Carrier

TRANSICOLD

Trailer Refrigeration Unit

Phoenix Ultra
Phoenix Ultra XL
Extra and Optima

SERVICE TRAINING

62-50457-00 $10.00

Carrier
TRANSICOLD

SERVICE TRAINING MANUAL

TRAILER REFRIGERATION UNIT

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UNITED TECHNOLOGIES
CARRIER
TRANSICOLD

Carrier Transicold Division, Carrier Corporation, P.O. Box 4805, Syracuse, N.Y. 13221

Foreword

This service training manual covers the Carrier Transicold Phoenix Ultra, Phoenix Ultra XL, Extra, and Optima trailer refrigeration units. Unless specific differences are discussed, components or operating sequences for *all* the units are considered to be the same as the Phoenix Ultra refrigeration unit.

The Carrier Transicold Optima refrigeration unit is similar to that of the Phoenix Ultra. The Optima is specifically designed for commodities that must be maintained at mid–range (perishable) temperatures.

The Phoenix Ultra XL, Extra, and Optima use the same microprocessor, frame, doors and skins as the Phoenix Ultra. The drive train for the Phoenix Ultra XL is Carrier Transicold's CT4-134DI Direct Injection Engine, 05G 40-CID Compressor. The Extra utilizes a CT4-114TV Tri-Vortex Engine, 05G 37-CID Compressor; the Optima uses the CT4-91TVO Tri-Vortex Engine, 05K 24-CID Compressor.

The Optima requires the use of an electric fuel pump and is not available with the Electric Standby option.

To receive full benefit from this training manual, you should have hands-on practice after reading each section. Previous experience with trailer refrigeration units will enhance your understanding of the Phoenix Ultra family.

Never attempt to troubleshoot or repair the unit without referring to the latest service and operations manual. The technical information in this service training manual is current only to the date of publication.

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The Carrier Transicold Phoenix Ultra trailer refrigeration unit is specifically engineered for maximum performance, reliability, and durability. The Phoenix Ultra's new microprocessor control brings you many exclusive advances not available with any other high-capacity trailer unit. Inside the front cover is a new user-friendly Click-Set style keypad with a large backlit digital display. The microprocessor provides precise temperature control and greater visibility. These user-friendly features place the following features at the operator's fingertips;

- Auto Start/Stop – Continuous Run selection
- Manual Defrost initiation
- Pretrip Check
- Unit Function Parameters
- Unit Data Display
- Unit Alarm Display
- Setpoint Selection
- Box Temperature Display

These and many other features are detailed in this text.

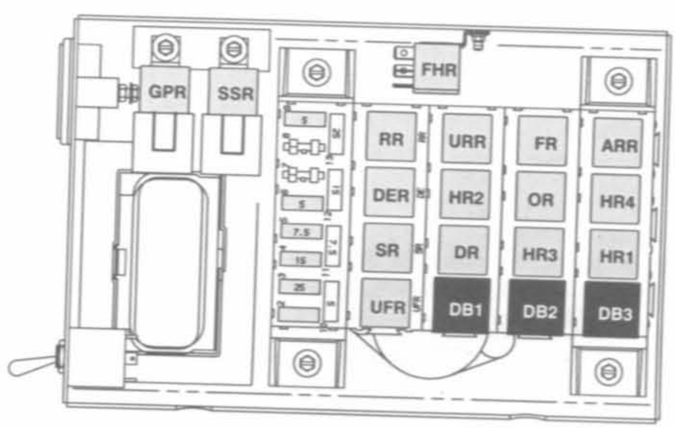
The microprocessor is mounted in its own self-contained, weatherproof compartment. This enhances the integrity of the compartment seal and keeps moisture away from the microprocessor. The microprocessor controls the entire unit's operation by constantly monitoring safety devices and temperature and pressure sensors. It also ensures precise and reliable cargo temperature control.

This newly designed microprocessor uses separate components to make up the control. The logic board, display panel and relay board include the microprocessor program memory and necessary input/output circuitry to interface with the unit.

The display board includes the LCD display, LCD driver, keypad and keypad interface.

CAUTION

Under no circumstances should a technician electrically probe the microprocessor at any point. Microprocessor components operate at different voltage levels and at extremely low current levels. Improper use of voltage meters, jumper wires, continuity testers, etc. could permanently damage the microprocessor.



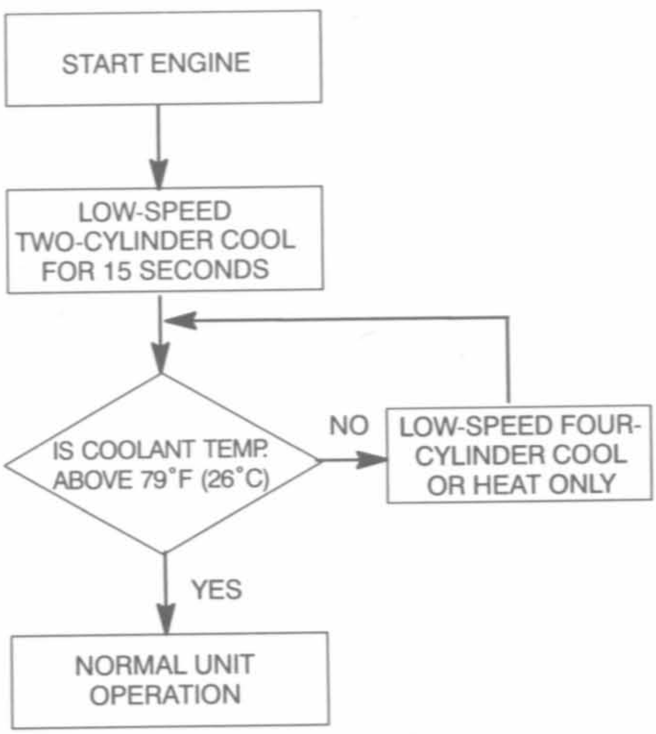
The relay box contains a relay board, ammeter and a Manual Glow/Crank switch (MGC). The relays on the relay board are energized when the microprocessor provides an electrical ground path.

The system fuses are located on the relay board. The diodes used in this system are designed as diode blocks. Diode blocks DB1, DB2, and DB3 are interchangeable. Most outputs from the microprocessor are switched through relays: (RR) Run Relay, (DER) Diesel Electric Relay, (SR) Speed Relay, (UFR) Unloader Front Relay, (URR) Unloader Rear Relay, (HR1), (HR2), (HR3), (HR4) Heat Relays, (DR) Defrost Relay, (FR) Fault Relay, (OR) Out-of-Range Relay, (FHR) Fuel Heater Relay, and (ARR) Auto Restart Relay for unit control. These relays are interchangeable with each other.

(SSR) Starter Solenoid Relay and (GPR) Glow Plug Relay are interchangeable with each other, but not with the other controlling relays.

The procedure for testing a diode can be found on page 50. The procedure for testing a relay can be found on page 50.

STARTING FLOWCHART



When the Phoenix Ultra microprocessor unit is switched on, the controller always completes a five-second self-test before a start attempt is made. If the microprocessor finds internal problems, it will not allow startup and will display an error message. If functioning properly, the controller will always start the unit in low-speed cool with the compressor fully unloaded (two cylinders operating) for the first 15 seconds. At the end of 15 seconds, the controller checks the engine coolant temperature. If the coolant temperature is above 79°F (26°C), the unit will operate as necessary to control the box temperature. If the coolant temperature is below 79°F (26°C), the controller will allow four-cylinder operation of the compressor (two-cylinder for Optima) and cool or heat operation, but will prevent high engine speed until the engine coolant temperature reaches 79°F (26°C).

PERISHABLE RANGE OPERATING MODES

<u>**ABOVE 10°F (–12.2°C)**</u>

High-speed six-cylinder cool
Low-speed four-cylinder cool
Low-speed two cylinder cool
Low-speed four-cylinder heat
Low-speed six-cylinder heat
High-speed six-cylinder heat

As discussed in Low-Speed Start, the microprocessor can control the compressor unloaders separately from engine speed. This is one major advantage of the microprocessor control.

In the chart above, the switching points for each mode of operation are not identified. This is because they are not fixed in relation to the setpoint. As the box temperature approaches setpoint on the initial pulldown, the controller will switch from high speed to low speed at 2.16°F (1.2°C) above setpoint, and will not switch back to high speed until box temperature is 2.7°F (1.5°C) above setpoint. The control will switch from cool to heat at setpoint. At this time, the control will monitor the box temperature overshoot from setpoint and will offset the switching points to minimize overshoot. The only time the switching points are known is on initial pulldown; after that, they are not known. (The offset variables are reset to initial conditions each time the compressor is not operating or when a new setpoint has been entered.) This greatly increases the accuracy of the controller. The important thing to remember is the operating sequence, not the switching points.

FROZEN RANGE OPERATING MODES

<u>10°F (–12.2°C) OR BELOW</u>

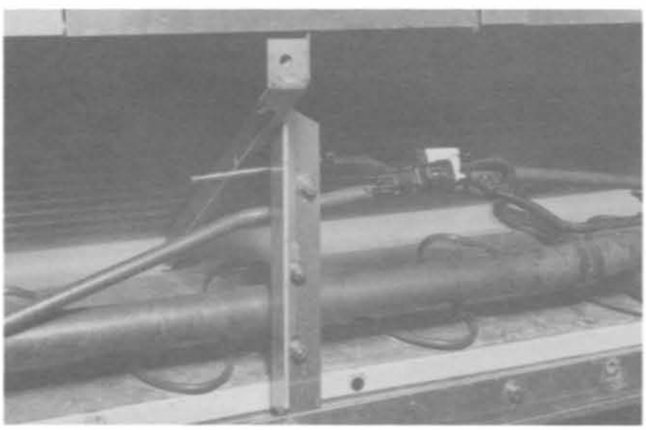
High-speed six-cylinder cool
Low-speed six-cylinder cool
Low-speed four-cylinder cool

Controller operation for Frozen Range setpoints is similar to perishable operation, except that heating mode is not allowed. The perishable/frozen switching point is a setpoint of 10°F (−12.2°C).

This is also the setpoint at which the microprocessor will switch from the Supply Air Sensor (SAS) to the Return Air Sensor (RAS) for temperature control on units equipped with an optional Supply Air Sensor (SAS) if SUP PROBE is selected. For setpoints above 10°F (−12.2°C), the unit will control on the Supply Air Sensor. For setpoints 10°F (−12.2°C) or below, the unit will control on the Return Air Sensor.

For this reason, 10°F (−12.2°C) is sometimes referred to as the "heat lockout point" or "probe changeover point."

TEMPERATURE SENSORS



The microprocessor measures air temperatures in the box using thermistor sensors. A thermistor is an electrical device that changes resistance as its temperature changes. The microprocessor uses this signal to control box temperature for setpoints from −22°F to +86°F (−30°C to +30°C). This signal is also used for the digital box temperature display. The display range is −36°F to +158°F (−38°C to +70°C).

The standard model comes equipped with only one thermistor, usually located in the return air stream. The microprocessor has the ability, however, to read an optional second thermistor signal which can be used for several purposes. To understand these functions more easily, a thermistor sensor can be defined in two ways, according to function:

1) Control Probe: A thermistor used by the controller to control box temperature. Its signal can be displayed.

2) Thermometer: A thermistor used for temperature display only. <u>No</u> control function.

Using these definitions, the operation of the controller can now be explained.

SINGLE PROBE CONTROL

Single probe control is the standard model configuration. This means that the microprocessor will only use one thermistor signal for temperature control. This control probe is usually mounted in the evaporator return air stream (RAS). A second sensor can be plugged into the controller to be used as a remote *thermometer* (REM or FN4 A) It could be mounted in the supply air stream or in the cargo as a pulp thermometer. Remember, a thermistor used as a thermometer can display temperature only and is therefore used for digital temperature display only.

A unit can have two thermistors but will still be called a single *probe* unit because only one of the probes is used for unit control. If supplied with a supply air probe, it will be located at the outlet of the supply air stream.

If the return air probe fails on a single probe unit, it will cause the unit to shut down in the perishable range or lock into low-speed cool for frozen operation to prevent cargo damage. In addition, the fault light will be on to indicate an alarm is present. The display will alternate the default display (setpoint/box temperature) and "RA SENSOR" alarm. No indication will be given for a remote *thermometer* (REM) probe failure until the thermometer signal (REM) is accessed on the keypad. The digital display will show (− − −) for an open or shorted probe.

DUAL PROBE CONTROL

The microprocessor can be programmed to convert the second thermistor sensor to a control probe (FN4 B). The controller will choose between the supply (SAS) and return (RAS) air probe for control. For perishable setpoints above 10°F (−12°C), the controller will select the supply air probe (SAS) as the "active" controlling probe. Its signal will be used for all control and digital display functions. During supply air control, the return air probe (RAS) is not used, but its temperature can be displayed by depressing the appropriate keys on the keypad.

When a frozen setpoint is entered 10°F (−12°C) or below, the controller will automatically switch display and control functions over to the return air sensor (RAS). The return air probe will now be the "active" controlling probe; the supply air probe (SAS) is "inactive." Again, the inactive probe temperature can be accessed on the keypad.

Dual probe control has three main advantages. First, it provides better product quality by minimizing top freezing and overcooling of perishable loads; return air control is better for frozen products, keeping them at or slightly below setpoint temperature.

Second, in the event of an "active" probe failure, the controller will automatically switch over to the "inactive probe" for control of the unit. The display will alternate the default display (setpoint/box temperature) and the appropriate alarm.

The third benefit of the second probe is for troubleshooting. It can be used to measure the temperature difference across the evaporator, which can help solve airside and refrigeration system problems.

For programming instructions, refer to Function Change Key, Function Parameters Table found on page 9.

Note: For dual probe control, the second probe must be located in the supply air outlet of the unit, *NOT* as a pulp or a remote probe. It is never recommended that a probe placed in the load be used as a controlling probe.

COMPRESSOR DISCHARGE TEMPERATURE SENSOR (CDT)

The Compressor Discharge Temperature Sensor (CDT) is a thermistor-type sensor located in the center head of the compressor. This sensor provides an input to the microprocessor. The compressor discharge temperature may be read from the display by pressing the unit data key and scrolling to (CDT) or (CD9).

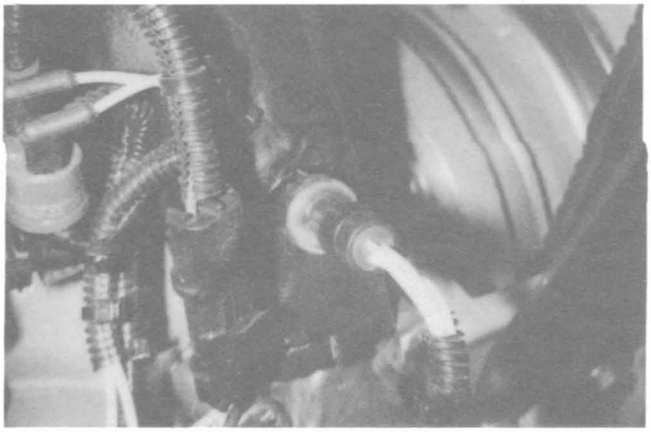
The compressor discharge temperature alarm is displayed with the description "HIGH CDT" or "AL12." This alarm is generated, and the unit will shut down, if the compressor temperature is sensed above 310°F (155°C) for 3 minutes. If the discharge temperature exceeds 350°F (177°C), the 3-minute timer will be overridden, and the unit will shut down immediately. The fault light (FL) will turn on.

The compressor discharge temperature sensor alarm is displayed with the description "CD SENSOR" or "AL13." The alarm is generated if the sensor is open or shorted.

The discharge temperature reading, along with ambient temperature, allow the microprocessor to decide when to open the hot gas valve (SV−3) during heat or defrost.

To check out the (CDT), the temperature of the sensor must be known before testing. Disconnect the watertight plug from the (CDT) on the compressor head, and check the resistance reading of the sensor. [See resistance chart for (CDT) on page 51.] The (CDT) may also be checked by immersing the sensor in an ice bath. At 32°F (0°C), the reading will be approximately 327,000 ohms.

SUCTION PRESSURE TRANSDUCER (SPT)



The Suction Pressure Transducer (SPT) is installed in the suction manifold of the compressor. Suction pressure can be read directly from the microprocessor readout by pressing the unit data key and scrolling to (SUCT) or (CD1). The suction pressure, along with the ambient temperature, may determine the compressor unloading sequence.

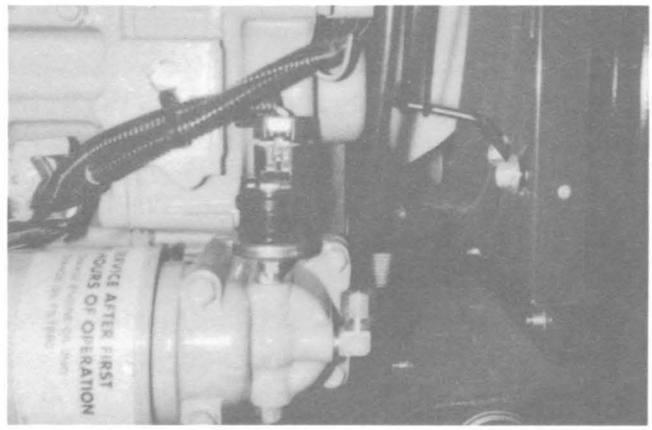
If it becomes necessary to calibrate the microprocessor to the (SPT) or replace the (SPT), the calibration procedure cannot be performed if the run relay is energized. This prevents the operator from calibrating the unit with the sensor in the system. The reading of the sensor must be at atmospheric pressure (0 psig or 14.7 psi). If the sensor reading is greater than 20 psig (34.7 psi) or less than −6.7 psig (8 psi), it cannot be calibrated. Once the microprocessor is calibrated, the display will read out the actual value.

There is a Schrader valve in the fitting in the compressor body so that it is possible to remove the (SPT) without pumping the compressor down or removing the charge. If the compressor is pumped down or the suction pressure is running in a vacuum while the (SPT) is removed, air may be drawn into the compressor through this fitting.

Turn the unit off, and remove the starter solenoid wire. Place the RUN/STOP switch (RS) in the run position, and let the unit fail to start. This will de-energize the run relay. With the (SPT) disconnected, press the unit data key to read suction pressure on the display. While the suction pressure is displayed, press the ENTER key for 3 seconds; the display should read "0." If so, install the suction pressure transducer into the compressor.

The (SPT) cannot be tested reliably for voltage without the use of the microprocessor test unit.

OIL PRESSURE SAFETY SWITCH

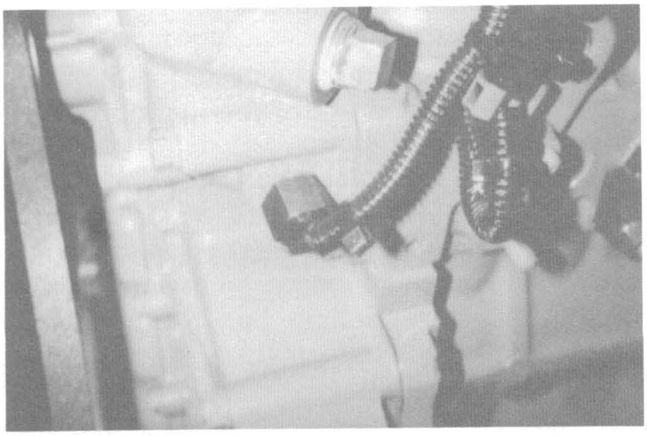


Engine oil pressure is monitored by the Oil Pressure Safety Switch (OP), mounted on the engine.

The Oil Pressure Safety Switch is used as a safety device to prevent unit operation below 15 psig oil pressure, provided that 15 seconds has passed since the alternator signal became true (oil pressure startup delay). This signal is also used to verify that the engine is running for the auto start mode. If the switch is open for more than 2 seconds, the microprocessor will shut the engine down. This 2-second delay prevents nuisance shutdowns. The microprocessor will turn on the Fault Light (FL), and the display will alternate between setpoint/box temperature and the "ENG OIL" alarm. To verify proper controller operation, with the engine running, simply disconnect the watertight plug from the Oil Pressure Safety Switch. After a 2-second delay, the the engine should shut down, and the fault light should turn on.

For diesel/electric units, the standby electric motor will be locked out when oil pressure is sensed.

