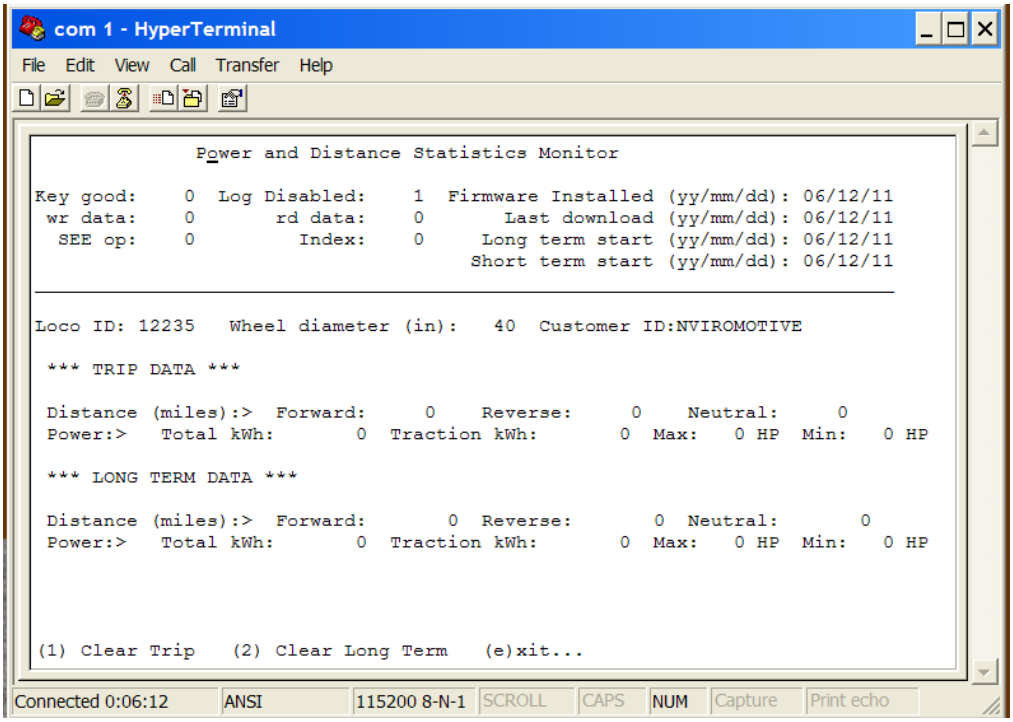


Figure 6-21 – *FS0 Serial EEPROM* Monitor Screen

* = IF EQUIPPED

All of the settable parameters may be set from the *NFORCE* command prompt. A list of the set commands may be found by activating the *NFORCE* Help Menu (Figure 6-22) by pushing the 'H' key at the command prompt:

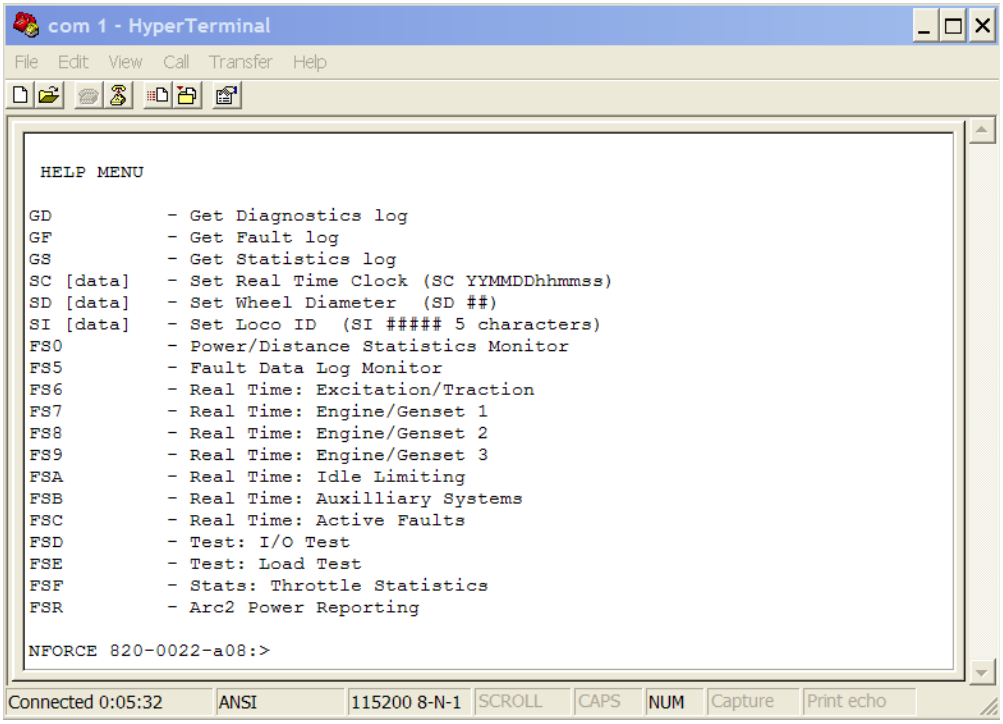


Figure 6-22 – Help Menu

Note that all of the set commands begin with the letter 'S'.

REAL TIME CLOCK

To set the real time clock, enter the date and time in the following format:

SC *YYMMDDhhmmss*

Where:

- YY = The last two digits of the calendar year
- MM = The two digit representation of the calendar month
- DD = The day of the month
- hh = The hour in 24-hour nomenclature (i.e. 23 = 11 PM.)
- mm = The current minutes value.
- ss = The current seconds value.

If accepted, the *NFORCE* will reply with:

RTC time set!

WHEEL DIAMETER (inches)

Wheel diameter settings are accepted in inches. To set the wheel diameter to 40 inches (for example) enter the following command at the *NFORCE* command prompt:

SD 40

The acceptable range of wheel diameters is from 36 to 42 inches. If accepted, the *NFORCE* will reply with:

New Wheel Diameter set!

LOCOMOTIVE ID

The locomotive ID is represented by 5 alpha-numeric characters. Acceptable values for each character are the numbers 0-9, letters a-z and

letters A-Z. Blank is represented by a space in the event that the locomotive ID is less than 5 characters long. To enter an ID of 12345 (for example), enter the following command at the *NFORCE* command prompt:

SI 12345

If accepted, the *NFORCE* will reply with:

New Loco ID set!

CLEARING STATISITICS LOGS

Both the long term and short term statistics logs may be cleared from the FS0 Serial EEPROM Monitor Screen (Figure 6-21). To clear the short term log, press ‘1’. To clear the long term log, press ‘2’.

UPLOADING NEW SYSTEM FIRMWARE

The internal firmware installation procedures described here can be used to install the *NFORCE* system firmware for the first time, to re-install it if start-up problems occur, or to upload revised firmware if changes are required. Installing the firmware is done using a portable computer and the analysis software program.

The program required to communicate with the *NFORCE* is called Hyper Terminal and is included with the Microsoft Windows operating system.

To upgrade the *NFORCE* firmware, you must do the following:

- Isolate the locomotive and shut down the engine(s).
- Connect the communications cable to the front of the CPU board and your laptop.
- Within the Hyper Terminal window (setup as above) type RESET at the *NFORCE* command prompt. This should look like this: ***NFORCE* 820-0022-a19:> RESET**
- The *NFORCE* system will reset and run the bootloader. Press 'L' on your laptop keyboard to bring up the bootloader menu (Figure 6-23):

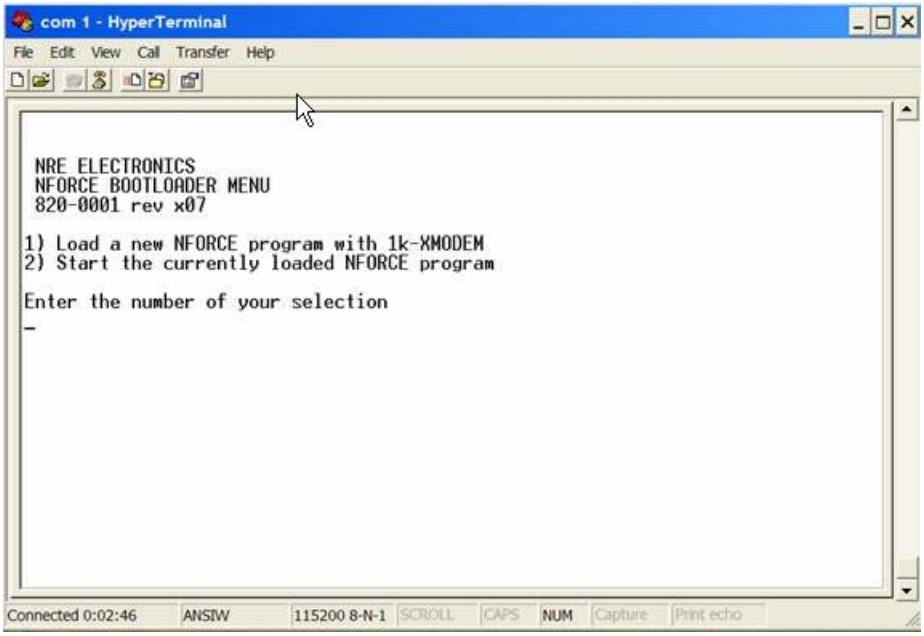


Figure 6-23 – Bootloader Menu

- Select option '1' to load a new program with 1k-XMODEM. The *NFORCE* will then begin the 1k-XMODEM file transfer process. Note this step is time sensitive as the *NFORCE* will allow 30 seconds for the file transfer to begin. The letter 'C' appearing on the terminal window is normal and denotes the *NFORCE* is waiting for the file (Figure 6-24).

* = IF EQUIPPED

- From Hyper Terminal, select the ‘Transfer->Send File’ drop down menu.

- Browse to the location of the *NFORCE* firmware on your laptop. The *NFORCE* firmware has an .ecm extension. Make sure to select 1k-XMODEM as the protocol to transfer the file with. Click ‘Send’ when the correct file has been chosen.

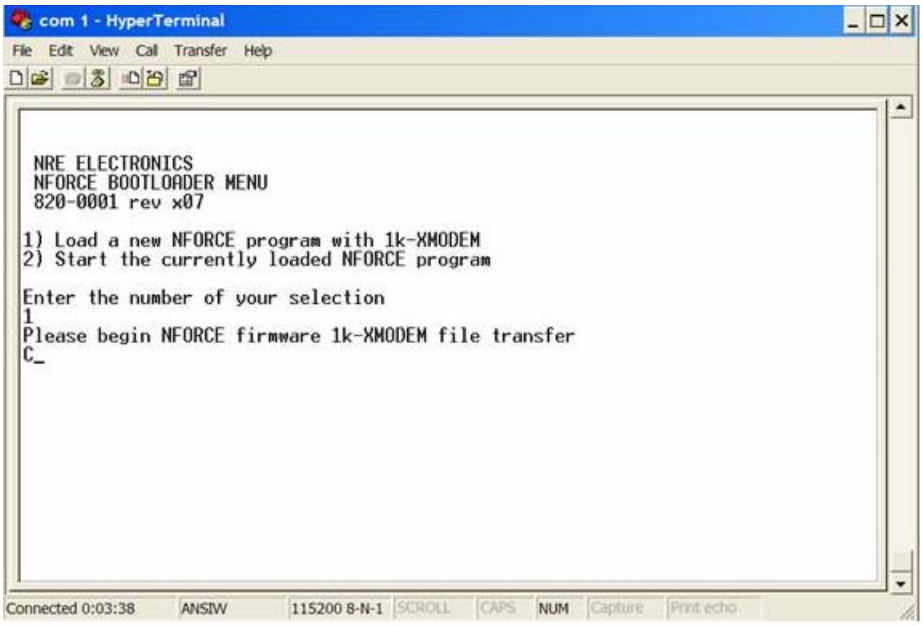


Figure 6-24 – 1k-XMODEM File Transfer

- The file transfer progress window should appear within Hyper Terminal. Once the file transfer is successful, the *NFORCE* will ask if you wish to apply the program, press the ‘Y’ key on the laptop to say yes and accept the new program into memory:

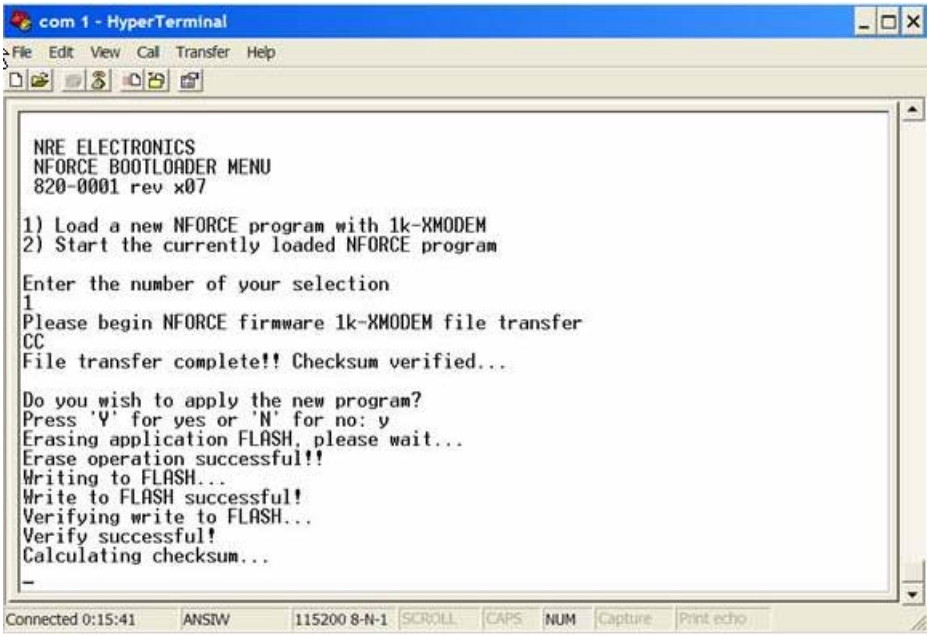


Figure 6-25 – Program Application

* = IF EQUIPPED

- Once the file has been successfully loaded into memory, the *NFORCE* will start automatically. Press the ENTER key on your laptop to confirm that the *NFORCE* is communicating, it should respond with the command prompt.

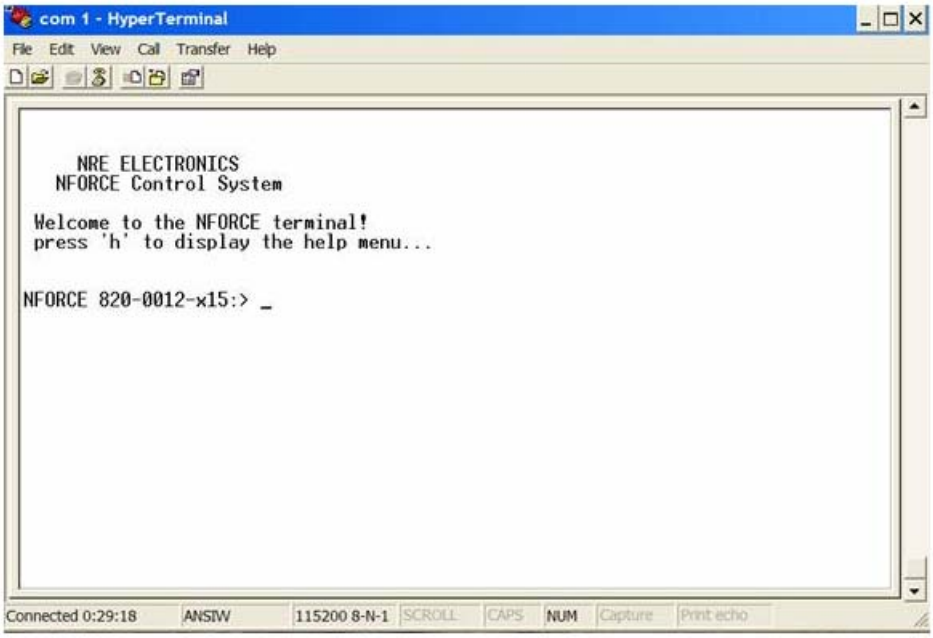


Figure 6-26 – Terminal Interface

- If the file was corrupted during the transfer or is in any way invalid, the *NFORCE* will reject the file and post a warning message indicating that the file was corrupted and it will not use the bad file.

