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Instruction Manual

TCU 40/80plus

Single Channel
Temperature Control Unit

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1. Preface

1.1 Safety Considerations

Many safety features have been designed into the TCU 40/80 plus to protect the operator and the equipment. The following symbols are used in this manual to indicate the various safety conditions.

General Alert 	General Alert symbol denotes the potential of personal hazards or equipment failure. Warnings are given when failure to observe the instruction could result in injury or death to persons. Cautions are given where failure to observe the instruction could result in damage to the equipment, associated equipment and process. Statement on avoiding the hazard.
Electric Shock 	Electric Shock symbol denotes the presence of high voltage or current. It calls attention to the procedure, practice, or the like, which if not done correctly or adhered to could result in injury or death. Statement on avoiding the hazard.
Eye Protection 	Eye Protection symbol denotes a hazard which could cause injury or irritation to the eyes. Statement on avoiding the hazard.
Toxic Gases 	Toxic Gases symbol denotes a personal hazard. It calls attention to the procedure, practice, or the like, which if not done correctly or adhered to could result in injury or death. Statement on avoiding the hazard.

Hot Surfaces 	Hot Surfaces symbol denotes a hazard which could cause injury or burns. Statement on avoiding the hazard.
Hand Protection 	Hand Protection symbol denotes a hazard which could cause injury or burns Statement on avoiding the hazard.
High Pressure 	High Pressure symbol denotes a personal hazard or equipment failure. It calls attention to the procedure, practice, or the like, which if not done correctly or adhered to could result in equipment damage, injury or death. Statement on avoiding the hazard.
Extreme Temperature 	Extreme Temperature symbol denotes a hazard which could cause injury or burns. Statement on avoiding the hazard.

2. TCU 40/80 *plus*

2.1 Scope of the Manual

This manual provides information on the installation, start-up and operation of Edwards High Vacuum Model 40/80 Temperature Control Unit (TCU 40/80 *plus*).

The **Quick Start Procedure** on page 5 is a step by step guide for the start up and use of an installed, working system.

Installation, starting on page 17, provides instructions and information for installing the system. The installer must have sufficient technical understanding of electrical and mechanical systems to properly use this information.

Operation, starting on page 21, provides more complete instructions on the preparation and use of the system.

2.2 Description of the TCU 40/80 *plus*

The TCU 40/80 *plus* is a single-channel temperature control unit engineered for temperature control of remote heat loads.

From distances up to 50 feet, the TCU 40/80 *plus* can cool the heat load generated by the process equipment. The coolant circulates through the TCU 40/80 *plus*, where it is cooled or heated as required, then is transferred to the process equipment, and returns in a closed loop. The TCU 40/80 *plus* maintains supply coolant at a temperature between -40 °C and +80 °C, selectable in 0.1 °C increments, with a tolerance of ±1.0 °C.

2.3 Lockout Procedure

To prevent accidental or unauthorized starting of the TCU 40/80 *plus* during maintenance, disconnect the power cord from the receptacle and install an appropriate lock-out device (Hubbell Small Plugout™ or equivalent) on the end of the power cord.

2.4 Safety Features

The safety features listed in Table are designed into the TCU 40/80 *plus*.

Table 1 - Safety Features

Component	Ref. Des. *	Function
EMERGENCY OFF button (EMO)	(PB1)	Shuts off power to major system components.
Remote **EMERGENCY OFF**	(J72J2)	Remote shut off of power to major system components.
Drawer safety switch	(LS1)	Upon opening the drawer, shuts off power to major system components.
Pressure switch	(PS1)	Protects the refrigeration system against high discharge pressure. Interrupts operation at 300 psig.
Condenser pressure relief valve	(W2)	Vents refrigerant to the atmosphere above 350 psig. Fail safe for PS1, works even if there is no power applied to the system.
Reservoir pressure relief valve	(W1)	Protects the reservoir from over-pressure.
Temperature switch	(TS1)	Protects the process fluid from exceeding 99 °C
Coolant flow switch	(FS1)	Protects the process equipment from inadequate coolant flow rates.
Coolant float switch	(LLS1)	Protects against low level in the coolant reservoir by stopping the equipment.
Coolant float switch	(LLS3)	Protects against overfill of the coolant reservoir. Indication on front and rear panels.
Thermal overload	(K3)	Protects the pump motor from excess current.
Surge suppression	VR1-4	Protects the TCU 40/80 *plus* against voltage surges and power line transients.
Line phase monitor	PMR1	Protects the equipment against incorrect wiring of the supply phases and low voltage burn-out.
Current sensor	CSR1	Protects the compressor against abnormal conditions.
Secondary containment		Captures fluids (internal to the TCU) in the event of a leak.

* See Figure 3 on page 10

3. Quick Start Procedure

This Quick Start procedure is for easy start up and operation of an installed and fully working TCU 40/80 *plus*. If your TCU 40/80 *plus* is not installed, go to **Installation,** Section 5 on page 17. Detailed operating instructions are in **Operation,** Section 6 on page 21. If at any time an alarm occurs, press **STOP** and correct the fault indicated by the display as directed in the **Troubleshooting Guide,** Section 8 on page 43. Press **RESET** and **START** to continue operation.

3.1 Power Up

Before applying power, verify that all water and coolant lines are connected to the system. The handles on both coolant line valves should be in the open position. For the location of these connections, refer to Figure 9 on page 19.

To power up the TCU 40/80 *plus*:

1. **READY** light should be on. If the ready light is not on see **Powering Up the TCU 40/80 *plus*** on page 21.
2. Press **RESET**. Verify that front panel indicators are as shown in the Reset column of Table 2 on this page.
3. Press **START**. Verify that front panel indicators are as shown in the **Start Condition** column of Table on this page.

If in steps two or three any front panel indicators do not match, refer to the **Troubleshooting Guide** Section 8 on page 43 for corrective action.

4. Verify that the coolant pressure gauge (located on the front access panel) reads less than 100 psig.

Table 2 - Front Panel Indicators

Indicator	Reset Condition	Start Condition
Power On	Green	Green
Reset	White	White
Facility Power	Off	Green
Facility Water	Green	Green
Circuit Breakers	Green	Green
Compressor	Off	Green
Temperature	Green	Green
Flow	Off	Green
Normal Level	Green	Green
Low Level	Off	Off
Remote RTD (Optional)	Green (if used)	Green (if used)

3.2 Setpoint Verification

Verify that the manual mode setpoint value (SV1) displayed on the temperature control is the value desired. To change the Setpoint value see **Changing the Setpoint Value (SV1)** Section 6.3 on page 22.

Do not to exceed the normal operating parameters. The system is designed to operate from -40 °C to +80 °C.

4. Product Description

4.1 Refrigeration and Coolant Circuits

Figure 1, Figure 2, and Table 3 on page 80 describe the refrigeration and coolant components of the TCU 40/80 *plus*.

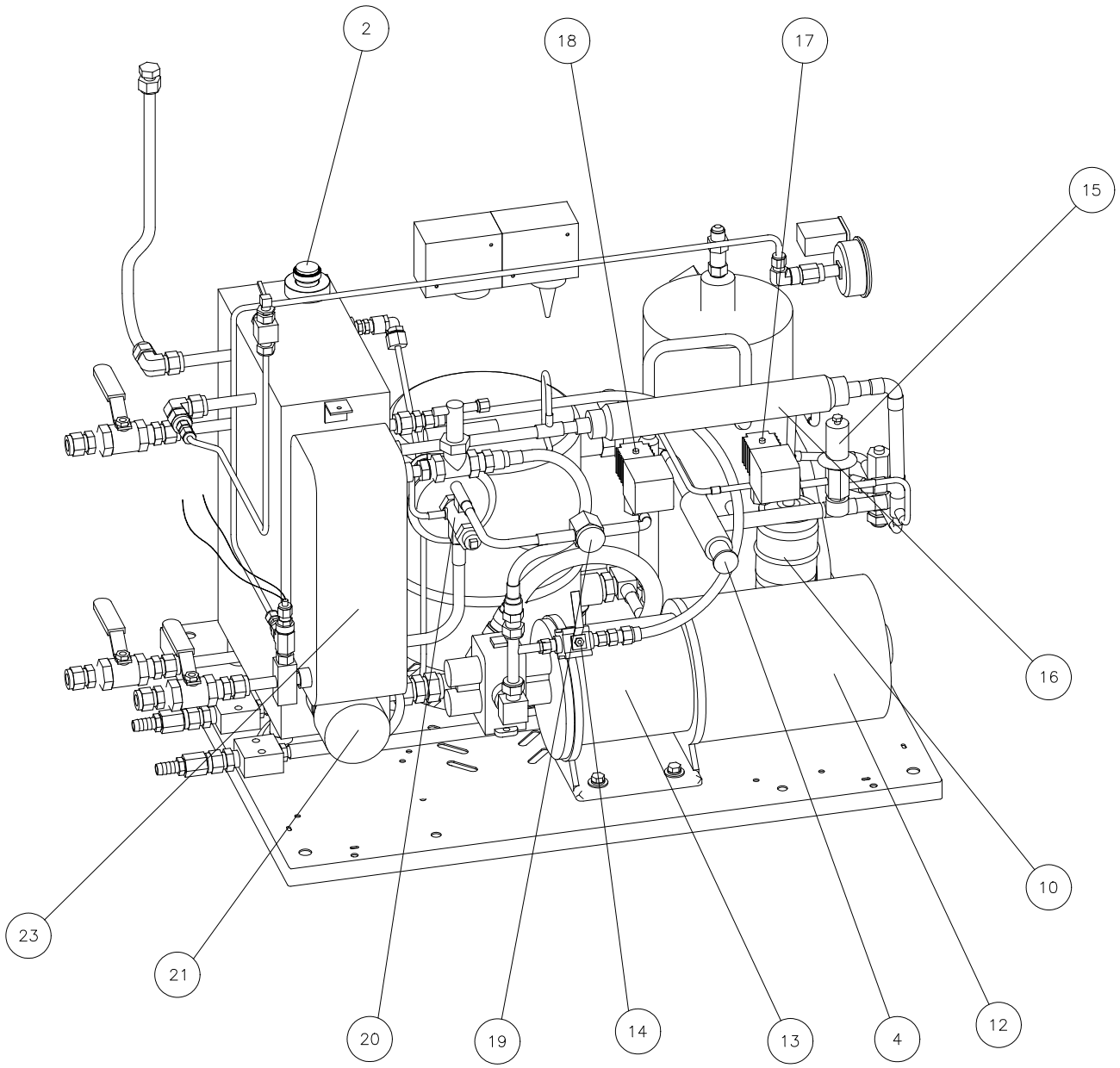

Figure 1- Refrigeration and Coolant Components
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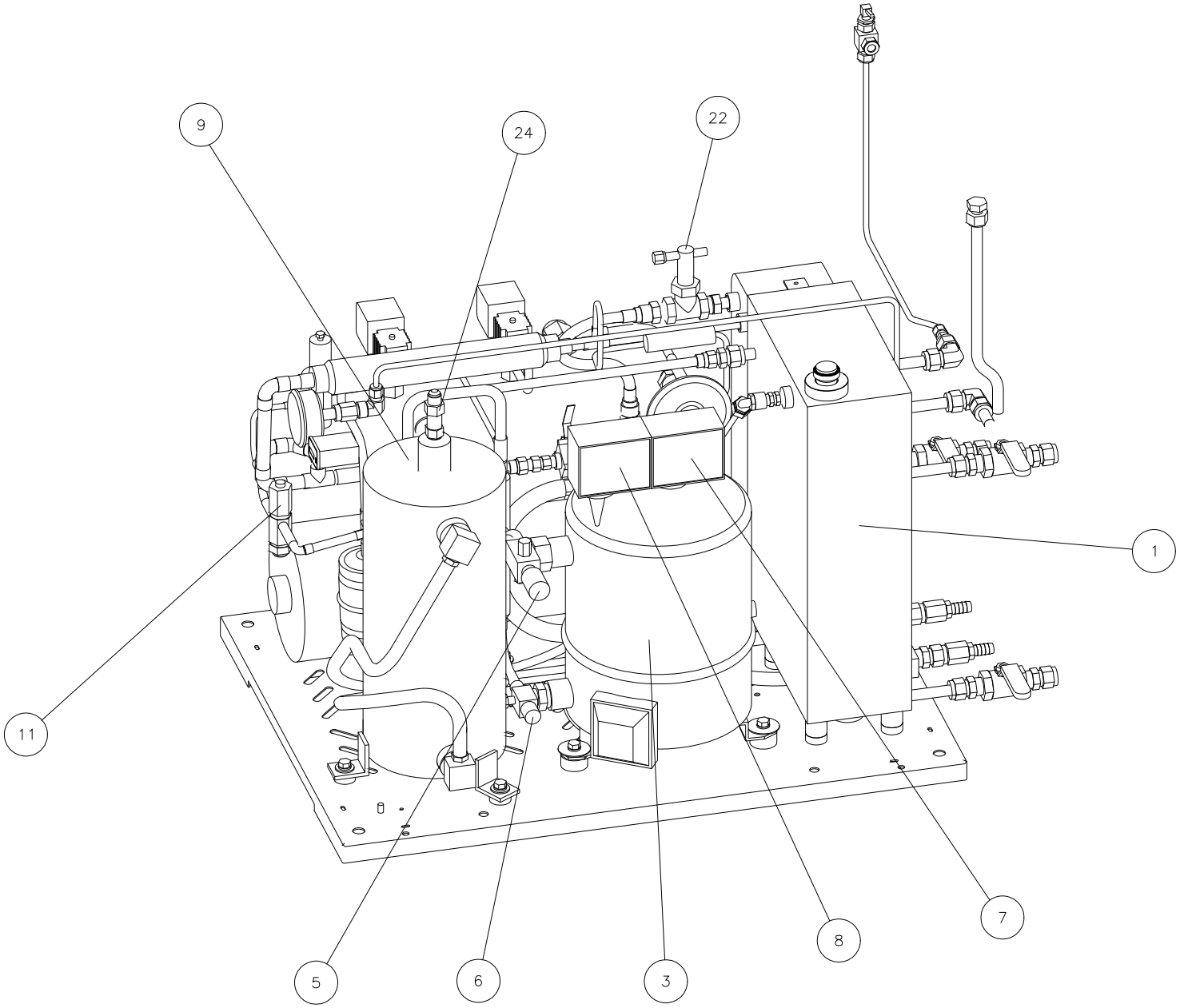

Figure 2 - Refrigeration and Coolant Components
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Table 3 - Refrigeration and Coolant Components

Item	Component Name	Function
1	Reservoir	A holding tank for the Fluorinert coolant.
2	Level Switch	Monitors the coolant level in the reservoir.
3	Compressor	Compresses the refrigerant fluid.
4	Crankcase Regulator	Protects the compressor against pressure overload.
5	Suction Service Valve	Allows isolation at the compressor.
6	Discharge Service Valve	Allows isolation at the compressor.
7	Temperature Switch	High limit switch for reservoir heater.
8	Pressure Switch	Limits maximum allowable discharge pressure.
9	Condenser	Transfers heat from the compressed refrigerant to the facility water.
10	Filter Dryer	Removes contaminants and moisture from the refrigerant.
11	Safety Cooling Valve	Limits the discharge temperature.
12	Motor	Drives the coolant pump.
13	Pump	Circulates the Fluorinert coolant.
14	Bypass Valve	Regulates coolant flow.
15	Hot Gas Bypass Valve	Regulates cooling capacity.
16	Subcooler	Further cools the refrigerant that is returning to the compressor.
17	Solenoid Valve SV2	Allows refrigerant to pass through the hot gas bypass valve, then to the compressor suction line when energized.
18	Solenoid Valve SV1	Allows refrigerant to pass to the TEV when energized.
19	Sight Glass	Allows visual inspection of the refrigerant charge and presence of moisture in the system.
20	TEV (Thermostatic Expansion Valve)	Allows the refrigerant to expand from a liquid to a gas.
21	Heater	Raises the temperature of the coolant when the process requires heating.
22	Flow Switch	Monitors the flow rate.
23	Heat Exchanger	Extracts heat from the coolant and transfers it to the refrigerant.
24	Pressure Relief Valve	Discharges refrigerant from the system to the atmosphere in the event of severe over-pressure condition.