WATER TEMPERATURE SENSOR



The Water Temperature Sensor (WTS) on the Phoenix Ultra is a thermistor-type sensor and is located near the thermostat housing in the cylinder head of the diesel engine. The engine water temperature may be read from the display by pressing the unit data key and scrolling to (WT) or (CD3). Its functions in the system are:

1) Signal for digital display of engine coolant temperature −58°F (−50°C) to 266°F (130°C).

2) Signal to shut the unit down if coolant temperatures exceed 230°F (110°C).

3) Signal for low-speed starting; keeps unit in low speed if coolant temperature is below 79°F (26°C).

4) Signal to determine amount of glow time in autostart mode.

5) Signal to restart engine in Auto Start/Stop if coolant temperature drops below 32°F (0°C).

6) Signal to prevent unit shutdown in Auto Start/Stop if coolant temperature is below 122°F (50°C).

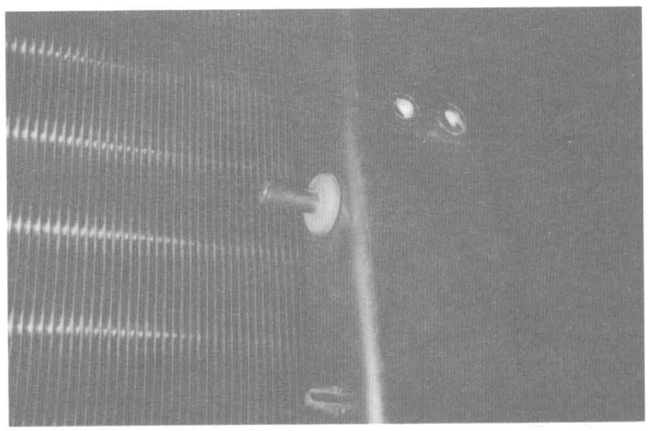
7) Signals for "ENG HOT" and "WT SENSOR" alarms.

The "ENG HOT" or "AL1" alarm is generated if the coolant temperature is over 230°F (110°C). The fault light will be on, and the display will alternate between the default display (setpoint/box temperature) and the "ENG HOT" alarm. The unit will be shut down.

The "WT SENSOR," AL11 alarm is generated if (WTS) is sensed defective (open or shorted). The unit data will display −58°F (−50°C) for an open sensor, and 266°F (130°C) for a shorted sensor. If the sensor is open or shorted, the display will alternate between the default display (setpoint/box temperature) and the "WT SENSOR," AL11 alarm. The unit will continue to operate normally, but with the safeties non-functional. This *must* be corrected immediately.

To check out the (WTS), the temperature of the sensor must be known before testing. Disconnect the wire from the (WTS) on the diesel engine, and check the resistance reading of the sensor using a digital ohm meter. [See resistance chart for (WTS) on pg 51.] The (WTS) may also be checked by immersing the sensor in an ice bath. At 32°F (0°C), the reading will be approximately 32,700 ohms.

AMBIENT TEMPERATURE SENSOR (ATS)

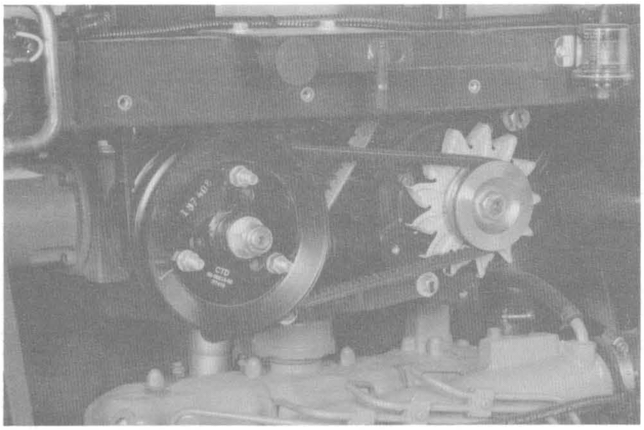


The Ambient Temperature Sensor (ATS) is a thermistor-type sensor located behind the front grill at the center of the condenser. To read ambient temperature, press the unit data key, and scroll to (ATS) or (CD7). This information, along with other signals to the microprocessor, are used to determine:

1. The unloading sequence.
2. The correct defrost cycle.
3. Cycling of (SV-3) during Heat and Defrost.

To check out the (ATS), the temperature of the sensor must be known before testing. Disconnect the watertight plug from the (ATS) in the wire harness, and check the resistance reading of the sensor using a digital ohm meter. [See the resistance chart for (ATS), on pg 51.] The (ATS) may also be checked by immersing the sensor in an ice bath. At 32°F (0°C), the reading will be approximately 32,700 ohms.

DURADRIVE



The new DuraDrive clutch assembly has replaced the swing arm and jack shaft assembly used on previous units. The gear box is designed to be maintenance-free for life. With the use of the gear box, the alternator is mounted up front for easier access.

During the defrost mode of operation, the electric clutch is de-energized to stop the condenser and evaporator fans from rotating. By stopping fan rotation during defrost, the defrost damper door assembly is no longer needed.

The electric clutch has special locking pins that allow direct drive to the fans, should the clutch fail.

COMPRESSOR UNLOADER OPERATION

The maximum suction pressure is controlled by the microprocessor. Suction pressures for R-22 are higher than those of other refrigerants used in transportation refrigeration products. This unloading sequence ensures that the unit will provide all the capacity that the engine can deliver at high ambient temperature and ensures maximum utilization of engine horsepower.

The Unloading Sequence

There are two modes of unloader operation, temperature control and suction pressure control.

Temperature Mode

If the box temperature is within 1.4°F (0.8°C) of setpoint, the Cool Light (CL) or Heat Light (HL) may be illuminated (depending on mode of operation).

If the unit is in low-speed cooling, unloader relays (UFR, or UFR and URR) may energize to unload compressor banks. See table on following page.

The heat mode forces the rear unloader (UR) to a loaded condition (de-energized) for diesel operation. In low-speed heating, unloader front (UF) energizes to unload the front bank of the compressor.

Suction Pressure Mode

The unloading sequence that is programmed into the microprocessor is calculated using information from the suction pressure transducer and the ambient temperature sensor. This unloader sequence takes precedence over the box temperature demands. There are two unloader schemes, one for high engine speed and one for low engine speed.

High-speed Compressor Unloading

Ambient air temperature below 90°F (32°C):

1. When suction pressure is less than 27 psig. The compressor is fully loaded (six-cylinder operation).
2. When suction pressure is between 27 and 53 psig. The rear unloader is energized (four-cylinder operation).
3. When suction pressure is above 53 psig. Both unloaders energized (two-cylinder operation).

Ambient air temperature above 90°F (32°C):

The unloaders will unload at a lower and lower suction pressure as the ambient air temperature rises above 90°F (32°C).

Low Speed Compressor Unloading

Ambient air temperature below 90°F (32°C):

1. When suction pressure is less than 22 psig. The compressor is fully loaded (six-cylinder operation).
2. When suction pressure is between 22 and 56 psig. The rear unloader is energized (four-cylinder operation).
3. When suction pressure is above 56 psig. Both unloaders energized (two-cylinder operation).

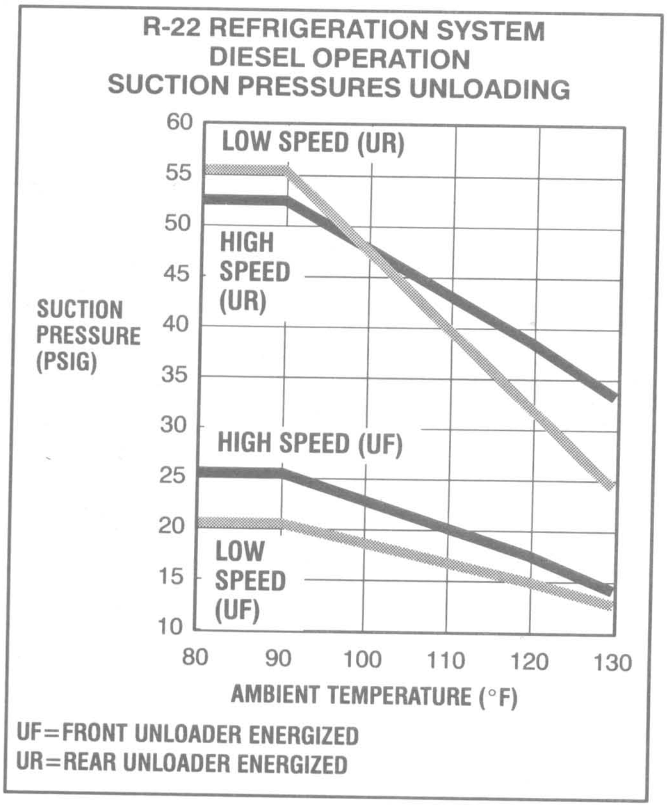
Ambient air temperature above 90°F (32°C):

The unloaders will unload at a lower and lower suction pressure as the ambient air temperature rises above 90°F (32°C).

Note: During heat and defrost, the rear unloader cannot be energized. The compressor will always have at least four cylinders compressing during the heat or defrost cycles.

Once an unloader is energized because of suction pressure, it is locked in for a minimum of two minutes, regardless of pressure or temperature changes. The "2-minute lock in" does not apply if unloaders are energized because of box temperature requirements.

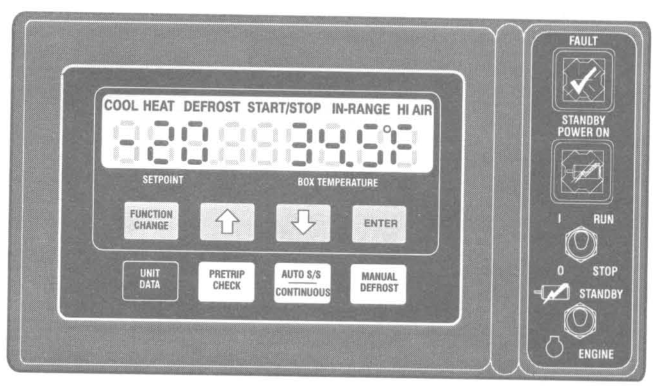
There is a delay of 30 seconds between de-energizing one unloader and de-energizing the other.



SYSTEM WIRING

The wires used throughout the unit are color-coded and labeled. All control voltage wires (12VDC) are white. All (DC) ground wires are black. The high-voltage (AC) circuit wires used for standby operation are red. All (AC) ground wires are green. Each wire is labelled with an address code every 2–3 inches (50–75 mm) along its length. The address code identifies where the wire comes from and where it is going to. Using the example below, a white wire labeled SPTA-MPF3 is a 12VDC wire coming from the Suction Pressure Transducer (SPT), pin 3, and going to the Microprocessor Plug (MP), pin F3.

PHOENIX ULTRA OPERATING INSTRUCTIONS



AUTOMATIC OPERATION
Starting

1. Place the RUN-STOP switch in the RUN (I) position. The microprocessor will perform a self-test (all display segments will appear in display window). Setpoint and box temperature will then be displayed.

The microprocessor will energize the glow plugs (length of time depends on engine temperature) and start the engine.

2. To change the setpoint, press the UP or DOWN arrow key, and then press the ENTER key.

3. Pressing the AUTO S/S - CONTINUOUS key changes the operation of the unit between automatic start/stop and automatic start/ continuous run. If start/stop is selected, the unit will automatically start and stop in response to a change in box temperature. If automatic start/continuous run is selected, the unit will start automatically and run continuously.

Stopping

Place RUN-STOP switch in the STOP (0) position.

AUTO S/S – CONTINUOUS KEY – This key changes the operation of the unit between automatic start/stop and continuous run. This key can also be used for manual starting; refer to Manual Starting section.

ENTER KEY – This key is multi-functional. It will enter a new setting into memory, initiate a selected function change, or extend data display time to 30 seconds.

UP or DOWN KEYS – These keys are used to scroll up or down through the displayed menus or to change the setpoint.

MANUAL DEFROST KEY – This key will initiate manual defrost. "DF" will appear on the display. Note: Box temperature must be below 40°F (± 2°F).

PRETRIP KEY – This key initiates pretrip. "PPPP" will appear on the display. The unit will cycle through all modes at 30-second intervals. Note: Box temperature must be below 40°F (± 2°F).

Function Change – The function settings below can be changed through the FUNCTION CHANGE key.

TO CHANGE A FUNCTION

1. Press the FUNCTION CHANGE key until the desired function appears on the display.

2. Press ENTER.

3. Press the UP or DOWN ARROW key until the desired function appears on the display.

4. Press ENTER.

FUNCTION PARAMETERS

CODE	ENGLISH	DATA
FN0	DEFR	Defrost Interval
FN1 ON	HIGH AIR	High Air Flow
FN1 OFF	NORM AIR	Norm Air Flow
FN2	OFF T	Offtime
FN3	ON T	Ontime
FN4 A	REM PROBE	Controlling Probe – Return Air
FN4 B	SUP PROBE	Controlling Probe – Supply Air
FN5	Degrees F or C	Temperature Unit °C or °F
FN6 ON	TIME STRT	Maximum Off-time 30 Min.
FN6 OFF	TEMP STRT	Temperature-Based Restarting
FN7	MOP STD	Future Expansion
FN8	2SET	Compartment 2 Setpoint
FN9	3SET	Compartment 3 Setpoint
FN10 ON	AUTO OP	Auto Start Operation
FN10 OFF	MAN OP	Manual Start Operation
FN11	T RANGE	Out-of-Range Tolerance
Code vs English = Code or English display format		
Manual Glow Override = Normal or Add 30 sec		
Alarm Reset = Alarm Reset or No Alarms		

UNIT DATA – The Unit Data key provides access to unit data listed below.

TO DISPLAY UNIT DATA

The unit data list can be scrolled through by pressing the UNIT DATA key. The list will advance one with each key push; or, press the UNIT DATA key once and use the UP or DOWN ARROW keys to scroll through the list faster. Press the ENTER key to display the desired data for 30 seconds.

UNIT DATA		
CODE	ENGLISH	DATA
CD1	SUCT	Suction Pressure
CD2	ENG	Engine Hours
CD3	WT	Engine Temperature
CD4	RAS	Return Air Temperature
*CD5	SAS	Supply Air Temperature
*CD6	REM	Remote Air Temperature
CD7	ATS	Ambient Temperature
CD8	EVP	Future Expansion
CD9	CDT	Discharge Temperature
CD10	BATT	Battery Voltage
CD11	SBY	Standby Hours
CD12	MOD V	Future Expansion
CD13	REV	Software Revision
CD14	SERL	Serial Number Low
CD15	SERU	Serial Number Upper
CD16	2RA	Compartment 2 Air Temperature
CD17	3RA	Compartment 3 Air Temperature
CD18	MHR1	Maintenance Hour Meter 1
CD19	MHR2	Maintenance Hour Meter 2
CD20	SON	Switch On Hour Meter

* Codes 5 & 6 are variable. SAS is displayed when the SUP Probe Function is selected. REM is displayed when the REM Probe Function is selected.

ALARM DISPLAY AND SAFETY FEATURES

The display will alternate between an alarm message and the normal display whenever any of the failures listed below occur.

Note: Whenever the fault light is on, check the display for a fault message. Before resetting the fault display, the fault must be corrected. To reset the fault message on the microprocessor, press FUNCTION CHANGE key, then the UP/DOWN arrow until ALARM RST is displayed. Press enter to clear alarm. Alarm CLR will now be displayed, and unit can be restarted. Other method to restart: move RUN/STOP switch to STOP. Unit resets and will start when RUN/STOP switch is moved to the run position.

ALARM DISPLAY		
CODE	ENGLISH	ALARM DESCRIPTION
AL0	ENG OIL	✔Low Oil Pressure
AL1	ENG HOT	✔High Coolant Temperature
AL2	HI PRESS	✔High Pressure
AL3	STARTFAIL	✔Auto Start Failure
AL4	LOW BATT	✔Low Battery Voltage
AL5	HI BATT	✔High Battery Voltage
AL6	DEFRFAIL	Defrost Override
AL7	ALT AUX	✔Alternator Auxiliary
AL8	STARTER	✔Starter Motor
AL9	RA SENSOR	✔Return Air Sensor
AL10	SA SENSOR	Supply Air Sensor
AL11	WT SENSOR	Coolant Temperature Sensor
AL12	HIGH CDT	✔High Discharge Temperature
AL13	CD SENSOR	Discharge Temperature Sensor
AL14	SBY MOTOR	✔Motor Overload
AL15	FUSE BAD	✔Fuse
AL17	DISPLAY	Display
AL18	SERVICE 1	Maintenance Hour Meter 1
AL19	SERVICE 2	Maintenance Hour Meter 2
AL20	RAS OUT	✔Main Compartment Out-of-range
AL21	2RA OUT	✔Remote Compartment 2 Out-of-range
AL22	3RA OUT	✔Remote Compartment 3 Out-of-range

✔ = FAULT LIGHT ON

Manual Starting

1. Place the RUN/STOP switch in the RUN (1) position.

2. If START/STOP appears in the mode of operation display, press the AUTO S/S-CONTINUOUS key to change modes.

3. Press the FUNCTION CHANGE key until AUTO OP or MAN OP appears.

a. If AUTO OP appears:

(1) Press the ENTER key.

(2) Press the UP or DOWN arrow key until MAN OP appears.

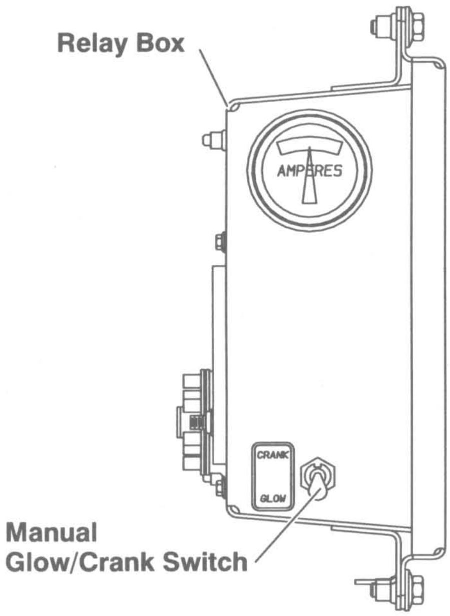
(3) Press the ENTER key. The unit is now in MANUAL START mode.

b. IF MAN OP appears, the unit is in the MANUAL START mode.

4. Use the MANUAL GLOW/CRANK switch to glow and start the unit. This switch is located on the Relay Box inside the roadside front door. See table below for glow time.

NOTE: Once the function parameter is programmed for MAN OP, the AUTO S/S-CONTINUOUS key can be used to toggle between AUTO START/STOP and MANUAL START/CONTINUOUS RUN.

Ambient Temperature	Glow Time in Seconds	
	TV	DI
Less than 32°F (0°C)	15	55
33°F to 50°F (1°C to 10°C)	10	40
51°F to 77°F (11°C to 25°C)	5	25
Greater than 78°F (26°C)	0	10



STOPPING

Place RUN-STOP switch in the STOP (0) position to stop the unit.

STANDBY OPERATION

To operate unit on standby:

1. Place the RUN/STOP switch in the STOP (0) position.

2. Place the ENGINE/STANDBY switch in the STANDBY position.

3. Plug in the power cord.

4. Place the RUN/STOP switch in the RUN (1) position.

5. Check for proper motor rotation. Condenser air must be drawn into the unit. To reverse rotation, stop unit, disconnect power cord, and change polarity.

PRETRIP SEQUENCE CHART

The PRETRIP mode is for checking unit operation, evaluating the operation of all modes, and indicating a failure when detected.

To successfully perform a pretrip, the unit must be operating and the box temperature must be below 40°F (4.4°C).

When the operator presses the PRETRIP key, and if the defrost thermostat (DTT) is closed, the controller will display, "PPPP." If DTT is open, a pretrip cannot be initiated.

Mode		Time Duration (Sec.)	Display*	Status
High-Speed	6-Cylinder Cool	30	PPPP	Cool
Low-Speed	4-Cylinder Cool	30	PPPP	Cool
Low-Speed	2-Cylinder Cool	30	PPPP	Cool
Low-Speed	4-Cylinder Heat	30	PPPP	Heat
Low-Speed	6-Cylinder Heat	30	PPPP	Heat
High-Speed	6-Cylinder Heat	30	PPPP, Coolant Temp.	Heat
High-Speed	6-Cylinder Cool	30	PPPP, Defrost Interval	Cool
Defrost	Var.** Set Point		DF	Heat, Defrost

* The display message can be overridden at any time by depressing certain keypad functions.