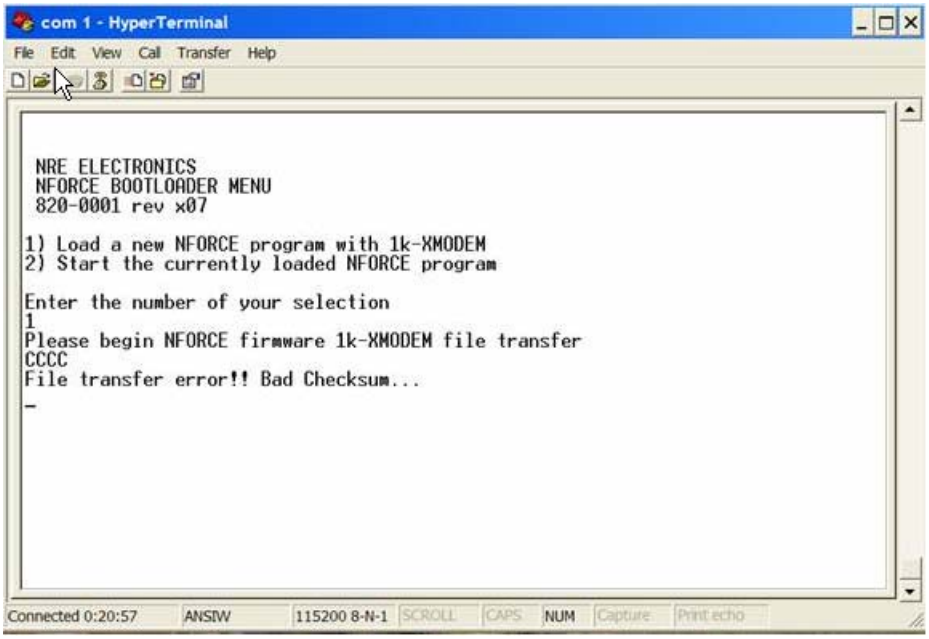


Figure 6-27 – Corrupted Program File Transfer

SETTING UP EXTERNAL EEPROM MEMORY

The *NFORCE* Power Supply Harness is equipped with external non-volatile memory, used to store locomotive and *NFORCE* parameters.

To verify the EEPROM is setup correctly, you must do the following:

- Connect to the *NFORCE* as described in *PC Communications & Analysis Software p.23*
- Enter "FS0" and terminal. A screen similar to that shown in Figure below should be displayed.
- Verify that "KEY GOOD" is displayed as "1" and "LOG DISABLED" is displayed as "0". If this is not the case reset EEPROM as follows.
- Enter "$" followed be "E" to exit FSO screen. Reset *NFORCE*.

WARNING

DO NOT SHUT DOWN *NFORCE* DURING THIS PROCESS.

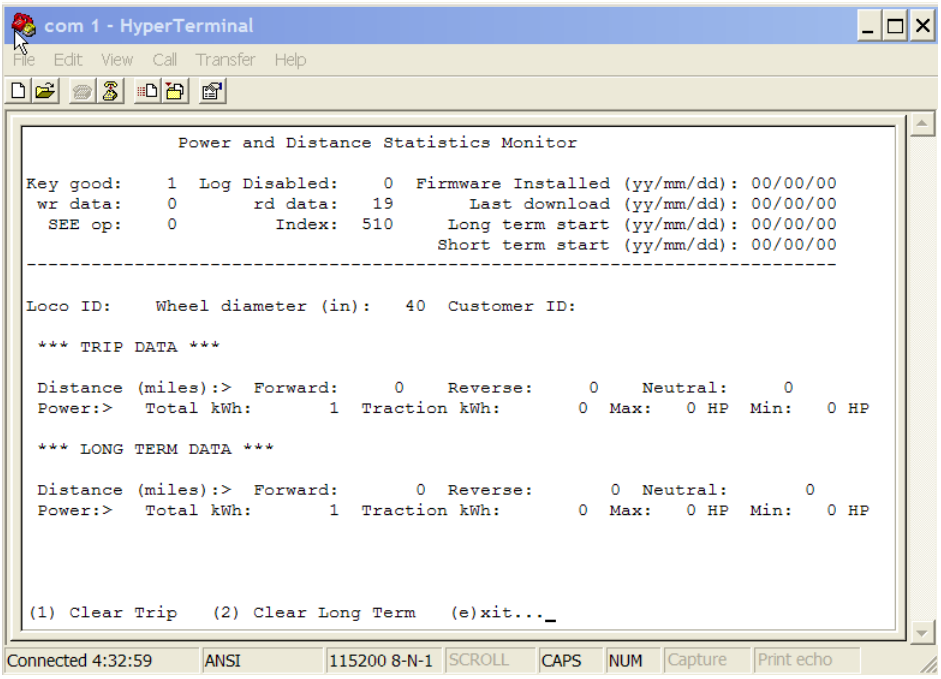


Figure 6-28 – *FS0 Serial EEPROM* Monitor Screen

* = IF EQUIPPED

MCM SYSTEM HARDWARE

Many train interface and ancillary equipment options are available for *NFORCE* Systems. The N-VIRO Low Emissions Switcher system includes the equipment listed below:

Table 6-3 – N-VIRO Low Emissions Switcher *NFORCE* Equipment

Item	Part Number	Qty.
NFORCE System	901-0002-000	1
NFORCE CPU Harness	725-0002-000	1
NFORCE Power Supply Harness	725-0007-000	1
NFORCE IO Harness	725-0001-000	4
Water/AMB Temperature Sensor	775-0001-000	1
Ambient Temperature Mounting Plate	665-0017-000	1
Temperature Sensor Cable	057-0001-000	1
Low Current Sensor	775-0007-000	4
Transformer (480VAC to 120VAC)	445-0001-000	1
Pressure Sensor	775-0005-000	2
Pressure Sensor Cable	057-0002-000	2
Train Line Load Resistor Panel	904-0001-000	1
NFORCE Communication Cable	058-0001-000	1
Axle Generator Cable	051-0001-000	1
Axle Generator Drive shaft	680-0001-000	1
Axle Generator Cable Support Bracket	665-0015-000	1
Axle Generator	908-0001-000	1

* = IF EQUIPPED

INPUT/OUTPUT SUMMARY

The *NFORCE* contains conditioning circuitry to interface to both digital (On/Off) and analog devices on the locomotive. All sensing, logic, communications, and control functions of the locomotive are interfaced to the *NFORCE* system via the cables/harnesses on the back of the *NFORCE*. The *NFORCE* hardware primarily consists of a series of printed circuit boards which perform the various tasks.

Each board that plugs into the *NFORCE* electronic control unit typically has a 9-pin connector for a proprietary system bus and two 41-pin connectors for the input/output (I/O).

DIGITAL SIGNAL PROCCESSING BOARD (DSP)

The Digital Signal Processing board contains the computer memory to process all input data and output data. The Statistics, Alarm, and Diagnostic Logs are all stored in on-board memory, with the alarms and statistics in non-volatile (battery-backed) memory for long-term storage.

This board also contains the serial ports and drivers for the *NFORCE* to communicate with the Operator Interface Panel and a laptop computer.

In addition, it contains the (16) 4-20mA inputs, (6) 4-20mA outputs, and (8) speed input channels.

Table 6-4 – DSP Board Inputs/Outputs

Ch	Hardware	Function
01	4-20mA Current Loop Input #1	DCH4 VOLTS
02	4-20mA Current Loop Input #2	DCH4 AMPS
03	4-20mA Current Loop Input #3	DCH3 VOLTS
04	4-20mA Current Loop Input #4	DCH3 AMPS
05	4-20mA Current Loop Input #5	DCH2 VOLTS
06	4-20mA Current Loop Input #6	DCH2 AMPS
07	4-20mA Current Loop Input #7	DCH1 VOLTS
08	4-20mA Current Loop Input #8	DCH1 AMPS
09	4-20mA Current Loop Input #9	BCPT
10	4-20mA Current Loop Input #10	BAT CHR AMPS
11	4-20mA Current Loop Input #11	DC BUS AMPS
12	4-20mA Current Loop Input #12	DC BUS VOLTS
13	4-20mA Current Loop Input #13	MRPT
14	4-20mA Current Loop Input #14	LVPS AMPS
15	4-20mA Current Loop Input #15	EQP BW AMPS

Ch	Hardware	Function
16	4-20mA Current Loop Input #16	AIR COMP AMPS
17	0-20mA Current loop Output #1	DCH1 CONTROL
18	0-20mA Current loop Output #2	DCH2 CONTROL
19	0-20mA Current loop Output #3	DCH3 CONTROL
20	0-20mA Current loop Output #4	DCH4 CONTROL
21	0-20mA Current loop Output #5	SPARE
22	0-20mA Current loop Output #6	SPARE
23	Speed Input #1	SPEED IN
24	Speed Input #2	SPARE
25	Speed Input #3	SPARE
26	Speed Input #4	SPARE
27	Speed Input #5	SPARE
28	Speed Input #6	SPARE
29	Speed Input #7	SPARE
30	Speed Input #8	SPARE

* = IF EQUIPPED

POWER SUPPLY BOARD (P/S)

The Power Supply board contains the circuits required to supply isolated filtered power for each of the boards in the *NFORCE* cabinet. It receives a 74V supply from the locomotive batteries and outputs a 12V signal to power all system boards.

In addition to the power supply function this board also contains an AC Voltage Analog Input, Load Meter Drive, (2) 100V Analog Inputs, (2) 100V Analog Outputs, VR Control, SE Control, and one Speed Output.

Table 6-5 – Power Supply Board

Ch	Hardware	Function
01	AC Voltage/Hz	AC BUS VOLTS
02	0-200mA Output	LOAD METER
03	100V Analog Input #1	BATTERY VOLTS
04	100V Analog Input #2	SPARE
05	100V Analog Input #3	SPARE
06	100V Analog Input #4	SPARE
07	100V Analog Output #1	SPARE
08	100V Analog Output #2	SPARE
09	Voltage Regulation	VR Control
10	SE Control	SCR Control
11	Speed Output	SPEED INDICATOR

INPUT/OUTPUT BOARD (I/O)

The *NFORCE* will have four Input/Output boards installed. All the Input/Output boards are physically the same. Each board has (2) 4-20mA Current Loop Inputs, and (12) digital outputs. Each digital output is capable of driving either 24 or 74 volts.

Table 6-6 Board Readings

Ch	Hardware	Board 3	Board 4	Board 5	Board 6
1	4-20mA Current Loop Input #1	24V AMPS	GENSET3 PH1 AMPS	GENSET3 PH3 AMPS	ATS
2	4-20mA Current Loop Input #2	GENSET1 PH3 AMPS	GENSET1 PH1 AMPS	GENSET2 PH1 AMPS	GENSET2 PH3 AMPS
3	Digital Outputs #1	P1	GENSET1 FAULT	SPARE	GENSET1 EE
4	Digital Outputs #2	P2	GENSET1 SERV	MCOR	GENSET1 VRO
5	Digital Outputs #3	P3	GENSET 3 SERV	GR RESET	GENSET1 ST
6	Digital Outputs #4	P4	GENSET 2 FAULT	CRL	GENSET11-3 SHT
7	Digital Outputs #5	SPARE	GENSET2 SERV	WLR	GENSET1-3 EMCP
8	Digital Outputs #6	RVF	GENSET3 FAULT	NSR	GENSET2 EE
9	Digital Outputs #7	MTR	AC1P	ABR	GENSET2 VRO

* = IF EQUIPPED

10	Digital Outputs #8	MCO4	AC2P	MFR	GENSET2 ST
11	Digital Outputs #9	MCO1	EBC	AUX PWR FAULT	LSC
12	Digital Outputs #10	MCO2	CC1	MVCC	GENSET 3 EE
13	Digital Outputs #11	MCO3	CC2	MV2SR	GENSET 3 VRO
14	Digital Outputs #12	BUZZERS	CC3	MV1SF	GENSET 3 ST

INPUT/OUTPUT BOARD (I/O) CONTINUED

The *NFORCE* will have four Input/Output boards installed. All the Input/Output boards are physically the same. Each board has (24) digital inputs. The digital inputs are capable of reading 20 volts.

Table 6-7 Board Readings

Ch	Hardware	Board 3	Board 4	Board 5	Board 6
15	Digital Inputs #1	P1	IS	AC RESET	CHCB
16	Digital Inputs #2	P2	MCO1	6T	DCH1 Failed
17	Digital Inputs #3	P3	MCO2	3T	DCH1 Fatal Fault
18	Digital Inputs #4	P4	MCO3	7T	DCH1 Aux Fault
19	Digital Inputs #5	RV1	MCO4	12T	DCH2 Aux Fault
20	Digital Inputs #6	RV2	GR	15T	DCH2 Failed
21	Digital Inputs #7	RV3	LSF	8T	DCH2 Fatal Fault
22	Digital Inputs #8	RV4	GRCO	9T	DCH3 FAILED
23	Digital Inputs #9	M CONTACTORS	EBC	16T	DCH3 FATAL FAULT
24	Digital Inputs #10	SPARE	CC1	LD TRK SND	DCH4 FAILED
25	Digital Inputs #11	FPCR	CC2	2T	DCH4 FATAL FAULT
26	Digital Inputs #12	LTS	CC3	10T	DCH Power
27	Digital Inputs #13	MCOS1	SPARE	13T	SPARE
28	Digital Inputs #14	MCOS2	SPARE	5T	SPARE
29	Digital Inputs #15	MCOS3	SPARE	NSR	SPARE
30	Digital Inputs #16	MCOS4	SPARE	23T	SPARE
31	Digital Inputs #17	ACC1	SPARE	PCR	SPARE
32	Digital Inputs #18	ACC2	SPARE	ENG START	SPARE
33	Digital Inputs #19	ACC3	SPARE	26T	SPARE
34	Digital Inputs #20	PA	SPARE	22T	SPARE
35	Digital Inputs #21	GENSET1 BRK	SPARE	SPARE	SPARE
36	Digital Inputs #22	GENSET2 BRK	SPARE	SPARE	SPARE
37	Digital Inputs #23	GENSET3 BRK	24V SUP	SPARE	SPARE
38	Digital Inputs #24	DC RECT TEMP	SPARE	SPARE	SPARE

* = IF EQUIPPED

DESCRIPTION

The genset is a self-contained diesel engine, generator assembly that is mounted on its own frame. This will allow for the interchanging of gensets for maintenance.

The genset produces DC voltage for the traction system and AC voltage for the locomotive auxiliary systems. The design intent of the locomotive is to start and run only those gensets required to move the train. For example, in low notches, only one genset will be started and run. As the throttle is increased and more power is required, the *NFORCE* will start and run the remaining gensets as necessary. This method of operation maximizes fuel economy and minimizes air pollution.

The genset contains the followings items:

- Diesel engine
- Generator
- Radiator and fan assembly
- Fresh oil supply tank and oil change system
- Fuel filter and pump assembly
- Air cleaners
- Engine block heater
- Circuit breaker panel
- DC rectifier

QSK19 ENGINE

Refer to Cummins Operation and Maintenance Manual for QSK19 Series Engine.

Fig. 7-1 – QSK19 Engine (Installed)

572RDL GENERATOR

MAINTENANCE

Dirt, heat, moisture, and vibration are common enemies of a generator. Keeping the generator clean and dry, maintaining proper alignment of the generator and its prime mover, and preventing overloads will result in efficient operation and long life.

Generators that are outdoors should be protected from the elements by suitable houses or enclosures.

Dirt and dust will conduct electricity between points of different electrical potential. Moisture will aggravate the problem further. Insulation system failure can result if corrective action is not taken. The condition of the insulation system can be tested by measuring insulation resistance.

Insulation resistance should be checked when putting the generator into service after it has been in storage and any time contamination by moisture and dirt is suspected. Normally, moisture buildup is not a problem when the generator is running since heat produced internally will tend to keep it dry. Moisture can collect in the generator when it is shut down. The problem will be worse in humid environments or in areas where extreme temperature changes cause condensation (dew) to form inside the generator. Space heaters, air filters, and premium insulation systems, such as our VPI process, should be considered in difficult environments.

Accumulations of dust and dirt not only contribute to insulation breakdown, but they can also increase temperature by restricting ventilation and by blocking the dissipation of heat. Some machines are exposed to accumulations of materials such as talc, lint, rock dust, or cement dust which may obstruct the ventilation. The most harmful type of foreign materials include carbon black, metallic dust and chips, and similar substances which not only impede the ventilation, but also form a

* = IF EQUIPPED

conductive film over the insulation, increasing the possibility of insulation failure. Machines operating in dirty places should be disassembled and cleaned periodically.

AIR INTAKE AND EXHAUST

Check the area around the air intake and exhaust openings to be sure they are clean and unobstructed. Remove all foreign material and clean all screens.

ELECTRICAL CONNECTIONS AND WINDINGS

Inspect for loose or contaminated connections. Check wires for cracked or frayed insulation. Tighten connections and replace defective or oil-soaked insulation.

If inspection shows that varnish coating on the windings have deteriorated, they should be recoated with insulating varnish. Please refer to NREC for insulation system requirements.

LUBRICATION

All generators are lubricated before leaving the factory and are ready for operation. No routine relubrication is required of the bearings.

During an overhaul, the bearings and grease should be replaced.

DRYING ELECTRICAL INSULATION

Electrical components must be dried before placing in operation if tests indicate that the insulation resistance is below a safe value (see GENERATOR TESTING for test procedure).

Machines that have been idle for sometime in unheated and damp locations may have absorbed moisture. Sudden changes in temperature can cause condensation or the generator may have become wet by accident. Windings should be dried out thoroughly before being put into service. The following are recommended drying methods.