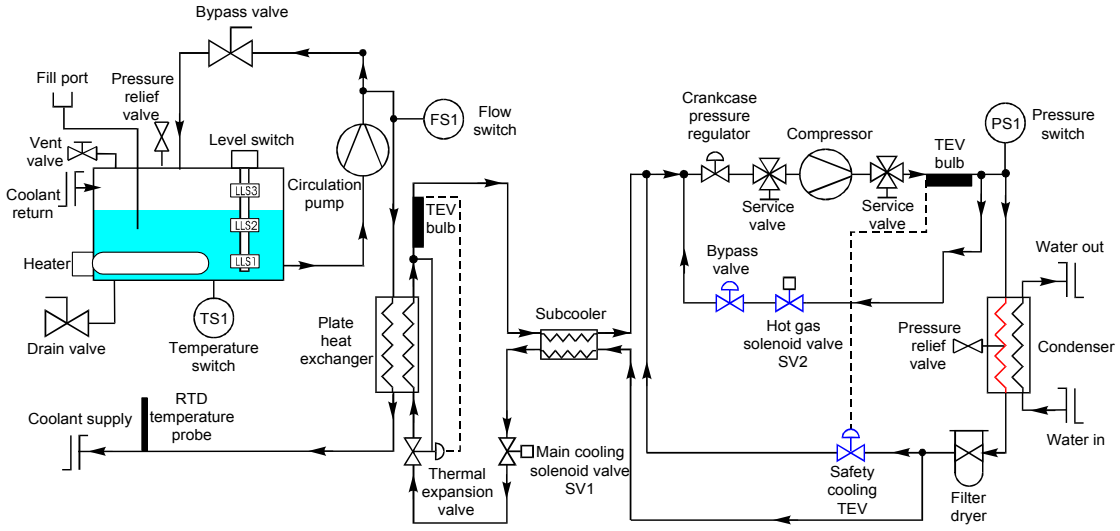

Figure 3 - Refrigeration and Coolant Circuits
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4.2 **Refrigeration -** (See figure 3 above)

1. Refrigerant gas enters the compressor at low temperature and pressure. It leaves the compressor at high pressure and temperature.
2. The gas passes into the condenser, where heat is removed by the external water supply, causing the gas to condense into a liquid.
3. The cool liquid refrigerant exits the condenser and passes through a filter dryer that removes any residual moisture or contaminants.

4.2.1 If Cooling Is Required:

1. Solenoid valve SV1 opens (coil energized), allowing the refrigerant to flow into the Thermostatic Expansion Valve (TEV). The pressure drop across the TEV causes the refrigerant to change from a liquid to a mixture of liquid and gas.
2. The liquid and gas mixture enters the heat exchanger where it becomes entirely a gas. The process of expansion from a liquid to a gas reduces the temperature by absorbing energy.
3. The refrigerant leaving the heat exchanger returns to the compressor through the sub-cooler and a crankcase pressure regulator. The sub-cooler further cools the refrigerant entering the TEV.

4.2.2 If Cooling Is *Not* Required:

1. Solenoid valve SV1 closes (coil de-energized).
2. Hot refrigerant from the compressor is passed through SV2 (coil energized) and a hot gas bypass valve before returning to the compressor suction line. This bypassing allows the compressor to run continuously.
3. Cooling, required to prevent the compressor from overheating, is provided by allowing some of the liquid from the condenser to pass through the safety cooling automatic expansion valve into the suction line, thus maintaining the discharge gas temperature below 99 °C.

4.3 Coolant Circuit

Coolant is pulled from the reservoir by the circulation pump and transferred to the heat exchanger where it is cooled by the refrigeration system as required. It then flows to the process equipment by means of the coolant supply hose. The coolant returns to the TCU 40/80 *plus* reservoir by means of the coolant return hose. The coolant system requires 8 liters of coolant for the reservoir plus the volume of the circulation lines and any other spaces filled with coolant that are attached to the TCU 40/80 *plus*. To increase the coolant temperature, the reservoir uses an electrical resistance heater that is controlled by the temperature controller. The heater must be fully submerged at all times, and if the coolant in the reservoir falls below 3.5 liters, a level switch causes the status alarm signal to automatically shut down the TCU 40/80 *plus*. A three-float level switch, a thermostat, and a flow sensor provide coolant status signals to the TCU 40/80 *plus* control system.

4.4 Temperature Monitoring

A Resistance Temperature Device (RTD) monitors the temperature of the coolant leaving the TCU 40/80 *plus* and transmits this information to the temperature controller. The TCU 40/80 *plus* compares the output of the RTD to the selected process temperature (SV1) and determines if the coolant needs to be cooled or heated. The temperature controller then operates the main cooling solenoid valve or heater. The coolant temperature at the supply port on the rear panel is measured by a local, internally connected RTD. If sensing of process equipment temperature is needed, connect an RTD to J72J3 at the rear panel (See Figure 5 on page 13). For remote connection schematic details, see Figure 16 on page 56.

4.5 Front Panel

Figure 4 shows the Front Panel. Table 4, Table 5 and Table 6 identify its controls and indicators.

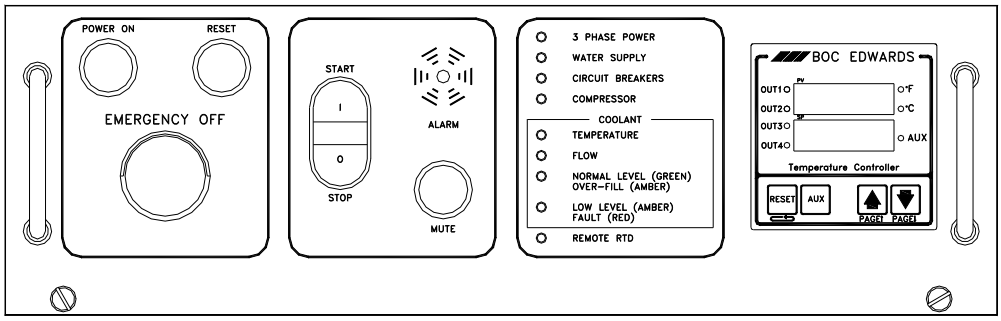

Figure 4 - Front Panel
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Table 4 - Front Panel Controls

Control Name	Description
Power On	Lights green when power is being supplied to the TCU 40/80 *plus*.
Reset	Resets alarms and makes the TCU 40/80 *plus* ready to operate. The white light indicates that the TCU 40/80 *plus* is ready to operate.
Emergency Off	Removes power from all TCU 40/80 *plus* circuits except the **EMERGENCY OFF** circuit. To shut off power, push **EMERGENCY OFF** (EMO). To reset, rotate the **EMERGENCY OFF** button clockwise as shown on the switch.
Start/Stop	Starts and stops the operation of the TCU 40/80 *plus*.
Alarm	Emits a high pitched sound when there is a fault condition which has caused the TCU 40/80 *plus* to stop operation.
Mute	Silences the audible alarm.

Table 5 - Front Panel LED Indicators

LED Name	Condition	Description
Facility Power	Green Red	Power phases are normal. Power phases are reversed or low line voltage.
Facility Water	Green Red	Water pressure and flow are normal. Water pressure or flow are not adequate. (See **Specifications** Section 4.7 on page 14.
Circuit Breakers	Green Red	Rear panel circuit breakers 2, 3, and 4 are on. One or more of these breakers is tripped or off.
Compressor	Green Red	Compressor is operating normally. Compressor has stopped operating.
Coolant Temperature	Green Red	Coolant reservoir temperature is normal. Coolant temperature is above the operating range.
Coolant Flow	Green Red	Coolant flow is normal. Coolant flow is not adequate.
Coolant Normal Level	Green Amber	Coolant level is normal . Coolant level is over filled.
Coolant Low Level	Off Amber Red	Coolant level is normal Coolant level is low. Coolant level is very low.
Remote RTD	Off Green	Remote RTD not connected. Remote RTD temperature probe is in use.

Table 6 - Temperature Controller

Controls and Indicators	Description
Process Value (PV)	The present temperature of the coolant, as indicated by the internal RTD or the remote RTD.
Setpoint Value (SP)	The TCU 40/80 *plus* regulates to this temperature, as set by the operator.
Pushbuttons	Used to program the controller.
Remote Mode Led (AUX)	Indicates mode of operation: Off indicates local operation. On indicates remote operation.

4.6 Rear Panel **

Figure 5 shows the rear panel. Table 7 identifies the controls and indicators on the rear panel.

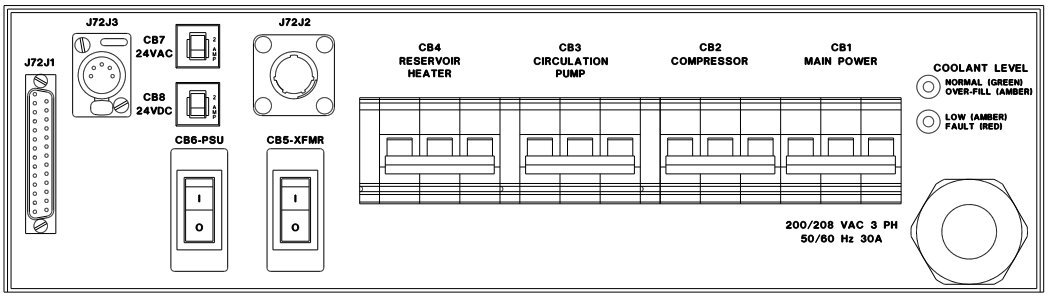

Figure 5 - Electrical Rear Panel
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Table 7 - Description of Rear Panel Components and Indicators

Label	Description
J72J3	Five-pin connector for remote RTD interface. See Figure 16 on page 56 for pinouts.
CB7 24 VAC	1-pole, 2 Amp circuit breaker. Isolates the 24 VAC transformer. Normally on (in).
CB8 24 VDC	1-pole, 2 Amp circuit breaker. Isolates the 24 VDC power supply output. Normally on (in).
J72J2	Nine pin connector for remote EMERGENCY OFF, start-stop operation, and remote setpoint operation enable. See Figure 16 on page 56 for pinouts.
CB4 Reservoir Heater	3-pole, 10 Amp circuit breaker. Normally on (up).
CB3 Circulation Pump	3-pole, 6 Amp circuit breaker. Normally on (up).
CB2 Compressor	3-pole, 16 Amp circuit breaker. Normally on (up).
CB1 Main Power	3-pole, 25 Amp circuit breaker. Normally on (up).
Normal/Overfill	Normal, LED Green Overfilled, LED Amber
Low/Fault	Low, LED Amber Fault, LED Red
200/208 VAC 3 PH 50/60 Hz 30A	Mains input power connector.
CB5-XFMR	2-pole, 0.5 Amp circuit breaker. Isolates the equipment transformer.
CB6-PSU	2-pole, 0.3 Amp circuit breaker. Isolates the power supply.
J72J1	37 pin D-subminiature connector, for setpoint value signal, process value signal, and remote fail and warning signals. See Figure 16 on page 56 for pinouts.

**** Note: If LONWORKS/RS-485/RS-232 option is chosen, see specific chapter for modified rear panel details.**

4.7 Specifications

Parameter	Conditions	Specification
Temperature Ramp	Coolant Short Circuit Conditions	
	+25 °C to +80 °C	Elapsed Time: <25 Minutes
	+25 °C to -30 °C	Elapsed Time: <15 Minutes
Cooling capacity @ process equipment 150 watt coolant line losses; coolant water @ 15 °C	Process Coolant @ -40 °C	750 Watts
	Process Coolant @-20 °C to +80 °C	2400 Watts
Heating Element		2800 Watts
System Flow	@20 °C, 60 psig	3 gpm (11.36 l pm)
Process Temperature Range		-40 °C to +80 °C
Setpoint Resolution		± 0.1 °C
Temperature Regulation		± 1.0 °C Typical
Facility Water Requirements	+10 °C (-0° +2°) to +26 °C (+0° -2°)	3 to 6 gpm (11.36 to 22.71 l pm)
Power Requirements	3-Phase Delta (Balanced Load), 4 Wire (3 Phases & Earth Gnd), 200 To 208 VAC, 50/60 Hz	30 Amp Outlet
Ambient Operating Temperature		+10 °C to +40 °C
Weight		416 lbs. (190kg) Dry Weight 460 lbs. (210 kg) Wet Weight 832 lbs. (308 kg) Dry Weight Dual Stacked 920 lbs. (420 kg) Wet Weight Dual Stacked
Dimensions		22" wide x 30" deep x 35" high (56 cm x 76 cm x 89 cm)
Altitude		Up to 2000 Meters (6562 ft.)
Max. Relative Humidity	Up to 31 °C	80%
	Above 31 °C	Derate Linearly to 50% @ 40 °C
Transient Over-Voltage	IEC 664, Installation Category II	2.5 kV
Pollution Degree	IEC 664	2 Π
Sound Pressure Level	At a distance of 1meter.	65dB(A)

4.8 Dimensions

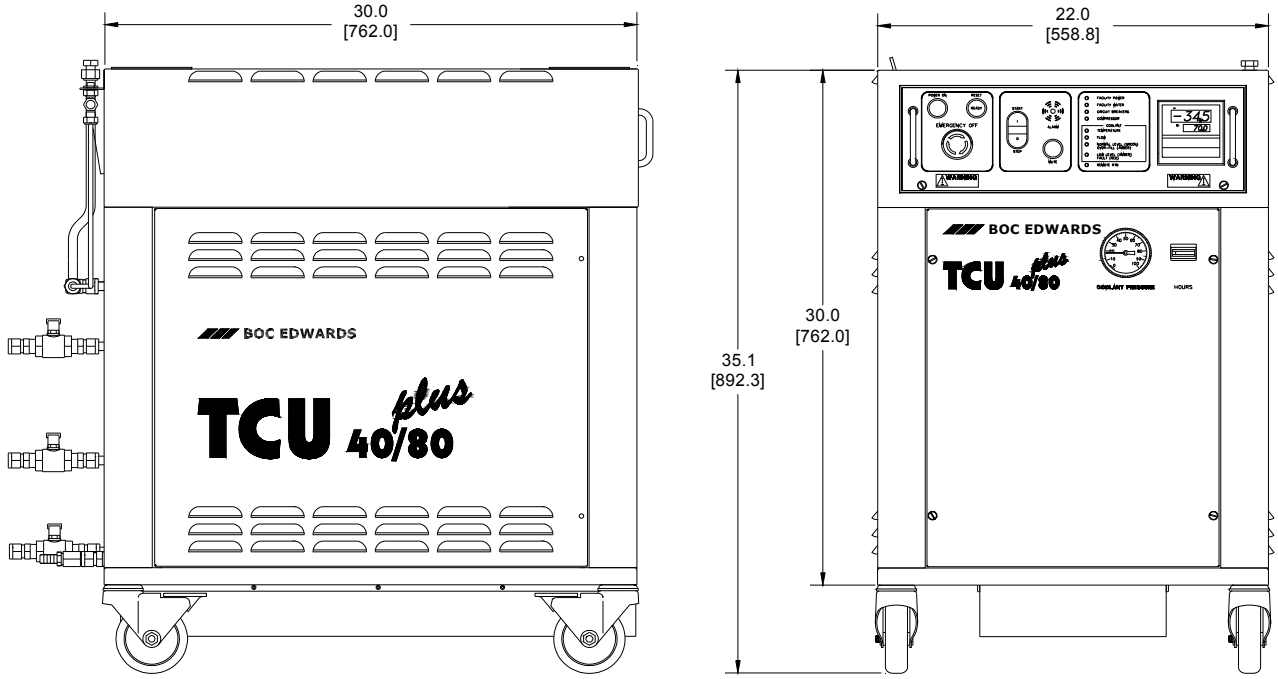

Figure 6 - TCU 40/80 (TCU 40/80 *plus*) Dimensions
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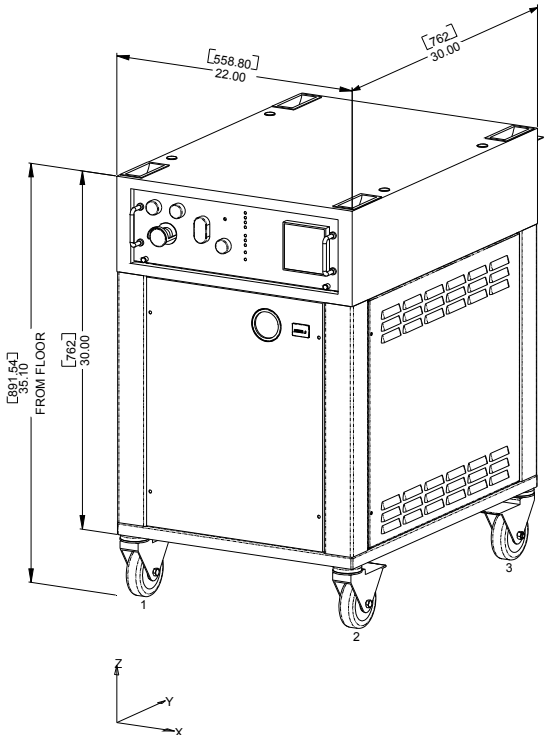

CENTER OF GRAVITY	X	Y	Z
SINGLE	11.10	16.86	17.02
DUAL STACKED	11.10	16.86	33.83

Figure 7 - TCU 40/80 (TCU 40/80 *plus*) Dimensions
(G:\Technical Documents\MANUALS\W95900011- All)

5.4.3 Water

Connections to the water supply and return are made to either ½" brass barb fittings or ½" compression fittings.