** The unit will remain in defrost until the defrost termination thermostats open.

After completion of the defrost cycle, pretrip is terminated, and the unit returns to normal operation.

Running the unit in reverse can damage the compressor, as the compressor oil pump only operates in one direction.

ELECTRICAL SCHEMATICS

Auto Start
Continuous Operation

LEGEND

A wiring schematic should be considered nothing more than a book of unit operational instructions, written with lines and electrical symbols. Should it become necessary for a technician to electrically troubleshoot a piece of equipment, he may, on occasion, find a symbol that is not fully understood. This can be rapidly clarified by looking up the symbol definition in the legend such as the one shown on page fifteen. It is also important to read the "notes." They give important information relating to wiring changes, etc. for specific options. Also, none of the keypad functions are listed in the legend, because they are not shown on the schematic. All electrical connections to them are made internally in the microprocessor, the circuits of which are not drawn on the schematic.

ZONE	SYMBOL	DESCRIPTION
J2	A	AMMETER
N3,E15,G15	ALT	ALTERNATOR
L8	ARL	AUTO RESTART LIGHT (LIGHT BAR)
F9, J8	ARR	AUTO RESTART RELAY
A9	ATS	AMBIENT TEMPERATURE SENSOR
N2	BTY	BATTERY
A10	CDT	COMPRESSOR DISCHARGE TEMPERATURE SENSOR
P7	CL	COOL LIGHT (LIGHT BAR)
P9	CLH	CLUTCH
F5	DA	DEFROST AIR SWITCH
F10,N5/6	DER	DIESEL ELECTRIC RELAY
P8	DL	DEFROST LIGHT (LIGHT BAR)
F9,N8/9	DR	DEFROST RELAY
F5	DTT	DEFROST THERMOSTAT
K2	F1	FUSE (MAXI-FUSE)(80 AMPERE)
L11	F2	FUSE (20 AMPERE) (OPTIONAL)
I3	F3	FUSE (25 AMPERE)
I5	F4	FUSE (15 AMPERE)
I7	F5	FUSE (7.5 AMPERE)
I9	F6	FUSE (5 AMPERE)
D1	F9	FUSE (5 AMPERE)
P11	FH	FUEL HEATER (OPTIONAL)
R5,N11	FHR	FUEL HEATER RELAY (OPTIONAL)
O11	FHT	FUEL HEATER THERMOSTAT (OPTIONAL)
L9/10	FL	FAULT LIGHT (LIGHT BAR AND DOOR)
F12,J9	FR	FAULT RELAY
O4	FP	FUEL PUMP (OPTIONAL)
P5	FS	FUEL SOLENOID
M5	GP	GLOW PLUG
F7,J5	GPR	GLOW PLUG RELAY
F4/12,K4/10,P4/9	HC	HIGH CURRENT BOX PLUG
P6	HL	HEAT LIGHT (LIGHT BAR)
F6	HP1	HIGH PRESSURE CUT-OUT-SWITCH (N.C.)
Q4	HP2	HIGH PRESSURE CUT-OUT-CONTROL (N.C.)
F10,N7/8	HR1	HEAT RELAY #1
F8,N6/7	HR2	HEAT RELAY #2
F11,J7	HR3	HEAT RELAY #3
F11,N10	HR4	HEAT RELAY #4
H10	MGC	MANUAL GLOW/CRANK
D3/D13	MP	MICROPROCESSOR BOARD
E2	OP	OIL PRESSURE SAFETY SWITCH (N.O.)
F11,J7	OR	OUT OF RANGE RELAY
L7	ORL	OUT OF RANGE LIGHT (LIGHT BAR)
A7	RAS	RETURN AIR SENSOR
A1	RS	RUN STOP SWITCH
F6,J3	RR	RUN RELAY
A8	SAS	SUPPLY AIR SENSOR (OPTIONAL)
L5	SCS	SPEED CONTROL SOLENOID
P2	SM	STARTER MOTOR
A6,F1/2/4/6,H2, P2,Q4/5,P4,R7 L5/6/7/8/9	SP	SPLICE POINT
A6	SPT	SUCTION PRESSURE TRANSDUCER
F10,J5	SR	SPEED RELAY
L4	SS	STARTER SOLENOID
N2	SSC	STARTER SOLENOID CONTACTOR
F7,J4	SSR	STARTER SOLENOID RELAY
P8	SV1	COND. PRESSURE CONTROL VALVE (N.O.)
Q7	SV2	LIQUID SOLENOID VALVE (N.C.)
L7	SV3	HOT GAS SOLENOID VALVE (N.C.)
P6	SV4	HOT GAS SOLENOID VALVE (N.C.)
L6	UF	UNLOADER FRONT
F8,J6	UFR	UNLOADER FRONT RELAY
P10	UR	UNLOADER REAR
F8,N4/10	URR	UNLOADER REAR RELAY
E14	VR	VOLTAGE REGULATOR
B5	WTS	WATER TEMPERATURE SENSOR

DIODE IS IN DIODE BLOCK1 (DB1), WITH THE CATHODE ON PIN 5 AND THE ANODE ON PIN 9 OF THE DIODE BLOCK FOR ALL DIODES.

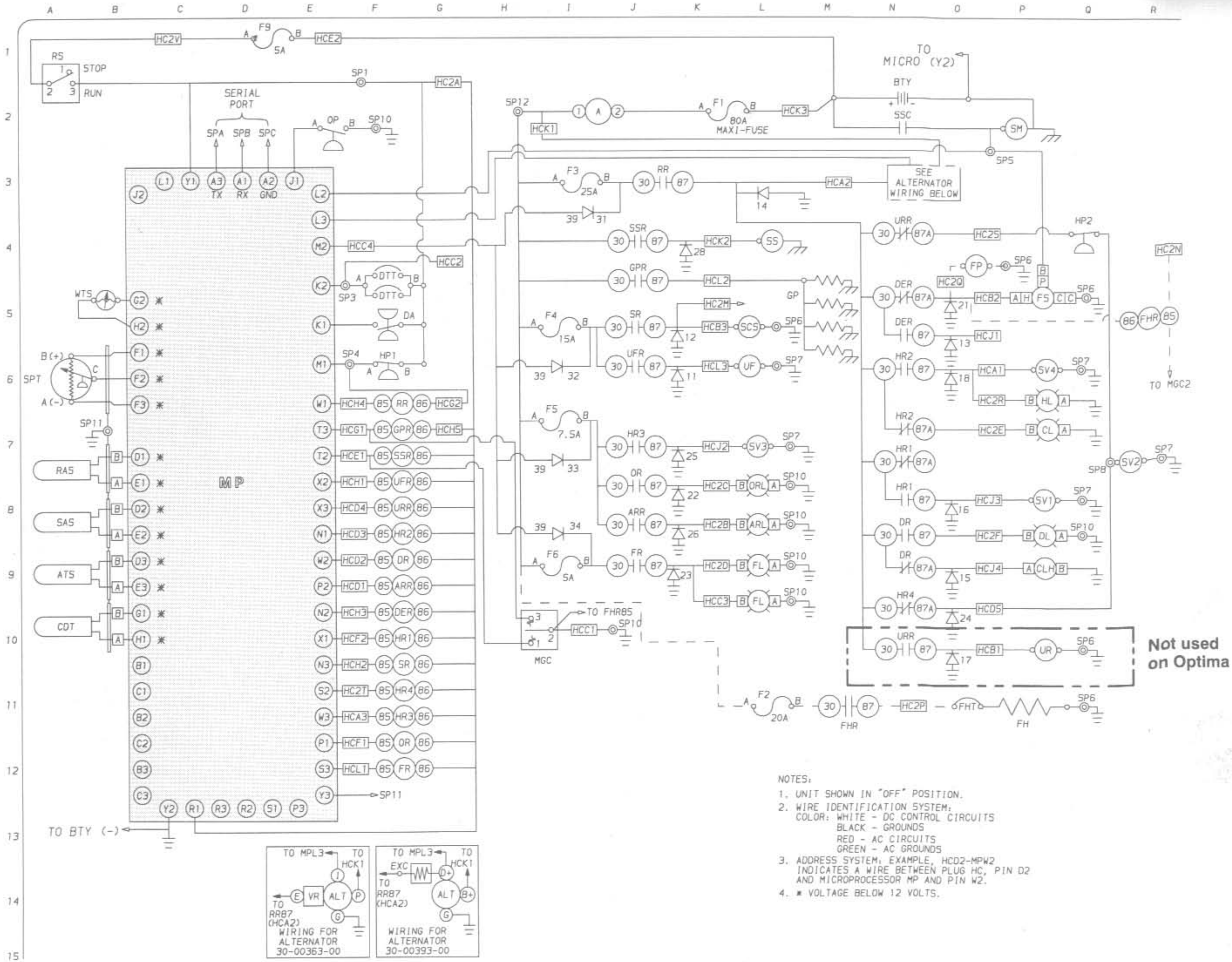
- INDICATES A SOLDERED SPLICE POINT.
- PIN CONNECTION
- LIGHT LINES INDICATE WIRES IN THE SYSTEM.
- NORMALLY CLOSED CONTACTS.
- NORMALLY CLOSED CONTACTS (OPEN)
- NORMALLY OPEN CONTACTS.
- NORMALLY OPEN CONTACTS (CLOSED)
- INDICATES CONNECTION
- MULTIPLE PLUG CONNECTION NUMBER
- COMPONENT CONNECTION NUMBER OR LETTER
- SWITCH SYMBOL INDICATES MOMENTARY CONTACTS.
- INDICATES A WIRE GROUND.
- INDICATES A CHASSIS GROUND (NO WIRE).
- INDICATES STANDARD OPTIONS.
- INDICATES A CONNECTION,WIRE,LUG,ETC.

Figure 5-1. NDA-94A & NDA-94B Electrical Schematic Wiring Diagram – Starting with S/N DAF90209263 – Dwg. No. 62-02589 Rev A (Sheet 1 of 2)

LAYOUT

This is the electrical schematic for the Phoenix Ultra microprocessor-controlled units. For the schematic description in this section, the AUTO OP/CONTINUOUS RUN function has been selected. Refer to pages 35 thru 39 for AUTO START/STOP operation.

The schematics that follow have been highlighted to show the various operating modes. Red traces indicate positive potential, while green indicates the ground paths for energized loads. To make it easier to locate the schematic components, a ZONE column has been added to the legend, and map coordinates to the margins of the schematic. For example, to locate the Hot Gas Solenoid Valve (SV4) on the schematic, find (SV4) in ZONE P6. This indicates that it is closest to lines (P) and (6) on the schematic.



NOTES:
1. UNIT SHOWN IN "OFF" POSITION.
2. WIRE IDENTIFICATION SYSTEM:
COLOR: WHITE - DC CONTROL CIRCUITS
BLACK - GROUNDS
RED - AC CIRCUITS
GREEN - AC GROUNDS
3. ADDRESS SYSTEM: EXAMPLE, HCD2-MPW2 INDICATES A WIRE BETWEEN PLUG HC, PIN D2 AND MICROPROCESSOR MP AND PIN W2.
4. * VOLTAGE BELOW 12 VOLTS.

NDA-94 Electrical Schematic Wiring Diagram – Starting with S/N DAF90209263 – Dwg. No. 62-02589 Rev A (Sheet 2 of 2)

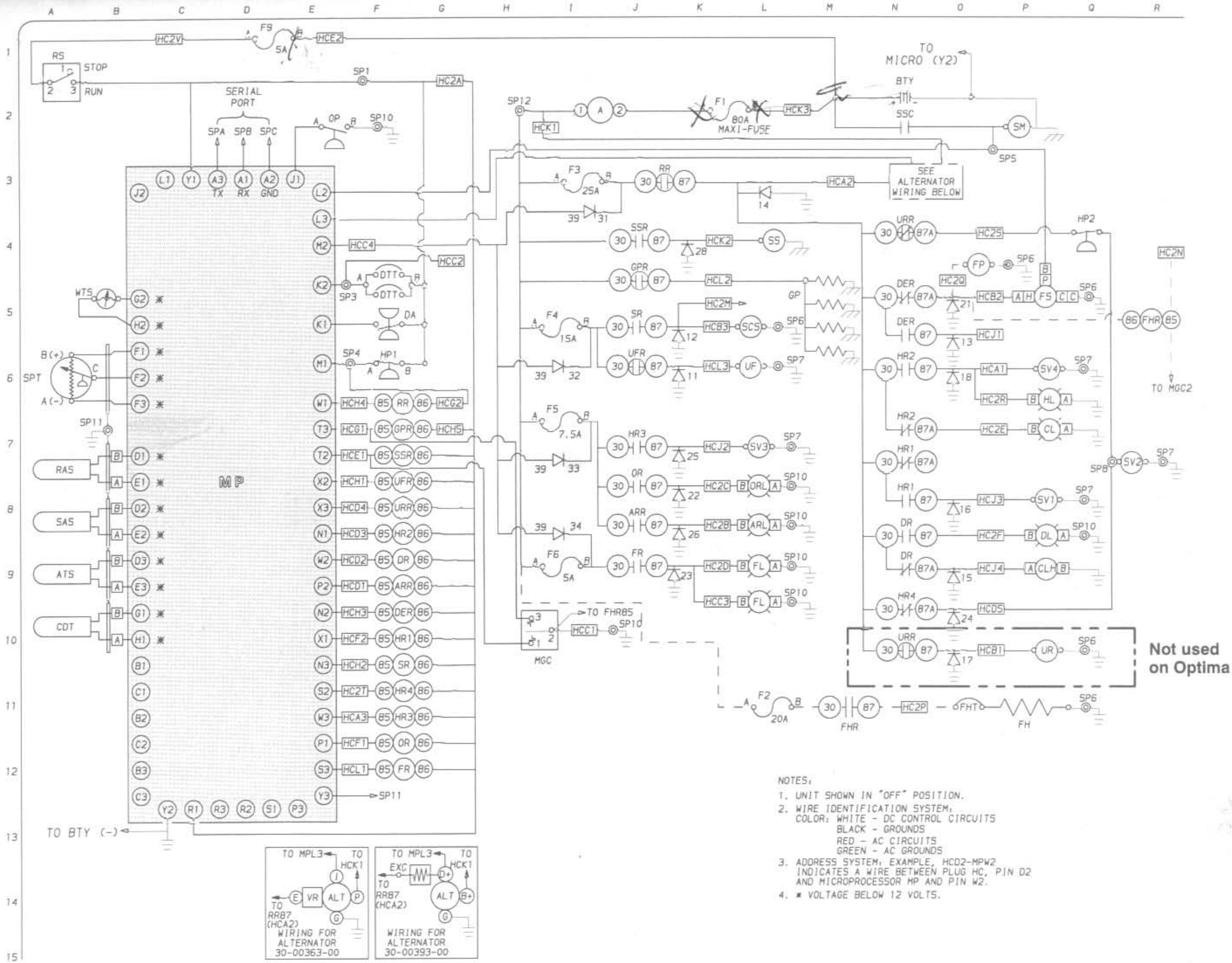
PREHEAT

To preheat the engine, place the Run Stop Switch (RS) in the run position. This allows current to flow from the battery through F9 fuse (5 amp) and the run stop switch to the microprocessor input (MPY1), to Splice Point 1 (SP1), through High-Pressure Cut-Out Switch (HP1) to (SP4), and from (SP4) to microprocessor input (MPM1) and pin 86 of the Run Relay (RR). From (SP1), voltage will be available to pin 86 on all relays controlled by the microprocessor (the microprocessor energizes relays by supplying a ground path to pin 85), and to microprocessor input (MPR1). At the same time, current will be available through F1 fuse (80 amp), ammeter to (SP12), and from (SP12) through F3 fuse (25 amp), F4 fuse (15 amp), F5 fuse (7.5 amp), F6 fuse (5 amp) and also to one side of the N.O. Starter Solenoid (SSR) and Glow Plug Relay (GPR) contacts. The microprocessor will perform a 5-second self-test and allow the preheat sequence to start, as long as the following conditions are met:

1. Engine coolant temperature is below 230°F (110°C).
2. One controller probe (SAS or RAS) is functional.
3. Battery voltage is within prescribed limits.
4. Valid setpoint is entered.

Five seconds after the microprocessor senses 12V at (MPY1), (RR), Unloader Rear Relay (URR), and Unloader Front Relay (UFR) will energize simultaneously (Optima will energize UFR only), closing the N.O. (RR), (URR), and (UFR) contacts. Voltage will be available from the (RR) contacts through the N.C. Diesel Electric Relay (DER) contacts to the holding coil of the Fuel Solenoid (FS), but will not energize until (FS) receives voltage to the pickup coil during the start sequence. Voltage will also flow through the N.C. Heat Relay 2 (HR2) contacts to energize the Cool Light (CL) on the light bar. Voltage is also available through the N.C. Defrost Relay (DR) contacts and the N.C. Heat Relay 4 (HR4) contacts to energize the Clutch (CLH) and Liquid Solenoid Valve 2 (SV2), respectively. With (UFR) and (URR) energized, the N.O. (UFR) and (URR) contacts close to energize Unloader Front (UF) and Unloader Rear (UR).

Five seconds after (RR) is energized, the microprocessor will energize the Glow Plug Relay (GPR) for a predetermined amount of glow time. The amount of time that (GPR) is energized is determined by engine coolant temperature and the engine being used. (See chart on page 11)



NOTES:

1. UNIT SHOWN IN "OFF" POSITION.
2. WIRE IDENTIFICATION SYSTEM:
   COLOR: WHITE - DC CONTROL CIRCUITS
   BLACK - GROUNDS
   RED - AC CIRCUITS
   GREEN - AC GROUNDS
3. ADDRESS SYSTEM: EXAMPLE, HCD2-MPW2 INDICATES A WIRE BETWEEN PLUG HC, PIN D2 AND MICROPROCESSOR MP AND PIN W2.
4. * VOLTAGE BELOW 12 VOLTS.

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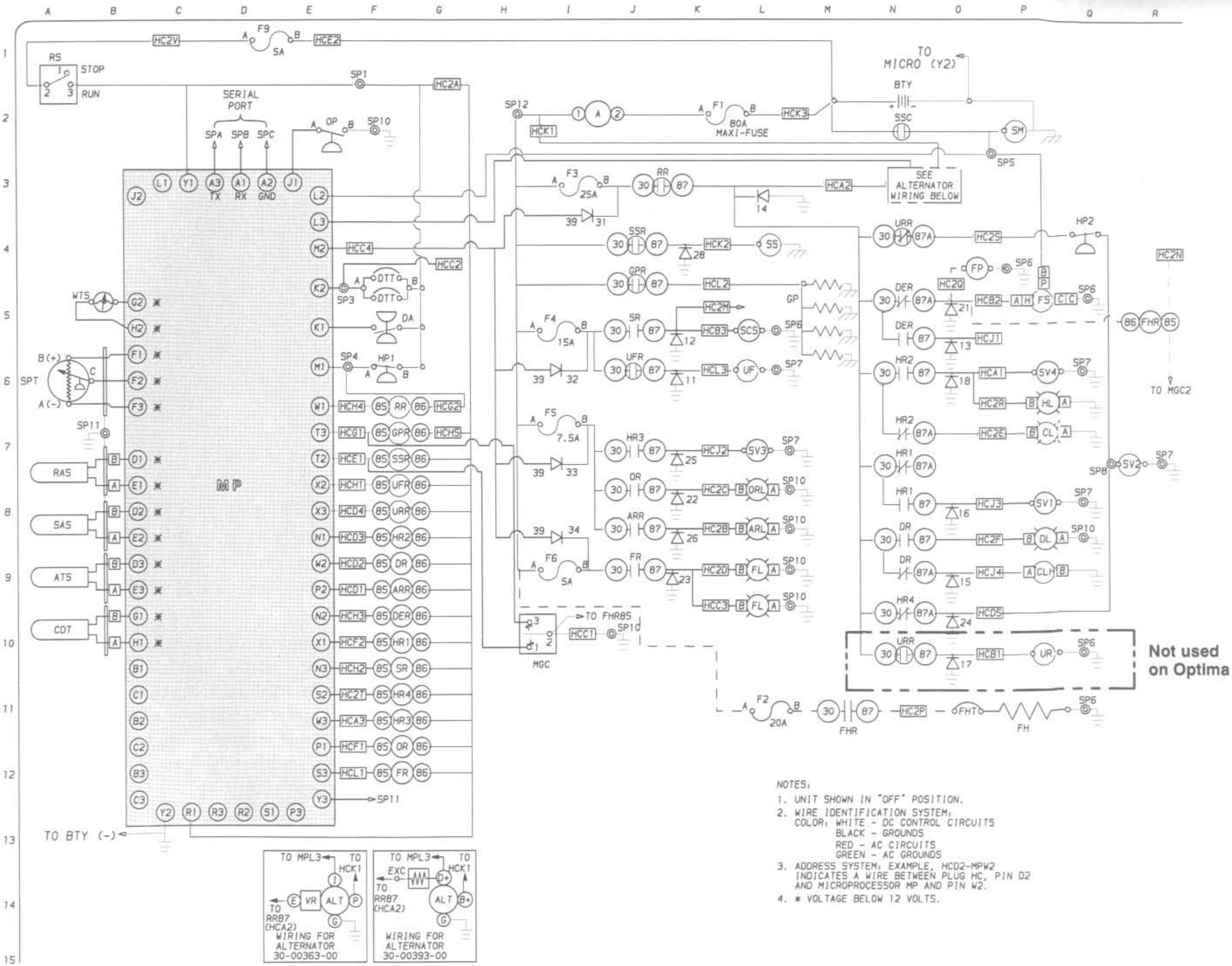
STARTING

Building onto the preheat schematic, the unit is shown here in the starting mode. After the predetermined glow time, the microprocessor will energize the Starter Solenoid Relay (SSR), closing the N.O. (SSR) contacts, energizing the Starter Solenoid (SS). When (SS) is energized, it will close the N.O. set of contacts labeled (SSC), energizing the Starter Motor (SM). At the same time, 12 volts are supplied to the pickup coil input of (FS), energizing (FS). When (SM) is de-energized, the (FS) pickup coil will be de-energized; however, the (FS) holding coil will keep (FS) energized.