SPACE HEATERS

Electric Space heaters can be installed inside of the generator. When energized (from a power source other than the generator), they will heat and dry the inside of the generator. If an alternate source of electricity is not available, enclose the generator with a covering and insert heating units to raise the temperature 15-18°F (8-10°C) above the temperature outside of the enclosure. Leave a hole at the top of the enclosure to permit the escape of moisture.

OVEN

Place the machine in an oven and bake it at a temperature not to exceed 194°F (90°C). The voltage regulator and any electronic component accessories must be removed from the generator when using this method.

FORCED AIR

A portable forced air heater can be used by directing heat into the air intake (conduit box) and running the generator with no load and without excitation (this can be accomplished by removing the regulator fuse). Heat at point of entry should not exceed 150°F (66°C).

"SHORT CIRCUIT" METHOD

The generator can be dried out quickly and thoroughly by using this method.

WARNING

Be sure that all of the following steps are performed and all precautions taken as personal injury or serious damage to the generator could result.

1. Disconnect exciter leads F1 and F2 from the regulator.

2. Connect a battery or other DC power source of approximately 20-35 volts to the exciter leads F1 and F2. An adjustable voltage source is desirable; however a rheostat (rated approximately 2 amps) in series with the DC power source will work.

3. Short circuit the generator output lead wires to each other (L1 to L2 to L3). If using jumpers, be sure they are large enough to carry full load amperage.

4. Start the generator and measure the current through the output leads with a clip-on ammeter.

5. Adjust the voltage source to produce approximately 80% of the rated AC nameplate amps, but in no case exceed nameplate amps. If an adjustable source is not available and current is excessive, use a lower DC source voltage or a larger resistor in series with the source.

   Running time will be determined by the amount of moisture present in the machine. Insulation resistance checks should be taken every one to four hours until a fairly constant value is obtained.

6. After the generator is dry and the insulation resistance is brought up to specifications, remove the short circuit from the line leads, disconnect the DC source, and reconnect the F1 and F2 leads at the regulator. Be sure all connections are tight and correct before attempting to run the generator.

CLEANING METHODS

When electrical components get dirty, the insulation must be cleaned. There are a number of acceptable methods for cleaning the generator, each of which will necessitate disassembly of the unit. The method of cleaning will be determined by the kind of dirt and when the unit must be returned to service. Drying after cleaning is necessary.

Whenever the generator is disassembled, the windings should be given a thorough inspection and the insulation cleaned, if necessary. The inspection should include the connection of the windings, insulation, and varnish coverage. Check the winding ties and coil supports. Look for any signs of coil movement or looseness and repair as required.

SOLVENTS

A solvent is usually required to remove accumulated soil containing oil or grease.

Only petroleum distillates should be used for cleaning electrical components.

Petroleum solvents of the safety type with a flash point greater than 100°F (38°C) are recommended.

WARNING

Winding varnishes are epoxy or polyester based. A solvent that does not attack these materials should be used.

WARNING

Adequate ventilation must be available to avoid fire, explosions, and health hazards where solvents are used. Avoid breathing solvent vapors. Rubber gloves or other suitable protection for the hands should be used. Wear eye protection.

Apply the solvent with a soft brush or rag. Be careful not to damage the magnet wire or insulation on the windings.

Dry components thoroughly with moisture-free, low pressure compressed air.

CLOTH & COMPRESSED AIR

Cleaning with a dry cloth may be satisfactory when components are small, the surfaces are accessible, and only dirt is removed.

Blowing dirt out with compressed air is usually effective particularly when the dirt has collected in places which cannot be reached with a cloth. Use clean dry air at 30 psi (206 kPa).

BRUSHING & VACUUM CLEANING

Dry dust and dirt may be removed by brushing with bristle brushes followed by vacuum cleaning. Do not use wire brushes. Vacuum cleaning is an effective and desirable method of removing dry and loose dirt.

SHELL BLASTING

Air blasting with ground nut shells may be satisfactory for removal of hard dirt deposits from insulation. Use mild abrasives such as 12-20 mesh ground walnut shells.

STEAM CLEANING

If the generator is completely disassembled, including bearings and electronic components, steam cleaning of the major parts and windings is very effective. However, before the generator can be put back into service, the machine must be thoroughly dried in an oven to remove all moisture.

AIR CLEANERS

The genset is equipped with two, canister style air cleaners. During periodic locomotive maintenance, inspect the air cleaner housing and filter element. Replace any dirty or defective filters.

AIRSEP CRANKCASE BREATHER

Fig. 7-5 – Airsep Crankcase Breather

The Airsep System only requires that the filter to be changed after every 750 hours of use.

HC025S19 RADIATOR

MAINTENANCE

The radiator is nearly maintenance free. Minor maintenance items should be performed to ensure the radiator operates at top performance and to avoid hazards.

CLEANING

Periodically inspect the radiator core for signs of damage, corrosion, and clogging. Straighten any fins that have become bent or have been flattened. If the radiator core appears to be clogged with debris, it should be cleaned using water and mild detergent that does not react with copper or aluminum. Clean the cores from the AIR DISCHARGE side of the radiator to avoid pushing the debris further into the core. Clean the outside of the radiator, if dirty, to aid in routine inspection of the cooling system. Take care to keep all sight glasses clean to ease system fluid inspection. Repair or replacement of the core should be performed by qualified service personnel. If any air filters are used upstream of the core, inspect and replace as needed. Periodically test coolant fluid samples to assure it is free of sediment, corrosive products, and/or biological contaminants. If automatic air vents are not used in the cooling system, periodic air venting should be performed to remove accumulated air. **CAUTION** should be exercised when venting the cooling system to avoid injury. High pressure and/or high temperature fluids can cause serious injury.

RADIATOR FAN MOTOR

The radiator fan motor is a 20 HP induction motor capable of running on 3-phase voltages and frequencies between 120VAC 30 Hz and 240VAC 60Hz.

Coolant Level Sensor

The radiator is equipped with a low coolant sensor. The sensor supplies a signal to the engine control module when the water level in the radiator is below operating levels.

Circuit Breaker Panel

The circuit breaker panel contains the genset

* = IF EQUIPPED

control system. On the bottom left side of the panel, there is a 36 pin connector that serves to connect the genset control system to the locomotive control system. The circuit breaker contains the items described in the following paragraphs.

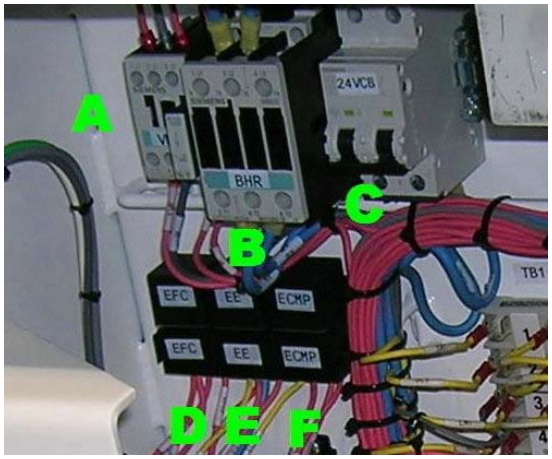


Fig. 7-3 – CB Box Components

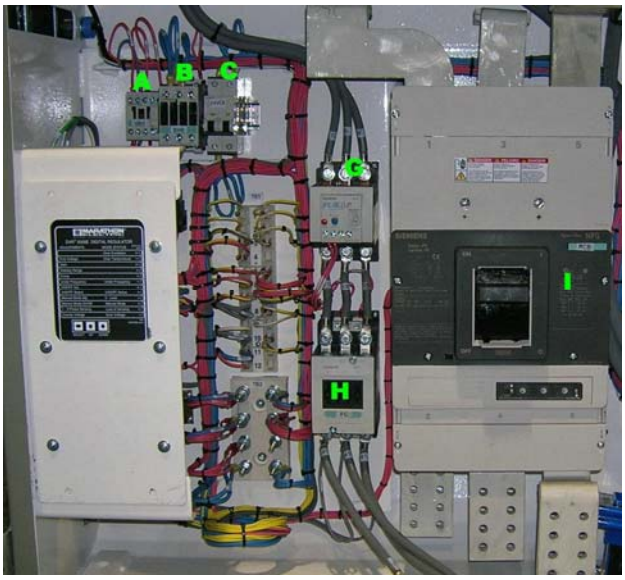


Fig. 7-4 – Circuit Breaker Box

A. Voltage Regulator On Relay
B. Block Heater Relay
C. 24Volt Circuit Breaker
D. Engine Fan Control Relay
E. Engine Enable Relay
F. Engine Control Module Power Relay
G. Fan Contactor Overload
H. Fan Contactor
I. Main Circuit Breaker

24CB; 24VDC CIRCUIT BREAKER

This 24VDC 32A breaker provides a means to turn off battery power to the genset control circuits. It also provides over current protection for the genset control system.

BHR; BLOCK HEATER RELAY

This relay is controlled by the ECMP and EE relays and is energized whenever the genset is not running. The BHR receives power from the block heater circuit breaker in the MEC and supplies power to the block heater from any other genset that is running.

BUZZER PANEL

This panel is controlled by the *NFORCE* and provides an audible warning that the genset is in idle limiting mode of operation or signaling the starting of an engine.

ECMP; ENGINE CONTROL MODULE POWER RELAY

This relay is controlled by the *NFORCE* and supplies 24VDC battery voltage to the genset engine control module.

EE; ENGINE ENABLE RELAY

This relay is controlled by the *NFORCE* and the FPCR relay. When the ECMP and EE relays are energized, the engine control module of the genset is powered, and will control the engine's operation.

EFC; ENGINE FAN CONTROL RELAY

This relay is controlled by the engine control module. When the engine water temperature reaches a specified temperature, the engine control module energizes the EFC relay to energize the FC contactor.

FC; FAN CONTACTOR

This contactor is controlled by the EFC relay

* = IF EQUIPPED

and connects genset 3-phase AC voltage to the radiator fan motor.

FCOL; FAN CONTACTOR OVERLOAD

The fan contactor overload monitors current being supplied to the radiator fan motor. It interrupts the control circuitry to the FC contactor if the fan motor is operating in an overload condition.

MCB; MAIN CIRCUIT BREAKER

This 1600A 3PH breaker, when opened, disconnects the generator from the DC rectifier and all auxiliary system loads. The breaker contains an electronic trip unit to provide over current protection for the generator and locomotive wiring. The breaker contains an electrical shunt trip coil that is controlled by the *NFORCE*. This coil allows the *NFORCE* to instantly interrupt generator output in response to overload situations.

SHT; SHUNT TRIP RELAY

This relay is operated by the *NFORCE* to energize the shunt trip coil and open the main circuit breaker.

VR; VOLTAGE REGULATOR

The voltage regulator is an electronic, solid-state, microprocessor based control device. It regulates the output voltage the generator by controlling the current into the generator exciter field. Input power to the voltage regulator is from the permanent magnet section of the generator.

Front panel indicators (LED's) annunciate regulator status and system conditions. A 9-pin DB-9 style connector on the rear panel provides communication between the voltage regulator and an IBM compatible PC.

The voltage regulator is programmed to provide an output voltage of the generator dependant on the speed of the engine. For example, at 1500 RPM the generator voltage will be approximately 167VAC and at 1800 RPM the generator voltage will be 240VAC.

VRO; VOLTAGE REGULATOR ON RELAY

This relay is controlled by the *NFORCE* to turn on the voltage regulator of the genset, when it is determined that an output voltage is required from the genset. In fault conditions, the *NFORCE* turns off the VRO to stop generator excitation.

GENSET ELECTRICAL DEVICES

BTHR; BLOCK HEATER

The block heater is mounted on the genset frame on the right side of the engine. The heater is thermostatically controlled to maintain the engine water temperature to 120°F to facilitate engine starting and reduce engine emissions when the engine is first started. When the block heater is energized, coolant is circulated through the engine block and back into the heater. The heater pressurizes the coolant, without the use of a mechanical pump, to provide the circulation into and out of the engine.

DC RECT; DC RECTIFIER

A rectifier is used to convert alternating current (AC) from the generator, to direct current (DC), for the chopper modules. The DC rectifier has two separate rectifiers and a over-temperature sensor.

The AC from the generators is separated into two circuits and rectified. The Dc outputs from each side or the rectifier are then connected in series to the other rectifiers of the adjacent gensets.

* = IF EQUIPPED

RECAN; J1939 CAN BUS RESISTOR

This resistor is mounted in the junction box on the left side of the engine. It is a 240 ohm 1 W resistor that is used to terminate the J1939 CAN BUS.

The J1939 CAN BUS is the communication's network connecting the *NFORCE* to the genset ECM. The data transmitted includes engine RPM and engine operating status.

ST; STARTING CONTACTOR

The starting contactor is located in a junction box mounted to the right of the circuit breaker box. This contactor is controlled by the *NFORCE*. When it is energized, it provides battery power to the starter solenoid to start the engine.

OIL CHANGE SYSTEM

DESCRIPTION

The genset contains a system that automatically replenishes engine oil. The oil change system is provided to extend service intervals of the engine. The components necessary for the oil change system are described in the following paragraphs.

Fresh Oil Supply Tank

The oil supply tank holds approximately 65 gallons of fresh oil. The purpose of the tank is to provide fresh oil supply to the engine when the oil level regulator determines that the engine oil is below a predetermined level.

Two sight glasses are mounted on the left side of the tank to monitor oil level in the tank.

OCM; OIL CHANGE MODULE

The oil change module allows a metered amount of pressurized engine oil to leave the engine and enter the oil retention tank located beneath the gensets on the underframe. The module contains an electronic timing system that routinely energizes an internal magnet valve that controls the flow of the engine oil. Two internal dials in the module are provided to adjust the amount of oil that exits the engine during each cycle.

Fig. 7-2 – Oil Change Module

OLR; OIL LEVEL REGULATOR

The oil level regulator is mounted on the left side of the engine. A clear sight glass on the regulator allows inspection of the oil and the float level. The regulator has an internal float operated valve that opens and allows oil to flow from the fresh oil supply tank into the sump of the engine. The valve opens whenever the engine sump oil level is lower than the float level in the regulator.

OLS; OIL LIMIT SWITCH

This switch is mounted in the left side of the fresh oil tank below the bottom sight glass. The switch has a float inside the fresh oil tank that monitors the oil level in the tank. When the switch detects a low oil level, the switch contacts open. This turns off the oil change module in order to prevent the module from exiting all the oil from the engine.

The oil limit switch is constructed in such a manner that the float portion can remain inside the fresh oil tank if the electrical portion of the switch needs replaced.

* = IF EQUIPPED

LUBE OIL RETENTION TANK

DESCRIPTION

Each locomotive is equipped with a 200 gallon used oil retention tank. The tank is located underneath genset 2 and is a self-contained system. Drain the used oil retention tank by means of the retention tank drain pipe assembly. First remove the plug from the end of the pipe assembly, attach the drain hose, if used, and then open the drain valve in the pipe assembly. Close the valve and replace the plug after draining the tank.

Each Genset contains a lube oil system.

* = IF EQUIPPED

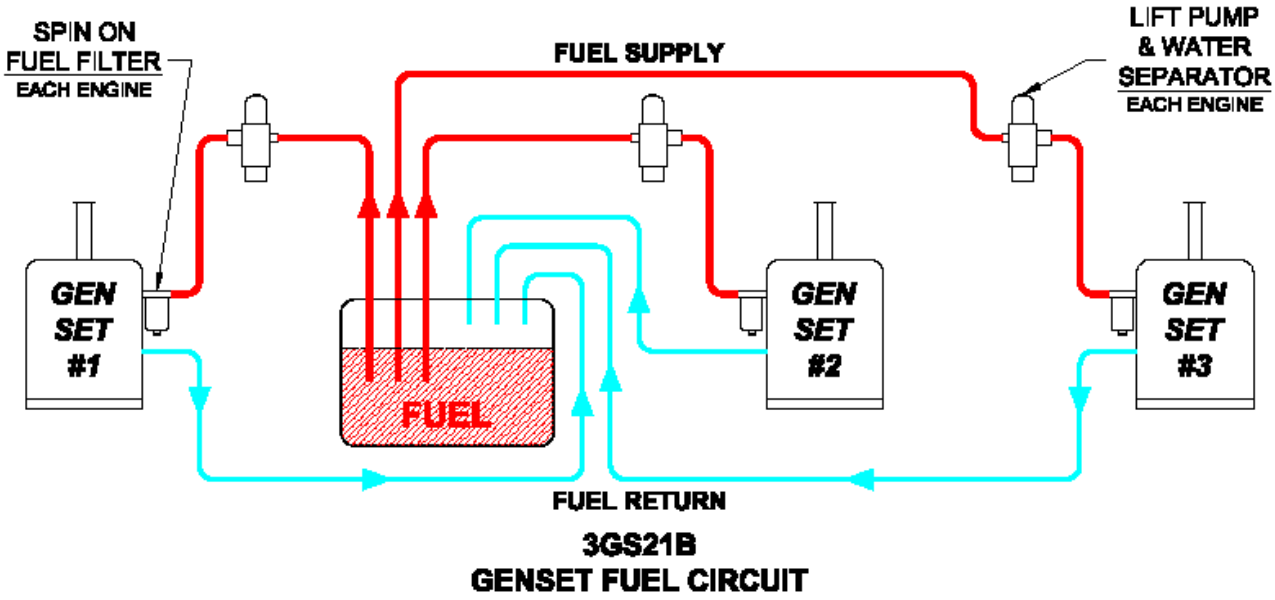


Fig. 7-6 Fuel Circuit

* = IF EQUIPPED

INTRODUCTION

This section contains procedures to load test and determine the horsepower of the locomotive. To properly test the operation of the locomotive electrical system, the field circuits of the traction motors are utilized during the load test procedure. Table is the horsepower schedule for the N-VIRO locomotive.