For bare hose connections (½" nominal ID):
1. Slip the hose over the barb fitting and tighten the hose clamp.
2. Turn on the water supply and check for leaks.

For connections using hose with tube adapters or tubing (½" nominal OD):
1. Remove the adapter coupled to the hose barb.
2. Insert the tube adapter or tubing with the appropriate ferrule and compression nut.
3. Tighten the compression nut, turn on the water supply, and check for leaks.

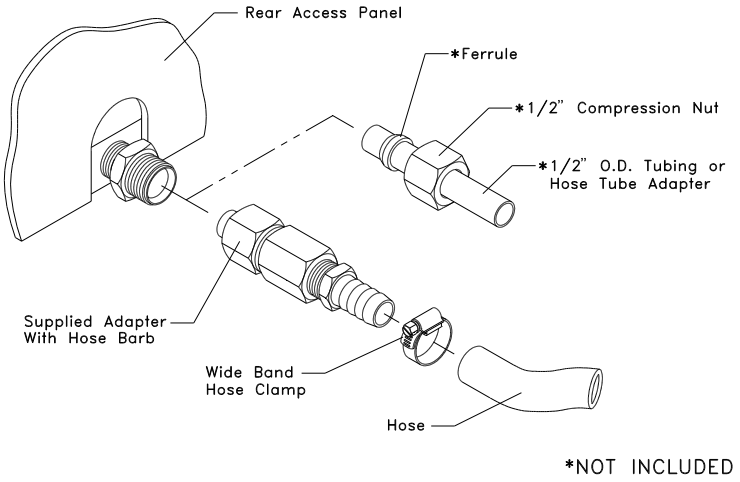

Figure 10 - Water Connections
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5.4.4 Coolant

Note: *If this TCU 40/80 plus is being installed on process equipment that has been used with a coolant other than Fluorinert, contact process equipment supplier for retrofit instructions.*

Connections to the coolant supply and return are made on the rear panel (See Figure 9 on page 19). The maximum distance between the process equipment and the TCU 40/80 plus is 50 feet (100 feet total hose length).

1. Attach the hoses to the supply and return compression fittings. Follow the hose manufacturer recommendations for appropriate adapters.
2. Insulate the hoses with closed cell insulation in order to minimize heat loss.
3. Tape and glue the insulated joints to avoid condensation and icing.

5.4.5 Remote Connections

Wiring details for remote connections are shown in Figure 16 on page 56. Remote connections should not be run near or parallel to A.C. power lines or in the vicinity of equipment that generates large electric fields.

5. Installation

5.1 Receiving and Unpacking

Do a complete visual inspection of the TCU 40/80 *plus* for any damage. Do not use the TCU 40/80 *plus* if physical damage is evident. If there is any damage, notify your supplier and the carrier in writing within three days; state the item number of the TCU 40/80 *plus* together with your order number and supplier's invoice number. Retain all packing materials for inspection.

Caution 	When using a forklift to move or position the TCU 40/80 *plus*, do not install the secondary containment receptacle until the TCU 40/80 *plus* is in position. Failure to follow these instructions may lead to damage of the secondary containment receptacle caused by the forks of the forklift.

5.2 Location

Allow a space 46" wide x 54" deep for the TCU 40/80 *plus* cable and coolant connections. The TCU 40/80 *plus* should have at least two feet of clearance at the rear and one foot along the sides of the unit. Be sure that the mounting surface can safely support the weight of the TCU 40/80 *plus* (460 lbs. evenly distributed). The center of gravity is approximately the center of the refrigeration compartment. When using a forklift to move the TCU 40/80 *plus*, position the forks from the side of the unit.

Warning 	The TCU 40/80 *plus* weighs 460 pounds (210 kg). Failure to take proper care in moving or lifting these units can result in serious bodily injury.

A 3 ft. (1m) service length of the power cable is required to fully open the electrical drawer. Therefore, do not install the TCU 40/80 *plus* further than 7 feet (2.1m) from the power source.

5.2.1 Securing the Unit

The four lockable casters of the TCU 40/80 plus swivel to provide maximum maneuverability. Make sure that all four casters are turned inward and locked in position once the TCU 40/80 plus is situated.

5.2.2 Installing the Secondary Containment Receptacle

The secondary containment receptacle slides into the base from the rear of the unit.

5.2.3 Floor Levelers

An optional floor leveler kit is available to compensate for uneven surfaces. See Table 15 on page 57 for ordering information.

5.3 Stacking

The TCU 40/80 *plus* may be stacked two high. Be sure that the mounting surface can safely support the weight of the two units (920 lbs., 420 kg). Be sure that the casters of the top unit are turned inwards, but are not locked, until the top unit is fully seated.

5.3.1 Tie-Bolts

An optional tie-bolt kit is available for attaching stacked units. See Table 15 on page57 for ordering information.

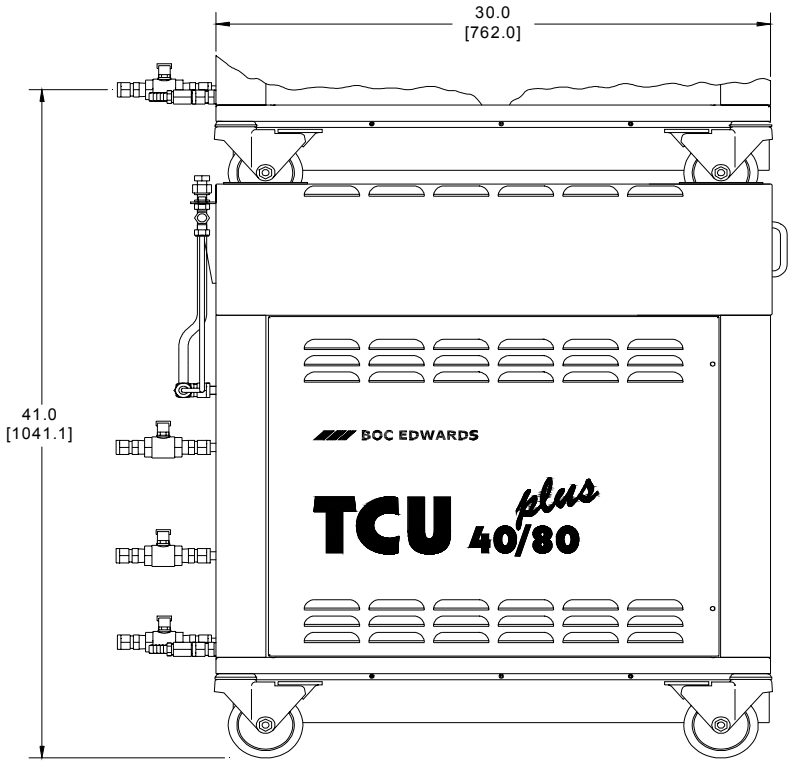

Figure 8 - Stacked TCU 40/80 (TCU 40/80 plus) systems
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5.4 Facilities

The TCU 40/80 *plus* requires a water supply flow rate between 3 to 6 gallons per minute at a maximum pressure of 100 psig, and an inlet temperature range of 10 °C to 26 °C. Power input is by a fused, suitable isolating electrical outlet, 208 VAC, 50/60 Hz, 30 amp, 3-phase delta (balanced load), 3-wire and earth. The required receptacle type is Hubbell P/N L21-30R2810-A, or equivalent.

5.4.1 50 Hz Installations

For 50 Hz installations, adjust the Phase Monitor Relay (PMR1). Open the electrical drawer by loosening the two screws at the front. Locate PMR1 (reference Figure 13). Remove the "CAUTION" label, and turn the dial to align with the "50" mark. Replace the "CAUTION" label and close the drawer.

5.4.2 Water and Coolant Connections

Figure 9 shows a rear view of the TCU 40/80 *plus* with its water and coolant connections.

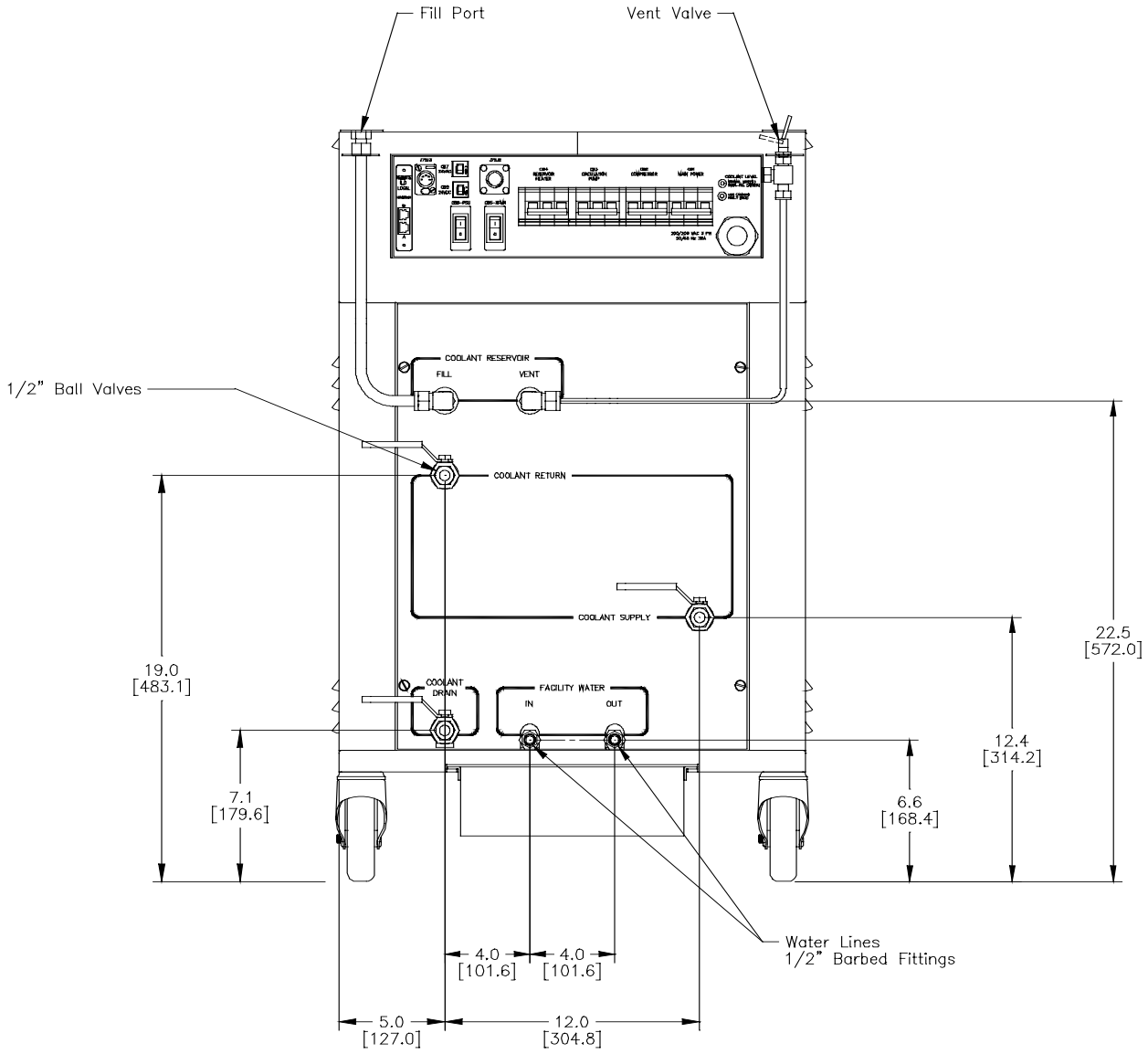

Figure 9 - System Rear View
(G:\Technical Documents\MANUALS\W95900011- All)

5.4.3 Water

Connections to the water supply and return are made to either ½" brass barb fittings or ½" compression fittings.

For bare hose connections (½" nominal ID):
1. Slip the hose over the barb fitting and tighten the hose clamp.
2. Turn on the water supply and check for leaks.

For connections using hose with tube adapters or tubing (½" nominal OD):
1. Remove the adapter coupled to the hose barb.
2. Insert the tube adapter or tubing with the appropriate ferrule and compression nut.
3. Tighten the compression nut, turn on the water supply, and check for leaks.

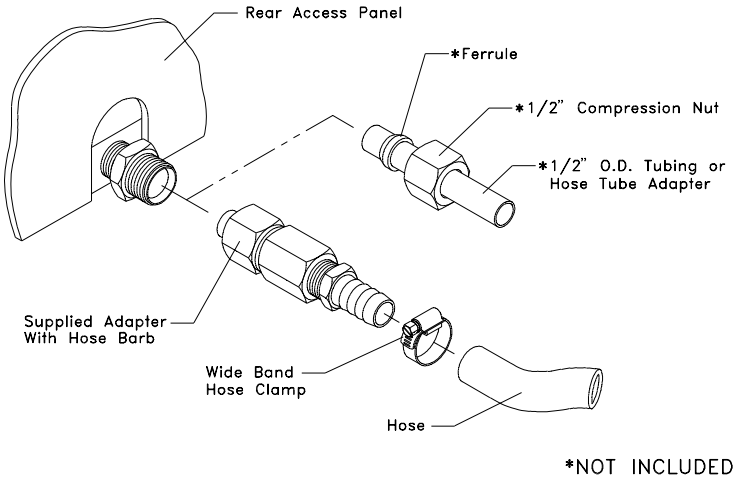

Figure 10 - Water Connections
(G:\Technical Documents\MANUALS\W95900011- All)

5.4.4 Coolant

Note: *If this TCU 40/80 plus is being installed on process equipment that has been used with a coolant other than Fluorinert, contact process equipment supplier for retrofit instructions.*

Connections to the coolant supply and return are made on the rear panel (See Figure 9 on page 19). The maximum distance between the process equipment and the TCU 40/80 plus is 50 feet (100 feet total hose length).

1. Attach the hoses to the supply and return compression fittings. Follow the hose manufacturer recommendations for appropriate adapters.
2. Insulate the hoses with closed cell insulation in order to minimize heat loss.
3. Tape and glue the insulated joints to avoid condensation and icing.

5.4.5 Remote Connections

Wiring details for remote connections are shown in Figure 16 on page 56. Remote connections should not be run near or parallel to A.C. power lines or in the vicinity of equipment that generates large electric fields.