If the microprocessor does not sense (SM) cranking (at MPL2) within two seconds from energizing (SSR), it will initiate a second start attempt after a 15-second delay. If the microprocessor does not sense (SM) cranking within two seconds on the second start attempt, Alarm AL8 (STARTER) will be initiated.

Once the engine has started, [the microprocessor senses engine start at (MPL3) alternator aux output], the microprocessor de-energizes (GPR) and (SSR) to terminate cranking.

The microprocessor holds the unit in low-speed unloaded cool for 15 seconds after terminating the starting sequence.



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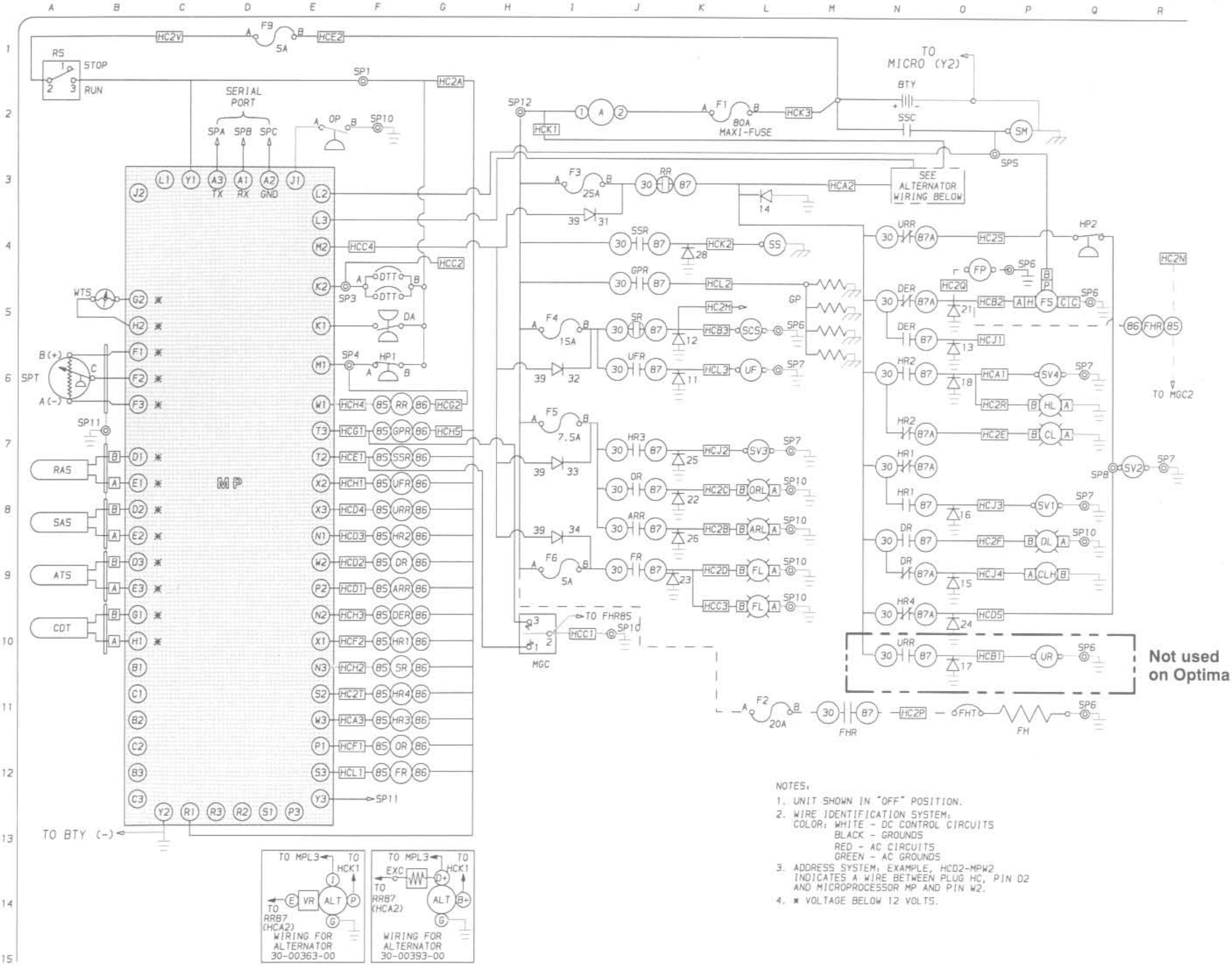
HIGH-SPEED LOADED COOL

When the trailer temperature is sufficiently above the desired setpoint, the microprocessor will place the unit in high-speed loaded cool, depending on suction pressure/ambient temperature. To do this, the microprocessor will energize (SR). This will cause the N.O. (SR) contacts to close, energizing the Speed Control Solenoid (SCS) on the engine. When (SCS) pulls in, it opens the fuel rack on the injection pump, placing the engine in high-speed operation.

NOTE: There is a one-minute delay for high speed after switching to cool from heat. If cool is required upon startup then there is no delay if high speed is required.

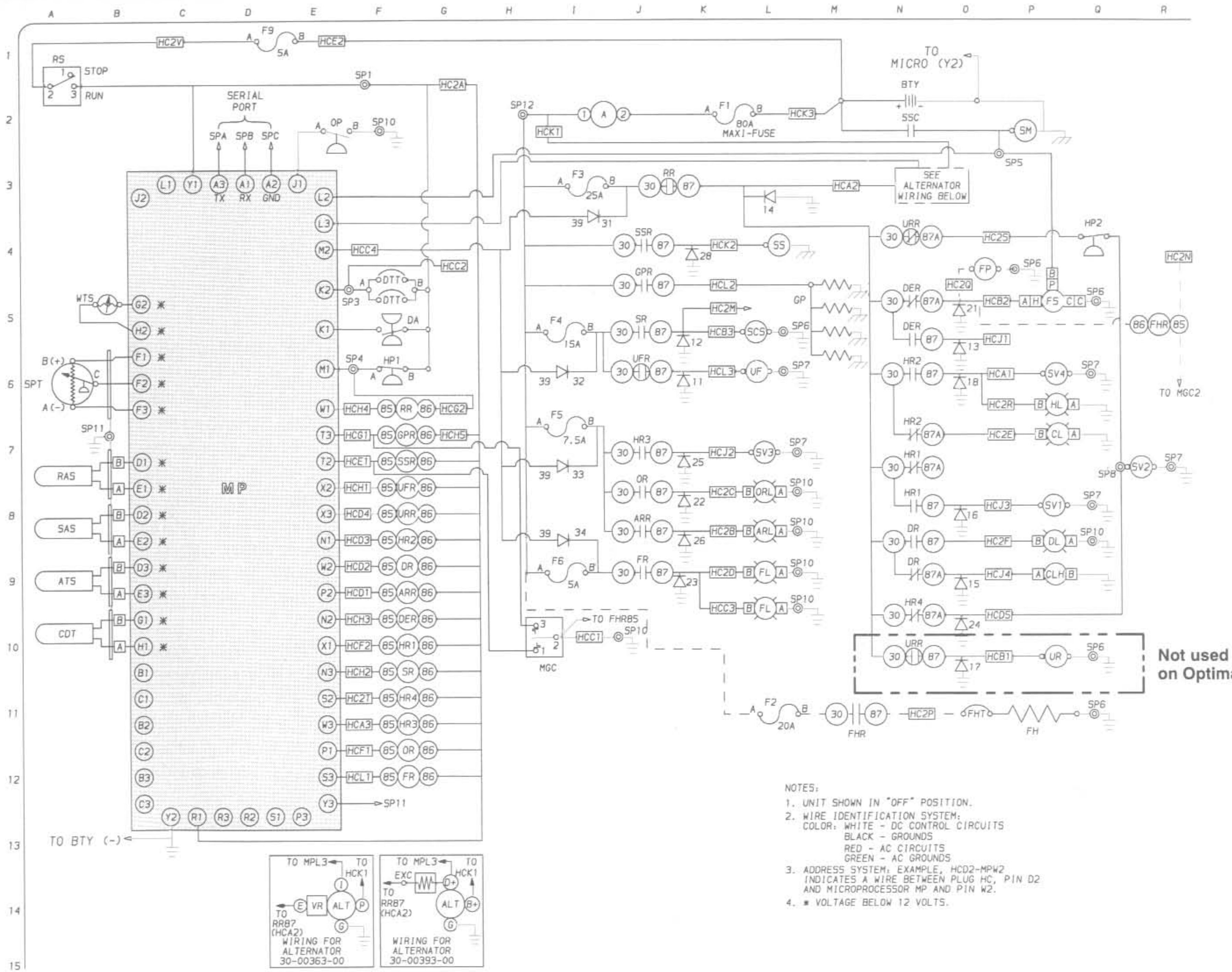


Dwg. No. 62-02589 Rev A (Sheet 2 of 2)

LOW-SPEED UNLOADED COOL

As the trailer temperature falls toward setpoint, the microprocessor will first place the unit into low-speed four-cylinder cooling. The temperature at which this occurs is not fixed. It depends upon the average temperature of the active controller probe in relation to the setpoint. To place the unit into low-speed four-cylinder cooling, the microprocessor will de-energize (SR) and energize (UFR). This will open the N.O. (SR) contacts to de-energize (SCS), placing the engine in low-speed operation. At the same time, it will close the N.O. (UFR) contacts, energizing (UF). This will cause the front compressor bank to unload, leaving the center and rear cylinders compressing refrigerant through the system.

As the trailer temperature continues to fall closer to setpoint, the microprocessor will place the unit into low-speed two-cylinder cooling by energizing (URR). This will close the N.O. (URR) contacts, causing the rear compressor bank to unload (excluding Optima), leaving just the center cylinders compressing refrigerant. The N.C. (URR) contacts open; however, this will have no effect on (SV2), because (SV2) will remain energized through the N.C. (HR4) contacts.



NOTES:

1. UNIT SHOWN IN "OFF" POSITION.
2. WIRE IDENTIFICATION SYSTEM:
   COLOR: WHITE - DC CONTROL CIRCUITS
   BLACK - GROUNDS
   RED - AC CIRCUITS
   GREEN - AC GROUNDS
3. ADDRESS SYSTEM: EXAMPLE, HCD2-MPW2 INDICATES A WIRE BETWEEN PLUG HC, PIN D2 AND MICROPROCESSOR MP AND PIN W2.
4. * VOLTAGE BELOW 12 VOLTS.

Dwg. No. 62-02589 Rev A (Sheet 2 of 2)

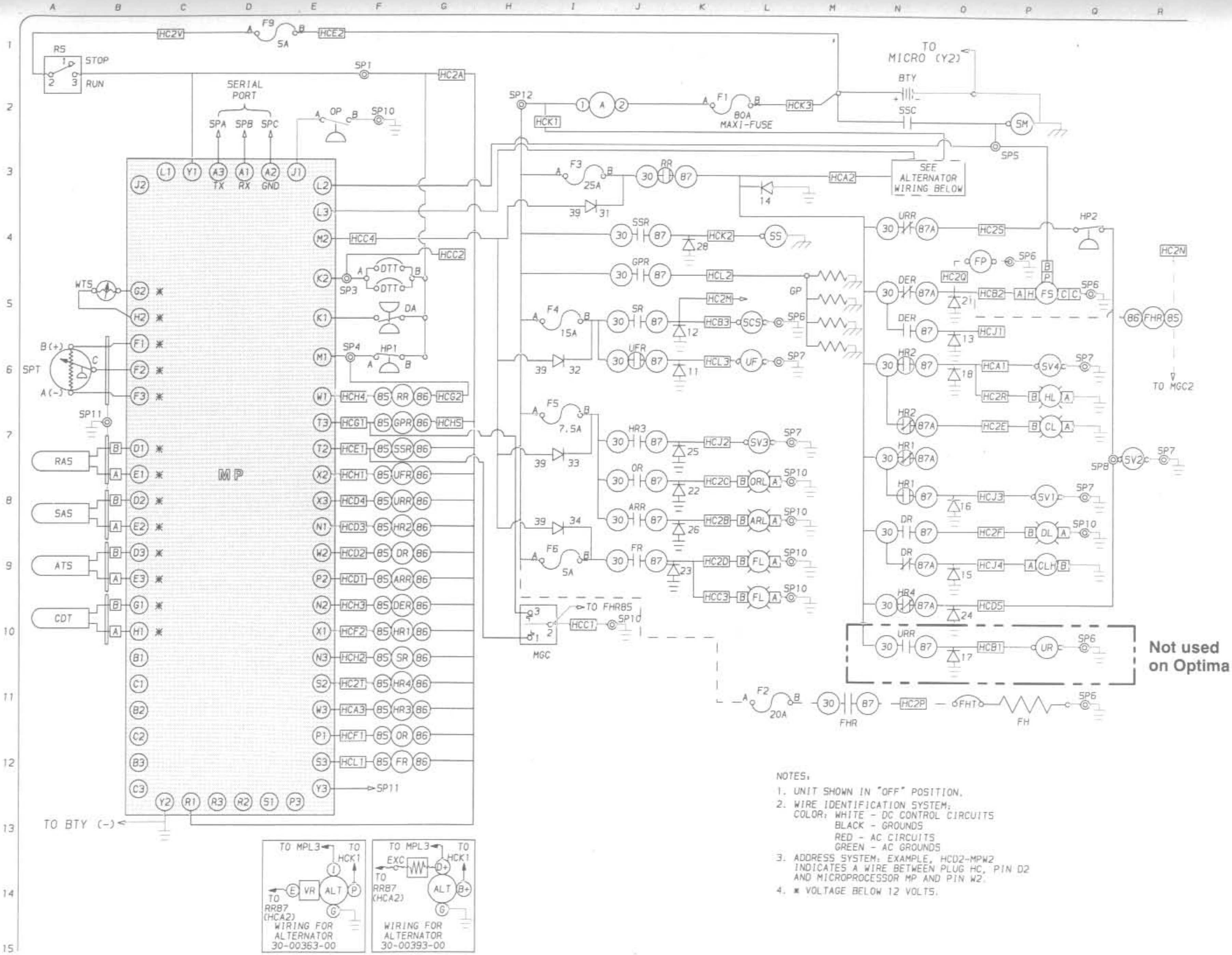
LOW-SPEED UNLOADED HEAT

The controller will switch the unit into low-speed unloaded heat if low-speed unloaded cool continues to drop the trailer temperature toward setpoint or below. The microprocessor will energize (UFR), (HR1), (HR2), and (HR4). (URR will not energize in heat.) When these relays energize, several actions take place. Heat Relay 1 (HR1) closes a set of N.O. (HR1) contacts to energize the Condenser Pressure Control Valve (SV1), thus closing the condenser outlet.

Heat Relay 2 (HR2), when energized, opens a set of N.C. (HR2) contacts to de-energize the Cool Light (CL). At the same time, (HR2) closes a set of N.O.(HR2) contacts to energize the Hot Gas Solenoid Valve 4 (SV4) and the Heat Light (HL). With (SV4) energized, high-pressure vapor is allowed to enter the evaporator.

(HR4) will open a set of N.C. (HR4) contacts , placing (SV2) under the control of the Head Pressure Control switch (HP2). With a rise or decrease in head pressure, (HP2) will open or close to control (SV2). (SV2) will now cycle open and closed to control discharge pressure.

NOTE: The controller will only place the unit into heat for entered setpoints above 10°F (−12°C). Heating is locked out for setpoints at or below 10°F (−12°C).



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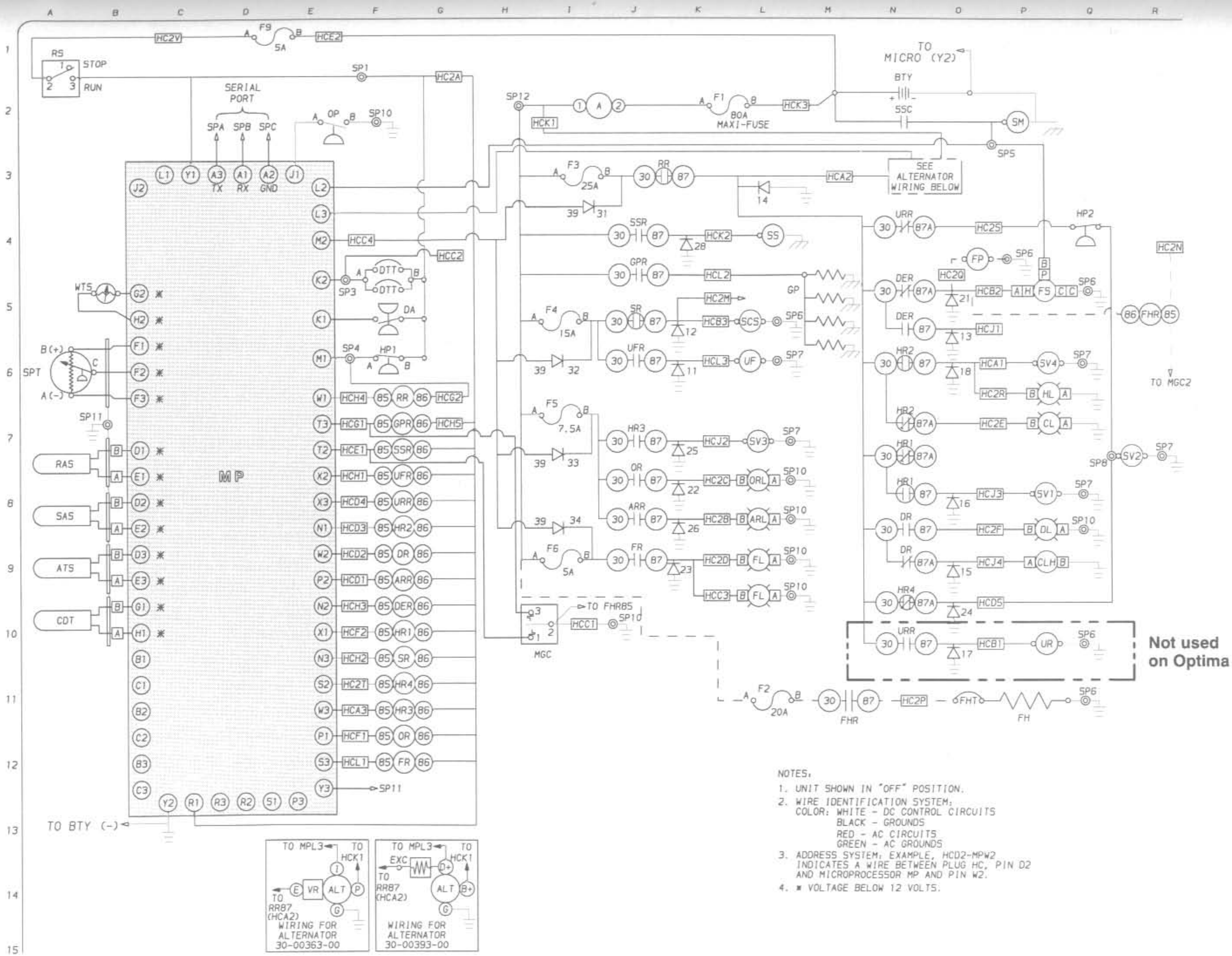
HIGH-SPEED LOADED HEAT

When maximum heating capacity is required, the microprocessor will place the unit into high-speed heat. (HR1), (HR2), (HR4) and (SR) will be energized by the microprocessor. (HR1), (HR2) and (HR4) will put the unit into the heat mode just as it does in low-speed heat. To place the unit in high speed, the microprocessor will energize (SR). This will cause the N.O. (SR) contacts to close, energizing the Speed Control Solenoid (SCS) on the engine. When (SCS) pulls in, it opens the fuel rack on the injection pump to place the engine in high-speed operation. There may be a 5-minute delay for the unit to energize the Speed Relay when switching to heat from low-speed cool.