LOAD BOX

The load box shall have four grid resistors. Each resistor shall be 0.86 ohms. One or more of the grids can be tapped to operate a cooling motor to cool the load box. The total resistance of the grid and the motor must be 0.86 ohms.

CAUTION

The leads connecting the grids to the locomotive shall connect the grid directly to the locomotive. Under no circumstances are there to be any electrical connections between any of the four grids.

PRELIMINARY PREPARATION FOR LOAD TEST

1. Stop the genset engines and turn off the control, local control, electronic control and chopper control circuit breakers.

2. Check that the fuel tank contains sufficient fuel (minimum 500 gallons) for the period of the load test.

3. Inspect the genset engines for proper coolant and engine oil level. Service if required before starting the testing.

4. Connect a load box that contains four 0.86 ohm resistive grids and a cooling fan for the grids. One of the four grids may be a center tapped grid to operate the cooling fan.

5. Connect one grid cable to the load test positive (LTP) bus bar on the top of the M1 contactor and the other cable of the same grid to the load test negative (LTN) bus bar on terminal 3 of the RV1 reverser. Perform the same procedure to the number 2, 3, and 4 traction motor circuits. The cable used to connect the load box grids to the locomotive should be minimum of 1100/24 EXANE cable. See Figure

6. To provide ground relay protection, connect a cable from the load box frame to the locomotive underframe with a minimum of a 6AWG EXANE cable.

LOAD TEST PROCEDURE FOR ALL 3 GENSETS

1. Set the Hand Brake on the locomotive.

2. Turn on the control, local control, electronic control and chopper control circuit breakers.

3. Connect a laptop computer utilizing HyperTerminal software to connect to the *NFORCE*.

4. Select the FS6 screen.

5. Place the LOAD TEST switch on the engine control panel to the TEST position.

6. Start a genset by pressing the start switch on the control stand.

7. Place the Isolation Switch in the RUN position. The LOAD TEST light should illuminate.

8. Place reverser handle in center position.

9. Turn the generator field switch on.

10. Place the power throttle in notch 1 position. The engine will start loading.

11. Inspect the load box to ensure the cooling fan is operational.

12. On the FS6 screen, the *NFORCE* will display the brake horsepower being produced.

13. Advance the throttle one step at a time. The *NFORCE* will start the secondary and tertiary engines as the throttle is increased.

14. It is recommended that the total time in load test be limited to one hour. When the throttle is in notch 3, the primary engine is operating at rated horsepower. At notch 8, all engines are operating at rated horsepower.

*= IF EQUIPPED

15. At the conclusion of the test, shut the engines down. Open the control, local control, electronic control and chopper control circuit breakers. Disconnect the load box.

LOAD TEST PROCEDURE FOR 1 GENSET

1. Set the Hand Brake on the locomotive.

2. Turn on the control, local control, electronic control and chopper control circuit breakers.

3. Connect a laptop computer utilizing HyperTerminal software to connect to the *NFORCE.*

4. Select the FS6 screen.

5. Place the LOAD TEST switch on the engine control panel to the TEST position.

6. Simultaneously press the engine start and the air conditioning reset switches. The *NFORCE* will indicate which engine can be started by a series of beeps. One beep indicates genset 1, two beeps indicates genset 2, three beeps indicates genset 3. When the desired number of beeps is heard, release the air conditioner reset switch and continue to hold the engine start switch for 3 seconds. The *NFORCE* will then start the indicated engine.

7. Place the Isolation Switch in the RUN position. The LOAD TEST light should illuminate.

8. Place reverser handle in center position.

9. Turn the generator field switch on.

10. Place the power throttle in notch 1 position. The engine will start loading.

11. Inspect the load box to ensure the cooling fan is operational.

12. On the FS6 screen, the *NFORCE* will display the brake horsepower being produced.

13. Advance the throttle one step at a time. The *NFORCE* will start the secondary and tertiary engines as the throttle is increased.

14. It is recommended that the total time in load test be limited to one hour. When the throttle is in notch 3, the engine is operating at rated horsepower.

NOTE

If the throttle is advanced higher than notch 3, the *NFORCE* will start the secondary engine.

15. At the conclusion of the test, shut the engine down. Open the control, local control, electronic control and chopper control circuit breakers.

WARNING

Wait at least 20 minutes for the choppers to discharge completely before beginning to disconnect the load box.

16. Disconnect the load box.

Table 9-1– N-VIRO Throttle Schedule

Throttle Notch	Eng 1 BHP	Eng 1 THP	Eng 1 RPM	Eng 2 BHP	Eng 2 THP	Eng 2 RPM	Eng 3 BHP	Eng 3 THP	Eng 3 RPM	Loco BHP	Loco THP
Idle	67	0	1200							67	0
1	228	145	1500							228	145
2	388	305	1500							388	305
3	685	585	1800							685	585
4	547	447	1800	390	373	1500				937	820
5	661	561	1800	485	469	1500				1146	1030
6	594	494	1800	514	494	1800	429	412	1500	1537	1400
7	667	567	1800	587	567	1800	587	567	1800	1841	1701
8	697	597	1800	686	664	2000	686	664	2000	2069	1925

*= IF EQUIPPED

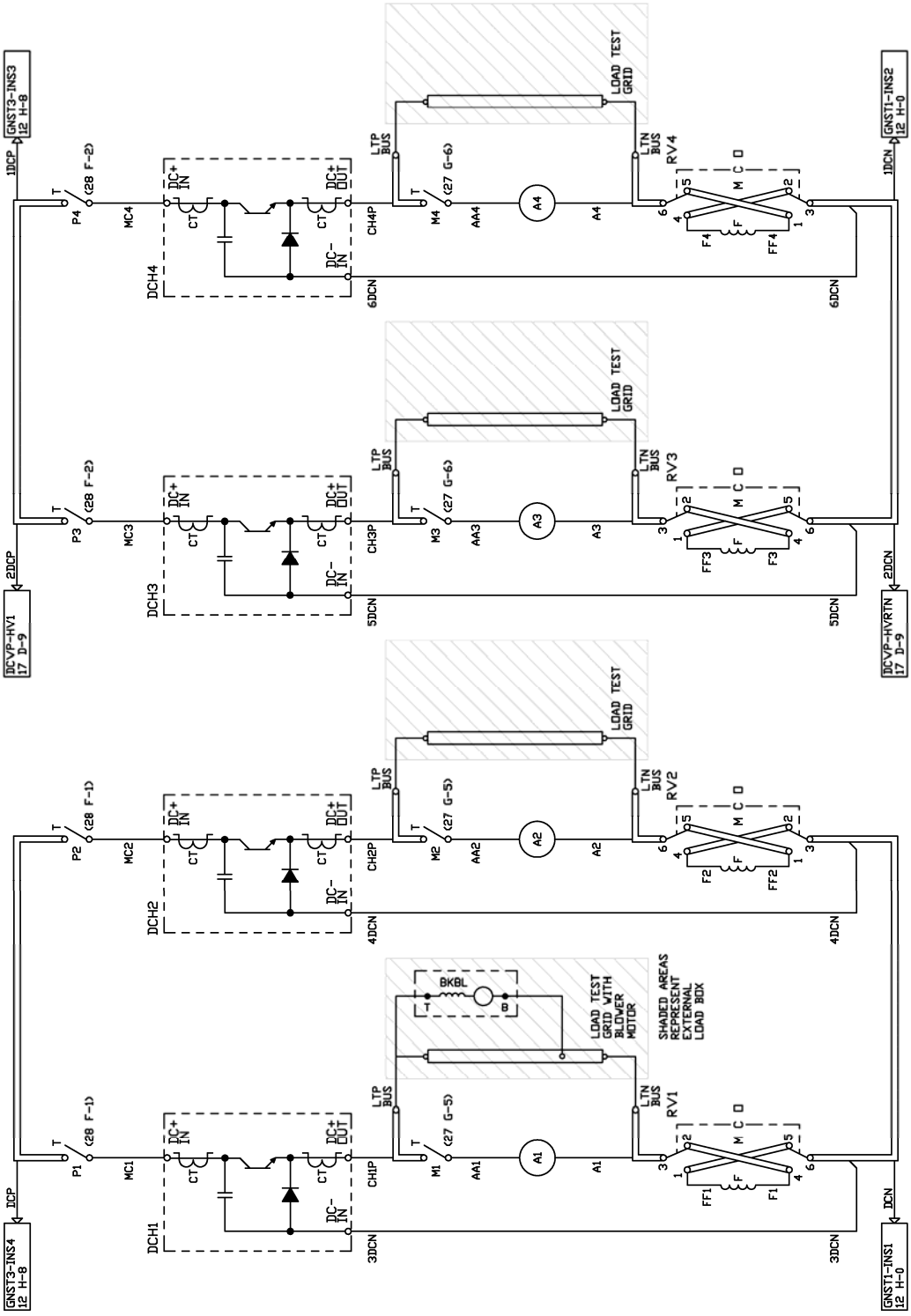


Figure 9-1– Load Test Grid Connection

*= IF EQUIPPED

INTRODUCTION

The High Voltage System of the 3GS21B locomotive contains the three genset generators, the three genset rectifier assemblies, the four DC choppers, the four traction motors, the equipment blower motor, the air compressor and the LVPS. The best method of performing high potential testing is to test each segment of the system.

GENSET, DC CHOPPERS, TRACTION MOTORS & AUXILIARY BUS

1. Shut the genset engine(s) down.
2. Open the 64 VDC battery switch.
3. Open the 24 VDC battery switch.
4. Connect a jumper wire(s) between Genset 1 terminals INS1, INS2, INS3 and INS4. Perform the same procedure on Genset 2 and Genset 3.
5. Connect a jumper wire(s) Genset 1 MCB terminals 1, 3 and 5 to Genset insulator INS1.
6. Close the MCB on Genset 1. Perform the same procedure on Genset 2 and Genset 3.
7. Connect a jumper wire to between the top and bottom (main contacts) of P1. Perform the same procedure to P2, P3, P4, M1, M2, M3 and M4.
8. Connect a jumper(s) between the DCH1, DC+, DC+ IN and DC-IN terminals. Perform the same procedure to DCH2, DCH3 and DCH4.
9. Remove the control cable from the DCH1 chopper. Perform the same procedure to DCH2, DCH3 and DCH4.
10. Connect a jumper(s) between the LVPS L1, L2 and L3 terminals.
11. Close the Block Heater circuit breaker.
12. All traction motor reversers are to be “CUT IN”.
13. Connect a 500 VDC meggohmmeter positive lead to the AC2P relay 3C terminal; connect the meggohmmeter negative terminal to ground. A reading of one megohm or more indicates satisfactory insulation resistance.
14. Connect a 1,000 VDC meggohmmeter positive lead to the AC2P relay 3C terminal; connect the meggohmmeter negative terminal to ground. A reading of one megohm or more indicates satisfactory insulation resistance.
15. Reading less than one megohm should be investigated and the locomotive not returned to service until insulation resistance is above one megohm.
16. Remove all jumper wires applied to perform the test.

AIR COMPRESSOR MOTOR

1. Shut the genset engine(s) down.
2. Open the 64 VDC battery switch.
3. Open the 24 VDC battery switch.
4. Connect a jumper wires between CC3 contactor 1, 2, 3, 4, 5, and 6 terminals.
5. Connect a 1,000 VDC meggohmmeter positive lead to the CC3 contactor terminal 6; connect the meggohmmeter negative terminal to ground. A reading of one megohm or more indicates satisfactory insulation resistance.
6. Remove all jumper wires applied to perform the test.

EQUIPMENT BLOWER MOTOR

1. Shut the genset engine(s) down.
2. Open the 64 VDC battery switch.
3. Open the 24 VDC battery switch.
4. Connect a jumper wires between EBC contactor 2, 4, and 6 terminals.

*=IF EQUIPPED

5. Connect a 1,000 VDC meggohmmeter positive lead to the EBC contactor number terminal 6; connect the meggohmmeter negative terminal to ground. A reading of one megohm or more indicates satisfactory insulation resistance.

6. Remove all jumper wires applied to perform the test.

LOW VOLTAGE POWER SUPPLY

1. Shut the genset engine(s) down.

2. Open the 64 VDC battery switch.

3. Open the 24 VDC battery switch.

4. Connect a jumper wires between LVPS L1, L2 and L3 terminals.

5. Connect a 1,000 VDC meggohmmeter positive lead to the LVPS L1 terminal; connect the meggohmmeter negative terminal to ground. A reading of one megohm or more indicates satisfactory insulation resistance.

6. Remove all jumper wires applied to perform the test.

AUXILIARY & BLOCK HEATER CIRCUITS

1. Shut the genset engine(s) down.

2. Open the 64 VDC battery switch.

3. Open the 24 VDC battery switch.

4. Turn on the block heater circuit breaker.

5. Connect a jumper wires between EBC contactor 1, 3, and 5 terminals.

6. Connect a 1,000 VDC meggohmmeter positive lead to the EBC contactor number terminal 5; connect the meggohmmeter negative terminal to ground. A reading of one megohm or more indicates satisfactory insulation resistance.

7. Remove all jumper wires applied to perform the test.

GENSET RADIATOR FAN

NOTE

This procedure can be used on Genset 1, 2 or 3*.

1. Shut the genset engine(s) down.

2. Open the 64 VDC battery switch.

3. Open the 24 VDC battery switch.

4. Connect a jumper wires between FC contactor 1, 3, and 5 terminals.

5. Connect a 1,000 VDC meggohmmeter positive lead to the FC contactor number terminal 5; connect the meggohmmeter negative terminal to ground. A reading of one megohm or more indicates satisfactory insulation resistance.

6. Remove all jumper wires applied to perform the test.

GENSET BLOCK HEATER

NOTE

This procedure can be used on Genset 1, 2 or 3*.

1. Shut the genset engine(s) down.

2. Open the 64 VDC battery switch.

3. Open the 24 VDC battery switch.

4. Connect a jumper wire between terminal board TB2L4 and TB2R4 terminals.

5. Connect a 1,000 VDC meggohmmeter positive lead to the TB2L4 terminal; connect the meggohmmeter negative terminal to ground. A reading of one megohm or more indicates satisfactory insulation resistance.

6. Remove all jumper wires applied to perform the test.

*=IF EQUIPPED

GROUND RELAY TEST PROCEDURE

Follow the steps listed below to test the ground relay:

1. Shut engines down and wait for at least 20 minutes for all components to discharge all energy.
2. Once the time has passed, connect a jumper wire from the DCVP HVP terminal to a chassis ground.
3. Start the engine and look for the ground indication.
4. The ground relay should trip within 10 seconds of the EBV Contactor closing.
5. When this occurs, shut the engine down and wait for at least 20 minutes before removing the jumper wire.

TROUBLESHOOTING A GROUND RELAY FAULT

The key to troubleshooting a GR fault is determining at what point in the locomotive process the fault occurred.

If the GR trips as soon as the engine is started, complete the following steps:

1. Shut down the locomotive.
2. Complete a visual inspection of the MEC, traction motors, and traction motor leads.
3. If all looks to be in good condition, cut out the #1 traction motor. Start the engine and check to see if the GR fault reoccurs.
4. If the GR fault reappears, repeat steps 1 and 3 with the #2 traction motor while keeping #1 cut out.
5. If the GR fault persists, repeat these steps with the #3 traction motor.
6. If the GR fault persists, repeat these steps with the #4 traction motor.

If the GR trips as the A/C contactors close:

1. Shut down the locomotive.
2. Wait for at least 20 minutes for the components to discharge the remaining energy.
3. Disconnect the output leads to the equipment blower.
4. Restart engines to see if the GR fault remains.
5. Shut down the engine and wait for at least 20 minutes before reinstalling the output leads.