6. Operation

6.1 Preparation

Verify that water and coolant connections are made at both ends that the drain valve is closed and the coolant supply and return valves are open. Connect the remote interfaces if required.

1. To use an external RTD probe, attach it to connector J72J3. Refer to Figure 16 on page 60. Verify that the plug J72J2 is installed.
2. Press the EMERGENCY OFF button on the front panel.
3. Plug the TCU 40/80 *plus* power cord into a fused, switchable, 30 amp, 3-phase, 208 VAC outlet.
4. Ensure that all circuit breakers on the rear panel are in the ON position. CB7 and CB8 are non-switchable circuit breakers and will trip when there is a problem. They cannot be turned on or off, but they are re-settable.

6.2 Powering up the TCU 40/80 *plus*

1. Verify that the POWER ON lamp on the front panel is illuminated.
2. Release the EMERGENCY OFF button.

Caution 	If the Facility Power LED illuminates, the line voltage is low, or the phase of the main power supply is reversed. Adjust the line voltage, if it is low. Correct the phases by swapping two phases in the electrical outlet.

3. Press the RESET button and verify the front panel indicators are as in the Reset Condition column of Table .

Table 8 - Front Panel Power Up Indicator Conditions

Indicator	Reset Condition	Start Condition
Power On	Green	Green
Reset	Off	White
Facility Power	Off	Green
Facility Water	Green	Green
Circuit Breakers	Green	Green
Compressor	Off	Green
Temperature	Green	Green
Flow	Off	Green
Normal Level	Off	Green
Low Level	Red	Off
Remote RTD (If Used)	Green	Green

4. Press MUTE to silence the alarm.
   The TCU 40/80 *plus* is shipped without coolant. The coolant level alarm will sound and the front panel Reservoir Coolant Low Level LED will be red indicating that the reservoir must be filled.
5. Fill the coolant reservoir using the procedure Filling the Reservoir on page 31.
6. Press the START button and verify the front panel indicators are as in the Start Condition column of Table 8.
7. Use a halogen leak detector to check all supply and return line connections at both the TCU and process equipment, around the pump head assembly, drain valve, heater, flow switch, vent line, fill line, and reservoir pressure relief valve.

6.3 Changing the Setpoint Value (SV1)

The following instructions are for local temperature control only.

Caution 	Do not exceed the temperature range of -40 °C to +80 °C. This is the normal operating range of the TCU 40/80 *plus*.

To change the temperature settings press page up or page down to either increase or decrease the temperature. The red display "PV" indicates the process value. The green display "SP" indicates the current setpoint.

Note: *The temperature controller has been programmed to prevent the setpoint from exceeding the normal operating range of the TCU 40/80 plus. The controller is also protected from unauthorized changes to the PID and other settings. Contact the process equipment supplier for access to these settings and other information.*

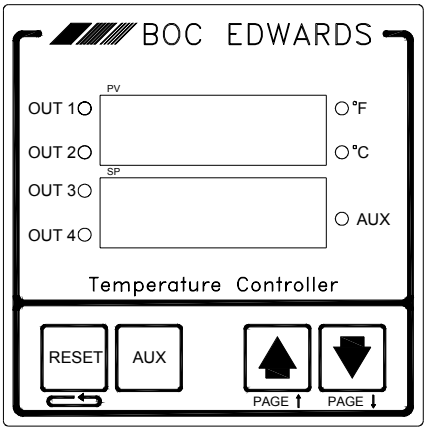

Figure 11 - Temperature Controller
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6.4 Temperature Controller PID Settings

BOC Edwards default settings are:

PID1 - Heating	Value	PID2 - Cooling	Value	Parameter
Pb1	14.0	Pb2	18.0	Proportional Band
Ar1	1.0	Ar2	4.5	Automatic Reset
rAt1	3.0	rAt2	4.0	Rate
db1	1.0	db2	1.0	Deadband

6.5 Remote Set-Point

To use the remote set point, wire the J72J2 mating connector as illustrated on page 56.
24vac must be applied to pins 3 and 4.
The AUX LED on the temperature controller will illuminate indicating remote setpoint enable mode as soon as the mating connector is installed.

6.6 Flow Rate Adjustment

Caution 	Do not exceed coolant pressure of 100 psi. Exceeding the coolant pressure may result in damage to the pump.

The Fluorinert flow rate of the TCU 40/80 *plus* is factory set to provide approximately 3 gpm at 60 psig/20°C for a unit operating at 208vac/3-ph/60Hz. If the flow rate requires adjustment to accommodate the process equipment suppliers' recommendations, follow the steps below. The flow rate may be measured using a flow meter external to the TCU 40/80 *plus*.

1. Open the left side access door.
2. Peel back the insulation covering the by-pass valve. Refer to Figure 1 on page 7.
3. The valve handle can be found in the plastic bag secured to the pump. Reduce the flow by turning the valve stem clockwise. To increase the flow, turn the stem counter clockwise. The valve is a 1/4 turn valve.
4. Once the required flow rate has been achieved, return the valve handle to the bag for future use, glue the insulation back in place, and secure the access door.

7. Maintenance

This section contains information that will allow you to safely keep your TCU 40/80 *plus* in working order. It contains important Hazard Warnings, and a Preventive Maintenance Schedule on page 28.

Warning 	Maintenance to the electrical system of the TCU40/80 should be performed by qualified personnel only.

Warning 	The refrigeration units are sealed and are not user serviceable. Only trained and licensed refrigeration personnel should perform repairs on this equipment. All applicable EPA regulations apply.

7.1 Hazard Warnings

High Pressure 	Water and the coolant are pressurized within this equipment. Water pressure will depend upon utility supply, but usually is up to 60 psig. The coolant can be at pressures up to 100 psig. Refrigerant pressures can be up to 300 psig. Do not open lines with pressure present.

Toxic Gases 	The coolant breaks down above 215 °C. If the coolant is allowed to reach these temperatures; toxic gasses may be discharged from the unit. Refer to the Appendix for Material Safety Data Sheets for the coolant and refrigerant used in this system.

High Pressure 	The reservoir may become pressurized due to changes in temperature. Under no circumstances should the reservoir pressure relief valve be removed or capped off.

High Pressure 	The refrigerant lines are at high pressure. Under no circumstances should the refrigerant pressure relief valve be removed or capped off.
Eye Protection 	Leakage or failure of high-pressure circuits may cause injury or irritation of the eyes. Eye protection should be worn when working with fluid systems.
Hand Protection 	Hot or cold fluids and surfaces can cause injury or irritation of the hands. Hand protection should be worn when working with these fluid systems.
Electric Shock 	Ensure that all electrical power has been removed and the main circuit breaker has been turned off prior to opening the electrical drawer. The EMERGENCY OFF circuit (EMO) does not disconnect all power from the electrical drawer. Extreme caution must be observed if performing maintenance operations with the drawer open.
Hot Surface 	Refrigeration and circulating fluid lines can attain temperatures as high as 110 °C. Caution must be observed.

7.2 Hazards

Table 9 gives the classifications of electrical hazards. This number indicates the severity of the hazard as defined by SEMI S2-93.

Table 9 - Electrical Hazards Classifications

Classification	Description	Comment
Type 1	Equipment is fully de-energized.	None called out.
Type 2	Equipment is energized. Live circuits are covered or insulated. Work is performed at a remote location to preclude accidental shock.	Called out as Type 2.
Type 3	Equipment is energized. Live circuits are exposed and accidental contact is possible. Potential exposures are less than 30 volts RMS, 42.2 volts peak, 240 volt-amps, 20 Joules. (See NFPA 79-14.3, IEC 204, UL 1950 & 1262, IEC 950.)	Called out as Type 3.
Type 4	Equipment is energized. Live circuits are exposed and accidental contact is possible. Potential exposures are greater than 30 volts RMS; 42.2 volts peak, 240 volt-amps, 20 Joules or radio frequency (RF) is present.	Called out as Type 4.
Type 5	Equipment is energized and measurements and adjustments require physical entry into the equipment, or equipment configuration will not allow the use of clamp-on probes.	None called out.

7.3 Filling the Reservoir

Warning 	When retrofitting a TCU 40/80 *plus* in place of a water/glycol unit, the coolant lines must be flushed with nitrogen to remove moisture prior to installation.

1. Open the vent port valve (See Figure 9 on page 19) to avoid air locks that may slow filling.
2. Remove the plug and fasten the funnel accessory to the ½" fill port located at the rear of the unit (See Figure 9 on page 19).
3. Fill the reservoir with Fluorinert heat transfer fluid. The amount needed for a new installation is approximately 44 pounds for the TCU and an additional amount for process lines (approximately 0.15 pounds/ft of 1/2" tube) and other external volumes.
4. Begin filling the reservoir until the Coolant Normal Level LED on the rear electrical panel turns green. When the LED turns green, add approximately 4 liters more of fluid (approximately 17 pounds).
5. If this is a new installation, the lines to the tool are empty. If possible, start the TCU. The coolant will leave the TCU to fill the lines and the level in the TCU reservoir will decrease. Observe the TCU to determine if the Coolant Low Level LED on the rear panel turns amber. If so, add approximately 4 liters more fluid (approximately 17 pounds).
6. In the event of over-filling, the Coolant Normal LED will change from green to amber. Drain excess fluid until the Coolant Normal Level LED turns green. Refer to Draining/Bleeding the Coolant Reservoir, below.

7.4 Draining/Bleeding the Coolant Reservoir

It may be necessary to drain the coolant reservoir for storage of the TCU 40/80 *plus* or due to moisture contamination of the coolant.
It may be necessary to bleed the coolant reservoir to correct an overfill condition.

Note: The unit may continue running during this procedure.

Follow the procedure below whenever it becomes necessary to drain or bleed the system.

Extreme Temperature 	Hot or cold coolant may reach -40°C to +80°C during operation. Hot or cold fluid can cause burns. Coolant should be at ambient temperature before handling.

1. Open the vent valve located at the top of the unit.
2. Place an appropriate container beneath the drain valve. The capacity of the container used needs to be 10 liters *plus* the volume of the hoses and the volume of the process equipment.
3. Remove the cap fitting from the end of the drain valve.
4. Open the reservoir drain valve.
5. To correct an overfill condition,
   a. Drain the reservoir until the Coolant Level Normal LED on the rear electrical panel turns green. Close the reservoir drain and vent valves when the LED turns green.
   b. To empty the reservoir, remove power to the TCU and allow the unit to drain until all coolant has been removed.
6. Close the reservoir drain and vent valves.
7. For proper disposal of the coolant, follow the manufacturer recommendations.

Note: Uncontaminated Fluorinert may be reused. The Fluorinert should be stored in a compatible and sealed container.

7.5 Temperature Probe Calibration

The BOC Edwards Temperature Controller comes equipped with a factory calibrated internal ±10V remote input/output option making calibration unnecessary.

7.6 Preventive Maintenance Schedule

Table 10 shows the maintenance required to keep the TCU 40/80 *plus* in good working order. Failure to follow this schedule may result in degradation of system performance.

Table 10 - Preventive Maintenance Schedule

Frequency	Operation	Hazard
Semi-annually	Verify system status	
	Check coolant level	
	Check lamps	(Type 3)
	Coolant leak check	(Type 3)
	Refrigeration leak check	(Type 3)
	Insulation repair	(Type 3)
	Water leak check	(Type 3)
Annually	Replace solenoid coils SV1 and SV2	(Type 3)
	System check	(Type 3)
	Lamp replacement	(Type 3)

Note: All maintenance should be recorded on the Preventative Maintenance Record label located on the inside of the left-hand side access panel.

7.7 Semi-Annual Preventative Maintenance

Refer to the Troubleshooting section 8 on page43 when results for any of the following checkpoints are not as expected.

7.7.1 Required Equipment

- 12” slotted screwdriver
- 4” slotted screwdriver
- Two 10” adjustable wrenches
- Halogen leak detector
- Spare lamps (24 vac / 60 mA)
- Fluorinert
- Insulation Tape

7.7.2 Preparation

- Locate the two screws securing each of the side access panels and loosen to open doors.
- Listen for excessive or questionable noise or sounds coming from the pump assembly, motor, compressor, or solenoid valves (SV1 and SV2).

7.7.3 Verify System Status

- Verify system status led indicators on the front electrical panel. (See Table 8 on page 21.)

7.7.4 Refrigeration Leak Check

- Visually check for signs of compressor oil on the base, insulation, and on all refrigeration Tube assembly.
- Using a halogen leak detector check around the discharge and suction service valves of the compressor, and all accessible refrigeration tube assembly.

7.7.5 Fluorinert Leak Check

- Use a halogen leak detector to check all supply and return line connections at both the TCU and process equipment, around the pump head assembly, drain valve, heater, flow switch, vent line, fill line, and reservoir pressure relief valve.

7.7.6 Water Leak Check

- Visually check for signs of water leaks at all water line connections external to the TCU and at the condenser connections inside the unit.

7.7.7 Insulation Repair

Note: If ice formation is excessive, it may be necessary to correct this condition before insulation can be repaired.

- Visually inspect refrigeration and process fluid lines both inside the TCU cabinet and at the supply and return line connections for signs of ice formation. Correct insulation as necessary.

7.7.8 Lamp Check/Replacement

Electric Shock 	Ensure all electrical power has been removed and the main circuit breaker has been turned off due to the presence of high voltage or current.

Caution 	Should a lamp require replacement, notify the appropriate personnel that an EMO condition will occur. Failure to follow these instructions may result in the shutdown of the process tool and associated equipment.

Visually verify that the POWER ON and RESET lamps are working. If either lamp needs replacement and the proper authorization has been obtained:

1. Press STOP.
2. Turn off the main circuit breaker (CB1).
3. Disconnect power cord from mains power supply.
4. Locate the two securing screws on the front electrical panel and loosen. Open the electrical drawer.
5. If replacing the POWER ON lamp, locate contactor block (LP1) on the backside of the front electrical panel. If replacing the RESET lamp, locate contactor block (PB1) on the backside of the front electrical panel.
6. Pry up the metal retaining ring attached to the coupling plate. Remove the contact block assembly.
7. Replace the defective lamp.
8. Reinstall the contact block assembly by snapping it back onto the front element.
9. Close the electrical drawer and tighten securing screws.
10. Reconnect main power and turn on the main circuit breaker (CB1). The POWER ON lamp should be illuminated.
11. Press RESET. The lamp should illuminate. Press START to reactivate the TCU.

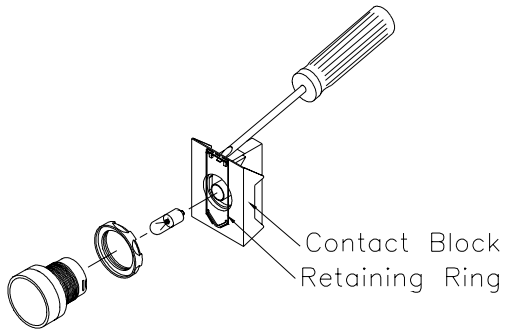

Figure 12 - Lamp Replacement
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7.8 Annual Preventative Maintenance

Refer to the Troubleshooting section 8 on page47 when results for any of the following checkpoints are not as expected.

7.8.1 Required Equipment

- 12” slotted screwdriver
- 4” slotted screwdriver
- 7” slotted screwdriver
- 8” Phillips screwdriver
- Two 10” adjustable wrenches
- Wire strippers (14 AWG)
- Two test clips w/12” leads
- Miniature diagonal cutters
- Halogen leak detector
- 3\8” open-ended wrench
- 1\4” open-ended wrench
- Wire crimpers - Insulated terminal
- Digital multimeter (DMM)
- Remote RTD connector plug (J72J3)

7.8.2 Required Supplies

- Preventative Maintenance Kit (P60153005)
- Fluorinert
- Insulation Tape

7.8.3 Solenoid Valve Coil Replacement

Electric Shock 	Ensure all electrical power has been removed and the main circuit breaker has been turned off due to the presence of high voltage or current.

Caution 	Should a solenoid valve coil require replacement, notify the appropriate personnel that an EMO condition will occur. Failure to follow these instructions may result in the shutdown of the process tool and associated equipment.