NOTE: Hot Gas Solenoid Valve 3 (SV3) will open after a 60-second delay if the engine is in high speed, and the difference between ambient and discharge temperatures exceeds 100°F (55.5°C). If the difference goes below 50°F (27.8°C), SV-3 will close.



NOTES:

1. UNIT SHOWN IN "OFF" POSITION.
2. WIRE IDENTIFICATION SYSTEM:
   COLOR: WHITE - DC CONTROL CIRCUITS
   BLACK - GROUNDS
   RED - AC CIRCUITS
   GREEN - AC GROUNDS
3. ADDRESS SYSTEM: EXAMPLE, HCD2-MPW2 INDICATES A WIRE BETWEEN PLUG HC, PIN D2 AND MICROPROCESSOR MP AND PIN W2.
4. * VOLTAGE BELOW 12 VOLTS.

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DEFROST

The defrost mode can be initiated in three different ways. Manual defrost is accomplished by pressing the manual defrost key on the keypad. Defrost can be initiated automatically at preset intervals by the defrost timer built into the controller. Since the defrost intervals and manual defrost are part of the microprocessor, they are not shown on the schematic.

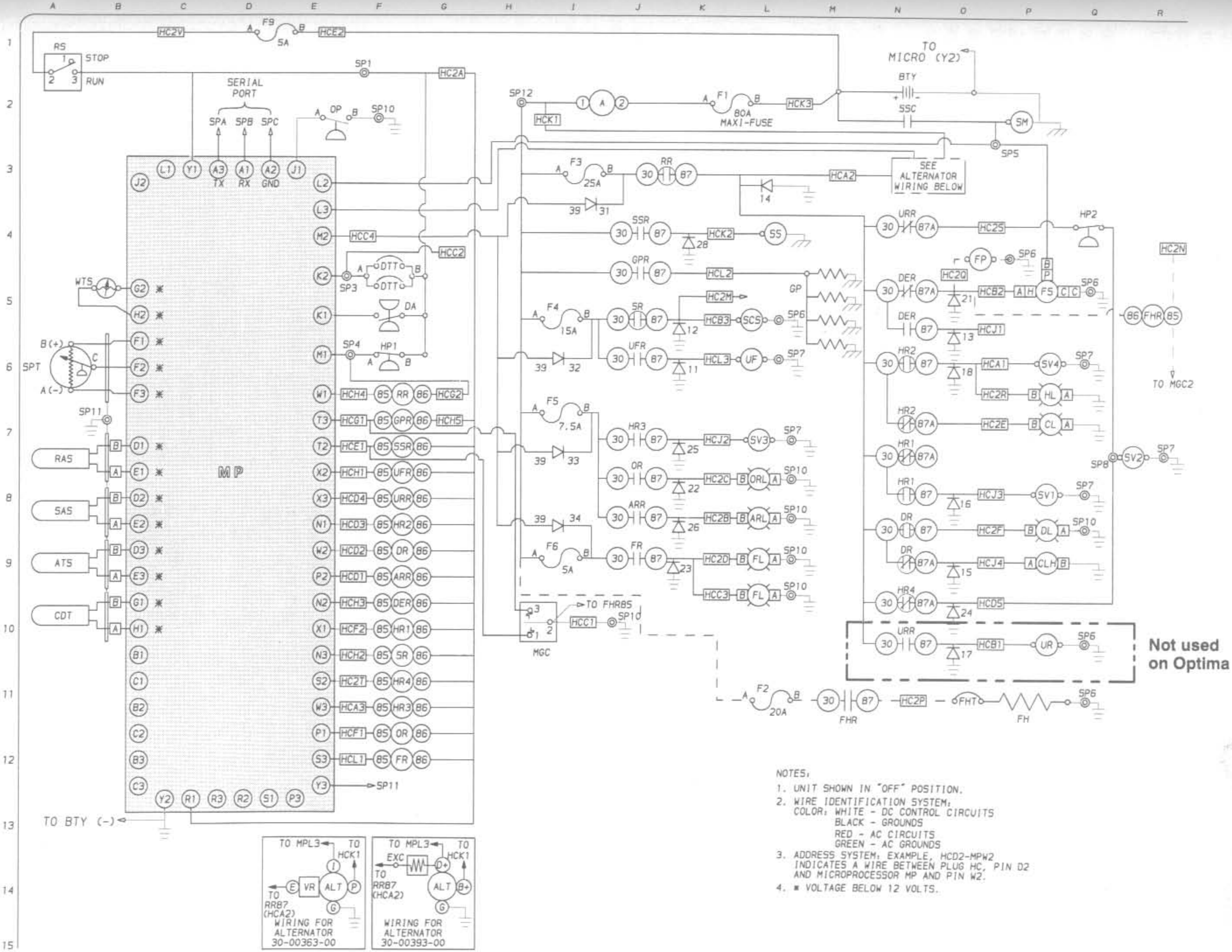
This schematic shows the third means of defrost initiation: by the Defrost Air Switch (D.A.). When the airflow through the evaporator coil becomes restricted from ice build-up during the cooling operation, the pressure differential across the evaporator coil will cause (D.A.) to close. This will initiate a defrost cycle to clear the evaporator coil of ice and frost. The air switch will close, supplying 12V potential to pin (MPK1) on the microprocessor. The microprocessor then looks for voltage at pin (MPK2). Voltage at pin (MPK2) indicates that at least one Defrost Thermostat (DTT) is closed. [The DTT defrost thermostats close below 40°F ± 5°F (4.4 ± 3°C)]. If both thermostats are open, defrost cannot be initiated by any of the methods listed above.

The Defrost Relay (DR) is energized during defrost. When (DR) energizes, a set of N.O. (DR) contacts close, energizing the Defrost Light (DL). At the same time, a set of N.C. (DA) contacts open to de-energize the clutch, stopping fan rotation. This will prevent hot air circulation to the load.

In addition, during defrost, (SR, HR1, HR2, HR4) are enabled to apply high-speed heat (with SV3 available for ambients below 100°F) (37.8°C) for hot gas heating.

With ambients above 100°F (37.8°C), the microprocessor will perform a 30-second to 90-second pumpdown prior to entering defrost. In addition, SV3 will be locked out during this defrost cycle.

NOTE: When exiting Defrost, the microprocessor will place the unit in low-speed operation by de-energizing (SR). This will open the N.O. (SR) contacts to de-energize (SCS), slowing the engine speed to 1350 RPM. After a 5-second delay, the microprocessor will de-energize (DR); the N.O. (DR) contacts open, de-energizing (DL), while the N.C. (DR) contacts close, engaging the clutch.



Dwg. No. 62-02589 Rev A (Sheet 2 of 2)

AUTOMATIC START/STOP

Start/Stop Features

- Variable glow time
- Three start attempts
- Selectable minimum on-time
- Low engine temperature protection
- Low-battery protection
- Selectable minimum off-time temp start (FN6 OFF)
- Maximum off-time time start (FN6 ON)

The automatic start/stop system is used to start and stop the diesel-driven compressor as required. The main function of the start/stop system is to cycle the refrigeration system off and on to save fuel, reduce wear and tear, and thus reduce operating cost. This feature is standard on all microprocessor-controlled units. It utilizes the same controller sensors, glow plug, and starter solenoid relays used for AUTO START CONTINUOUS RUN and MANUAL START CONTINUOUS RUN operation.

Several design improvements have been made over previous trailer refrigeration start/stop controls. These are:

1) Variable glow time: Based on engine coolant temperature, as follows:

Ambient Temperature	Glow Time in Seconds	
	TV	DI
Less than 32°F (0°C)	15	55
33°F to 50°F (1°C to 10°C)	10	40
51°F to 77°F (11°C to 25°C)	5	25
Greater than 78°F (26°C)	0	10

2) Three start attempts: If the unit fails to start and run the minimum run time on three consecutive start attempts, the alarm START FAIL (AL3) is activated, and the Fault Light is energized.

3) Selectable minimum on-time: The engine is allowed to turn off only after a minimum of 4 or 7 minutes of run time (selectable through the keypad's Function Change key).

The unit will shut down when the box temperature is within ± 0.5°F (± 0.3°C) of setpoint for the Perishable Range or +0.5°F (+0.3°C) above setpoint for the Frozen Range.

4) Low engine temperature protection: The engine will not shut down if engine coolant temperature is below 122°F (50°C). If engine coolant temperature drops to 32°F (0°C) during "off-time," the engine will restart.

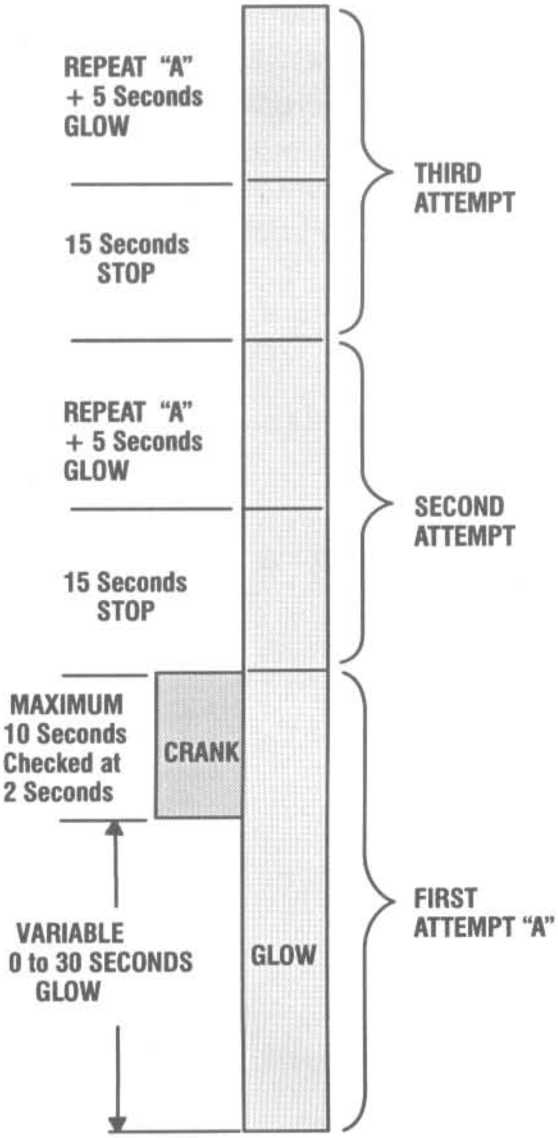
5) Low battery voltage protection: The battery voltage must be above 13.4 volts to allow shutdown. If battery voltage drops to 11.0 volts during "off-time," the engine will restart. If battery voltage drops below 10.0 volts during glow cycle, the starter will not be engaged, and the start sequence will continue; this is considered a failed start. The start sequence is repeated until the unit starts or three consecutive start attempts have failed.

6) Selectable minimum off-time (FN6 OFF): The engine will restart after minimum off-time of 10, 20, 30, 45, or 90 minutes (selectable through the keypad's Function Change key).

After the minimum off-time, the unit will restart for temperatures beyond ± 3.6°F (± 2.0°C) of setpoint for the Perishable Range or above +3.6°F (+2.0°C) of setpoint for the Frozen Range.

7) Maximum off time (FN6 ON): The engine will restart 30 minutes after the engine has stopped regardless of the box temperature (selectable through the keypad's Function Change key).

START SEQUENCE



When the starting conditions are met, the start sequence will begin by energizing the Run Relay (RR), and after 5 seconds, energizing the Glow Plug Relay (GPR) to supply voltage to the glow plugs. After a pre-determined glow time the Starter Solenoid Relay (SSR) is energized, energizing the starter motor (SM) to crank the engine. The engine cranking period is a maximum of 10 seconds. If the engine starts before 10 seconds has elapsed, the alternator auxiliary signal will cause the microprocessor to de-energize the (SSR), de-energizing the (SM). The oil pressure signal is ignored for 15 seconds from this time, as it is during manual operation.

If the engine fails to start, after a 15-second null cycle, a second start attempt with glow time increased by 5 seconds over the first attempt will begin. If this attempt fails, after a 15-second null cycle, a third and final attempt identical to the second attempt will begin. If the unit fails to start after the third attempt, starting is locked out, and the alarm START FAIL (AL3) is activated with the (FL) energized. The START/FAIL alarm (AL3) will also be activated if the unit fails to run for the minimum run time (4 or 7 minutes) on three consecutive start attempts. This will eliminate battery drain and unnecessary unit wear and tear caused by high-pressure shutdowns, low-fuel shutdowns, etc.

Note: The starting sequence for START/STOP is the same for that of AUTO START CONTINUOUS RUN, with the following exception:

The microprocessor will energize the AUTO RESTART RELAY (ARR) 5 seconds before (RR) and (DR). This will close a set of N.O. (ARR) contacts, energizing the Auto Restart Light (ARL) on the light bar, indicating to the operator that the unit is in the START/STOP mode and may start at any time.

SHUTDOWN CONDITIONS

- Minimum run time complete (4 or 7 minutes)
- Battery voltage must be above 13.4 volts
- Box temperature within ± 0.5°F (0.3°C) of setpoint for perishable range +0.5°F (0.3°C) above setpoint for frozen range
- Engine coolant temperature must be above 122°F (50°C)

Once the unit has started automatically, the unit *must* run for a minimum of 4 or 7 minutes before shutting off. This minimum run time is to prevent short cycling and ensure adequate airflow through the load to allow the controller to accurately sense load temperature and bring the battery up to minimum voltage level. It also prevents "hot spots" in a properly loaded box.

After the minimum run time is complete, the microprocessor will check the remaining conditions that must be satisfied to allow a shutdown. These are:

1) Battery voltage must be above 13.4 volts (measured at Y1).

2) The box temperature (active probe) must be satisfied:

Perishable Range Setpoints ± 0.5°F (0.3°C)

Frozen Range Setpoints + 0.5°F (0.3°C)

3) Engine coolant temperature must be above 122°F (50°C).

If *ALL* of these conditions are not satisfied, the engine will continue to run until they are.

When *ALL* the shutdown conditions are satisfied, the microprocessor will break the run relay (RR) ground path at W1, causing the engine to stop.

RESTART CONDITIONS

- Minimum off-time complete, temp start (FN6 OFF) (10, 20, 30, 45 or 90 minutes)
- Box temperature out of range ± 3.6°F (2.0°C) from setpoint for Perishable Range +3.6°F (2.0°C) above setpoint for Frozen Range
- Maximum off-time, time strt (FN6 ON)

"Override" Conditions

(Overrides 1, 2 and 3 above)

- Engine coolant temperature falls to 32°F (0°C)
- Battery voltage drops to 11.0 volts
- Box temperature override out of range ± 11°F (6°C) from setpoint for Perishable Range + 11°F(6°C) above setpoint for Frozen Range

Once the engine has cycled off, it will remain off for the selected off-time **TEMP STRT (FN6 OFF) Temperature-Based restarting.** This prevents the engine from rapid cycling due to changes in air temperature. Air temperature in the box can change rapidly, but it takes time for product temperature to change.

After the off-time is complete, the microprocessor checks the active probe temperature (box temperature). It must be at least ± 3.6°F (± 2.0°C) beyond setpoint for the Perishable Range or above +3.6°F (+2.0°C) of setpoint for the Frozen Range for a restart to be initiated.

If **TIME STRT (FN6 ON) Maximum Off-Time 30 min**. has been selected, restart will be initiated 30 minutes after the unit cycles off.

There are three conditions that can override the off-time and box temperature for immediate restart. They are:

- Coolant temperature falls to 32°F (0°C)
- Battery voltage drops to 11.0 volts
- Box temperature more than 11°F (6°C) away from setpoint

  ± 11°F (6°C) from setpoint for Perishable Range

  +11°F (6°C) above setpoint for Frozen Range.

Whenever the engine restarts, it must satisfy all shutdown conditions before it can automatically shut off.

ELECTRICAL SCHEMATICS

Auto Start / Stop Operation

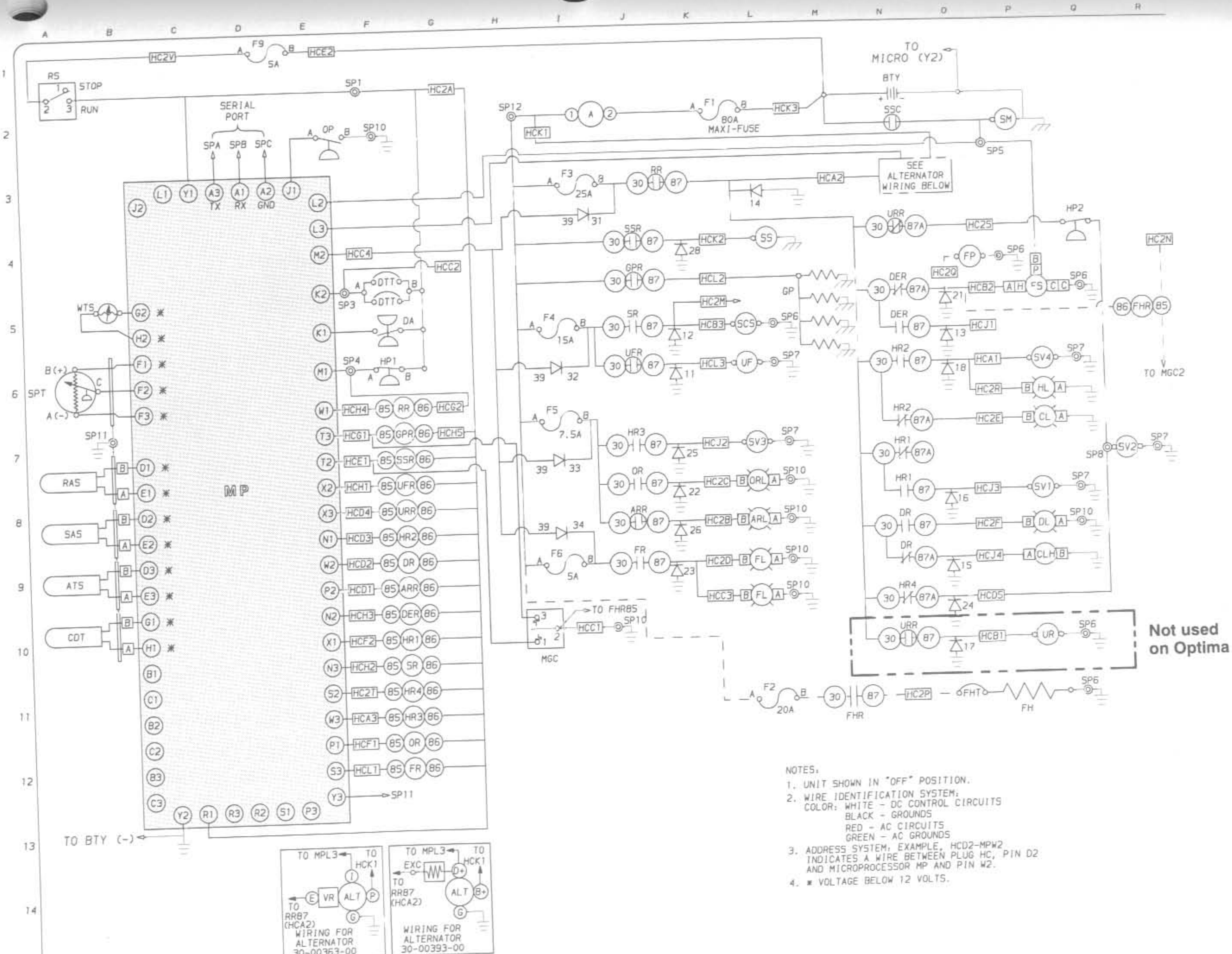
PREHEAT DURING CRANKING

To start the unit in the Start/Stop mode, place the RUN/STOP switch in the RUN position. The microprocessor will perform a self-test (all display messages will appear in display window). Then, setpoint and box temperature will be displayed. Press the AUTO START/STOP - CONTINUOUS key until the START/STOP symbol appears in the display, indicating that the unit is in START/STOP mode.