WHEELSLIP TEST PROCEDURE

In order to test the wheel slip function complete the following steps:

1. Shut down the engines.
2. Wait at least 20 minutes for the components to shed stored energy.
3. Remove the Arc Shoot from the M1 contactor.
4. Insert a small piece of paper between the main contactor tips for insulation.
5. Reapply the Arc Shoot.
6. Restart the engine.
7. Load with the reverser in FORWARD.
8. The wheel slip indicator light should light within 45-60 seconds.
9. Shut down engines and wait at least 20 minutes again.
10. Remove the Arc Shoot and the paper from between the contactor tips.
11. Reinstall the Arc Shoot.

N-FORCE ALARMS & MESSAGES

INTRODUCTION

Purpose

The purpose of this document is to describe the requirements for the N-Viromotive N-FORCE System.

Interface and Control Requirements

The N-FORCE uses various software routines for monitoring and controlling the locomotive. These software routines, alarms, and messages are described in the following pages.

Alarm Bell Control

The alarm circuit alerts the operator to abnormal conditions or protective device activity. The alarm bell can be activated be either closing the Attended Call button or when the N-FORCE energizes the ABR relay.

Events that will activate the alarm bell are as follows:

GROUND RELAY DETECTION

The alarm bell rings when the N-FORCE detects that the Ground Relay is active. The alarm bell will continue to ring until the Ground Relay is reset.

AIR COMPRESSOR FAULT

The alarm bell rings 2 seconds on then off repeatedly when the N-FORCE detects an Air Compressor alarm.

TM BLOWER FAILED

The alarm bell rings for 5 seconds when the N-FORCE detects a TM BLOWER FAILED alarm.

OPEN TRACTION MOTOR & PINION SLIP FAULTS

The alarm bell rings when the N-FORCE detects either an open traction motor or pinion slip alarm. The alarm bell will continue to ring until this alarm is cleared.

SERVICE ENGINE SOON

Th**is** alarm sounds for 5 seconds when the N-FORCE detects a fault.

GEN SET FAULT

If the N-FORCE senses that an engine ECM has activated an engine fault indication, the N-FORCE will ring the alarm bell for five seconds.

GEN SET START FAILURE

If the N-FORCE senses that the engine ECM has activated the GEN SET “NO ST” indicator the N-FORCE will ring the alarm bell for five seconds.

LVPS FAULT or LVPS OVERTEMP

If the LVPS Fault indicator is on the N-FORCE will set a LVPS FAULT alarm, and ring the alarm bell for 5 seconds.

DC RECTIFIER FAULT

If the DC Rectifier Fault indicator is on the N-FORCE will ring the alarm bell for 5 seconds.

*=IF EQUIPPED

EXCITATION FAULT

If the N-FORCE determines that it can not control any of the Traction Motor Current Choppers it will ring the alarm bell for five seconds.

24 VOLT SUPPLY FAULT

The alarm bell will ring continuously until the Isolate switch is placed in the isolate position when this alarm is active.

BATTERY VOLTS FAILED

If the N-FORCE monitors a BATTERY VOLTS FAILED alarm the alarm bell will ring for 5 seconds.

CHOPPER # FAULT

If the NFORCE detects a faulted chopper (represented here by #) the alarm bell will ring for 5 seconds (see Traction Motor Current Chopper Control).

ALARM NOT THIS LOCO

If another locomotive in the consist activates the Attendant Call and Alarm MU line (2T), this alarm is set

MU LINE FAILED 2T

When the N-FORCE energizes ABR relay to drive a MU 2T line it checks to ensure the MU line becomes active. This alarm is set if the MU line fails to become active.

DC RECTIFIER OVERTEMP

If the DC Rectifier over temperature signal from the rectifier is off, the N-FORCE will set a DC RECTIFIER OVERTEMP alarm, ring the alarm bell for 5 seconds, shut down the engines, and turn on the AUX PWR Fault indicator.

CONTACTOR FAILED RV1
CONTACTOR FAILED RV2
CONTACTOR FAILED RV3
CONTACTOR FAILED RV4

If a contactor fails to pick up or drop out, a CONTACTOR FAILED RVF‘*’ alarm is set, where ‘*’ is the contactor that failed. The N-FORCE senses the auxiliary contacts on these contactors. When the N-FORCE energizes or releases the coil through the RVF relay, it checks for the correct feedback from the auxiliary contacts on the reverser contactors. If the correct feedback is not received, one of these alarms is set.

MU 8T AND 9T HIGH

This alarm is set if the MU lines command both Forward (8T) and Reverse (9T) at the same time. The traction motor chopper control is disabled if this occurs. Loading is prevented until only one of these lines is high.

RELAY FAILED RVR

If a contactor fails to pick up or drop out, a CONTACTOR FAILED RVF‘*’ alarm is set, where ‘*’ is the contactor that failed. The NFORCE senses the auxiliary contacts on these contactors. When the *NFORCE* energizes or releases the coil through the RVF relay, it checks for the correct feedback from the auxiliary contacts on the reverser contactors. If the correct feedback is not received, one of these alarms is set.

LOW AC BUS VOLTAGE

If AC bus voltage is less than 100 VAC while the engines are operating for 30 seconds, and the N-FORCE has not nullified AC excitation the N-FORCE will set this alarm.

EXCESSIVE PHASE I GS

If the average phase current for any operational Genset (1,2 or 3*) exceeds 1750A for 2 seconds continuously or 1950A for 200 milliseconds the

*=IF EQUIPPED

NFORCE will set this alarm and shut down the offending Genset.

PHASE I IMBALANCE GS

If the phase currents for any operational Genset (1,2 or 3*) differ from one another by more than 250A for at least one second continuously the NFORCE will set this alarm and shut down the offending Genset.

EXCESSIVE PHASE I GS1

If the average phase current of the gen set exceeds 1750A for 2 seconds continuously or 1950A for 200 milliseconds the *NFORCE* will set this alarm and shut down the gen set.

GR RESET

This alarm is set if the N-FORCE senses the GR Reset switch is closed. Activating the GR Reset reverts the fault counters back to two.

GR TRIPPED

When the N-FORCE senses a Ground Relay picked up a GR TRIPPED alarm is set. When this alarm is set the N-FORCE will set the traction motor current chopper control to zero, nullify AC generator excitation, idle the engines, and ring the alarm bell.

NO LOADING GR CUT OUT

If the N-FORCE senses the Ground Relay Cutout switch is open, this alarm is set and prevents loading. Throttle is limited to the IDLE position.

NO POWER DUE TO GR

If the GR fault counter reaches three with no more than one hour between ground faults, the N-FORCE will lock out the automatic ground relay reset and sets this alarm. The traction motor chopper control is disabled preventing loading. In order to regain normal operation use the GR RESET switch.

ENG UNEXPECTED SHUTDOWN

This alarm is set if the engine has been shut down for a reason that the N-FORCE is unable to determine. This will occur when the GEN SET READY output drops while the FPCR and N-FORCE Start/Run outputs are high. This alarm will clear once the engine has successfully started

.

ENG STOP BY CONTROL STAND

This alarm is set if an engine shutdown has been requested from the throttle handle on the control stand. This is detected by observing that the 3T MU line is high while the 15T, 12T, and 7T

MU lines remain low for a period of at least 1 second. This alarm clears once the throttle control handle is moved back to Idle, and the FPCR has been dropped by pressing the EFCO button.

TRANSDUCER FAILED CTD

When the N-FORCE detects the signal from CTD is less than 4mA a TRANSDUCER FAILED CTD alarm is set.

AMBIENT AIR TEMP FAIL

When the N-FORCE detects the signal from the temperature sensor is less than 4mA an AMBIENT AIR TEMP FAIL alarm is set.

BC PRESSURE SENSOR FAIL

When the N-FORCE detects the signal from the pressure sensor is less than 4mA a MR PRESSURE SENSOR FAILED alarm is set.

CONTACTOR FAILED LSC

If the LSC contactor fails to pick up or drop out, a CONTACTOR FAILED LSC alarm is set. The N-FORCE senses the auxiliary contacts on these contactors. When the N-FORCE energizes or releases the coil, it checks for the

*=IF EQUIPPED

correct feedback from the auxiliary contacts. If the correct feedback is not received, this alarm is set.

NO 24 VOLTS

If the digital input used to monitor the 24 volt supply from the LVPS is low, engine starting will be disabled and this alarm will be set.

BATTERY VOLTAGE TOO LOW

If the *NFORCE* monitors the battery voltage below 50 volts a BATTERY VOLTAGE TOO LOW alarm is set. Any operating Genset will be shutdown and engine starting will be inhibited. This alarm is cleared when the battery voltage is above 55 volts.

BATTERY NO CHARGE

If the N-FORCE monitors the battery voltage below 69 volts while the engines are running for 15 seconds a BATTERY NO CHARGE alarm is set. The N-FORCE will turn on the AUX PWR Fault indicator. This alarm is cleared when the battery voltage is above 70 volts.

LVPS FAULT

If the N-FORCE monitor the LVPS current load monitored by current transducer CTC above 40 amps, and/or battery voltage below 65 volts while the engines are running a LVPS FAULT alarm is set. The N-FORCE will ring the alarm bell for 5 seconds and turn on the AUX PWR Fault indicator. This alarm is cleared when the current drops below the current limit amps and/or the battery voltage is above 70 volts.

TRANSDUCER FAILED CTC

When the N-FORCE detects the signal from CTC is less than 4mA a TRANSDUCER FAILED CTC alarm is set.

AIR COMPRESSOR FAULT

If the current monitored by CTA rises above 200 amps the N-FORCE will drop CC1/CC2/CC3, and pick up MV-CC. The N-FORCE will then try to reactivate the air compressor as described above up to two additional times. If the current is still above 200 amps on the third attempt the N-FORCE will drop the CC1/CC2/CC3 contactors, set an AIR COMPRESSOR FAULT alarm, ring the alarm bell for 2 seconds on and off, disable the traction motor choppers, and flashes the AUX PWR Fault indicator. This alarm can only be cleared by shutting down the engines. This will also be set if a compressor contactor faults (CC1, CC2, and CC3). This fault is also set during COMPRESSOR MOTOR OVERLOAD and COMPRESSOR MOTOR UNDERLOAD conditions.

CONTACTOR FAILED CC1
CONTACTOR FAILED CC2
CONTACTOR FAILED CC3

If a contactor fails to pick up or drop out, a CONTACTOR FAILED CC‘*’ alarm is set, where ‘*’ is the contactor that failed to pick up or drop out. The N-FORCE senses the auxiliary contacts on these contactors. When the N-FORCE energizes or releases the coil, it checks for the correct feedback from the auxiliary contacts. If the
correct feedback is not received; one of these alarms is set and can only be cleared by shutting down the engine. This alarm also sets the AIR COMPRESSOR FAULT alarm.

MR PRESSURE SENSOR FAIL

When the N-FORCE detects the signal from a pressure sensor is less than 4mA a MR PRESSURE SENSOR FAILED alarm is set.

MU LINE FAILED 22T (CRL)

When the N-FORCE energizes the CRL relay to drive the 22T MU line it checks to ensure the MU line becomes active. This alarm is set if the

MU line status does not match the status of the CRL relay.

COMPRESSOR MOTOR OVERLOAD

When the *NFORCE* detects air compressor motor load current on CTA in excess of 65 A for 10 seconds continuously this fault is set. If the NFORCE detects CTA current in excess of 120A for 500 ms continuously this fault is set. Once this fault is set the air compressor is disabled and removed from the auxiliary bus. If excessive current persists once the compressor is disabled engines will be shutdown. Note that once this fault is latched it will not be cleared until the next manual engine start attempt.

COMPRESSOR MOTOR UNDERLOAD

When the *NFORCE* detects air compressor motor load current on CTA less than 15 A for 10 seconds continuously this fault is set. Once this fault is set the air compressor is disabled and removed from the auxiliary bus. Note that once this fault is latched it will not be cleared until the next manual engine start attempt.

TRANSDUCER FAILED CTA

When CC1, CC2, and CC3 are dropped and there is no AC power supplied to the air compressor motor the N-FORCE checks for near zero current on current transducer CTA. If CTA indicates more than 10 amps or less than -5 amps, a TRANSDUCER FAILED CTA alarm is set.

RELAY FAILED MTR

If the MTR Relay fails to pick up or drop out, a RELAY FAILED MTR alarm is set The N-FORCE senses the auxiliary contacts on this relay. When the N-FORCE energizes or releases the coil, it checks for the correct feedback from the auxiliary contacts. If the correct feedback is not received, this alarm is set.

CONTACTOR FAILED P1
CONTACTOR FAILED P2
CONTACTOR FAILED M1
CONTACTOR FAILED M2

If a contactor fails to pick up or drop out, a CONTACTOR FAILED P‘*’ alarm is set, where ‘*’ is the contactor that failed to pick up or drop out. The N-FORCE senses the auxiliary contacts on these contactors. When the N-FORCE energizes or releases the coil, it checks for the correct feedback from the auxiliary contacts. If the correct feedback is not received, one of these alarms is set.

RELAY FAILED NSR

If the No Speed Relay fails to pick up or drop out, a RELAY FAILED NSR alarm is set. The N-FORCE senses the auxiliary contacts on this relay. When the N-FORCE energizes or releases the coil, it checks for the correct feedback from the auxiliary contacts. If the correct feedback is not received, this alarm is set.

AMB AIR TEMP FAILED

When the N-FORCE detects the temperature sensor signal is less than 4mA an AIR TEMP FAILED alarm is set. If this sensor fails the N-FORCE sets ambient air temperature to 110°F.

CHOPPER 1 ACT FAILED
CHOPPER 2 ACT FAILED
CHOPPER 3 ACT FAILED*
CHOPPER 4 ACT FAILED*

When the choppers are shut down and there is no DC power supplied to the Traction Motors the N-FORCE checks for near zero current on current signals supplied by the chopper. If signal indicates more than 10 amps or less than -5 amps, a CHOPPER ‘*’ ACT FAILED alarm is set, where ‘*’ is the chopper that has failed. The Motor Fault Indicator is also turned on.

CHOPPER 1 FAULT
CHOPPER 2 FAULT
CHOPPER 3 FAULT*
CHOPPER 4 FAULT*

If a Traction Motor Chopper turns on its' "Fatal Fault" indicator the N-FORCE will set a CHOPPER '*' FAULT, where '*' is the chopper that failed. When this alarm is set the N-FORCE will ring the alarm bell for 5 seconds. The Motor Fault Indicator is also turned on.

CHOPPER 1 FAILED
CHOPPER 2 FAILED
CHOPPER 3 FAILED*
CHOPPER 4 FAILED*

If a Traction Motor Chopper turns on its' "Failed" indicator the N-FORCE will set a CHOPPER '*' FAILED, where '*' is the chopper that failed. While this alarm is active the N-FORCE will disable the failed chopper. When this alarm is set the N-FORCE will ring the alarm bell for 5 seconds. The Motor Fault Indicator is also turned on.

CHOPPER 1 VOLTS FAILED
CHOPPER 2 VOLTS FAILED
CHOPPER 2 VOLTS FAILED*
CHOPPER 4 VOLTS FAILED*

When the choppers are shut down and there is no DC power supplied to the Traction Motors, the N-FORCE checks for near zero voltage on voltage signals supplied by the chopper. If signal
indicates more than 10 volts or less than -5 volts, a CHOPPER '*' VOLTS FAILED alarm is set, where '*' is the chopper that failed. The Motor Fault Indicator is also turned on.

CHOPPER 1 NOT RESPONDING
CHOPPER 2 NOT RESPONDING
CHOPPER 3 NOT RESPONDING*
CHOPPER 4 NOT RESPONDING*

When the N-FORCE has applied a 5% control duty cycle or greater to a chopper and the output excitation is monitored to be less than 25 amps after 5 seconds a CHOPPER'*' NOT RESPONDING fault is set, where '*' is the chopper that has failed.

SOLENOID FAILED MCO1
SOLENOID FAILED MCO2
SOLENOID FAILED MCO3*
SOLENOID FAILED MCO4*

When the N-FORCE energizes a solenoid, it checks for the correct feedback from the coil sense inputs. If the correct feedback is not received a SOLENOID FAILED MCO'*' alarm is set, where '*' is the solenoid that failed.

TM 1 CUT OUT
TM 2 CUT OUT
TM 3 CUT OUT*
TM 4 CUT OUT*

The N-FORCE determines traction motor cutout status based on the status from the Cutout switches and motor cutout solenoids. If a traction motor is cutout, a TM '*' CUT OUT alarm is set, where '*' is the specific traction motor that is cutout. The Motor Fault Indicator is also turned on.

CHOPPER DISABLED OPEN TM1
CHOPPER DISABLED OPEN TM2
CHOPPER DISABLED OPEN TM3*
CHOPPER DISABLED OPEN TM4*

If an open traction motor alarm occurs three times on the same traction motor within five minutes the Traction Motor Current Chopper associated with that traction motor will be disabled and a CHOPPER DISABLED OPEN TM'*' alarm will be set, where '*' is the specific traction motor that failed. This alarm can be reset by placing the Isolate switch in the isolate position.