1. Press STOP. Turn off the main circuit breaker (CB1).
2. Disconnect the power cord from the mains power supply.
3. Locate the main cooling solenoid valve (SV1) from the left side access door.
4. Remove the junction box attachment screw. Slide off the junction box cover.
5. Back off the strain relief-retaining nut.
6. Unfasten the ground screw. Cut off the wire butt splices (ensuring that the wire labels remain attached to the base assembly) and pull the wires through the junction box.
7. Remove the solenoid valve coil lock nut. Lift off the spacer cup. Separate the coil from the solenoid valve body by gently pulling up on the coil.
8. Remove replacement solenoid valve coil from packaging.
9. Remove the junction box.
10. Note the location of the conduit hole on the coil removed and remove the appropriate “knock-out” on the replacement coil.
11. Gently slip the replacement coil onto enclosing tube of solenoid valve body.
12. Pull the base assembly wiring through conduit hole and slip on the strain relief-retaining nut.
13. Attach the ground wire to coil.

14. Strip the ends of all wires on base assembly and solenoid valve coils.
15. Attach wires and secure mating connections per figure 13 below.
16. Tighten the strain relief-retaining nut.
17. Install the original junction box cover and fasten attachment screw.
18. Install the spacer cup.
19. Install and tighten the lock nut.
20. Verify the coil junction box is labeled SV1.
21. Repeat the procedure for Hot Gas Bypass solenoid valve coil (SV2).
22. Discard the old solenoid coils.
23. Perform the System Check procedure.

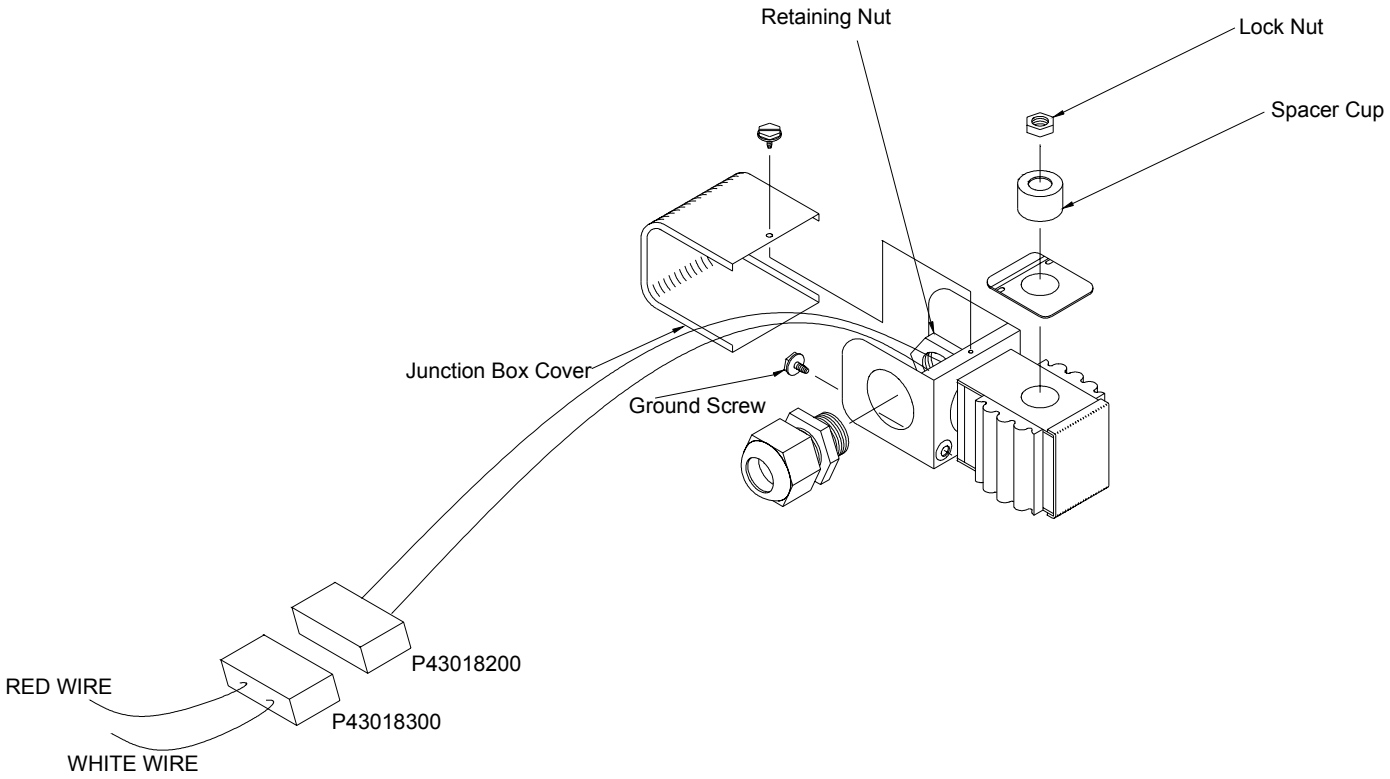

Figure 13 - Solenoid Coil Replacement
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7.8.4 System Check

Component Settings

Motor Overload Setting (K3)	3.5 amps
Current Sensing Relay Setting (CSR)	25 amps
Thermostat Setting (TS1)	210°F (Differential set at 10°F)
High Pressure Switch Setting (PS1)	300 psig. (Differential set at 40 psig)

Power-Up Conditions

- Power cord connected to mains power supply.
- All circuit breakers on.
- EMO released.
- Drawer interlock switch in maintenance position.
- Host connector J72J2 installed (Pins 5 & 6 shorted).

Indicator	Condition
Relays	All off
LED	All off
Power	On
Reset	Off
PMR	Green
Current Sensing Relay	Off

Note: REMOTE RTD is optional. LED will be green if used.

Reset Button

1. Press RESET.
2. Verify contactor K1 engages.
3. Verify LED indicator on PMR is green.

Indicator	Condition
Relays	CR1, CR4, & CR12 on all others off
LED	Facility Water, Circuit Breakers, Coolant Temperature, Coolant Normal Level, Green Facility Power, Compressor, Coolant Flow, Coolant Low Level, Remote RTD, Off
Power	On
Reset	On
PMR	Green
Current Sensing Relay	Off

Note: REMOTE RTD is optional. LED will be green if used.

Temperature Controller

1. All control parameters and selections procedures for the temperature controller are accomplished through simple MENU selections. These MENU selections are organized into PAGES. On each page you will find a specific set of related functions. The PAGES setup structure is as follows: diSP PAGE, Ctrl PAGE, inPt PAGE, ScAL PAGE, Out1 PAGE and Out2 PAGE.

   To select a PAGE:
   Press and hold the RESET key, while pressing the ▲ or ▼ keys. The upper display of the temperature controller will increment or decrement through the PAGEs, and PAGE will be displayed in the lower display.

   To select a MENU:
   After reaching the correct page, press reset to move through MENUs. The alpha cue for the MENU will appear on the upper display and the current value will appear in the lower display.

   To change a MENU value:
   After the MENU is selected and displayed, use the ▲ and ▼ keys to change the value.

2. **To enter the SetUp Mode**, press the controller RESET key and hold it for about 3 seconds. The controller will display **LocH XXX** where **XXX** is the security code. The security code number should be 458. If not, press either the ▲ or ▼ keys until the display reads 458. This is the first menu in the **Ctrl PAGE.**

3. Verify that the menu settings for the **Ctrl PAGE** are as follows:

PID1 - Heating	Value	PID2 - Cooling	Value	Parameter
Pb1	14.0	Pb2	18.0	Proportional Band
Ar1	1.0	Ar2	4.5	Automatic Reset
rAt1	3.0	rAt2	4.0	Rate
db1	1.0	db2	1.0	Deadband

OFst = 0.0 FL = On	Orng = 0.0	LooP = OFF	Auto = 4	rrAt = OFF	Cont = HtCl
CooL = PID2	rSP = On	Enti = rSP	Au = none	Aout = Proc	rSEn = OFF

4. Select the next page, which is the **InPT PAGE.** Verify that the menu settings for the **InPt PAGE** are as follows:

SEnS = rtdt unit = °C	CoFF = .0	SPLL = -40.0	SPUL = 80.0

5. Select the next page, which is the **ScAL PAGE.** Verify that the menu settings for the **ScAL PAGE** are as follows:

DP = 1 AinL = -50.0	AinH = 100.0	AotL = -100.0	AotH = 100.0	rSPL = -100.0
rSPH = 100.0				

6. Select the next page, which is the **Out1 PAGE.** Verify that the menu settings for the **Out1 PAGE** are as follows:
   Cyc1 = 16 OL1 = 100.0 HoFF = .0
7. Select the next page, which is the **Out2 PAGE.** Verify that the menu settings for the **Out2 PAGE** are as follows:
   Cyc2 = 16 OL2 = 100.0 CoFF = .0
8. Press START.
   To return to Operating Mode, press and hold the RESET key for more than 3 seconds. The controller will automatically return to operating mode after 10 minutes of no push-button activity.
9. Press START.

EMO Circuit

Warning 	Do not perform the EMO circuit check while the TCU is on-line with the process tool. Failure to follow these instructions will lead to the shutdown of the process tool and other associated equipment.

1. Press the EMO button and check that the following occur.
   - READY lamp goes out.
   - All front panel LED indicators go out.
   - Temperature controller shuts off.
   - K1 contactor opens.
2. Release the EMO button and press RESET. Perform the following:
   - Remove rear panel connector J72J2. The READY lamp should go out. Contactor K1 should open, the temperature controller and the front panel LED indicators should go out. Replace J72J2 connector and press RESET.
3. Press in the interlock switch then release it. The READY lamp should go out. Contactor K1 should open, the temperature controller and the front panel LED indicators should go out. Place the drawer interlock switch in the maintenance position.
   - Press RESET
   - Press START

PMR

1. On the PMR rotate the adjustment knob completely clockwise.
2. Verify the unit shuts down, LED 1 (Facility Power) illuminates red, and that the alarm sounds.
3. Press MUTE.

Indicator	Condition
Relays	CR1, CR4, CR11, CR12, CR13 On all others, Off
LED	Facility Water, Circuit Breakers, Coolant Temperature, Coolant Normal Level, Green Compressor, Coolant Flow, Coolant Low Level, Remote RTD, Off Facility Power, Red
Power	On
Reset	Off
PMR	Red
Current Sensing Relay	Off

Note: *REMOTE RTD is optional. LED will be green if used.*

4. Return the PMR adjustment control to the original position.
5. Press RESET then START

Current Sensing Relay

1. Set CSR1 to 50 amps. The indicator LED on CSR1 should go from green to red.
2. After a 5 second time delay, verify that the unit shuts down, COMPRESSOR illuminates red and the alarm sounds.
3. Press MUTE.

Indicator	Condition
Relays	CR1, CR4, CR8, CR11, CR12, CR13 On all others, Off
LED	Facility Water, Circuit Breakers, Coolant Temperature, Coolant Normal Level, Green Facility Power, Coolant Flow, Coolant Low Level, Remote RTD, Off Compressor, Red
Power	On
Reset	Off
PMR	Green
Current Sensing Relay	Off

Note: *REMOTE RTD is optional. LED will be green if used.*

4. Reset CSR1 to 25 amps.
5. Press RESET.
6. Press START.

Circuit Breaker

1. Power off CB4. The TCU will shut down, alarm will sound and CIRCUIT BREAKER LED should be red.
2. Press MUTE.
3. Power on CB4, press START.
4. Repeat steps 1 through 3 for CB3 and CB2.

Indicator	Condition
Relays	CR4, CR11, CR12, CR13 On all others, Off
LED	Facility Water, Coolant Temperature, Coolant Normal Level, Green Facility Power, Compressor, Coolant Flow, Coolant Low Level, Remote RTD, Off Circuit Breakers, Red
Power	On
Reset	Off
PMR	Green
Current Sensing Relay	Off

Note: *REMOTE RTD is optional. LED will be green if used.*

Water Supply

1. Open TCU right side panel and remove PS1 cover. Using a flat head screwdriver, lift up PS1 tab. The TCU will shut down, alarm will sound, and FACILITY WATER LED should illuminate red.
2. Press MUTE.

Indicator	Condition
Relays	CR1, CR2, CR4, CR11, CR12, CR13 On all others, Off
LED	Circuit Breakers, Coolant Temperature, Coolant Normal Level, Green Facility Power, Compressor, Coolant Flow, Coolant Low Level, Remote RTD, Off Facility Water, Red
Power	On
Reset	Off
PMR	Green
Current Sensing Relay	Off

Note: *REMOTE RTD is optional. LED will be green if used.*

3. Reinstall PS1 cover.
4. Press RESET.
5. Press START.

Reservoir Over-Temperature

1. Open TCU right side panel and remove TS1 cover. Using a flat head screwdriver, lift up TS1 tab. The TCU will shut down, alarm will sound and COOLANT TEMPERATURE LED should be red.
2. Press MUTE.

Indicator	Condition
Relays	CR1, CR4, CR6, CR11, CR12, CR13 On all others, Off
LED	Facility Water, Circuit Breakers, Coolant Normal Level, Green Facility Power, Compressor, Coolant Flow, Coolant Low Level, Remote RTD, Off Coolant Temperature, Red
Power	On
Reset	Off
PMR	Green
Current Sensing Relay	Off

Note: *REMOTE RTD is optional. LED will be green if used.*

3. Reinstall TS1 cover.
4. Press RESET.
5. Press START.

Coolant Flow

1. Shut off coolant supply valve. After 5 second delay, the TCU will shut down, alarm will sound and COOLANT FLOW LED should be red.
2. Press MUTE.

Indicator	Condition
Relays	CR1, CR4, CR7, CR11, CR12, CR13 On all others, Off
LED	Facility Water, Circuit Breakers, Coolant Temperature, Coolant Normal Level, Green Facility Power, Compressor, Coolant Low Level, Remote RTD, Off Coolant Flow, Red
Power	On
Reset	Off
PMR	Green
Current Sensing Relay	Off

Note: *REMOTE RTD is optional. LED will be green if used.*

3. Open coolant supply valve.
4. Press RESET
5. Press START

Compressor

1. Remove wire #60 from CSR1. After 5 second delay, the TCU will shut down, alarm will sound and COMPRESSOR LED will be red.
2. Press MUTE.

Indicator	Condition
Relays	CR1, CR4, CR8, CR11, CR12, CR13 On all others, Off
LED	Facility Water, Circuit Breakers, Coolant Temperature, Coolant Normal Level, Green Facility Power, Coolant Flow, Coolant Low Level, Remote RTD, Off Compressor, Red
Power	On
Reset	Off
PMR	Green
Current Sensing Relay	Off

Note: *REMOTE RTD is optional. LED will be green if used.*

3. Reinstall wire #60 to N.O. contact of CSR1.
4. Press RESET.
5. Press START.

Circulation Pump

1. Adjust overload trip on K3 to the minimum setting. Within three minutes the overload will trip. After a five second time delay, the TCU will shut down, the alarm will sound and the COOLANT FLOW LED should illuminate red.
2. Press MUTE.