CAUTION

The starting sequence for START/STOP is the same as that for AUTO START CONTINUOUS RUN, on pages 16 and 18, with the following exception:

The microprocessor will energize the AUTO RESTART RELAY (ARR) 5 seconds before (RR). This will close a set of N.O. (ARR) contacts, energizing the Auto Restart Light (ARL) on the light bar, indicating to the operator that the unit is in the START/STOP mode and may start at any time.



NOTES:

1. UNIT SHOWN IN "OFF" POSITION.
2. WIRE IDENTIFICATION SYSTEM:
   COLOR: WHITE - DC CONTROL CIRCUITS
   BLACK - GROUNDS
   RED - AC CIRCUITS
   GREEN - AC GROUNDS
3. ADDRESS SYSTEM: EXAMPLE, HCD2-MPW2 INDICATES A WIRE BETWEEN PLUG HC, PIN D2 AND MICROPROCESSOR MP AND PIN W2.
4. * VOLTAGE BELOW 12 VOLTS.

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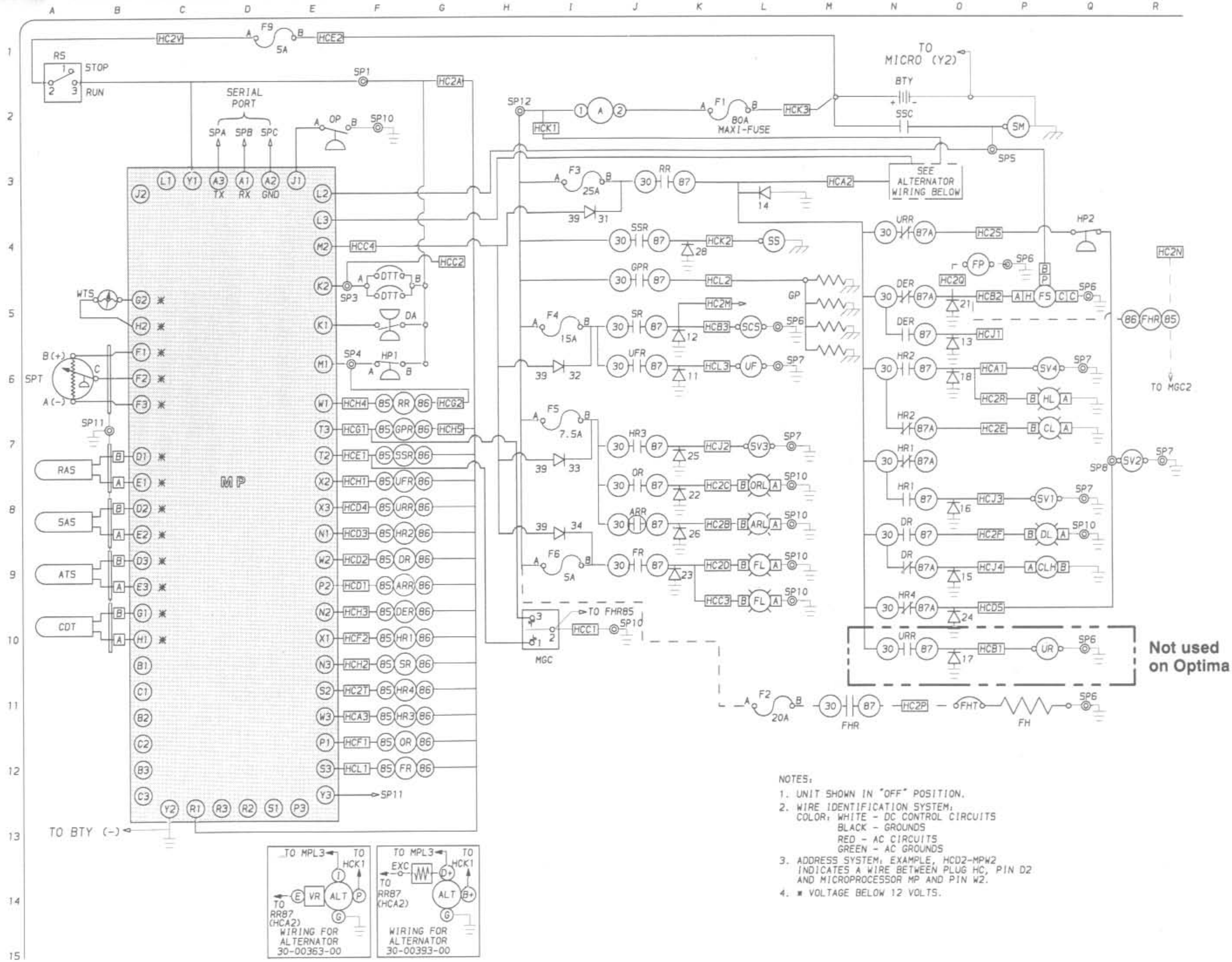
OFF CYCLE

When in Start/Stop off cycle, the microprocessor will de-energize all of the relays, with the exception of (ARR). (ARR) will remain energized to keep the Auto Restart Light (ARL) energized on the light bar.

The microprocessor will continue to monitor the system and will initiate a restart sequence when restart conditions are satisfied.



NOTES:

1. UNIT SHOWN IN "OFF" POSITION.
2. WIRE IDENTIFICATION SYSTEM:
   COLOR: WHITE - DC CONTROL CIRCUITS
   BLACK - GROUNDS
   RED - AC CIRCUITS
   GREEN - AC GROUNDS
3. ADDRESS SYSTEM: EXAMPLE, HCD2-MPW2 INDICATES A WIRE BETWEEN PLUG HC, PIN D2 AND MICROPROCESSOR MP AND PIN W2.
4. * VOLTAGE BELOW 12 VOLTS.

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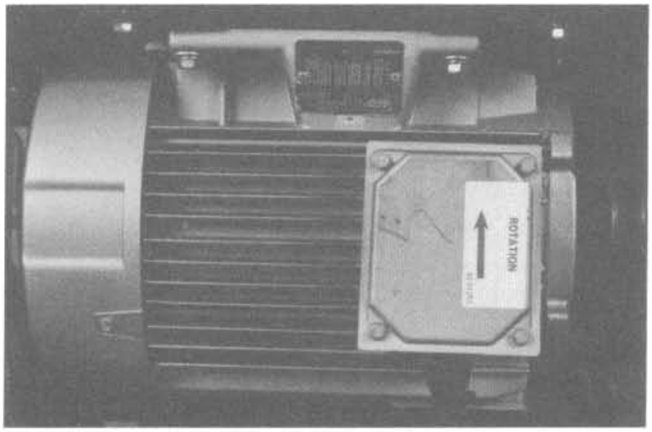


ELECTRIC STANDBY OPERATION

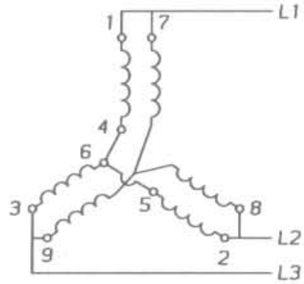
Model NDM-94 is similar to model NDA-94, except that it contains a standby electric motor, standby motor contactor and a receptacle for a power plug.

When in operation, the diesel engine drives the compressor directly through a centrifugal clutch assembly. During standby operation, the centrifugal clutch is disengaged from the compressor sheave assembly. The compressor is then belt-driven by the standby motor.

During standby operation, the microprocessor controls the cycling of the unit and provides a minimum on-time of 5 minutes and off-time of 5 minutes, to avoid short cycling of the electric motor. The microprocessor will restart the unit if the battery voltage drops below 11.0 volts to recharge the battery after the minimum off-time delay. At startup, the microprocessor will also energize the unloaders for 5 seconds to allow the electric motor to reach proper rpm.

STANDBY MODEL CHART

MODEL	NDA-94	NDM-94
REFRIGERANT	R-22	R-22
COMPRESSOR 05G	41cfm	37cfm
ENGINE	CT4-134-TV	CT4-134-TV
ENGINE HIGH SPEED	1900	1700
ENGINE LOW SPEED	1350	1350
ELECTRIC STANDBY		230V 60hz



230V CIRCUIT

STANDBY MOTOR DATA, 60HZ

HORSEPOWER	15hp
VOLTAGE	230
FULL LOAD AMPS	35.6
LOCK ROTOR AMPS	298
RPMS	3550

STARTING

1. Place the RUN/STOP (RS) switch in the STOP position.

2. Plug in the power cord to the Power Supply Receptacle (PSR).

3. Place the Selector Switch (SSW) in the Standby position.

4. Place the RUN/STOP (RS) switch in the RUN position.The microprocessor will perform a 5-second self-test (all display messages will appear in the display window). Then, setpoint and box temperature will be displayed.

5. Check for proper motor rotation. Condenser air must be drawn into the unit. To reverse rotation, stop unit, disconnect power cord, and change polarity.

STOPPING

Place the RUN/STOP (RS) switch in the stop position.

WARNING

When changing from standby operation to diesel operation, first turn the unit off, turn off the main power supply, and remove the power cord from the Power Supply Receptacle (PSR).

FEATURES

- Two operating modes
- Minimum on-time (5 minutes)
- Minimum off-time (5 minutes)
- Low-battery protection

Electric Standby can operate in the Start/Stop mode or the Continuous Run mode.

PERISHABLE RANGE

Setpoints above 10°F (–12°C)

- STANDBY COOL
- STANDBY OFF
- STANDBY HEAT

During Start/Stop operation, (Perishable Range) the unit will operate in 3 modes: A) "Cool" cycle, B) "Off" cycle and, C) "Heat" cycle.

FROZEN RANGE

Setpoints at or below 10°F (–12°C)

- STANDBY COOL
- STANDBY OFF

During Start/Stop operation (Frozen Range), the unit will operate in two modes: "Cool" cycle and "Off" cycle.

In Start/Stop mode, when the box temperature gets within ± 0.5°F (0.3°C) of setpoint in Perishable Range[+0.5°F (0.3°C) in the Frozen Range], the controller cycles the Standby Motor (SBM) off to conserve energy. The microprocessor automatically locks out heating for entered setpoints at or below 10°F (−12°C). Therefore, it is possible for the box temperature to fall below setpoint in the Frozen Range.

2) Minimum "ON" time (5 minutes): The unit *must* run for the minimum run-time before it can shut off. This minimum run time prevents short cycling and ensures adequate airflow through the load to allow the controller to accurately sense load temperature and bring the battery up to minimum voltage level. It also prevents "hot spots" in a properly loaded box.

After the minimum run time is complete, the microprocessor will check the remaining conditions that must be satisfied to allow a shutdown:

A) Battery voltage must be above 13.4 volts (measured at Y1).

B) The box temperature (active probe) must be satisfied:

Perishable Range Setpoints less than ± 0.5°F (0.3°C)

Frozen Range Setpoints less than + 0.5°F (0.3°C)

If *ALL* of these conditions are not satisfied, the motor will continue to run until they are to prevent rapid cycling of the electric drive motor.

3) Minimum off-time (5 minutes): Once the motor has cycled off, it will remain off for the minimum off-time. This prevents the motor from rapid cycling due to changes in air temperature. Air temperature in the box can change rapidly, but it takes time for the product temperature to change.

After the minimum off-time, the microprocessor will restart the standby motor if the box temperature drifts out of range, ± 3.6°F (2.0°C) from setpoint for Perishable Range and +3.6°F (2.0°C) above setpoint for Frozen Range.

4) Low battery voltage protection: The microprocessor will restart the unit if the battery voltage drops below 11.0 volts to recharge the battery after the minimum off-time delay.

NOTE: When in Continuous Run, Perishable Range, the unit will cycle between cool and heat to maintain box temperature at setpoint. In Frozen Range, the unit will run in cool only. Continuous Run is normally used for perishable products that require constant airflow.

Compressor Unloaders

On model NDM-94, the compressor unloaders operate the same as on model NDA-94 during diesel operation.

In standby mode, the suction pressure unloading points are different than in diesel operation.

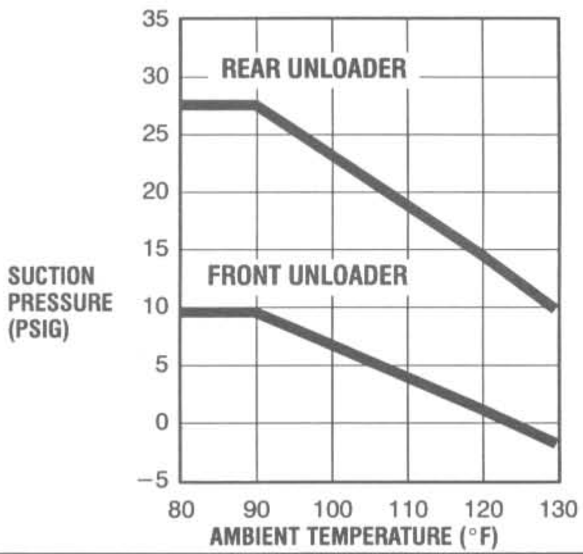
Suction Pressure Operation

The microprocessor will monitor suction pressure of the refrigeration system and control the unloaders to maintain a maximum operating pressure. A suction pressure transducer is used to signal the microprocessor to unload the compressor.

At Ambient Temperatures of 90°F (32.2°C) or Below

When the system is operating and the suction pressure is greater than 29 psig, both unloader banks are energized (unloaded). As the suction pressure drops below 29 psig, one bank is loaded. If the suction pressure drops below 11 psig, the remaining bank is loaded.

R-22 REFRIGERATION SYSTEM
STANDBY OPERATION
SUCTION PRESSURE UNLOADING



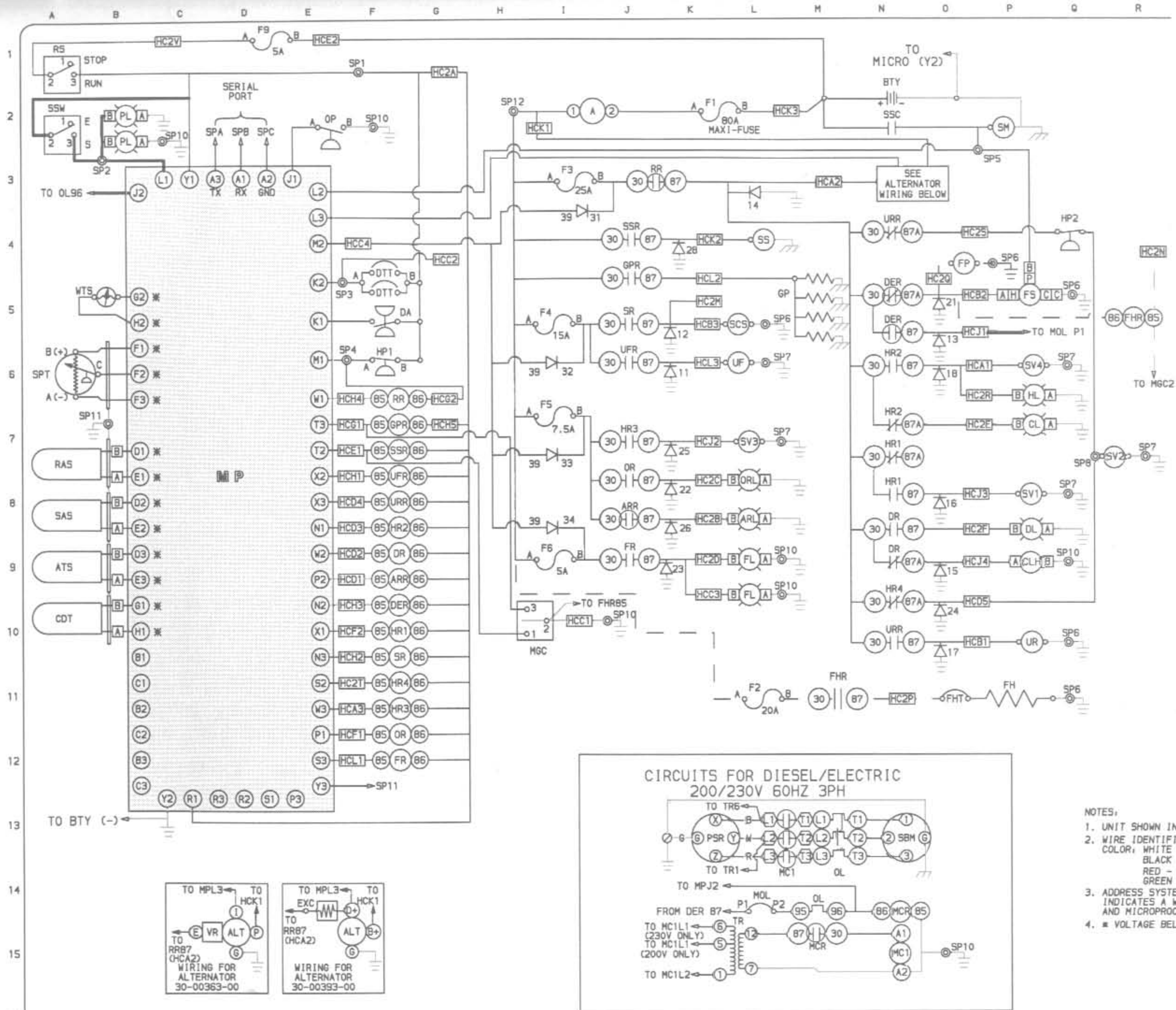
ELECTRICAL SCHEMATICS
Standby Operation

COOL

When in standby cool, the selector switch (SSW) is in the standby position. This energizes two power lights (PL), one on the display panel and the other on the optional light bar, indicating that the unit is in standby mode. The microprocessor first energizes (ARR). This closes a set of N.O. (ARR) contacts, energizing the Auto Restart Light (ARL) on the light bar, indicating that the unit is in the START/STOP mode and may start at any time. After a 5-second delay, the Diesel Electric Relay (DER) is energized; this opens the N.C. (DER) contacts, preventing the Fuel Heater Relay (FHR), Fuel Pump (FP), and the Run Solenoid (RS) from being energized during standby operation. At the same time, the N.O. (DER) contacts will close. This energizes the Motor Contactor (MC). The N.O. (MC) contacts close, supplying voltage to energize the standby motor.

At the same time, (RR) is energized, closing the N.O. (RR) contacts supplying voltage to the refrigeration control circuitry.

NOTE: At the beginning of the heat cycle, SV2 is de-energized. The microprocessor energizes SV1 and SV4 when suction pressure drops to 10 psig or after 1.5 minutes. The microprocessor then energizes SV2 after 30 seconds; it remains energized while the rear unloader is de-energized. When the rear unloader de-energizes, HP2 will control SV2.



NOTES:

1. UNIT SHOWN IN "OFF" POSITION.
2. WIRE IDENTIFICATION SYSTEM.
   COLOR: WHITE - DC CONTROL CIRCUITS
   BLACK - GROUNDS
   RED - AC CIRCUITS
   GREEN - AC GROUNDS
3. ADDRESS SYSTEM: EXAMPLE, HCD2-MPW2 INDICATES A WIRE BETWEEN PLUG HC, PIN D2 AND MICROPROCESSOR MP AND PIN W2.
4. * VOLTAGE BELOW 12 VOLTS.