CONTACTOR FAILED EBC

If the EBC contactor fails to pick up or drop out, a CONTACTOR FAILED EBC alarm is

*=IF EQUIPPED

set. The N-FORCE senses the auxiliary contacts on these contactors. When the N-FORCE energizes or releases the coil, it checks for the correct feedback from the auxiliary contacts. If the correct feedback is not received, one of these alarms is set. This alarm also sets TM BLOWER FAILED alarm.

TM BLOWER OVERLOAD

If the *NFORCE* monitors the TM Blower Motor loading current is operating above expected levels with respect to primary engine RPM this alarm will be set after 10 consecutive seconds. If the current exceeds 165A for 200 ms the alarm will be set before the 10 second timer expires. This alarm sets the TM BLOWER FAILED alarm. This fault is latched until the next engine start attempt is made. The following list shows the overload current levels with respect to primary engine rpm:

- 65A @ 1200 RPM
- 100A @ 1500 RPM
- 140A @ 1800 RPM

TM BLOWER UNDERLOAD

If the *NFORCE* monitors the TM Blower Motor loading current is operating below expected levels with respect to primary engine RPM this alarm will be set after 10 consecutive seconds. This alarm sets the TM BLOWER FAILED alarm. This fault is latched until the next engine start attempt is made. The following list shows the underload current levels with respect to primary engine rpm:

- 15A @ 1200 RPM
- 45A @ 1500 RPM
- 63A @ 1800 RPM

TM BLOWER FAILED

When this alarm is set the *NFORCE* will ring the alarm bell for 5 seconds, and turn on the AUX PWR Fault indicator light and drop the EBC contactor to disconnect the blower motor from the auxiliary bus. This alarm can be reset by shutting down the engines. This alarm is also set when CONTACTOR FAILED EBC is set. Once this alarm is set and the EBC contactor is dropped the system checks that blower motor load current has fallen below acceptable levels. If the current has not dropped below 165A within 1 second of the EBC contactor opening all engines are shutdown.

TRANSDUCER FAILED CTB

When EBC is dropped and there is no AC power supplied to the Traction Motor Blower motor the N-FORCE checks for near zero current on current transducer CTB. If CTB indicates more than 10 amps or less than -5 amps, a TRANSDUCER FAILED CTB alarm is set.

ENGINE SHUT DOWN BY FPCR

This message is set if the N-FORCE senses that the FPCR goes low while the engines are running.

ENGINE RUN SWITCH DOWN

The ENG RUN switch (ER) is down. The engine will not be allowed above Idle and will not load.

GEN FLD SWITCH DOWN

This message is set when the N-FORCE senses that the throttle has been moved from the idle position causing some of the governor solenoids to pickup while the 6T MU remains low.

LOCAL BREAKER OFF

This message indicates that the Local Control Breaker is Off.

NO CONTROL AND FUEL PUMP

The N-FORCE senses that the Positive Control and Fuel Pump on the 13T string are not energized. When this occurs, the train lined control functions won't operate and the engine won't load. After a short delay, the engine shuts down because the fuel pump is Off.

PCS

The Pneumatic Control Relay (PCR) has dropped out. If it is the lead locomotive, the feed to the throttle handle switches is dropped out. This prevents the throttle MU lines (6T, 3T, 7T, 12T, 15T) from picking up, effectively preventing loading on all locomotives in the consist. This occurs after an emergency brake application. The N-FORCE only displays the status of the PCR; loading is prevented by loss of GF (through open PCR interlocks).

NO LOAD GR CUT OUT

If the N-FORCE senses the Ground Relay Cutout switch is open, this alarm is set and prevents loading. Throttle is limited to the Idle position.

GEN SET #1 FAULT
GEN SET #2 FAULT*
GEN SET #3 FAULT*

If the engine ECM turns on the "FAULT" output the N-FORCE will set a GEN SET'*' FAULT, where '*' is the GEN SET that failed. While this alarm is active the N-FORCE will not allow the failed GEN SET to start. When this alarm is set, the N-FORCE will ring the alarm bell for 5 seconds.

GEN SET #1 SERVICE ENGINE
GEN SET #2 SERVICE ENGINE*
GEN SET #3 SERVICE ENGINE*

If the engine ECM turns on the "WARN" output the N-FORCE will set a GEN SET'*' SERV ENG, where '*' is the GEN SET that requires service.

GEN SET #1 START FAILURE
GEN SET #2 START FAILURE*
GEN SET #3 START FAILURE*

If the engine ECM turns on the "NO ST" output, the N-FORCE will set a GEN SET'*' START FAILURE, where '*' is the GEN SET that failed to start. While this alarm is active the N-FORCE will not allow the failed GEN SET to start. When this alarm is set the N-FORCE will ring the alarm bell for 5 seconds.

CONTACTOR FAILED ACC1
CONTACTOR FAILED ACC2*
CONTACTOR FAILED ACC3*

If a contactor fails to pick up or drop out, a CONTACTOR FAILED ACC'*' alarm is set, where '*' is the contactor that failed to pick up or drop out. The N-FORCE senses the auxiliary contacts on these contactors. When the N-FORCE energizes or releases the coil, it checks for the correct feedback from the auxiliary contacts. If the correct feedback is not received, one of these alarms is set.

MU LINE FAILED 10T

When the N-FORCE energizes a relay to drive a MU line it checks to ensure the MU line becomes active. This alarm is displayed if the MU line fails to become active. The fault could be with the N-FORCE ECM, on the driver board, the wiring to the relay coil, the relay coil, the wiring from the MU line, or the Digital I/O board.

WHEEL SLIP

If there is an active wheel slip for more than 1 second this alarm is set. The N-FORCE picks up the WS relay, which drives the Wheel Slip Alarm MU line (10T).

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WHEEL SLIP NOT THIS LOCO

Another locomotive in the consist activated the Wheel Slip Alarm MU line (10T).

GEN SET #1 START FAILURE
GEN SET #2 START FAILURE*
GEN SET #3 START FAILURE*

If the engine ECM turns on the "NO ST" output, the N-FORCE will set a GEN SET'*' START FAILURE, where '*' is the GEN SET that failed to start. While this alarm is active the N-FORCE will not allow the failed GEN SET to start. When this alarm is set the N-FORCE will ring the alarm bell for 5 seconds.

CONTACTOR FAILED ACC1
CONTACTOR FAILED ACC2*
CONTACTOR FAILED ACC3*

If a contactor fails to pick up or drop out, a CONTACTOR FAILED ACC'*' alarm is set, where '*' is the contactor that failed to pick up or drop out. The N-FORCE senses the auxiliary contacts on these contactors. When the N-FORCE energizes or releases
the coil, it checks for the correct feedback from the auxiliary contacts. If the correct feedback is not received, one of these alarms is set.

GEN SET #1 MAINTENANCE
GEN SET #2 MAINTENANCE*
GEN SET #3 MAINTENANCE*

If the engine ECM turns on the "MAINT" output the N-FORCE will set a GEN SET'*' MAINTENANCE, where '*' is the GEN SET that requires maintenance.

GEN SET #1 SERVICE ENGINE
GEN SET #2 SERVICE ENGINE*
GEN SET #3 SERVICE ENGINE*

If the engine ECM turns on the "WARN" output the N-FORCE will set a GEN SET'*' SERV ENG, where '*' is the GEN SET that requires service.

IDLE LIMITING CONTROL

The N-FORCE reduces fuel consumption and exhaust emissions by monitoring locomotive operating parameters and automatically shutting down and restarting the engines during locomotive idle times.

Before the N-FORCE will shut down the engines, the engines must idle for at least 15 minutes, regardless of any other system condition. After this idling period has elapsed, the following parameters must be met before the engines will be shut down:

1. Battery charging current is less than 25 amps.
2. Battery voltage is greater than 69V.
3. Ambient Air temperature is greater than 10ºF.
4. Reverser handle is centered (no direction).
5. BC Pressure above 22psi

When all of these conditions are met, the following shutdown sequence occurs:

The locomotive Warning Buzzers sound for one second on, and one second off for 30 seconds, warning the operator that the engines are about to shutdown. If any of the shut down parameters becomes invalid during this 30-second period, the engine shutdown is aborted. After the engines have shut down, the Warning Buzzers sound intermittently at 30-second intervals to indicate the locomotive is in Idle Limiting mode.
One of the engines will restart when any ONE of the following conditions exists:

1. Battery voltage is less than 60V.
2. Ambient Air temperature is less than 0ºF.
3. Reverser handle is in Forward or Reverse.
4. BC Pressure below 18.5psi
5. The Engine Start button has been closed.

If one or more of the engine restart requirements exist, the Warning Buzzers will ring for 30 seconds (one second on/one second off), and then begin standard engine startup

*=IF EQUIPPED

sequence. During the startup sequence the Warning Buzzers will sound continuously. Following the engine restart, loading is disabled for 60 seconds to allow the locomotive to stabilize before continuing with normal operations.

The N-FORCE will also load shed the air conditioning during Idle Limiting if the locomotive remains at idle and no direction has been set for 60 minutes. If this is the case the N-FORCE will drop the LSC contactor shutting down the air conditioning. The operator can reactivate the air conditioning by pressing the AC Reset Button.

DIAGNOSTIC MODE

In order to enter the Diagnostic Mode, the Engine Start and the Ground Relay Pushbuttons must be held for 5 seconds. The operators Interface Panel will indicate that the Diagnostic Mode has been entered.

NOTE

Upon entering the Diagnostic Mode the lift pumps will run for 30 seconds.

On the top left side of each circuit breaker box mounted on the Gensets is a LED panel that will display any fault codes. The genset fault codes are as follows:

GENSET FAULT CODES

115

Engine speed/position circuit lost both of two signals from the magnetic pickup sensor causing the engine to be shutdown and unable to run.

122

Intake Manifold Pressure Sensor Circuit- voltage is below normal or shorted to the high source causing engine power derate to no air setting.

123

Intake Manifold Pressure Sensor Circuit- voltage is below normal or shorted to the low source causing engine power derate to no air setting.

124

Intake Manifold Pressure High- Data is valid but above the normal operational range. Moderately severe level.

No action is taken by the ECM.

135

Oil Pressure Sensor Circuit- Voltage is above normal or shorted to a low source.

No action is taken by the ECM.

141

Oil Pressure Sensor Circuit- Voltage is below normal or shorted to a low source.

No action is taken by the ECM.

143

Oil Pressure Low- Data valid but below the normal operational range. Moderately severe level causing the calibration dependent power derate and the engine shutdown with increasing time after alert.

144

Coolant Temperature Sensor Circuit- Voltage is above normal or shorted to a high source causing white smoke (possibly). The fan will remain on if controlled by the ECM and there will be no protection for the engine coolant temperature.

145

Coolant Temperature Sensor Circuit- Voltage is below normal or shorted to a low source causing white smoke (possibly). The fan will remain on if controlled by the ECM and there will be no protection for the engine coolant temperature.

146

Coolant Temperature High- Data valid but is above normal operational range. Moderately severe level causing progressive power derate increasing in severity from the time of the alert.

151

Coolant Temperature High- Data valid but is above normal operational range. Most severe level causing calibration dependent progressive power derate and engine shutdown with the increasing time after alert.

153

Intake Manifold Air Temperature Sensor Circuit- Voltage above normal or shorted to a high source causing white smoke (possibly). The fan will remain on if controlled by the ECM and there will be no protection for the engine coolant temperature.

154

Intake Manifold Air Temperature Sensor Circuit- Voltage below normal or shorted to a low source causing white smoke (possibly). The fan will remain on if controlled by the ECM and there will be no protection for the engine coolant temperature.

155

Intake Manifold Air Temperature High- Data valid but above normal operational range. Most severe level causing calibration dependent progressive power derate and engine shutdown with the increasing time after alert.

187

Sensor Supply 2 Circuit- Voltage below normal or shorted to a low source causing the loss of some sensor functionality.

195

Coolant Level Sensor Circuit- Voltage above normal or shorted to a high source.

No action is taken by the ECM.

196

Coolant Level Sensor Circuit- Voltage below normal or shorted to a low source.

No action is taken by the ECM.

197

Coolant Level Low- Data valid but below the normal operational range. Moderately severe level.

No action is taken by the ECM.

221

Barometric Pressure Sensor Circuit- Voltage above normal or shorted to a high source causing calibration specific power derate.

222

Barometric Pressure Sensor Circuit- Voltage below normal or shorted to a low source causing calibration specific power derate.

223

Engine Oil Burn Valve Solenoid Driver Circuit- Voltage below normal or shorted to a low source causing the ECM to turn off the burn valve supply voltage and Centinel system to be disabled.

224

Engine Oil Burn Valve Solenoid Driver Circuit- Voltage above normal or shorted to a high source causing the ECM to turn off the burn valve supply voltage and Centinel system to be disabled.

227

Sensor Supply 2 Circuit- Voltage above normal or shorted to a high source causing a loss of some sensor functionality.

234

Engine Speed High- Data valid but below normal operational range. Most severe level causing the fuel injection to be disabled until the engine speed falls below the overspeed limit.

235

Coolant Level Low- Data valid but below normal operational range. Most severe level causing calibration dependent progressive power and speed derate and engine shutdown with the increasing time after the alert.

237

External Speed Input (Multiple Unit Synchronization)- Data is erratic, intermittent, or incorrect causing the primary and secondary engines to shutdown with the increasing time after the alert if hard coupled. ONLY the secondary engine shuts down if it is soft coupled.

238

Sensor Supply 3 Circuit- Voltage is below normal or shorted to a low source causing the loss of some sensor functionality.

239

Sensor Supply 3 Circuit- Voltage is above normal or shorted to a high source causing the loss of some sensor functionality.

245

Fan Control Circuit- Voltage is below normal or shorted to a low source.

No action is taken by the ECM.

261

Engine Fuel Temperature High- Data valid but above the normal operational range. Moderately severe level causing the engine speed to derate.

263

Engine Fuel Temperature Sensor Circuit- Voltage is above normal or shorted to a high source.

No action is taken by the ECM.

265

Engine Fuel Temperature Sensor Circuit- Voltage is below normal or shorted to a low source.

No action is taken by the ECM.

266

Engine Fuel Temperature High- Data valid but above normal operational range. Most severe level causing the engine to shut down.

271

High Fuel Pressure Solenoid Valve Circuit- Voltage is below normal or shorted to a low source causing the engine to run poorly at idle, have less power, and have a higher fuel pressure than commanded.

272

High Fuel Pressure Solenoid Valve Circuit- Voltage is above normal or shorted to a high source causing to run poorly if at all.

285

SAE J1939 Multiplexing PGN Timeout Error- Abnormal update rate causing one or more multiplexed devices to not operate properly. One or more symptoms will occur.

286

SAE J1939 Multiplexing Configuration Error- Out of calibration causing at least one multiplexed device to not operate properly.

287

SAE J1939 Multiplexed Accelerator Pedal or Lever Position Sensor System- Received network data in error causing the engine to only idle or not accelerate to full speed.

288

SAE J1939 Multiplexing Remote Accelerator Pedal or Lever Position Sensor System- Received network data in error stopping the engine from responding to the remote throttle, although the cab or primary throttle can be utilized.

296

Auxiliary Pressure Sensor Input 1- Special instructions. OEM and calibration dependent progressive power and speed derate with engine shutdown as time progresses after alert.

319

Real Time Clock Power Interrupt- Data is erratic, intermittent, or incorrect causing the time and date to be incorrect in the ECM.

322

Injector Solenoid Cylinder 1 Circuit- The current is below normal or has an open circuit causing the engine to run rough and/or misfire.

323

Injector Solenoid Cylinder 5 Circuit- The current is below normal or has an open circuit causing the engine to run rough and/or misfire.

324

Injector Solenoid Cylinder 3 Circuit- The current is below normal or has an open circuit causing the engine to run rough and/or misfire.

325

Injector Solenoid Cylinder 6 Circuit- The current is below normal or has an open circuit causing the engine to run rough and/or misfire.

331

Injector Solenoid Cylinder 2 Circuit- The current is below normal or has an open circuit causing the engine to run rough and/or misfire.

332

Injector Solenoid Cylinder 4 Circuit- The current is below normal or has an open circuit causing the engine to run rough and/or misfire.

343

Engine Control Module Warning Internal Hardware Failure- Bad intelligent device or component causing either severe derate or possibly no loss of performance.

351

Injector Power Supply- Bad intelligent device or component causing possible smoke, low power, engine misfire, and/or engine starting difficulties.

352

Sensor Supply 1 Circuit- Voltage below normal or shorted low source causing loss of some sensor functionality.

386

Sensor Supply 1 Circuit- Voltage above normal or shorted high source causing loss of some sensor functionality.

415

Oil Pressure Low- Data valid but below the normal operational range. Most severe level causing calibration dependent progressive power and speed derate with engine shutdown as time from the alert increases.

418

Water in Fuel Indicator- Data valid but below the normal operational range. Most severe level causing white smoke (possible).

426

SAE J1939 Datalink can not Transmit- Data is erratic, intermittent, or incorrect.