Indicator	Condition
Relays	CR1, CR4, CR7, CR11, CR12, CR13 On all others off
LED	Facility Water, Circuit Breakers, Coolant Temperature, Coolant Normal Level, Green Facility Power, Compressor, Coolant Low Level, Remote RTD, Off Coolant Flow, Red
Power	On
Reset	Off
PMR	Green
Current Sensing Relay	Off

Note: *REMOTE RTD is optional. LED will be green if used.*

3. Reset overload trip to 3.5 amps.
4. Press RESET
5. Press START

Reservoir Overfill

1. Short wire #23 (TB1) to wire #63 (Relay board J3-4). COOLANT NORMAL LEVEL LED will go from green to amber.

Indicator	Condition
Relays	CR1, CR4, CR5, CR10 On CR12, Off
LED	Facility Power, Facility Water, Circuit Breakers, Compressor, Coolant Temperature, Coolant Flow, Coolant Normal Level, Green Coolant Low Level, Remote RTD, Off Coolant Normal Level, Amber
Power	On
Reset	On
PMR	Green
Current Sensing Relay	Green

Note: *REMOTE RTD is optional. LED will be green if used.*

Remote Start/Stop

1. Remove jumper from terminal strip (TB1). The TCU will shut down.
2. Press RESET.
3. Press START.

Remote Temperature Probe

1. Install connector J72J3 and verify REMOTE RTD illuminates green.

Indicator	Condition
Relays	CR1, CR4, CR9, CR10, CR12 On all others, Off
LED	Facility Power, Facility Water, Circuit Breakers, Compressor, Coolant Temperature, Coolant Flow, Coolant Normal Level, Remote RTD, Green Coolant Low Level, Off
Power	On
Reset	On
PMR	Green
Current Sensing Relay	Green

2. Remove connector J72J3.

Cooling

1. Change the temperature controller set point to -40°C.
2. Verify CR15 on the relay board illuminates.
3. Verify main solenoid valve (SV1) has opened by confirming that the sight glass has filled with refrigerant.
4. Verify OUT 2 LED on the temperature controller is on.

Indicator	Condition
Relays	CR1, CR4, CR10, CR12, CR15 On all others, Off
LED	Facility Power, Facility Water, Circuit Breakers, Compressor, Coolant Temperature, Coolant Flow, Coolant Normal Level, Remote RTD, Green Coolant Low Level, Remote RTD, Off
Power	On
Reset	On
PMR	Green
Current Sensing Relay	Green

Note: *REMOTE RTD is optional. LED will be green if used.*

Heating

1. Change the temperature controller set point to 80°C.
2. Verify contactor K4 pulls in.
3. Verify CR15 goes out. Verify OUT 1 on the temperature controller is on and OUT 2 is off.
4. Verify hot gas bypass solenoid (SV2) is energized.

Indicator	Condition
Relays	CR1, CR4, CR10, CR12 On all others, Off
LED	Facility Power, Facility Water, Circuit Breakers, Compressor, Coolant Temperature, Coolant Flow, Coolant Normal Level, Remote RTD, Green Coolant Low Level, Remote RTD, Off
Power	On
Reset	On
PMR	Green
Current sensing relay	Green

Note: *REMOTE RTD is optional. LED will be green if used.*

Process Value Setting

1. Set the temperature controller to the proper process set value.
2. Verify all the host interface connections are mated properly.

7.9 Preventive Maintenance Checklist

Record Date:		Serial No:	
Customer Name:		Line / Area:	
Checked By:		Tool Name:	

System Status

Timer Hours:		Hours	
Coolant Pressure:		psig	
Process Temperature:		°C	
Fluorinert Type:	□ FC8270	□ FC77	□ Other:
Quantity Of Fluorinert Added:		□ lbs.	□ Liters
Operation Mode:	□ Remote	□ Local	
Utilities Water Temperature:		°C	
Leak Check Results:	□ Pass	□ Fail	Remarks:

Parts Replaced	Quantity	Cause / Reason

Actions / Concerns

8. Troubleshooting

Table 11, Table 12, Table 13 and Table 14 identify fault conditions that may encounter with the TCU 40/80 *plus*. For additional assistance contact the BOC Edwards Service Department.

Table 11 - Faults Identified By Front Panel Lamps

Indicator	Possible Causes	Action	Hazard
POWER ON lamp is not illuminated.	No power to the TCU 40/80 plus.	Verify that the power cord is plugged in. Verify that outlet's circuit breaker is on. Verify that the outlet's EMO is not activated.	Type 4
	The main power circuit breaker (CB1) is off.	Verify that the main power circuit breaker (CB1) is on.	
	POWER ON lamp requires replacement.	Verify that the **POWER ON** lamp assembly is receiving 24 VAC. To do this, opening of the electrical drawer is necessary. This will activate the drawer interlock switch and shut the TCU 40/80 plus down. ***Notify the tool operator prior to opening the electrical drawer.*** Check to see that 24 VAC is present across the lamp assembly terminal block (LP1), terminals X1 and X2. If 24 VAC is present, then replace the **POWER ON** lamp. (EHVI part no. P23247900). ***Refer to the "Lamp Check/Replacement"*** *Section 7.7.8 page 30.*	Type 4
	The transformer isolating circuit breaker CB5 may be off.	Verify that the transformer isolating circuit breaker CB5 is on.	
	The transformer isolating circuit breaker CB7 may be tripped.	Verify that the transformer isolating circuit breaker CB7 is not tripped. Reset if necessary.	
	One of the following circuit breakers may not be functional: • main power circuit breaker (CB1) • transformer isolating circuit breaker CB5 • transformer isolating circuit breaker CB7	Verify that the main power circuit breaker CB1 is functional. Replace if necessary. (EHVI part no. P43126700). Verify that the transformer circuit breaker CB5 is functional. Replace if necessary. (EHVI part no. P43129500). Verify that the transformer circuit breaker CB7 is functional. Replace if necessary. (EHVI part no. P43129100).	Type 4

Table 11 - Faults Identified By Front Panel Lamps (continued)

Indicator	Possible Causes	Action	Hazard
POWER ON lamp is illuminated, but when **RESET** is pressed, it does not illuminate. The front panels LED's are not illuminated, and the temperature controller is off.	Local **EMERGENCY OFF** circuit (EMO) is engaged.	Verify the front panel **EMERGENCY OFF** (EMO) is engaged. Ensure that the interface connector J72J2 is installed with pins 5 and 6 linked. ***Refer to the "Remote Interface"*** *Figure 15 page 54.*	Type 3
	Electrical drawer safety interlock switch is not engaged.	Ensure the electrical drawer is fully closed and that the securing screws are tightened.	
	Remote **EMERGENCY OFF** circuit (EMO) is engaged.	Verify that the remote **EMERGENCY OFF** (EMO) is not engaged.	
	Remote **EMERGENCY OFF** circuit (EMO) is not wired properly to interface connector J72J2.	Verify the correct wiring to the interface connector J72J2. ***Refer to the "Remote Interface"*** *Figure 15 page 54.*	Type 3
POWER ON lamp is illuminated. When **RESET** is pressed it does not illuminate. The audible alarm is sounding, the front panels LED's are illuminated, and the temperature controller is on.	A failure condition exists that must be satisfied.	Review the front panel status indicators to identify the failure mode. ***Refer to the "Faults Indicated By Front Panel Lamps"*** *Table 12 on page 45.*	
POWER ON lamp is illuminated. When **RESET** is pressed, it does not illuminate. There is no audible alarm sounding. The front panels LED's are illuminated and do not indicate the presence of a failure mode. The temperature controller is on.	**RESET** lamp requires replacement.	Verify that the **RESET** lamp assembly is receiving 24 VAC. To do this, opening of the electrical drawer is necessary. This will activate the drawer interlock switch and shut the TCU 40/80 plus down. ***Notify the tool operator prior to opening the electrical drawer.*** Check to see that 24 VAC is present across the lamp assembly terminal block (LP2), terminals X1 and X2. If 24 VAC is present, then replace the **RESET** lamp. (EHVI part no. P23247900). ***Refer to the "Lamp Check/Replacement"*** *Section 7.7.8 page 30.*	Type 4

Table 12 - Faults Indicated By the Front Panel LED Indicators

Indicator	Possible Causes	Action	Hazard
FACILITY POWER LED is red; audible alarm is sounding; TCU will not start or has stopped operation.	Phasing of the incoming power is reversed.	Swap any two of the three power line supply phases in the outlet box.	Type 4
	Line voltage is low (below 177 VAC).	Correct low line voltage condition. ***Refer to the "Specifications"*** *Section 4.7 page 14.*	
	The phase monitor relay (PMR) is not set properly to 177 VAC.	The adjustment knob of the PMR should be positioned such that the arrow is pointing towards the calibration mark black ink marking) on the PMR. The PMR is calibrated to trip at 177 VAC. If necessary replace the PMR with a known calibrated PMR. (EHVI part no. P60056100).	Type 4
FACILITY WATER LED is red; audible alarm is sounding; TCU has stopped operation.	Water supply is off or not connected.	Verify that the water supply lines are connected properly to the unit. Verify water is turned on. ***Refer to the "Water and Coolant Connections"*** *Section 5.4.1 page 18.*	
	Water supply is below 3 gpm.	Verify that water supply valves are open and that the water flow is between 3 - 6 gpm. ***Refer to the "Specifications"*** *Section 4.7 page 14.*	
	Water is too warm.	Verify facilities water supply meets the temperature specification of 10 - 26°C. ***Refer to the "Specifications"*** *Section 4.7 page 14.*	
	Pressure switch (PS1) has tripped.	Verify that the pressure switch (PS1) is set to 300 psig.	Type 2
CIRCUIT BREAKER LED is red; audible alarm is sounding; TCU has stopped operation.	One of the following circuit breakers as tripped: • Compressor circuit breaker (CB2) • Circulation pump circuit breaker (CB3) • Heater circuit breaker (CB4)	Examine the rear electrical panel of the unit to determine which circuit breaker has tripped. ***Refer to the "Dimensions"*** *Section 4.8 page 15.* Reset the tripped circuit breaker. To restart the unit, press the **RESET** button to clear the alarm condition, then press **START**. If the circuit breaker trips again, monitor the current draw from the proper corresponding component. The maximum current draw is as follows: • Compressor: 7 amps per leg • Circulation Pump: 3.5 amps per leg • Heater: 3 amps per leg If the current draw is in excess of the values noted above, remove power to the unit and contact a BOC Edwards service representative.	Type 4

Table 12 - Faults Indicated by the Front Panel LED Indicators (continued)

Indicator	Possible Causes	Action	Hazard
	The circuit breaker may not be functioning properly.	Verify that the circuit breaker that is tripping is functioning properly. Replace if necessary. Compressor circuit breaker: EHVI part no. P43129400 Circulation pump circuit breaker: EHVI part no. P43129300 Heater circuit breaker: EHVI part no. P43129200	Type 4
COMPRESSOR LED is red; audible alarm is sounding; TCU has stopped operation.	Current sensing relay (CSR1) has tripped.	Verify that the current sensing relay (CSR1) is set to 25 amps. To do this, opening of the electrical drawer is necessary. This will activate the drawer interlock switch and shut the TCU 40/80 plus down. ***Notify the tool operator prior to opening the electrical drawer.***	Type 4
	Refrigerant leak.	Visually check for signs of compressor oil on the base, insulation, around the compressor service valves, and on all refrigeration tube assembly. Use a halogen leak detector to leak check all accessible refrigeration tube assembly and the compressor service valves. If compressor oil is noted or a leak is located remove all power to the unit and contact a BOC Edwards service representative.	Type 2
	Hot gas bypass solenoid valve (SV2) fail.	Verify 24 VAC is present between wire #15 (J4-5) on the relay board and wire #4 (TB1). To do this opening of the electrical drawer is necessary. This will activate the drawer interlock switch and shut the TCU 40/80 plus down. ***Notify the tool operator prior to opening the electrical drawer.*** Verify current draw of the solenoid is not above 1 amp. Verify that the resistance of the coil is about 8 Ω. If necessary, replace the coil (EHVI part no. P33030300).	Type 4
	Main cooling solenoid valves (SV1) fail.	Verify 24 VAC is present between wire #16 (J4-5) on the relay board and wire #4 (TB1). To do this, opening of the electrical drawer is necessary. This will activate the drawer interlock switch and shut the TCU 40/80 plus down. ***Notify the tool operator prior to opening the electrical drawer.*** Verify current draw of the solenoid is not above 1 amp. Verify that the resistance of the coil is about 8 Ω. If necessary, replace the coil (EHVI part no. P33030300).	Type 4

Table 12 - Faults Indicated by the Front Panel LED Indicators (continued)

Indicator	Possible Causes	Action	Hazard
	Compressor tripped on thermal over-load.	Verify that the temperature of the discharge line of the compressor has not exceeded 195°F. If the temperature is above 195°F, remove power to the unit and contact a BOC Edwards service representative. ***Warning: Ensure all electrical power has been removed and the main circuit breaker has been turned off prior to checking the compressor motor winding resistance.*** Verify compressor motor winding resistance. The resistance between any two terminals of the compressor motor should be 1.4 Ω (± 0.3 Ω). Verify all three phases are within specification. If the motor winding resistance is out of tolerance contact an BOC Edwards service representative.	Type 4
	Incorrect line voltage to the compressor.	Verify that the compressor is receiving all three phases (208 VAC) at the compressor terminals.	Type 4
Coolant **TEMPERATURE** LED is red; audible alarm; system shut down.	An excessive heat load is causing the coolant temperature to exceed 90 °C.	Ensure the heat load power does not exceed 2000 watts. ***Refer to the "Temperature Controller Table"*** *Table 6 page 12.*	
	The temperature switch (TS1) is not set correctly.	Verify that the temperature switch (TS1) is set at 210 °F.	Type 2
Coolant **FLOW** LED is red; audible alarm; system shut down.	Coolant supply shut-off valves at the rear of TCU are closed.	Verify coolant line valves are open.	
	Supply flow is inadequate.	Verify adequate supply flow. Eliminate possible coolant line restrictions. ***Refer to the "Temperature Controller Table"*** *Table 6 page 12*	
	Circulation pump thermal over-load protector (K3) is set improperly.	Verify that the circulation pump thermal over-load protector (K3) is set to 3.5A. To do this, opening of the electrical drawer is necessary. This will activate the drawer interlock switch and shut the TCU 40/80 plus down. ***Notify the tool operator prior to opening the electrical drawer.***	Type 4
	Circulation pump thermal over-load protector (K3) is tripped.	Press the "reset" button on the circulation pump thermal over-load protector (K3) to ensure that it is not tripped. To do this, opening of the electrical drawer is necessary. This will activate the drawer interlock switch and shut the TCU 40/80 plus down. ***Notify the tool operator prior to opening the electrical drawer.***	Type 4

Table 12 - Faults Indicated by the Front Panel LED Indicators (continued)

Indicator	Possible Causes	Action	Hazard
	Flow switch may not be set properly.	Monitor the voltage between wire #57 (J2-5) and wire #58 (J3-9) located on the relay board. To do this, opening of the electrical drawer is necessary. This will activate the drawer interlock switch and shut the TCU 40/80 plus down. ***Notify the tool operator prior to opening the electrical drawer.*** Place the drawer interlock switch in the maintenance position. Press the **RESET** button to clear the alarm condition, then press **START.** There should be 24 VDC present. If not, a minor adjustment of the reed contact of the flow switch is required. Remove the insulation from the enclosing tube of the flow switch. Loosen, but do not remove, the two locking plate-securing screws on the top of the flow switch. This will allow movement of the reed contact. Make minor adjustments to the reed contact until 0 VDC is seen at "no flow" and 24 VDC is present when the unit is running. After the proper adjustment to the reed contact is complete, tighten the locking plate securing screws and re-attach the insulation.	Type 4
	Excessive current draw from the circulation pump motor.	Verify current draw from each phase of the circulation pump motor does not exceed 3.5 Amps.	Type 4
Coolant **NORMAL LEVEL** LED is amber.	Reservoir is over-filled.	Drain the reservoir until the LED turns green. ***Refer to" Draining/Bleeding the Coolant Reservoir"*** *Section 7.4 page 28.*	
Coolant **LOW LEVEL** LED is amber.	Fluid volume is low (less than 8 liters).	Add fluid to reservoir until LED turns green. ***Refer to "Filling the Reservoir"*** *Section 7.3 page 27.*	
	There may be a leak.	Visually check for signs of leaks inside the unit and at all connections between the TCU 40/80 plus and the process tool. Check all process line connections for leaks. ***Refer to the "Fluorinerte Leak Check"*** *Section 7.7.5 page 29.*	Type 2
Coolant **LOW LEVEL** LED is red.	Coolant level is very low; less than 3.5 liters.	Reservoir needs to be filled. ***Refer to "Filling the Reservoir"*** *Section 7.3 page 27.*	
	Reservoir drain valve is open.	Close the drain valve.	
	There may be a leak.	Visually check for signs of leaks inside the unit and at all connections between the TCU 40/80 plus and the process tool. Check all process line connections for leaks. ***Refer to "Fluorinert Leak Check"*** *Section 7.7.5 page 29.*	Type 2
REMOTE RTD is in use but LED is off.	Terminals 4 and 5 on the interface connector J72J3 are not linked.	Verify that terminals 4 and 5 on interface connector J72J3 are linked. ***Refer to the "Remote Interface"*** *Figure 15 page 54.*	Type 3