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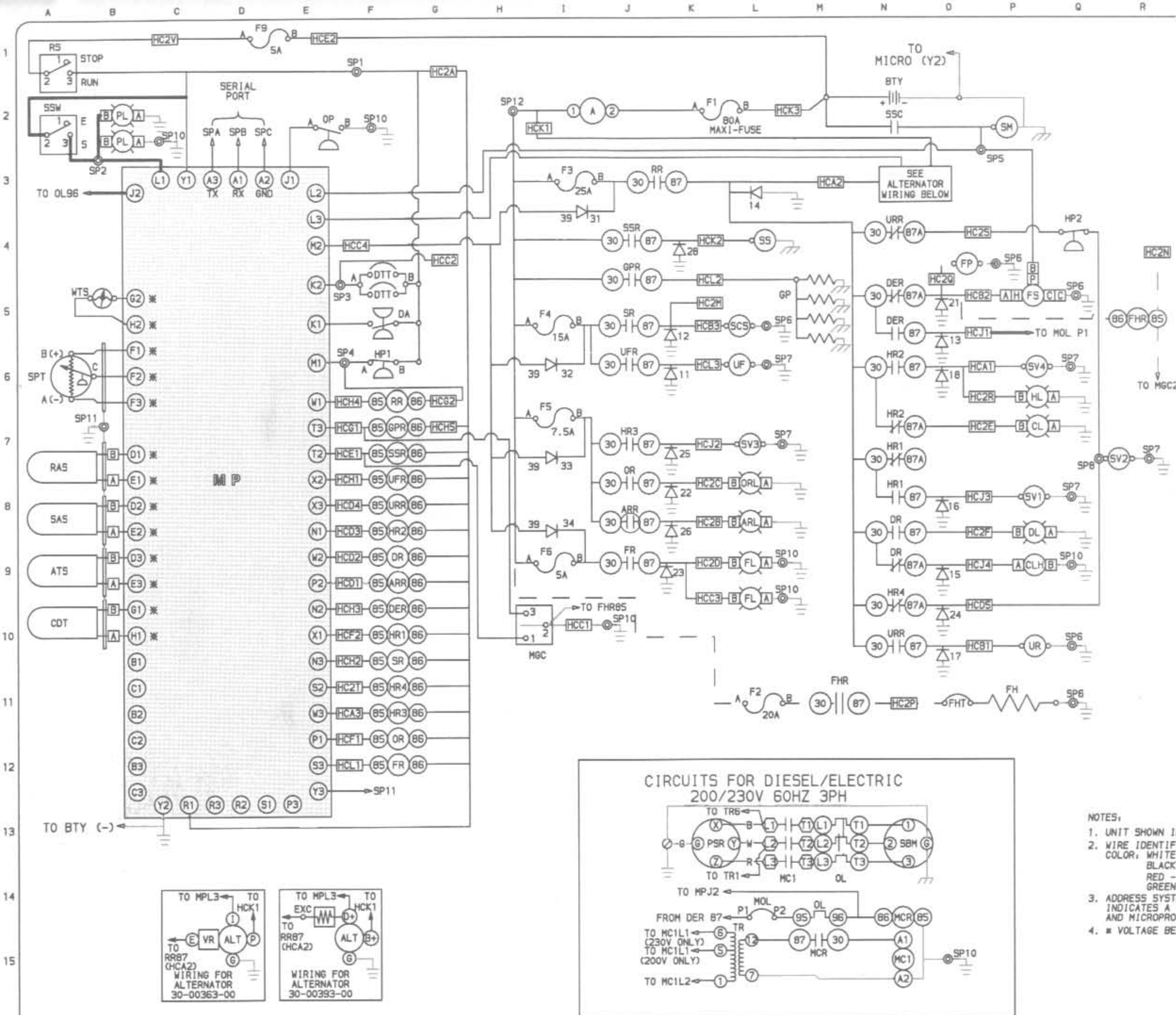
STANDBY OFF

In start/stop mode, after the standby motor has run at least 5 minutes and the controller is ready to switch from high speed cool to low speed cool (box temperature near setpoint), the microprocessor de-energizes the (RR), causing the standby motor to cycle off.

When the unit is "OFF," the microprocessor keeps (ARR) energized. The unit remains off for at least 5 minutes before restarting. If, after 5 minutes, the battery voltage drops below 11.0 volts or the box temperature drifts out of range, ± 3.6°F (2.0°C) from setpoint for Perishable Range and +3.6°F (2.0°C) above setpoint for Frozen Range, the standby motor restarts.



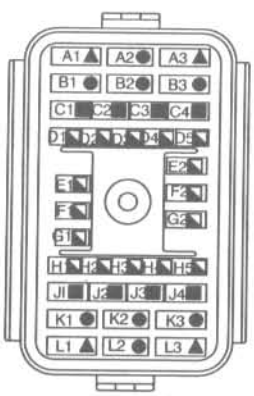
Dwg. No. 62-02620

NOTES:

1. UNIT SHOWN IN "OFF" POSITION.
2. WIRE IDENTIFICATION SYSTEM:
   COLOR: WHITE - DC CONTROL CIRCUITS
   BLACK - GROUNDS
   RED - AC CIRCUITS
   GREEN - AC GROUNDS
3. ADDRESS SYSTEM. EXAMPLE, HCD2-MPW2 INDICATES A WIRE BETWEEN PLUG HC, PIN D2 AND MICROPROCESSOR MP AND PIN W2.
4. * VOLTAGE BELOW 12 VOLTS.

HIGH-CURRENT PLUG CONNECTION POINTS					
A1	HR287	SV4	F2	HR185	MPX1
A2	DER30	SP9	G1	GPR85	MPT3
A3	HR385	MPW3	G2	RR86	SP4
B1	UR	URR87	H1	UFR85	MPX2
B2	FSHA	DER87A	H2	SR85	MPN3
B3	SCS	SR87	H3	DER85	MPN2
C1	DB19	SP10	H4	RR85	MPW1
C2	TP	SP3	H5	GPR86	MPR1
C3	FLB	FR87	J1	DER87	MOLA
C4	DB39	MPM2	J2	SV3	HR387
D1	ARR85	MPP2	J3	SV1	HR187
D2	DR85	MPW2	J4	CLHA	DR87A
D3	HR285	MPN1	K1	ALT+	A1
D4	URR85	MPX3	K2	SS	SSR87
D5	HR487A	SP8	K3	SSC	F1B
E1	SSR85	MPT2	L1	FR85	MPS3
E2	F9B	BAT+	L2	GP	GPR87
F1	OR85	MPP1	L3	UF	UFR87

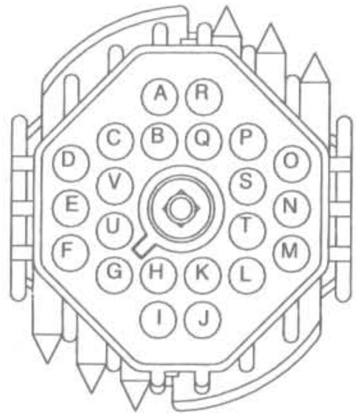
High-Current Plug



Shown above is an end view of the high-current plug, which is connected to the relay box. This plug connects the relay board to the electrical components of the unit.

(Example) A1 HR287 SV4 The high-current plug A1 has wires from the HC plug to the heat relay (HR2) connection 87, and from the HC plug to solenoid valve SV4.

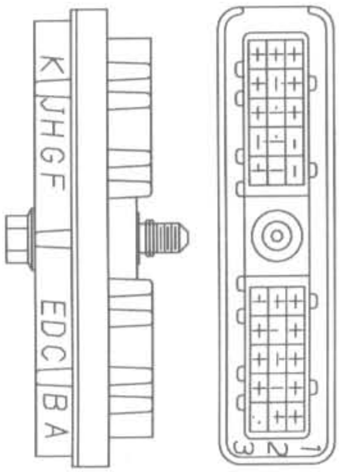
High-Current Plug 2



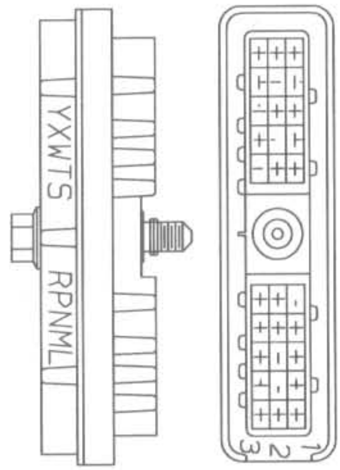
Shown above is an end view of high-current plug 2, which is connected to the relay box. This plug connects the relay board to the electrical components of the unit.

The chart below shows plug connection points from the relay box to specific electrical components and connections.

HIGH-CURRENT PLUG 2 CONNECTION POINTS			
CAV	LEAD	CAV	LEAD
A	DER86-SP1	L	CAVITY PLUG
B	ARLB-ARR87	M	CAVITY PLUG
C	ORLB-OR87	N	CAVITY PLUG
D	FLB-DB23	O	CAVITY PLUG
E	CLB-HR287A	P	FHR87-FHT
F	DLB-DR87	Q	FP-DB21
G	CAVITY PLUG	R	HLB-DB18
H	CAVITY PLUG	S	URR87A-HP2
I	CAVITY PLUG	T	MPS2-HR485
J	CAVITY PLUG	U	LBG-DB29
K	CAVITY PLUG	V	F9A-RS2



Microprocessor Wire Harness Plug A–K



Microprocessor Wire Harness Plug L–Y

Shown above are side and end views of the A through K plug that connects the microprocessor to the wiring harness of the unit.

Below are plug connection points from the microprocessor to specific electrical components and connections. For example, the wire from terminal A1 goes to serial port B (SPB) and is labeled MPA1–SPB.

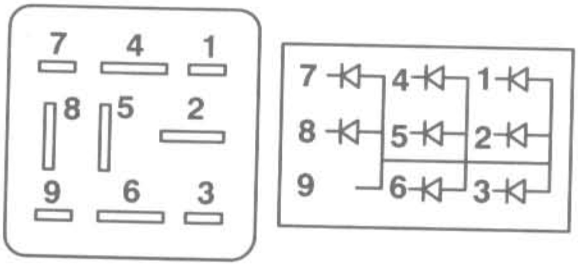
WIRE HARNESS PLUG CONNECTIONS/MICRO		
A1 SPB	D2 SASB	G3 SEAL PLUG
A2 SPC	D3 ATSB	H1 CDTA
A3 SPA	E1 RASA	H2 WTSB
B1 SEAL PLUG	E2 SASA	H3 SEAL PLUG
B2 SEAL PLUG	E3 ATSA	J1 OPA
B3 SEAL PLUG	F1 SPTB	J2 OL96
C1 SEAL PLUG	F2 SPTC	J3 SEAL PLUG
C2 SEAL PLUG	F3 SPTA	K1 DA
C3 SEAL PLUG	G1 CDTB	K2 SP3
D1 RASB	G2 WTSA	K3 SEAL PLUG

Shown above are side and end views of the L through Y plug that connects the microprocessor to the wiring harness of the unit.

Below are plug connection points from the microprocessor to specific electrical components and connections.

WIRE HARNESS PLUG CONNECTIONS/MICRO		
L1 SEAL PLUG	P2 ARR85	T3 GPR85
L2 SP5	P3 SEAL PLUG	W1 RR85
L3 ALTD+ (I)	R1 GPR86	W2 DR85
M1 SP4	R2 SEAL PLUG	W3 HR385
M2 DB39	R3 SEAL PLUG	X1 HR185
M3 SEAL PLUG	S1 SEAL PLUG	X2 UFR85
N1 HR285	S2 HR485	X3 URR85
N2 DER85	S3 FR85	Y1 SP1
N3 SR85	T1 SEAL PLUG	Y2 GRD
P1 OR85	T2 SSR85	Y3 SP11

Diode Block



Pin Layout Circuit Diagram

The diode block illustrations shown above are located on the relay board; they are labeled DB1, DB2, DB3 and are interchangeable. Each diode block contains eight diodes connected as shown above. The diodes are labeled on the schematic with a two-digit number, for example, "36." The first digit, "3," indicates that this diode is in diode block #3. The second digit, "6," indicates that this diode is the #6 diode.

If a diode is suspected defective, shut the unit off and remove the diode block from the relay board. Looking at the figure to the right, the #9 terminal is common with all of the diodes. With a voltage ohm meter (VOM), use the proper checkout procedures to examine a specific diode.

TESTING DIODES

Before a diode can be tested using an ohmmeter, the diode must be isolated from the circuit to which it is connected.

Using an Analog Meter

To use an analog VOM to test diodes, select the ohms R x 1 scale. A good diode should read very low resistance in one direction and very high in the other.

Using a Digital Meter

Because a digital meter has limited power output in the ohms scale, it cannot be used to test a diode in the same way as an analog meter. A good diode tested on the ohms scale on a digital meter would read infinite ohms in both directions, incorrectly indicating a defective diode. On digital meters, the diode test scale must be used. When using this scale to test a diode, the meter will read the voltage at which the diode begins to conduct in the forward direction. A normal reading is usually .4 – .7 V. Very high or very low readings indicate a defective diode. In the reverse direction, the diode will not conduct, and the meter will indicate "OL" or an open circuit. Any other reading signifies a defective diode.

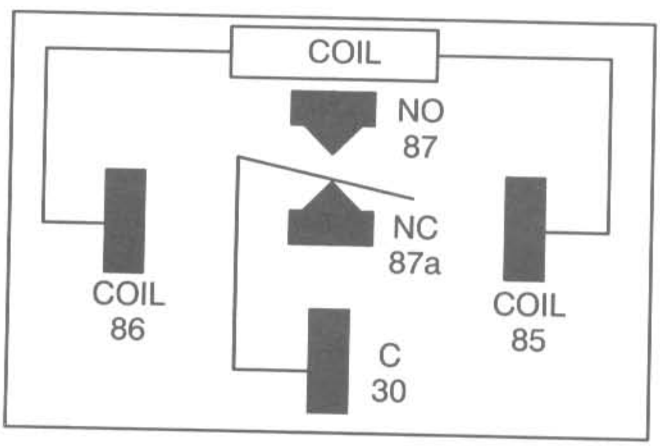
CHECKING RELAYS

1. Turn off and remove suspect relay from its socket. Refer to diagram on following page.

2. Check coil (pins 85 and 86) for continuity with an ohmmeter. A good coil has a resistance of approximately 90 to 100 ohms. A reading of zero ohms (shorted) or infinite (open) indicates a defective coil.

3. With the relay de-energized, there should be continuity between the common (pin 30) and the normally closed contact, N.C. (pin 87a). There should be no continuity between the common (pin 30) and the normally open contact, N.O. (pin 87).

4. Connect 12VDC across the coil connections (pins 85 and 86) to energize the coil of the relay. There should be continuity between the common (pin 30) and the normally open contact N.O. (pin 87). There should be no continuity between the common (pin 30) and the normally closed contact N.C. (pin 87a).



SENSOR RESISTANCE CHART

Sensor Resistance (ATS, CDT, RAS, SAS, & WTS)			
Temperature		ATS, RAS, SAS & WTS Resistance In Ohms	CDT Resistance In Ohms
°F	°C		
−20	−28.9	165,300	1,653,000
−10	−23.3	117,800	1,178,000
0	−17.8	85,500	855,000
10	−12.2	62,400	624,000
20	− 6.7	46,300	463,000
30	− 1.1	34,500	345,000
32	0	32,700	327,000
40	4.4	26,200	262,000
50	10.0	19,900	199,000
60	15.6	15,300	153,000
70	21.1	11,900	119,000
77	25	10,000	100,000
80	26.7	9,300	93,000
90	32.2	7,300	73,000
100	37.8	5,800	58,000
110	43.3	4,700	47,000
120	48.9	3,800	38,000
194	90	915	9,150
212	100	680	6,800
266	130	301	3,010
302	150	186	1,860
325	163.3	135	1,358
350	177.8	120	1,202

VOLTAGE CHART (SPT)

Sensor Voltage Chart (SPT)					
Psig	Voltage	Psig	Voltage	Psig	Voltage
20"	0.369	30	0.761	70	1.155
10"	0.417	35	0.810	75	1.204
0	0.466	40	0.860	80	1.253
5	0.515	45	0.909	85	1.303
10	0.564	50	0.958	90	1.352
15	0.614	55	1.007	95	1.401
20	0.663	60	1.056	100	1.450
25	0.712	65	1.106		

COOLING REFRIGERATION CYCLE

Following the refrigeration schematic for cooling, the refrigerant flow is as follows:

Starting with the discharge side of the compressor, the refrigerant exits the compressor as a high-temperature, high-pressure, superheated vapor into the discharge line.

HP-1 and HP-2 monitor head pressure at the compressor head. HP-1 is a safety switch for compressor high pressures. HP-2 controls the operation of SV-2 during heat/defrost.

The discharge vibrasorber isolates compressor and engine vibration from the rest of the refrigeration system.

The discharge check valve is closed in the off cycle to prevent liquid migration from the condenser to the compressor. While the unit is operating, the discharge check valve is open, allowing high-pressure vapor to pass through the valve.

Down the discharge line, SV-3 and SV-4 are normally closed valves that are de-energized and closed in the cooling cycle.

The refrigerant enters the condenser. Air moving across the condenser moves the heat from the hot refrigerant to the ambient air. The gas is condensed into a high-pressure, high-temperature, sub-cooled liquid.

Leaving the condenser, the liquid refrigerant passes through the condenser pressure control solenoid valve, SV-1. SV-1 is a normally open valve that is de-energized and open during cooling.

The liquid passes to the receiver, where the excess refrigerant is stored.

Exiting the receiver, the liquid refrigerant flows through the manually operated king valve and then back to the condenser, where it is further sub-cooled.

Leaving the sub-cooler, the refrigerant flows through the filter drier, where moisture and any particles are filtered out.

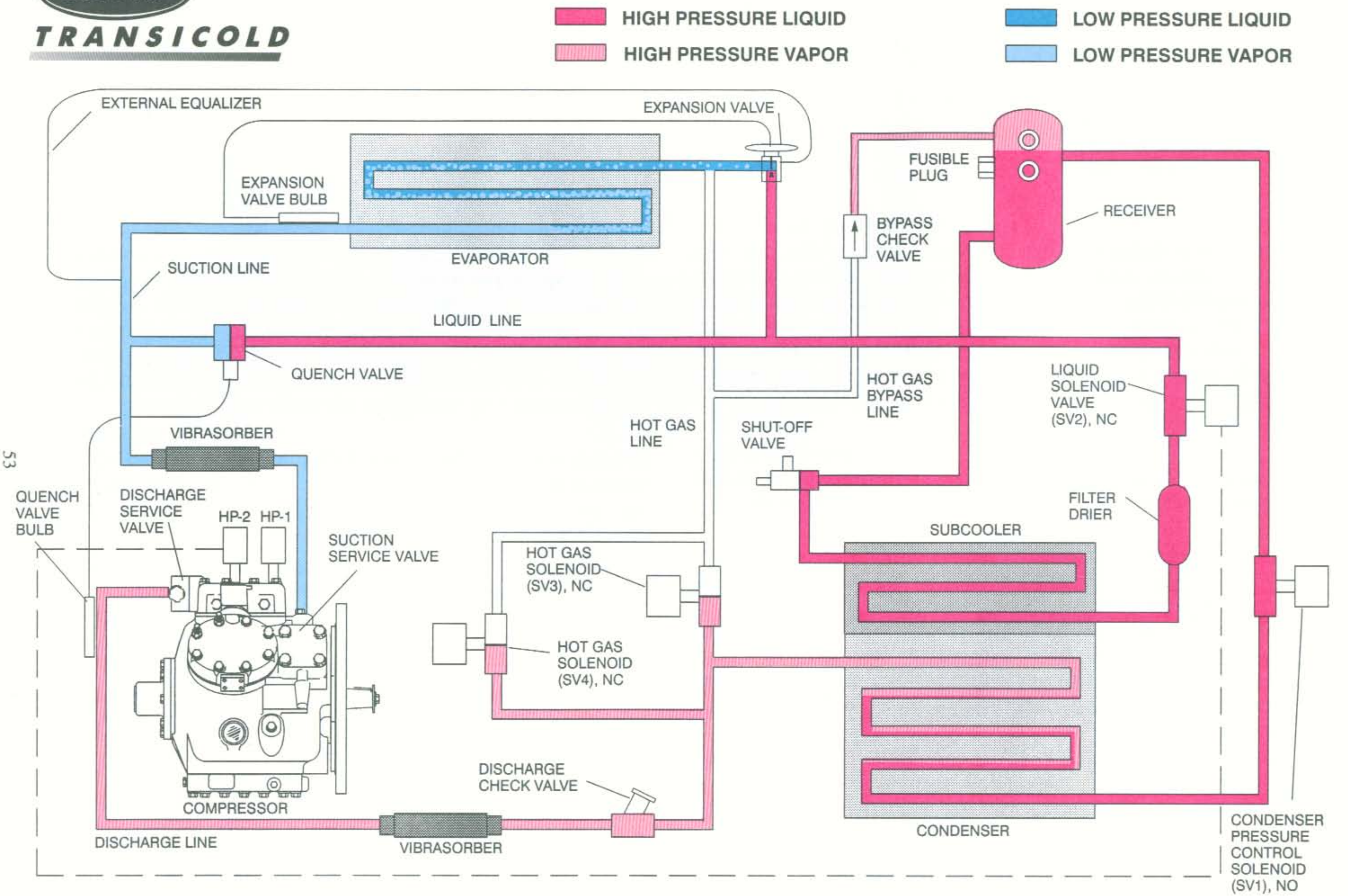
The flow of refrigerant then passes through the liquid line solenoid valve, SV-2. SV-2 is a normally closed valve that is energized and open during cooling. SV-2 prevents liquid migration from the receiver to the evaporator during the off cycle.