No action is taken by the ECM.

431

Accelerator Pedal or Lever Idle Validation Circuit- The data is erratic, intermittent, or incorrect.

No action is taken by the ECM.

432

Accelerator Pedal or Lever Idle Validation Circuit- Out of calibration causing the engine to run at idle only and not respond to the accelerator pedal.

435

Engine Oil Rifle Pressure- The data is erratic, intermittent, or incorrect causing no protection for the engine oil pressure.

441

Battery 1 Voltage Low- Data is valid but below the normal operational range. Moderately severe level causing the ECM voltage supply to approach level at which unpredictable operation will occur.

442

Battery 1 Voltage High- Data is valid but above the normal operational range. Moderately severe level causing possible damage to all electrical components.

449

Fuel Pressure High- Data valid but above the normal operational range. Moderately severe level that can cause engine noise associated with higher injection pressures (especially at idle or light load situations). Engine power will be reduced.

451

Injector Metering Rail 1 Pressure Sensor Circuit- Voltage above normal or shorted to a high source causing a power and/or speed derate.

452

Injector Metering Rail 1 Pressure Sensor Circuit- Voltage below normal or shorted to a low source causing a power and/or speed derate.

487

Start Enable Device 1 Canister Empty (Ether Injection)- Data valid but below normal operational range. Moderately severe level causing the ether system to be disabled.

488

Intake Manifold Air Temperature High- Data is valid but above normal operational range. Moderately severe level causing a calibration specific derate.

489

Transmission Output Shaft (Tailshaft) Speed Low- Data is valid but below normal operational range. Moderately severe level causing the ECM to change speed to a calibration dependent set point.

497

Multiple Unit Synchronization Switch Circuit- The data is erratic, intermittent, or incorrect causing the multiple unit synchronization feature to be disabled.

523

Auxiliary Intermediate (PTO) Speed Switch Validation- The data is erratic, intermittent, or incorrect causing the loss of the PTO functionality.

527

Auxiliary Input/Output 2 Circuit- Voltage is above normal or shorted to a high source.

No action is taken by the ECM.

529

Auxiliary Input/Output 3 Circuit- Voltage is above normal or shorted to a high source.

No action is taken by the ECM.

546

Fuel Delivery Pressure Sensor Circuit- Voltage is above normal or shorted to a high source.

No action is taken by the ECM.

547

Fuel Delivery Pressure Sensor Circuit- Voltage is below normal or shorted to a low source.

No action is taken by the ECM.

551

Accelerator Pedal or Lever Idle Validation Circuit- Voltage is below normal or shorted to a low source.

No action is taken by the ECM

554

Injector Metering Rail 1 Pressure- Data is erratic, intermittent, or incorrect causing the possibility of low power and erratic performance.

559

Injector Metering Rail 1 Pressure Sensor Circuit- Data valid but below normal operational range. Moderately severe level causing a possibility of engine noise associated with higher injection pressures (especially at idle or light load situations).

599

Auxiliary Commanded Dual Output Shutdown- Special Instructions. Causes engine shutdown.

611

Engine Hot Shutdown- Condition exists.
No action taken by the ECM, but possible loss of power and/or damage to the engine can occur.

689

Primary Engine Speed Sensor Error- The data is erratic, intermittent, or incorrect causing the engine to run rough or not start. Engine runs using backup speed sensor and the power is reduced.

731

Engine Speed/Position 2 Mechanical Misalignment between Camshaft and Crankshaft Sensors- Mechanical system is not responding properly or out of adjustment causing the engine to run derated. Can cause engine to produce black smoke, run rough at idle, and start with difficulty.

1117

Power Supply Lost with Ignition On- The data is erratic, intermittent, or incorrect can cause the engine to die or start with difficulty. The fault code table, trip information data, and maintenance monitor data can be inaccurate.

1357

Engine Oil Level Remote Reservoir- Data valid but below the normal operational range. Moderately severe level causing possible damage to the engine if left unresolved.

No action is taken by the ECM.

1358

Accelerator Pedal or Lever Position Sensor Circuit- Voltage is above normal or shorted to a high source causing a calibration dependent power and speed derate.

1359

Accelerator Pedal or Lever Position Sensor Circuit- Voltage is below normal or shorted to a low source causing a calibration dependent power and speed derate.

1361

Remote Accelerator Pedal or Lever Position Sensor Circuit- Voltage is below normal or shorted to a low source causing a calibration dependent power and speed derate.

1363

Intake Manifold Pressure Low- Data is valid but below normal operational range. Moderately severe level causing an engine power derate.

1369

Auxiliary Temperature Sensor Input 1 Circuit- Voltage is above normal or shorted to a high source causing no engine protection for OEM temperature.

1371

Auxiliary Pressure Sensor Input 1 Circuit- Voltage is above normal or shorted to a high source causing no engine protection for OEM pressure.

1372

Auxiliary Pressure Sensor Input 1 Circuit- Voltage is below normal or shorted to a low source causing no engine protection for OEM pressure.

1373

Start Assist Device Control Circuit Error (Ether Injection)- Root cause NOT known. Ether injection feature is disabled with a possibility of white smoke and hard starting in colder temperatures.

1374

Turbo charger 1 Speed Sensor Circuit- Voltage is above normal or shorted to a high source.

No action is taken by the ECM.

1375

Turbo charger 1 Speed Sensor Circuit- Voltage is below normal or shorted to a low source.

No action is taken by the ECM.

1376

Engine Speed Sensor (Camshaft) Error- The data is erratic, intermittent, or incorrect.

No action is taken by the ECM.

1381

Auxiliary Temperature Sensor Input 1- Special instructions. It causes a calibration dependent progressive power and speed derate with engine shutdown as the time increases from the alert.

1383

Intake Manifold 1 Pressure Sensor Circuit- Voltage above normal or shorted to a high source causing an engine power derate to no air setting.

1384

Intake Manifold 1 Pressure Sensor Circuit- Voltage below normal or shorted to a low source causing an engine power derate to no air setting.

1387

Engine Shutdown Commanded by J1939- Condition exists.
No action is taken by the ECM.

1514

Accelerator Pedal or Lever Position Sensor 1 Circuit Frequency- Above normal frequency, pulse width, or period. The engine operates at idle.

1516

Engine Crankshaft Speed/Position- Data is valid but above the normal operational range.

Least severe level causing the fuel injection to be disabled until the engine speed drops below the overspeed limit.

1595

Remote Accelerator Pedal or Lever Position Sensor Circuit- Voltage above normal or shorted to a high source causing a calibration dependent power and speed derate.

1596

Auxiliary Temperature Sensor Input 1- Voltage is below normal or shorted to a low source causing no engine protection for OEM temperature.

1597

Engine Control Module Critical Internal Failure- Bad intelligent device or component resulting in the failure of the engine to start.

1845

Water in Fuel Indicator Sensor Circuit- Voltage is above normal or shorted to a high source causing no inhibition to performance.

1846

Water in Fuel Indicator Sensor Circuit- Voltage is below normal or shorted to a low source causing no inhibition to performance.

1891

Engine Oil Change Interval- Condition exists. Causes a maintenance reminder only with no inhibition on performance.

1911

Injector Metering Rail 1 Pressure- Data is valid but above the normal operational range. Most severe level causing an engine power derate.

2185

Sensor Supply 4 Circuit- Voltage is above normal or shorted to a high source causing a loss of sensor functionality.

2186

Sensor Supply 4 Circuit- Voltage is below normal or shorted to a low source causing a loss of sensor functionality.

2215

Fuel Pump Delivery Pressure- Data is valid but below normal operational range. Moderately severe level causing the engine to start with difficulty, loss of power, and possibly smoke.

2261

Fuel Pump Delivery Pressure- Data is valid but above normal operational range. Least severe level causing the engine to start with difficulty, loss of power, and possibly smoke.

2262

Fuel Pump Delivery Pressure- Data is valid but above normal operational range. Least severe level causing the engine to start with difficulty, loss of power, and possibly smoke.

2265

Fuel Priming Pump Control Signal Circuit- Voltage is above normal or shorted to a high source causing the engine to start with difficulty.

2266

Fuel Priming Pump Control Signal Circuit- Voltage is below normal or shorted to a low source causing the engine to start with difficulty.

2311

Fueling Actuator 1 Circuit Error- Condition exists. Can cause loss of power.

2321

Engine Speed/Position Sensor 1- Data is erratic, intermittent, or incorrect causing the engine to exhibit misfire as the control switches from primary to backup speed sensor. While on the back up speed sensor, the power will be less than before.

2322

Engine Speed/Position Sensor 2- Data is erratic, intermittent, or incorrect causing a possibility of power loss.

2377

Fan Control Circuit- Voltage is above normal or shorted to a high source causing the fan to run continuously or not at all.

2557

Auxiliary PWM Driver 1 Circuit- Voltage is above normal or shorted to a high source causing lack of transmission control.

2558

Auxiliary PWM Driver 1 Circuit- Voltage is below normal or shorted to a low source causing lack of transmission control.

2963

Engine Coolant Temperature- Data valid but is above the normal operational range. Least severe level causing progressive power derate increasing in severity from the time of alert.

2964

Intake Manifold 1 Temperature- Data is valid but above the normal operational range. Least severe level causing a progressive power derate increasing in severity from the time of alert.

2973

Intake Manifold 1 Temperature- Data is erratic, intermittent, or incorrect causing an engine power derate to no air setting.

INTRODUCTION

This document provides average recommendations which should ensure satisfactory locomotive operation and economical maintenance cost where average load factors and average climatic conditions are encountered. It is intended to serve as a guide when establishing maintenance schedules that will meet the particular requirements of the individual operations, and planned life of the locomotive.

These recommendations are based on the following conditions:

1. Lubricating oil used will meet the specifications of Maintenance Instructions 1764 and will be changed at the intervals specified in this M.I.

2. Lubricating oil filters will be of a quality equal to original equipment and will be changed at the intervals specified in this M.I.

3. Procedures listed in M.I. 1705 or 1707 will be followed for new locomotives and newly installed replacement assemblies.

4. Traction motors and truck maintenance will coincide with standard EMD MI's such as: 3912-A, 3900, 3902, etc. for the traction motors and 1520 and 1504 for truck frames.

This Maintenance Instruction describes a program of locomotive maintenance to be performed on a "calendar period" basis or an "hourly usage" basis, whichever occurs first. The following charts illustrate these requirements by distinguishing which components are monitored on a "calendar period" or "hourly usage" basis.

	119001004 RESISTOR, CORROSION FILTER	119001008 INHIBITOR, CORROSION	169003001 WATER TEST KIT	119001003 FILTER, FUEL	119001002 FILTER, FUEL / WATER SEPARATOR	164001013 PRIMARY ELEMENT, AIR INTAKE	164001014 SAFETY ELEMENT, AIR INTAKE	119001001 FILTER, LUBRICATING OIL	169003002 OIL SAMPLE KIT(REQUIRED EVERY 375 HRS)	ENGINE OIL CHANGE 15w40	119001006 ELEMENT, BREATHER	171002001 FILTER KIT, AIR COMPRESSOR	171003000 A/C OIL CHANGE ROTO H OIL (5 GAL DRUMS)	140002008 BRUSH, GROUNDING	162001002 CAP FILLER 2" 15 PSI	171002000 AIR COMPRESSOR VALVES KITS	162009000 COOLANT CHANGE	171002002 KIT, COUPLING AIR COMPRESSOR	117001001 INJECTORS	171002003 KIT, GEARBOX OVERHAUL AIR COMPRESSOR
750 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										
1500 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										
2250 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
3000 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										
3750 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										
4500 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				
5250 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										
6000 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓			
6750 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		
7500 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										
8250 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										
9000 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				
9750 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										
10500 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										
11250 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					

Fig. 11-1 Hourly Maintenance Requirements

*=IF EQUIPPED

	119001004 RESISTOR, CORROSION FILTER	119001008 INHIBITOR, CORROSION	169003001 WATER TEST KIT	119001003 FILTER, FUEL	119001002 FILTER, FUEL / WATER SEPARATOR	164001013 PRIMARY ELEMENT, AIR INTAKE	164001014 SAFETY ELEMENT, AIR INTAKE	119001001 FILTER, LUBRICATING OIL	169003002 OIL SAMPLE KIT(REQUIRED EVERY 375 HRS)	ENGINE OIL CHANGE 15w40	119001006 ELEMENT, BREATHER	171002001 FILTER KIT, AIR COMPRESSOR	171003000 A/C OIL CHANGE ROTO H OIL (5 GAL DRUMS)	140002008 BRUSH, GROUNDING	162001002 CAP FILLER 2" 15 PSI	171002000 AIR COMPRESSOR VALVES KITS	162009000 COOLANT CHANGE	171002002 KIT, COUPLING AIR COMPRESSOR	117001001 INJECTORS	171002003 KIT, GEARBOX OVERHAUL AIR COMPRESSOR
12000 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓			
12750 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										
13500 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓
14250 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										
15000 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓									✓	
15750 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
16500 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										
17250 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										
18000 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
18750 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										
19500 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										
20250 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓		
21000 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										
21750 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										
22500 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				

Fig. 11-1 Hourly Maintenance Requirements (continued)

*=IF EQUIPPED

	119001004 RESISTOR, CORROSION FILTER	119001008 INHIBITOR, CORROSION	169003001 WATER TEST KIT	119001003 FILTER, FUEL	119001002 FILTER, FUEL / WATER SEPARATOR	164001013 PRIMARY ELEMENT, AIR INTAKE	164001014 SAFETY ELEMENT, AIR INTAKE	119001001 FILTER, LUBRICATING OIL	169003002 OIL SAMPLE KIT(REQUIRED EVERY 375 HRS)	ENGINE OIL CHANGE 15w40	119001006 ELEMENT, BREATHER	171002001 FILTER KIT, AIR COMPRESSOR	171003000 A/C OIL CHANGE ROTO H OIL (5 GAL DRUMS)	140002008 BRUSH, GROUNDING	162001002 CAP FILLER 2" 15 PSI	171002000 AIR COMPRESSOR VALVES KITS	162009000 COOLANT CHANGE	171002002 KIT, COUPLING AIR COMPRESSOR	117001001 INJECTORS	171002003 KIT, GEARBOX OVERHAUL AIR COMPRESSOR
23250 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓									
24000 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓		
24750 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				
25500 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓									
26250 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓									
27000 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
27750 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓									
28500 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓									
29250 HOURS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				
30000 HOURS	OVERHAUL ENGINE																		

Fig. 11-1 Hourly Maintenance Requirements (continued)

*=IF EQUIPPED

PART NUMBER	PART FAMILY	PART	EVERY 92 DAY	EVERY YEAR	EVERY 5 YEARS	
155002003	AIR SYSTEM	CAR BODY FILTERS	✓			
449001017	AIR SYSTEM	MAIN ELECTRICAL CABINET FILTERS		✓		
172001015	AIR BRAKE	AIR BRAKE AIR FILTER ASSY. KIT		✓		
172001006	AIR BRAKE	EQUALIZING RESERVOIR CONTROL PORTION			✓	
172001007	AIR BRAKE	16 CONTROL PORTION			✓	
172001008	AIR BRAKE	20 CONTROL PORTION			✓	
172001009	AIR BRAKE	13 CONTROL PORTION			✓	
172001010	AIR BRAKE	BRAKE CYLINDER CONTROL PORTION			✓	
172001011	AIR BRAKE	BRAKE PIPE CONTROL PORTION			✓	
172001017	AIR BRAKE	RELAY CONTROL PORTION			✓	

Fig. 11-2 Daily & Yearly Maintenance Requirements

*=IF EQUIPPED

PART NUMBER	PART FAMILY	PART	HOURS ON ENGINE	750	1500	2250	3000	3750
119001004	ENGINE/ WATER	RESISTOR, CORROSION FILTER		✓	✓	✓	✓	✓
119001008	ENGINE WATER	INHIBITOR, CORROSION		✓	✓	✓	✓	✓
169003001	ENGINE/ WATER	WATER TEST KIT		✓	✓	✓	✓	✓
119001003	ENGINE/ FUEL	FILTER, FUEL		✓	✓	✓	✓	✓
119001002	ENGINE/ FUEL	FILTER, FUEL / WATER SEPARATOR		✓	✓	✓	✓	✓
164001013	ENGINE/ AIR	PRIMARY ELEMENT, AIR INTAKE		✓	✓	✓	✓	✓
164001014	ENGINE/ AIR	SAFETY ELEMENT, AIR INTAKE		✓	✓	✓	✓	✓
119001001	ENGINE/ OIL	FILTER, LUBRICATING OIL		✓	✓	✓	✓	✓
169003002	ENGINE/ OIL	OIL SAMPLE KIT(REQUIRED EVERY 375 HRS)		✓	✓	✓	✓	✓
VALV PREM. BLUE	ENGINE/ OIL	ENGINE OIL CHANGE 15w40		✓	✓	✓	✓	✓
119001006	ENGINE/ BREATHER	ELEMENT, BREATHER				✓		
171002001	AIR COMPRESSOR	FILTER KIT, AIR COMPRESSOR				✓		
171003000	AIR COMPRESSOR	A/C OIL CHANGE ROTO H OIL (5 GAL DRUMS)				✓		
140002008	GENERATOR	BRUSH, GROUNDING				✓		
162001002	RADIATOR	CAP FILLER 2" 15 PSI				✓		
171002000	AIR COMPRESSOR	AIR COMPRESSOR VALVES KITS						
162009000	ENGINE/ WATER	COOLANT CHANGE						
171002002	AIR COMPRESSOR	KIT, COUPLING AIR COMPRESSOR						
117001001	ENGINE	INJECTORS						
171002003	AIR COMPRESSOR	KIT, GEARBOX OVERHAUL AIR COMPRESSOR						