Table 13 - Faults Identified By Rear Panel Indicators

Indicator	Possible Causes	Action	Hazard
Coolant **NORMAL LEVEL** LED is amber.	Reservoir is over-filled.	Drain the reservoir until the LED turns green. ***Refer to " Draining/Bleeding the Coolant Reservoir"*** *Section 7.4 page 28.*	
Coolant **LOW LEVEL** LED is amber.	Fluid volume is low; less than 8 liters.	Add fluid to reservoir until LED turns green. ***Refer to "Filling the Reservoir"*** *Section 7.3 page 27.*	
	There may be a leak.	Visually check for signs of leaks inside the unit and at all connections between the TCU 40/80 plus and the process tool. Check all process line connections for leaks. ***Refer to "Fluorinert Leak Check"*** *Section 7.7.5 page29.*	Type 2
Coolant **LOW LEVEL** LED is red.	Coolant level is very low; less than 3.5 liters.	Reservoir needs to be filled? ***Refer to "Filling the Reservoir"*** *Section 7.3 page 27.*	
	Reservoir drain valve is open.	Close the drain valve.	
	There may be a leak.	Visually check for signs of leaks inside the unit and at all connections between the TCU 40/80 plus and the process tool. Check all process line connections for leaks. ***Refer to "Fluorinert Leak Check"*** *Section 7.7.5 page 29.*	Type 2

Table 14 - Miscellaneous Fault Conditions

Indicator	Possible Causes	Action	Hazard
Host fail signal. Supplies fail signal to the host interface when any of the following occur:	Unit in **STOP** mode **FACILITY POWER** Fail **FACILITY WATER** Fail **CIRCUIT BREAKER** Fail **COMPRESSOR** Fail **TEMPERATURE** Fail **FLOW** Fail Coolant **LOW LEVEL FAULT**	***Refer to the "Faults Indicated By The Front Panel LED Indicators"*** *Table 12 on page 45.*	
Host warn signal. Supplies warn signal to the process tool when any of the following occur:	Coolant **NORMAL LEVEL OVER-FILL** Coolant **LOW LEVEL**	***Refer to the "Faults Indicated By The Front Panel LED Indicators"*** *Table 12 on page 45.*	
Temperature controller process value blinks.	RTD wired incorrectly to the interface connector J72J3.	Verify that the remote RTD is wired correctly. ***Refer to the "Remote Interface"*** *Figure 16 page 59.*	Type 3
	Terminals 4 and 5 are not linked on the interface connector J72J3.	Verify that terminals 4 and 5 on connector J72J3 are linked. ***Refer to the "Remote Interface"*** *Figure 16 page 56.*	Type 3
	Incorrect RTD type being utilized.	Verify that the RTD is 100 ohm European.	
	Temperature controller parameters are not set to factory defaults.	Verify temperature controller PID settings. ***Refer to the "Temperature Controller PID Settings"*** *Section 6.4 page 22.*	Type 2
Failure to cool.	Main cooling solenoid valve (SV1) fail.	Verify 24 VAC is present between wire #16 (J4-5) on the relay board and wire #4 (TB1). To do this, opening of the electrical drawer is necessary. This will activate the drawer interlock switch and shut the TCU 40/80 plus down. ***Notify the tool operator prior to opening the electrical drawer.*** Verify current draw of the solenoid is not above 1 amp. Verify that the resistance of the coil is about 8 Ω. If necessary, replace the coil (EHVI part no. P33030300).	Type 4
	Relay board failure.	Verify that the main cooling relay (CR15) comes on when the unit is in cooling mode.	Type 3
	Moisture is in the system.	Verify that the moisture indicator in the sight glass is green. If it appears yellow in color remove power from the unit and notify a BOC Edwards service representative.	Type 2

Table 14 - Miscellaneous Fault Conditions (continued)

Indicator	Possible Causes	Action	Hazard
	Refrigerant leak.	Visually check for signs of compressor oil on the base, insulation, around the compressor service valves, and on all refrigeration tube assembly. Use a halogen leak detector to leak check all accessible refrigeration tube assembly and the compressor service valves. If compressor oil is noted or a leak is located remove all power to the unit and contact a BOC Edwards service representative.	Type 2
	Temperature controller parameters are not set to factory defaults.	Verify temperature controller PID settings. ***Refer to the "Temperature Controller PID Settings"*** *Section 6.4 page 22.*	Type 2
	Temperature controller is not functioning properly.	Verify that the OUT 2 lamp on the front of the temperature controller is ON when the unit is in cooling mode. Replace the temperature controller if necessary (EHVI part no. P43008000).	Type 4
Remote START/STOP fail.	J72J2 interface connector is wired incorrectly.	Verify proper wiring of connector J72J2. ***Refer to the "Remote Interface"*** *Figure 16 page 56.*	Type 3
	Remote START/STOP jumper not removed	Verify that the remote START/STOP jumper located across terminal TB1-1 on terminal block TB1 is removed. To do this, opening of the electrical drawer is necessary. This will activate the drawer interlock switch and shut the TCU 40/80 plus down. ***Notify the tool operator prior to opening the electrical drawer.***	Type 4
Hour counter fail.	Hour counter not recording operating time.	Verify 24 VDC across the wires connected to the hour counter (wire #28 and wire #29). To do this, removal of the front access panel is necessary. Replace the hour counter if necessary (EHVI part no. P43144900).	Type 4
Remote setpoint enable fail.	Absence of 24 VAC supply to interface connector J72J2 or interface connector is wired incorrectly.	Verify the host 24 VAC supply to pin 3 and pin 4 on connector J72J2. ***Refer to the "Remote Interface"*** *Figure 16 page 56.*	Type 3
	Relay board failure (CR14).	Verify that the remote setpoint enable relay (CR14) is on.	Type 4
	Temperature controller parameters are not set to factory defaults.	Verify temperature controller PID settings. ***Refer to the "Temperature Controller PID Settings"*** *Section 6.4 page 22*	Type 2
	Temperature controller not functioning properly.	Verify temperature controller is in remote mode. The AUX lamp on the front of the controller should be ON. Replace the temperature controller if necessary (EHVI part no. P43008000).	Type 4

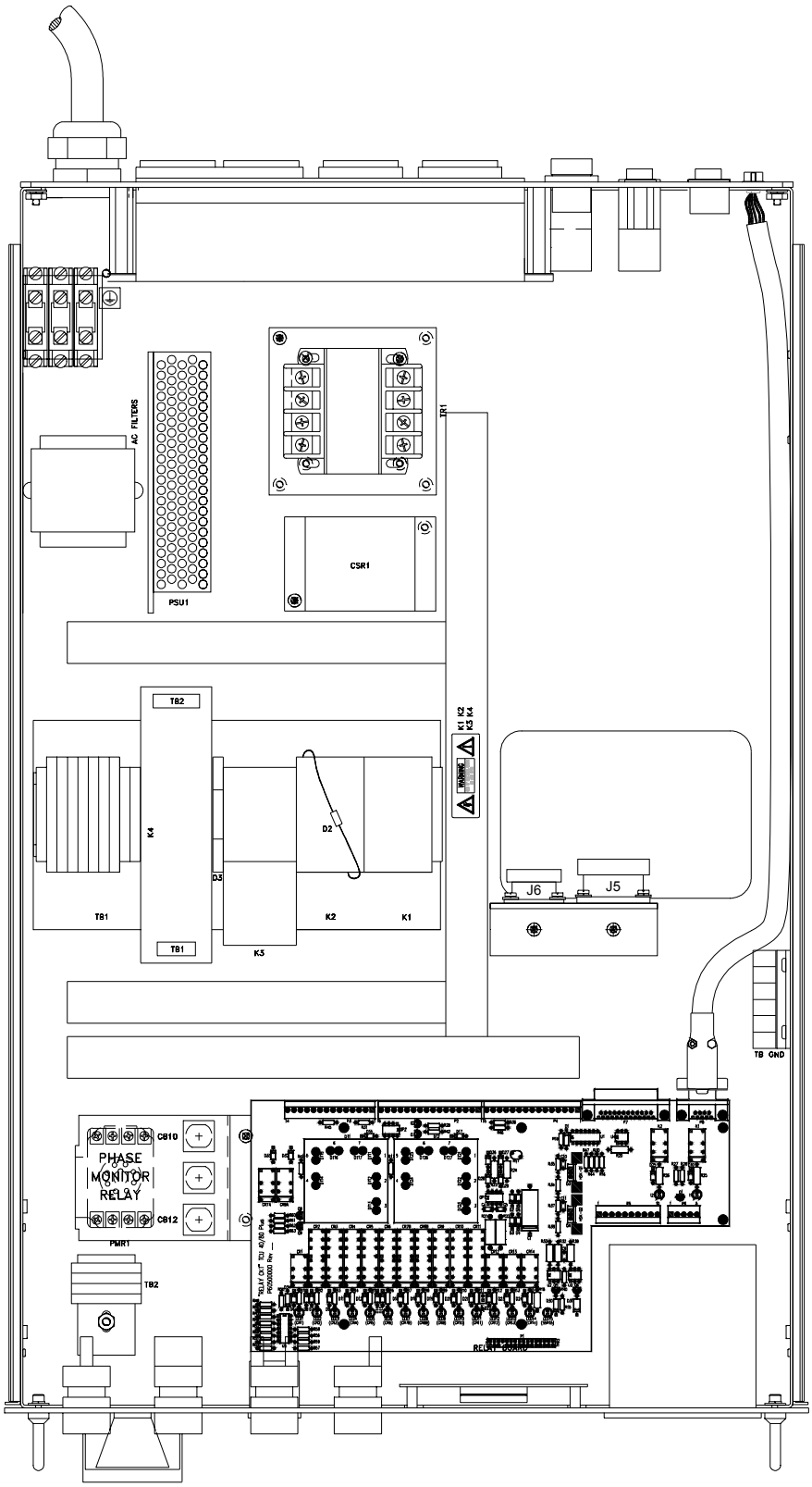

Figure 14 - Electrical Drawer Analog
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No Text

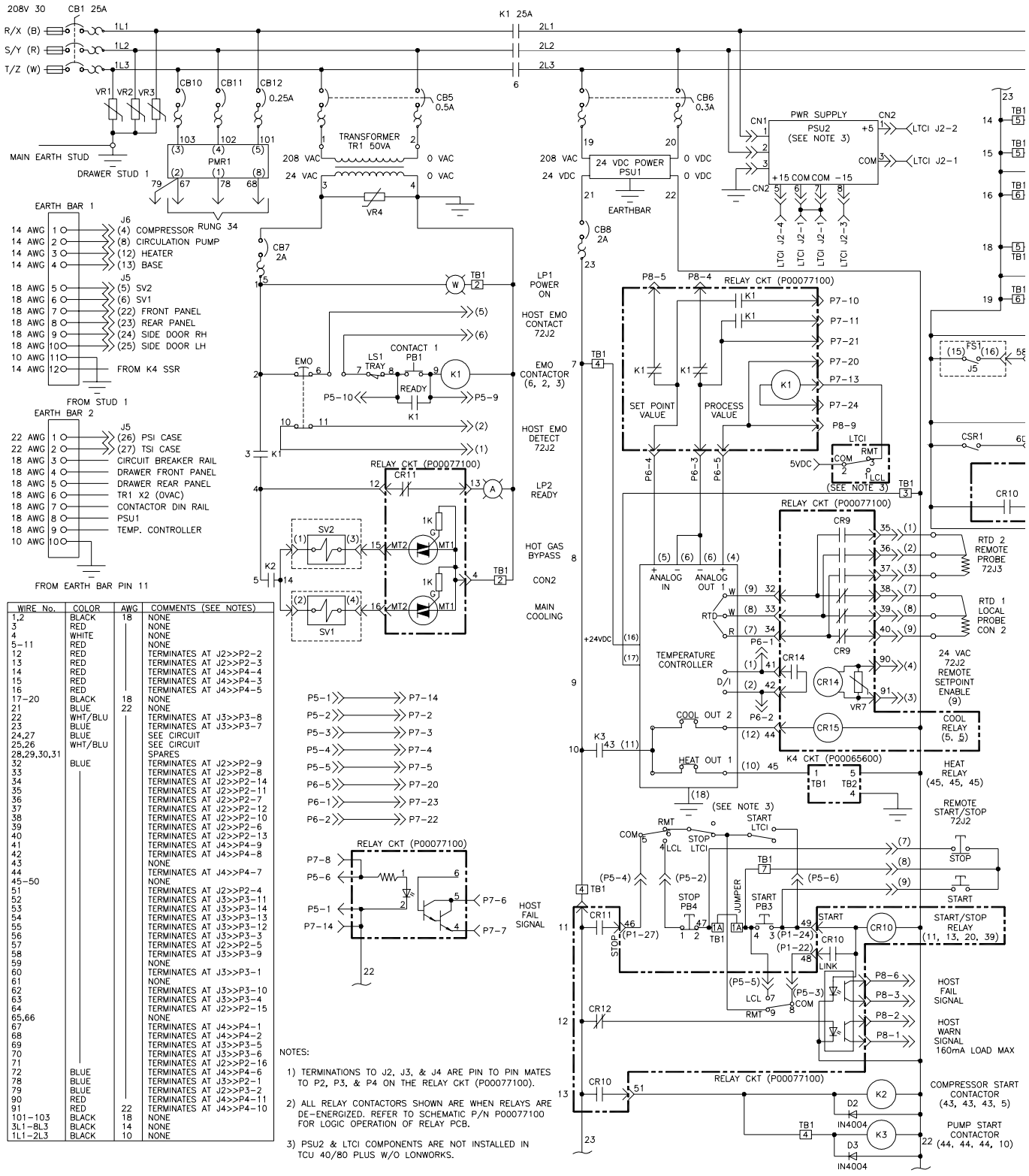

Figure 15 - Electrical Drawer Schematic (Page 1)
(G:\Technical Documents\MANUALS\W95900011- All)