From SV-2, the liquid passes to the TXV and is metered into the evaporator. The TXV expansion bulb monitors suction line temperature and controls the TXV to maintain a constant superheat of 8°F to 10°F (4.4°C to 5.6°C) for Phoenix Ultra [5°F to 8°F (2.8°C to 4.5°C) for Optima] R-22 units. The TXV external equalizer line pressure shuts off the TXV during extremely high suction pressures. This prevents refrigerant migration from the receiver to the evaporator during the off cycle.

The evaporator absorbs heat from the box as the fan circulates the air across the coil and fins. The liquid refrigerant inside the coil boils off into a vapor before entering the suction line. The low-pressure, low-temperature, superheated vapor moves to the compressor through the suction line, where the cycle is repeated.

A quench valve installed between the liquid line and the suction line is actually a small TXV with a thermobulb attached to the discharge line. At discharge line temperatures above 265°F (130°C), this quench valve will meter liquid refrigerant into the suction line, cooling the compressor discharge temperature. If compressor discharge temperature rises too high, oil and refrigerant begin to break down and may damage the unit components.

Carrier TRANSICOLD



NDA-94 COOLING CYCLE

HEAT/DEFROST REFRIGERATION CYCLE

Following the refrigeration schematic for heat/defrost, the refrigerant flow is as follows:

Starting with the discharge side of the compressor, the refrigerant exits the compressor as a high-temperature, high-pressure, superheated vapor into the discharge line.

HP-1 and HP-2 monitor head pressure at the compressor head. HP-1 is a safety switch for compressor high pressures. HP-2 controls the operation of SV-2 during heat/defrost.

The discharge vibrasorber isolates compressor and engine vibration from the rest of the refrigeration system.

The discharge check valve is closed in the off cycle to prevent liquid migration from the condenser to the compressor. While the unit is operating, the discharge check valve is open, allowing high-pressure vapor to pass through the valve.

The refrigerant enters the condenser. During heat mode, air moving across the condenser coil and fins moves the heat from the hot gas vapor to the air. The vapor is condensed into a high-pressure, high-temperature, sub-cooled liquid. During defrost mode, the clutch is de-energized, stopping fan rotation. This allows condenser pressure and temperature to rise faster to help shorten defrost times.

SV-1 is the outlet valve from the condenser coil. SV-1 is a normally open valve that is energized and closed during heating/defrost. Because SV-1 is closed, the condenser will fill with liquid refrigerant. This will force the hot gas vapor through SV-3 and SV-4.

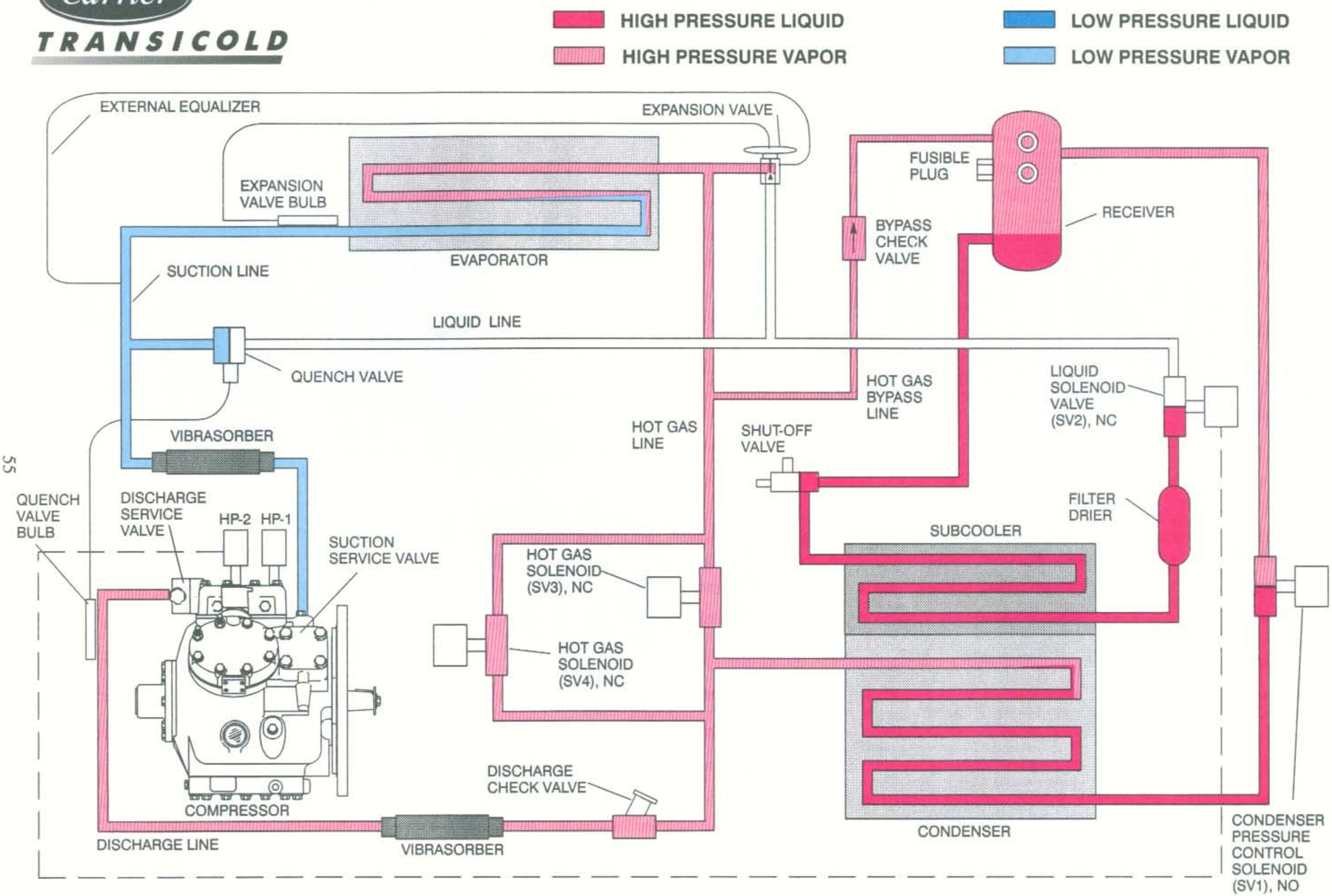
SV-3 and SV-4 are normally closed valves that are energized and open in the heating/defrost cycles. SV-4 opens immediately and, 60 seconds later, if discharge temperature is at least 100°F (37.8°C) higher than ambient temperature and the engine is in high speed, SV-3 will open. If SV-3 is open and the discharge temperature falls to less than 50°F (10°C) above the ambient temperature, SV-3 will close.

The hot gas vapor moves directly to the evaporator distributor header, bypassing the TXV valve. During the heat mode, the heat from the refrigerant is circulated across the load. During defrost mode, the heat from the refrigerant melts the ice from the evaporator coil. The high-temperature, high-pressure, superheated vapor is cooled to a low-pressure, low-temperature, superheated vapor *without condensing.*

The low-pressure, low-temperature, superheated vapor moves to the compressor through the suction line, where the cycle is repeated.

A quench valve installed between the liquid line and the suction line is actually a small TXV with a thermobulb attached to the discharge line. At discharge line temperatures above 265°F (130°C), the quench valve meters liquid refrigerant into the suction line. This cools the compressor discharge temperature. If compressor discharge temperature rises too high, oil and refrigerant begin to break down and may damage the unit components.

From the hot gas line to the top of the receiver is a hot gas bypass line. This line pressurizes the receiver to force the liquid refrigerant in the receiver through the TXV to the evaporator side for heating. A check valve (bypass check valve) in the hot gas bypass line prevents liquid refrigerant from migrating to the evaporator during cooling.



NDA-94 HEAT/DEFROST CYCLE

R-22 QUICK CHECK

This troubleshooting procedure is designed to test the major components of Carrier Transicold trailer refrigeration units (Phoenix Advantage, Phoenix Ultra, Ultra XL, Extra, and Optima) that use refrigerant R-22. This procedure, designed primarily to mechanically test the system components, can also point out many electrical problems. Sound knowledge of electrical and refrigeration fundamentals and Carrier Transicold heat, cool, and defrost cycle operations is essential to perform this procedure.

This procedure tests the following:

1. Refrigerant charge and high ambient compressor operation

 a. Correct refrigerant charge

 b. Pumping efficiency for high ambient conditions

2. Compressor unloader valve operation

 a. Proper loading and unloading of each valve

3. SV-3 and SV-4 solenoid valves and bypass check valve

 a. Ability of SV-3 and SV-4 and the bypass check valve to close tightly during cooling

4. Discharge check valve and SV-2 solenoid valve

 a. Leakage of the discharge check valve back to the compressor during the "off" cycle

 b. Seating ability of SV-2 in the "off" cycle

 c. Opening ability of SV-2

5. HP-2 and SV-2 cycling during heat and defrost

 a. Modulation of SV-2 by HP-2 in heat and defrost

6. SV-1 seating, SV-3 and SV-4 opening

 a. Ability of SV-1 to close tightly during heat and defrost

 b. Ability of SV-3 and SV-4 to open during heat and defrost

7. Defrost Operation

 a. Defrost termination switch (klixon) function

 b. Fan clutch disengages or damper door closes during defrost cycle

Several rules *must* be followed to ensure accurate results:

1. All directions for each step must be read through and thoroughly understood by the service technician before beginning that step.

2. Each step must be completed successfully in sequence.

– Results from early steps will be used to draw conclusions later on in the procedure.

3. Any problems must be repaired immediately, and the step repeated before continuing the procedure, unless otherwise noted.

4. All equipment must be operated in high speed cool for twenty minutes prior to starting this procedure.

– Operate with a 35°F (1.7°C) setpoint, fully loaded [unplug both unloaders when box temperature reaches 35°F (1.7°C)]. This allows the compressor oil to come up to operating temperature.

5. The ambient (air entering the condenser) air temperature should be above +60°F (15.6°C).

– Ambient temperatures below 60°F (15.6°C) could cause inaccurate results in any step of this procedure.

6. The microprocessor must be set for "MAN OP" and continuous run operation and left in this mode during the entire test.

The following tools are required and must be available before beginning the test to ensure its successful completion.

QTY	DESCRIPTION
1	Refrigeration ratchet
2	Refrigeration manifold gauge set
1	4-ft. jumper wire with alligator clips
1	8"–10" adjustable end wrench
1	Wire cutters
1	D.C. Voltmeter
1	5-ft. square piece of plastic to block condenser air

Before starting the test, install a manifold gauge set on the compressor service valve gauge ports and a second manifold gauge set connecting the high-pressure gauge only to the King Valve. *All* gauge lines *must* be purged of air that could enter the system.

The procedure may now be started. It may be helpful to refer to the flow diagram when following the procedure.

NOTE: Pressures and temperatures given in this manual are for R-22.

STEP ONE – Check the refrigerant charge and high ambient compressor operation.

A. Start the unit [setpoint of 0°F (–17.8°C)]. Allow the unit to run until the engine reaches high speed. The engine will always start in low speed and remain there for 15 seconds or until the engine coolant temperature reaches 79°F (26°C). Partially cover the condenser to raise the discharge pressure to 260–280 psig.

B. Check the receiver tank sight glasses for the proper refrigerant charge. The bottom glass should not be empty. The top glass should not be full.

C. Cover the condenser further to raise the discharge pressure to 350–375 psig. This ensures that the compressor can achieve sufficient discharge pressure to operate in high ambient temperatures. (It may be necessary to unplug the front unloader.)

D. Uncover the condenser. The unit should be left running in High-Speed Cool.

STEP TWO – Check compressor unloader valve operation.

A. With the unit still running in High-Speed Cool, remove the white positive wire from the unloader coils.

B. Note the suction pressure.

C. Using a jumper wire from the positive starter post (+), apply 12 VDC to the front unloader coil terminal. The suction pressure should rise noticeably (approx. 5–10 psig).

If no change in suction pressure occurs, check the unloader coil ground connection and the coil resistance before making any repairs to the unloader solenoid.

D. Remove the jumper wire; the suction pressure should drop.

E Repeat steps C and D to cycle the unloader three to four times to verify consistent operation.

F. Repeat steps B to E to check the rear unloader on the Phoenix Advantage, Phoenix Ultra, Ultra XL, and Extra.

G. Leave the unit running in High-Speed Cool.

STEP THREE – Check SV-3 SV-4, and bypass check valve seating ability during cool.

A. Reconnect unloader wires.

B. Slowly frontseat the King Valve (receiver tank outlet valve) and pump down the low side of the system to 0 psig. *(Do not allow the system to run in a vacuum.)*

C. Shut off the unit and observe the suction and discharge pressures at the compressor. They should not equalize in less than 30 seconds. If they do, it indicates:

1. The SV-3 or SV-4 (Hot Gas Solenoid Valves) are leaking discharge vapor into the evaporator;

2. The bypass check valve is leaking.

3. Internal leakage/inside the compressor - unloader valves, reed valves, head gaskets.

NOTE: The above problems can be located by carefully feeling the lines for hot/cold spots, or by listening for internal leakage.

D. Any leakage - internal or external - found in this step *must* be repaired before continuing.

E. The unit should be "OFF" at the end of this step.

STEP FOUR – Check discharge line check valve leakage, quench valve leakage, and SV-2 seating and opening ability.

A. Midseat (open) the hand valves on the manifold gauge set connected to the compressor. This allows the high-pressure refrigerant in the discharge line to bleed to the low side of the system and the gauge readings to balance out.

B. After a short time (10–15 seconds) frontseat (close) the hand valves on the manifold gauge set connected to the compressor and observe the high-side gauge. A continuous rise in pressure indicates that the discharge check valve is allowing pressure to leak back to the compressor.

NOTE: If the check valve leaks, it does *not* have to be repaired until after completing this procedure. It will have no effect on the remaining steps.

C. Very slowly, open the King Valve to allow refrigerant to pass through the filter-drier to the liquid line solenoid valve (SV-2). Bring the King Valve to the midseat position. SV-2 should remain closed, and there should be no rise in suction pressure. A rise in suction pressure indicates that SV-2 is leaking through and not seating properly.

D. On units where the quench valve is tapped off the liquid line in front of SV-2, a rise in suction pressure may indicate a quench valve that is leaking internally.

E. (Phoenix Ultra, Ultra XL, Extra, and Optima) Place the Run-Stop switch into the "RUN" position. Observe the suction pressure gauge. After 5 seconds, SV-2 energizes and opens, causing the suction pressure to rise to a maximum pressure of the MOP setting of the TXV.

E1.(Phoenix Advantage) Place the Start-Run-Stop switch into the "RUN" position and, after 5 seconds, the Glow Plug switch into the "GLOW" position. At this time, SV-2 will energize and open, causing the suction pressure to rise to a maximum pressure of the MOP setting of the TXV.

F. On units where the quench valve is tapped off the liquid line after SV-2, a rise in suction pressure above the MOP setting of the TXV may indicate a quench valve that is leaking internally.

NOTE: A leaking quench valve can be located by carefully feeling the outlet line of the quench valve for cold spots.

G. If the suction pressure does not rise, it may indicate a restricted or blocked liquid line or TXV. Check to be sure that SV-2 energized and opened.

NOTE: This step does *not* check the superheat setting of the expansion valve. This must be done separately, as outlined in the unit operation and service manual.

H. The unit should be "OFF" at the end of this step.

STEP FIVE – Check HP-2 and SV-2 for cycling during heat and defrost

A. Disconnect the white (positive) wire from the front unloader and SV-3 valve.

B. Adjust setpoint to 77°F (25°C) and start the unit. The unit will run in low speed for 15 seconds, then go into High Speed Heat. (It may be necessary to place the unit in High Airflow operation.)

C. Connect a voltmeter to the positive terminal of SV-2 (refer to the unit wiring schematic, if necessary), leaving all wires to both HP-2 and SV-2 connected. Observe the voltmeter and compressor discharge gauge readings. The compressor discharge pressure will rise because SV-1 should be closed, with only SV-4 open. When the discharge pressure rises to 350 psig, HP-2 will open, causing SV-2 to close. This can be seen by the voltmeter reading dropping to 0 VDC, and the compressor discharge pressure decreasing. When the discharge pressure drops to 290 psig, HP-2 closes, causing SV-2 to open, causing discharge pressures to rise, with 12 VDC showing on the voltmeter. This shows the proper cycling of SV-2 by HP-2. Immediately reconnect the wire to SV-3. (The HP-2/SV-2 cycling interval depends on the ambient and box temperatures.)

D. The unit should be "OFF" at the end of this step.

NOTE: This procedure does not check the actual settings for the HP-2 switch. If the switch opens and closes within 15–20 psig of the rated settings, the switch is functioning properly. To actually determine the opening and closing settings of the switch, refer to the operation and service manual for your unit.

STEP SIX – Check SV-1 for seating, SV-3 and SV-4 for opening.

A. Disconnect the oil pressure safety switch connector, and place a jumper across the plug terminals.

B. Remove the white (positive) wires from SV-3, SV-4, front unloader, and (1) wire from the HP–2 switch.

C. Re-adjust setpoint to 20°F to 25°F (–6.7°C to –3.9°C) above box temperature. (It may be necessary to run the unit in "Cool" prior to this step.)

D. Start the unit. Allow the unit to run 30–45 seconds. The suction pressure should fall to approximately 0 psig, and the receiver pressure near or below 200 psig. Closely monitor both high-pressure gauges while connecting the wire to the HP-2 switch. Compressor discharge pressure will begin to rise. Receiver pressure should not rise. When the compressor discharge pressure reaches 390 psig, shut the engine off using the stop lever on the injection pump. (The microprocessor will remain energized.) The compressor discharge pressure will drop off, but the receiver pressure should not change. Any rise in receiver pressure indicates internal leakage at the SV-1 valve.

E. Observe the suction gauge. Using a jumper wire, momentarily energize SV-4. The valve should open and the suction pressure begin to rise. Remove the jumper, and the valve should close; the suction pressure should stop rising. Energize the valve two to three times to verify consistent valve operation.

F. Repeat step E for SV-3.

G. Reconnect unit harness wires to SV-3, SV-4, front unloader, and the plug to the oil safety switch.

H. The unit should be "OFF" at the end of this step.

STEP SEVEN – Defrost operation.

A. Turn the unit on and re-adjust the setpoint to 0°F (–17.8°C). Run the unit in High-Speed Cool and allow the box temperature to drop below 35°F (1.7°C).

B. Place the unit into defrost manually.

C. Make sure the unit goes into defrost properly and that the engine is running in High Speed.

NOTE: If the ambient temperature sensor is above 100°F (37.8°C), the high ambient defrost cycle may be initiated. Refer to the operation and service manual.

D. Check that the fan clutch has disengaged and that the fan shaft is not turning on the Ultra, Ultra XL, Extra, and Optima, and that the defrost damper door is closed on the Advantage.

E. The unit should come out of defrost automatically. The Phoenix Ultra, Ultra XL, Extra, and Optima will shift to low speed, then engage the fan clutch. The Phoenix Advantage will open the damper door.