Fig. 11-3 Projected Maintenance Schedule

*=IF EQUIPPED

PART NUMBER	PART FAMILY	PART	HOURS ON ENGINE	4500	5250	6000	6750	7500
119001004	ENGINE/ WATER	RESISTOR, CORROSION FILTER		✓	✓	✓	✓	✓
119001008	ENGINE WATER	INHIBITOR, CORROSION		✓	✓	✓	✓	✓
169003001	ENGINE/ WATER	WATER TEST KIT		✓	✓	✓	✓	✓
119001003	ENGINE/ FUEL	FILTER, FUEL		✓	✓	✓	✓	✓
119001002	ENGINE/ FUEL	FILTER, FUEL / WATER SEPARATOR		✓	✓	✓	✓	✓
164001013	ENGINE/ AIR	PRIMARY ELEMENT, AIR INTAKE		✓	✓	✓	✓	✓
164001014	ENGINE/ AIR	SAFETY ELEMENT, AIR INTAKE		✓	✓	✓	✓	✓
119001001	ENGINE/ OIL	FILTER, LUBRICATING OIL		✓	✓	✓	✓	✓
169003002	ENGINE/ OIL	OIL SAMPLE KIT(REQUIRED EVERY 375 HRS)		✓	✓	✓	✓	✓
VALV PREM. BLUE	ENGINE/ OIL	ENGINE OIL CHANGE 15w40		✓	✓	✓	✓	✓
119001006	ENGINE/ BREATHER	ELEMENT, BREATHER		✓			✓	
171002001	AIR COMPRESSOR	FILTER KIT, AIR COMPRESSOR		✓			✓	
171003000	AIR COMPRESSOR	A/C OIL CHANGE ROTO H OIL (5 GAL DRUMS)		✓			✓	
140002008	GENERATOR	BRUSH, GROUNDING		✓			✓	
162001002	RADIATOR	CAP FILLER 2" 15 PSI		✓			✓	
171002000	AIR COMPRESSOR	AIR COMPRESSOR VALVES KITS		✓				
162009000	ENGINE/ WATER	COOLANT CHANGE				✓		
171002002	AIR COMPRESSOR	KIT, COUPLING AIR COMPRESSOR					✓	
117001001	ENGINE	INJECTORS						
171002003	AIR COMPRESSOR	KIT, GEARBOX OVERHAUL AIR COMPRESSOR						

Fig. 11-3 Projected Maintenance Schedule (continued)

*=IF EQUIPPED

PART NUMBER	PART FAMILY	PART	HOURS ON ENGINE	8250	9000	9750	10500	11250
119001004	ENGINE/ WATER	RESISTOR, CORROSION FILTER		✓	✓	✓	✓	✓
119001008	ENGINE WATER	INHIBITOR, CORROSION		✓	✓	✓	✓	✓
169003001	ENGINE/ WATER	WATER TEST KIT		✓	✓	✓	✓	✓
119001003	ENGINE/ FUEL	FILTER, FUEL		✓	✓	✓	✓	✓
119001002	ENGINE/ FUEL	FILTER, FUEL / WATER SEPARATOR		✓	✓	✓	✓	✓
164001013	ENGINE/ AIR	PRIMARY ELEMENT, AIR INTAKE		✓	✓	✓	✓	✓
164001014	ENGINE/ AIR	SAFETY ELEMENT, AIR INTAKE		✓	✓	✓	✓	✓
119001001	ENGINE/ OIL	FILTER, LUBRICATING OIL		✓	✓	✓	✓	✓
169003002	ENGINE/ OIL	OIL SAMPLE KIT(REQUIRED EVERY 375 HRS)		✓	✓	✓	✓	✓
VALV PREM. BLUE	ENGINE/ OIL	ENGINE OIL CHANGE 15w40		✓	✓	✓	✓	✓
119001006	ENGINE/ BREATHER	ELEMENT, BREATHER			✓			✓
171002001	AIR COMPRESSOR	FILTER KIT, AIR COMPRESSOR			✓			✓
171003000	AIR COMPRESSOR	A/C OIL CHANGE ROTO H OIL (5 GAL DRUMS)			✓			✓
140002008	GENERATOR	BRUSH, GROUNDING			✓			✓
162001002	RADIATOR	CAP FILLER 2" 15 PSI			✓			✓
171002000	AIR COMPRESSOR	AIR COMPRESSOR VALVES KITS			✓			
162009000	ENGINE/ WATER	COOLANT CHANGE						
171002002	AIR COMPRESSOR	KIT, COUPLING AIR COMPRESSOR						
117001001	ENGINE	INJECTORS						
171002003	AIR COMPRESSOR	KIT, GEARBOX OVERHAUL AIR COMPRESSOR						

Fig. 11-3 Projected Maintenance Schedule (continued)

*=IF EQUIPPED

PART NUMBER	PART FAMILY	PART	HOURS ON ENGINE	12000	12750	13500	14250	15000
119001004	ENGINE/ WATER	RESISTOR, CORROSION FILTER		✓	✓	✓	✓	✓
119001008	ENGINE WATER	INHIBITOR, CORROSION		✓	✓	✓	✓	✓
169003001	ENGINE/ WATER	WATER TEST KIT		✓	✓	✓	✓	✓
119001003	ENGINE/ FUEL	FILTER, FUEL		✓	✓	✓	✓	✓
119001002	ENGINE/ FUEL	FILTER, FUEL / WATER SEPARATOR		✓	✓	✓	✓	✓
164001013	ENGINE/ AIR	PRIMARY ELEMENT, AIR INTAKE		✓	✓	✓	✓	✓
164001014	ENGINE/ AIR	SAFETY ELEMENT, AIR INTAKE		✓	✓	✓	✓	✓
119001001	ENGINE/ OIL	FILTER, LUBRICATING OIL		✓	✓	✓	✓	✓
169003002	ENGINE/ OIL	OIL SAMPLE KIT(REQUIRED EVERY 375 HRS)		✓	✓	✓	✓	✓
VALV PREM. BLUE	ENGINE/ OIL	ENGINE OIL CHANGE 15w40		✓	✓	✓	✓	✓
119001006	ENGINE/ BREATHER	ELEMENT, BREATHER				✓		
171002001	AIR COMPRESSOR	FILTER KIT, AIR COMPRESSOR				✓		
171003000	AIR COMPRESSOR	A/C OIL CHANGE ROTO H OIL (5 GAL DRUMS)				✓		
140002008	GENERATOR	BRUSH, GROUNDING				✓		
162001002	RADIATOR	CAP FILLER 2" 15 PSI				✓		
171002000	AIR COMPRESSOR	AIR COMPRESSOR VALVES KITS				✓		
162009000	ENGINE/ WATER	COOLANT CHANGE		✓				
171002002	AIR COMPRESSOR	KIT, COUPLING AIR COMPRESSOR				✓		
117001001	ENGINE	INJECTORS						✓
171002003	AIR COMPRESSOR	KIT, GEARBOX OVERHAUL AIR COMPRESSOR				✓		

Fig. 11-3 Projected Maintenance Schedule (continued)

*=IF EQUIPPED

PART NUMBER	PART FAMILY	PART	HOURS ON ENGINE	15750	16500	17250	18000	18750
119001004	ENGINE/ WATER	RESISTOR, CORROSION FILTER		✓	✓	✓	✓	✓
119001008	ENGINE WATER	INHIBITOR, CORROSION		✓	✓	✓	✓	✓
169003001	ENGINE/ WATER	WATER TEST KIT		✓	✓	✓	✓	✓
119001003	ENGINE/ FUEL	FILTER, FUEL		✓	✓	✓	✓	✓
119001002	ENGINE/ FUEL	FILTER, FUEL / WATER SEPARATOR		✓	✓	✓	✓	✓
164001013	ENGINE/ AIR	PRIMARY ELEMENT, AIR INTAKE		✓	✓	✓	✓	✓
164001014	ENGINE/ AIR	SAFETY ELEMENT, AIR INTAKE		✓	✓	✓	✓	✓
119001001	ENGINE/ OIL	FILTER, LUBRICATING OIL		✓	✓	✓	✓	✓
169003002	ENGINE/ OIL	OIL SAMPLE KIT(REQUIRED EVERY 375 HRS)		✓	✓	✓	✓	✓
VALV PREM. BLUE	ENGINE/ OIL	ENGINE OIL CHANGE 15w40		✓	✓	✓	✓	✓
119001006	ENGINE/ BREATHER	ELEMENT, BREATHER		✓			✓	
171002001	AIR COMPRESSOR	FILTER KIT, AIR COMPRESSOR		✓			✓	
171003000	AIR COMPRESSOR	A/C OIL CHANGE ROTO H OIL (5 GAL DRUMS)		✓			✓	
140002008	GENERATOR	BRUSH, GROUNDING		✓			✓	
162001002	RADIATOR	CAP FILLER 2" 15 PSI		✓			✓	
171002000	AIR COMPRESSOR	AIR COMPRESSOR VALVES KITS					✓	
162009000	ENGINE/ WATER	COOLANT CHANGE					✓	
171002002	AIR COMPRESSOR	KIT, COUPLING AIR COMPRESSOR						
117001001	ENGINE	INJECTORS						
171002003	AIR COMPRESSOR	KIT, GEARBOX OVERHAUL AIR COMPRESSOR						

Fig. 11-3 Projected Maintenance Schedule (continued)

*=IF EQUIPPED

PART NUMBER	PART FAMILY	PART	HOURS ON ENGINE	19500	20250	21000	21750	22500
119001004	ENGINE/ WATER	RESISTOR, CORROSION FILTER		✓	✓	✓	✓	✓
119001008	ENGINE WATER	INHIBITOR, CORROSION		✓	✓	✓	✓	✓
169003001	ENGINE/ WATER	WATER TEST KIT		✓	✓	✓	✓	✓
119001003	ENGINE/ FUEL	FILTER, FUEL		✓	✓	✓	✓	✓
119001002	ENGINE/ FUEL	FILTER, FUEL / WATER SEPARATOR		✓	✓	✓	✓	✓
164001013	ENGINE/ AIR	PRIMARY ELEMENT, AIR INTAKE		✓	✓	✓	✓	✓
164001014	ENGINE/ AIR	SAFETY ELEMENT, AIR INTAKE		✓	✓	✓	✓	✓
119001001	ENGINE/ OIL	FILTER, LUBRICATING OIL		✓	✓	✓	✓	✓
169003002	ENGINE/ OIL	OIL SAMPLE KIT(REQUIRED EVERY 375 HRS)		✓	✓	✓	✓	✓
VALV PREM. BLUE	ENGINE/ OIL	ENGINE OIL CHANGE 15w40		✓	✓	✓	✓	✓
119001006	ENGINE/ BREATHER	ELEMENT, BREATHER			✓			✓
171002001	AIR COMPRESSOR	FILTER KIT, AIR COMPRESSOR			✓			✓
171003000	AIR COMPRESSOR	A/C OIL CHANGE ROTO H OIL (5 GAL DRUMS)			✓			✓
140002008	GENERATOR	BRUSH, GROUNDING			✓			✓
162001002	RADIATOR	CAP FILLER 2" 15 PSI			✓			✓
171002000	AIR COMPRESSOR	AIR COMPRESSOR VALVES KITS						✓
162009000	ENGINE/ WATER	COOLANT CHANGE						
171002002	AIR COMPRESSOR	KIT, COUPLING AIR COMPRESSOR			✓			
117001001	ENGINE	INJECTORS						
171002003	AIR COMPRESSOR	KIT, GEARBOX OVERHAUL AIR COMPRESSOR						

Fig. 11-3 Projected Maintenance Schedule (continued)

*=IF EQUIPPED

PART NUMBER	PART FAMILY	PART	HOURS ON ENGINE	23250	24000	24750	25500	26250
119001004	ENGINE/ WATER	RESISTOR, CORROSION FILTER		✓	✓	✓	✓	✓
119001008	ENGINE WATER	INHIBITOR, CORROSION		✓	✓	✓	✓	✓
169003001	ENGINE/ WATER	WATER TEST KIT		✓	✓	✓	✓	✓
119001003	ENGINE/ FUEL	FILTER, FUEL		✓	✓	✓	✓	✓
119001002	ENGINE/ FUEL	FILTER, FUEL / WATER SEPARATOR		✓	✓	✓	✓	✓
164001013	ENGINE/ AIR	PRIMARY ELEMENT, AIR INTAKE		✓	✓	✓	✓	✓
164001014	ENGINE/ AIR	SAFETY ELEMENT, AIR INTAKE		✓	✓	✓	✓	✓
119001001	ENGINE/ OIL	FILTER, LUBRICATING OIL		✓	✓	✓	✓	✓
169003002	ENGINE/ OIL	OIL SAMPLE KIT(REQUIRED EVERY 375 HRS)		✓	✓	✓	✓	✓
VALV PREM. BLUE	ENGINE/ OIL	ENGINE OIL CHANGE 15w40		✓	✓	✓	✓	✓
119001006	ENGINE/ BREATHER	ELEMENT, BREATHER				✓		
171002001	AIR COMPRESSOR	FILTER KIT, AIR COMPRESSOR				✓		
171003000	AIR COMPRESSOR	A/C OIL CHANGE ROTO H OIL (5 GAL DRUMS)				✓		
140002008	GENERATOR	BRUSH, GROUNDING				✓		
162001002	RADIATOR	CAP FILLER 2" 15 PSI				✓		
171002000	AIR COMPRESSOR	AIR COMPRESSOR VALVES KITS						
162009000	ENGINE/ WATER	COOLANT CHANGE			✓			
171002002	AIR COMPRESSOR	KIT, COUPLING AIR COMPRESSOR						
117001001	ENGINE	INJECTORS						
171002003	AIR COMPRESSOR	KIT, GEARBOX OVERHAUL AIR COMPRESSOR						

Fig. 11-3 Projected Maintenance Schedule (continued)

*=IF EQUIPPED

PART NUMBER	PART FAMILY	PART	HOURS ON ENGINE	27000	27750	28500	29250	30000
119001004	ENGINE/ WATER	RESISTOR, CORROSION FILTER		✓	✓	✓	✓	OVERHAUL ENGINE
119001008	ENGINE WATER	INHIBITOR, CORROSION		✓	✓	✓	✓	
169003001	ENGINE/ WATER	WATER TEST KIT		✓	✓	✓	✓	
119001003	ENGINE/ FUEL	FILTER, FUEL		✓	✓	✓	✓	
119001002	ENGINE/ FUEL	FILTER, FUEL / WATER SEPARATOR		✓	✓	✓	✓	
164001013	ENGINE/ AIR	PRIMARY ELEMENT, AIR INTAKE		✓	✓	✓	✓	
164001014	ENGINE/ AIR	SAFETY ELEMENT, AIR INTAKE		✓	✓	✓	✓	
119001001	ENGINE/ OIL	FILTER, LUBRICATING OIL		✓	✓	✓	✓	
169003002	ENGINE/ OIL	OIL SAMPLE KIT(REQUIRED EVERY 250 HRS)		✓	✓	✓	✓	
VALV PREM. BLUE	ENGINE/ OIL	ENGINE OIL CHANGE 15w40		✓	✓	✓	✓	
119001006	ENGINE/ BREATHER	ELEMENT, BREATHER		✓			✓	
171002001	AIR COMPRESSOR	FILTER KIT, AIR COMPRESSOR		✓			✓	
171003000	AIR COMPRESSOR	A/C OIL CHANGE ROTO H OIL (5 GAL DRUMS)		✓			✓	
140002008	GENERATOR	BRUSH, GROUNDING		✓			✓	
162001002	RADIATOR	CAP FILLER 2" 15 PSI		✓			✓	
171002000	AIR COMPRESSOR	AIR COMPRESSOR VALVES KITS		✓				
162009000	ENGINE/ WATER	COOLANT CHANGE						
171002002	AIR COMPRESSOR	KIT, COUPLING AIR COMPRESSOR		✓				
117001001	ENGINE	INJECTORS						
171002003	AIR COMPRESSOR	KIT, GEARBOX OVERHAUL AIR COMPRESSOR		✓				

Fig. 11-3 Projected Maintenance Schedule (continued)

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