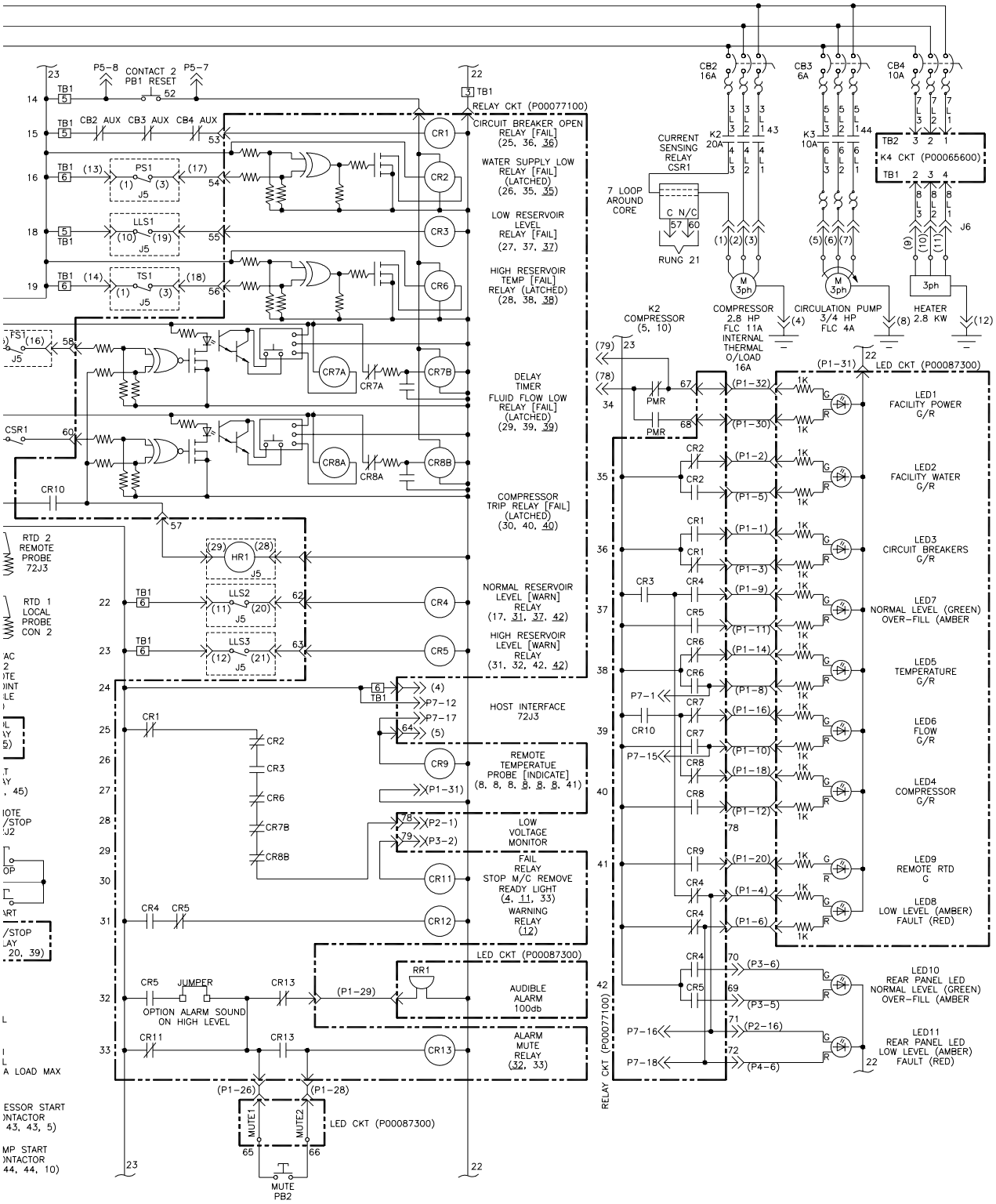

Figure 15 - Electrical Drawer Schematic (Page 2)
(G:\Technical Documents\MANUALS\W95900011- All)

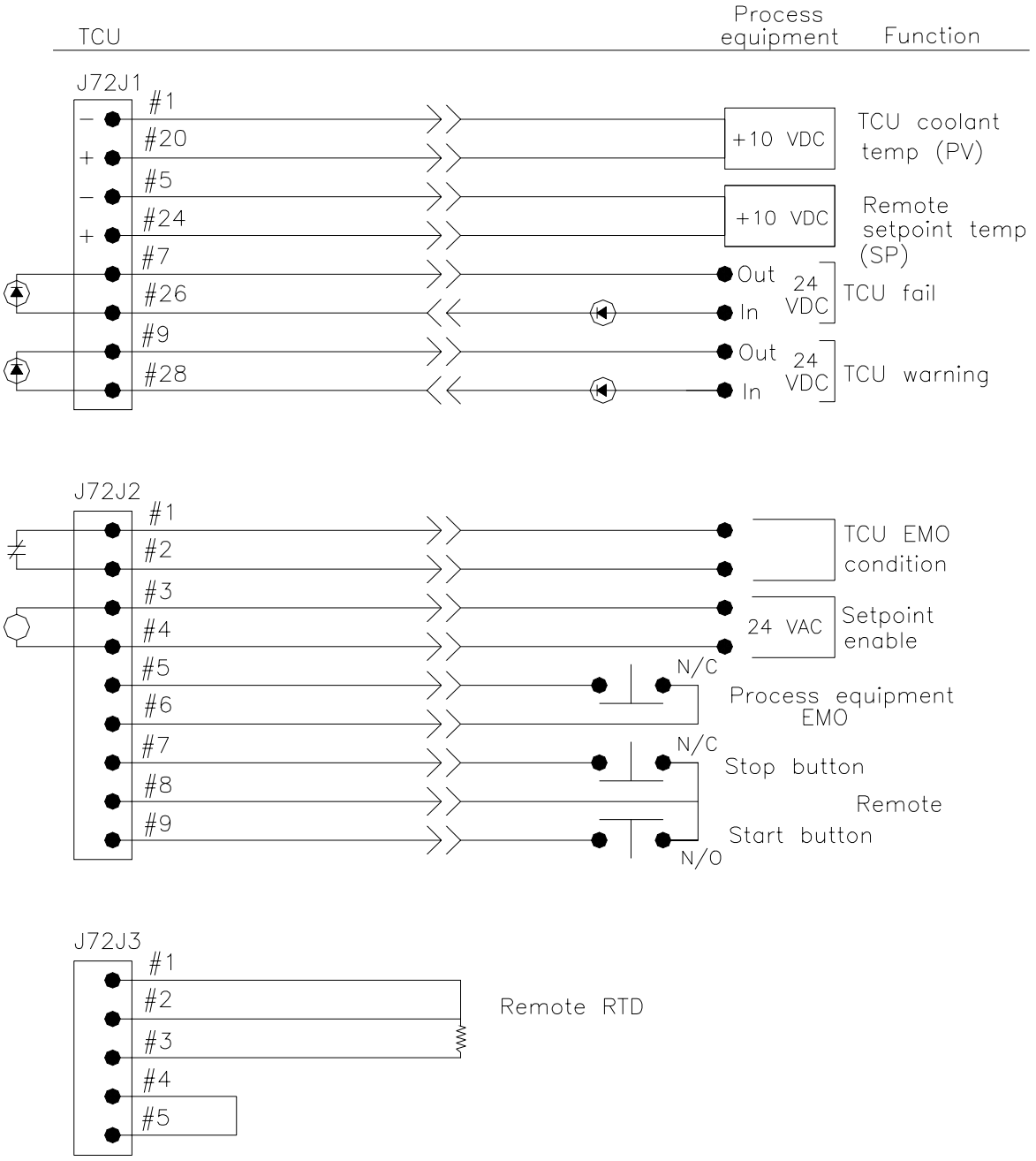

Figure 16 – Remote Interface
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9. Accessories And Spare Parts

Accessories and spare parts are available from service centers at BOC Edwards companies in Brazil, Canada, Germany, Great Britain, Italy, Japan, USA, and a worldwide network of distributors. The majority of these centers employ service engineers who have undergone comprehensive BOC Edwards training courses. When ordering please state for each part required:

- Model and code number of your equipment
- Description of part
- Serial number (if any)

Table 15 - Accessories

Part Number	Description	Contents	Qty
P60150400	Coolant connection kit	Ball valve 1/2" female NPT 1/2" male connector	2 4
P60152200	Tie-bolt kit (Anchors top to bottom unit when stacking)	Rod 3/8"-16 x 7" Hex nut 3/8"-16 Flat washer 3/8"	4 4 4
P60154600	Stabilization kit (Anchors bottom or single unit to floor.)	Unistrut® channel Studs 3/8"-16 x 5" Hex nut 3/8"-16 Flat washer 3/8" Lock washer 3/8"	2 4 4 4 4
P60153100	Remote RTD assembly (auxiliary)	100Ω RTD; 3 wire, 15' leads 5 pin circular connector (J72J3)	1 1
P60188300	Coolant RTD assembly (external)	100Ω RTD; 3 wire, 15' leads 5 pin circular connector (J72J3) ½" X ½" pipe connector	1 1 1
P60152100	Leveler kit	Leveler pad Rod 3/8"-16 x 7" Hex nut 3/8"-16 Flat washer 3/8" Lock washer 3/8"	4 4 4 4 4
P30152700	Secondary containment receptacle	Removable spill containment system	1
P60141100	Funnel	Off-set funnel with Swagelok connector	1
P60153200	Host interface connector kit	9 pin plug (J72J2) Sockets (J72J2) 37 pin male "D" connector (J72J1) 1 Backshell w/hardware (J72J1) 5 pin circular connector (J72J3)	1 9 1 1
P53289800	Fluorinert	11 pound container	1
P53289900	Fluorinert	44 pound container	1
P60153005	Preventative maintenance kit	Lamps, 28vac, 60 mA Solenoid valve coils	4 2
P60140600	Electrical drawer assembly	Electrical drawer	1
P60153001	Refrigeration refurbishment kit	Filter/dryer Discharge service valve Suction service valve	1 1 1
P60153003	Electrical refurbishment kit	Heater contactor Pump contactor Solenoid valves Lamps	1 1 2 2
P60153004	Coolant pump rebuild kit	Gear shafts Gears (idler & drive) Seals Wear plates Bearings	2 2 3 4 4
P60140301	Coolant pump/motor assembly	Coolant pump/motor	1

10. OPTIONS

10.1 LonWorks

10.1.1 References

[1] Lam, CSD5014 V0.1, *300mm Software Requirements Specification for Generic LonWorks Interface*, 21 April 1997

[2] Lam, CSD5139 V0.1, *Software Requirements Specification for LonWorks Interface for the BOC Edwards Chiller*, 20 June 1997

[3] Echelon Corporation, *The SNVT Master List and Programmers Guide*, May 1997

10.1.2 Overall Description

The LTCI is a microprocessor-based system installed in the TCU 40/80 *plus* chiller unit providing LonWorks network nodes with access to a number of chiller control and status monitoring points. When used with Lam processing equipment, the LTCI communicates primarily with a Lam Host Node using the LonWorks protocol in accordance with the specifications provided in [1]. Figure 17 shows the overall LTCI architecture.

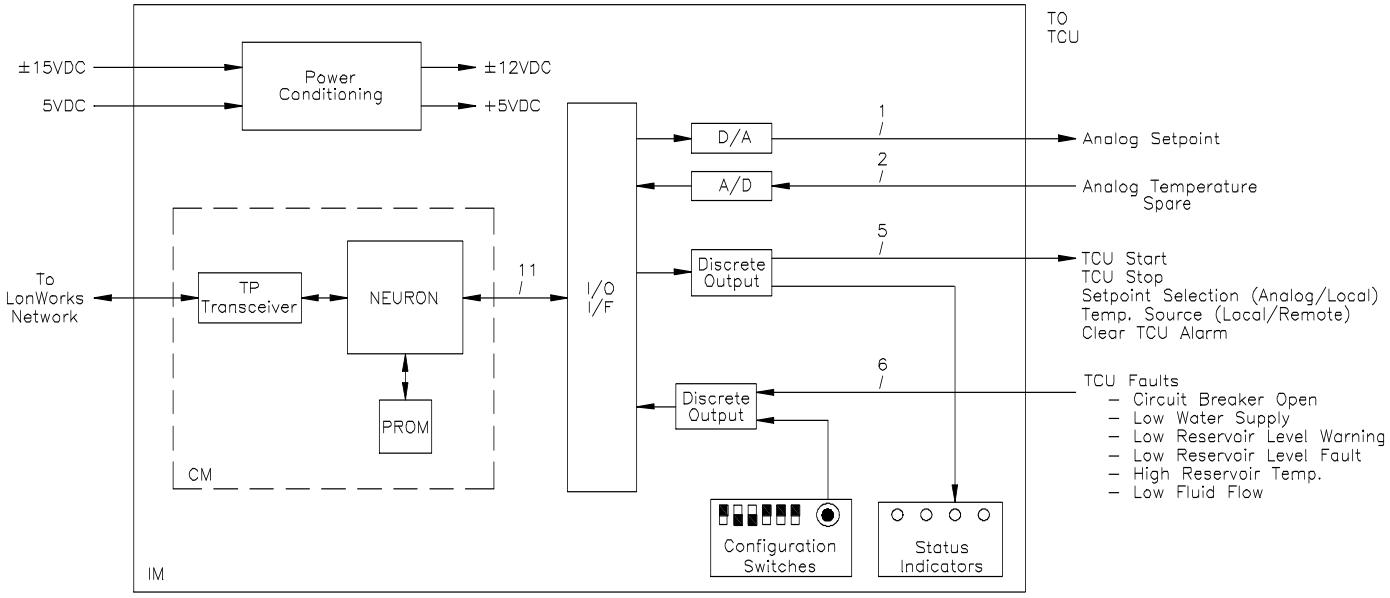


Figure 17 - Overall LTCI Architecture
(G:\Technical Documents\MANUALS\W95900011- All)

10.1.3 Requirements

1. Physical
The LTCI is configured as two subassemblies: the Interface Module (IM) and the Control Module (CM). The CM utilizes a standard Echelon twisted pair control module programmed to implement the control and status monitoring functions. In addition to the NEURON processor and support functions, the CM provides the LonWorks network interface transceiver, allowing the LTCI to be adapted to different LonWorks physical media by exchanging the CM. The IM provides recommended termination loads for both twisted pair and FTT transceiver types with termination selected via jumpers.

The IM supports 3 functions: (1) conditioning of ±15VDC and +5VDC input power to provide filtered +5VDC and ±12VDC supply power for digital and analog functions, (2) signal conversion and conditioning functions to support the analog and digital interfaces between the LTCI processor and TCU 40/80 *plus* and, (3) physical connection points supporting the TCU 40/80 *plus* and LonWorks network interfaces. The CM plugs into the IM directly as a daughterboard.

2. Size/Weight/Mounting Requirements
The CM and IM functions are implemented as separate modules that are connected together to operate. The IM supports the physical mounting within the TCU 40/80 plus drawer using three standoffs. The CM connects to the IM using two connectors: one supporting the LonWorks network interface and one supporting a digital interface between the NEURON processor circuitry on the CM and the power and signal conditioning circuitry on the IM. In addition to the electrical connections, the CM is secured to the IM using threaded standoffs.

Figure 18 shows a preliminary physical layout of the LTCI unit, combining the IM and CM modules.

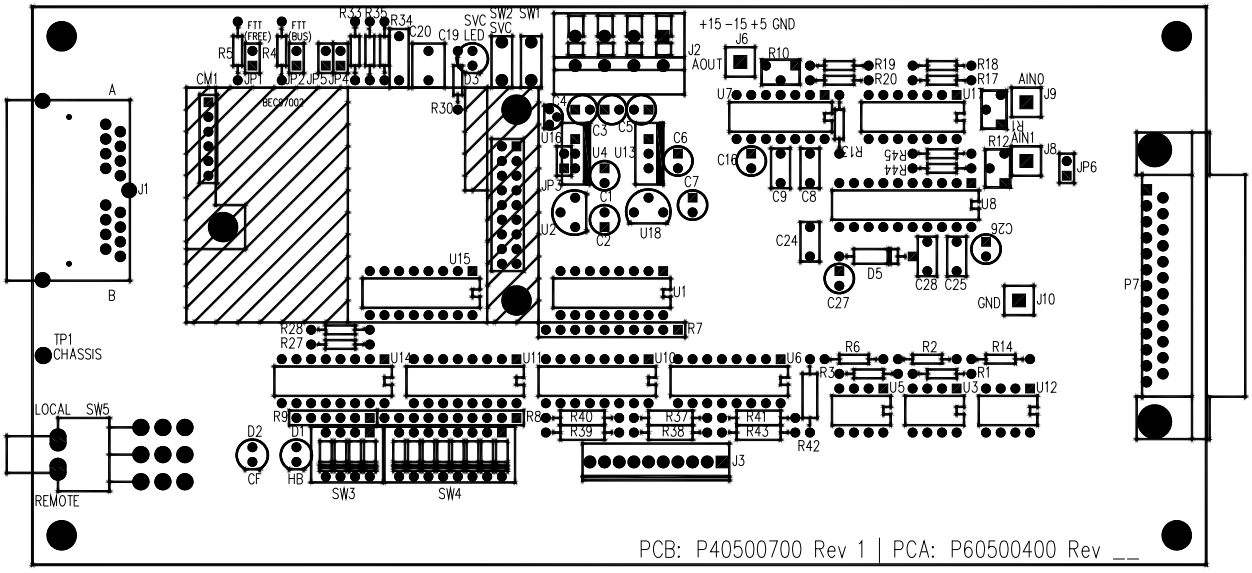
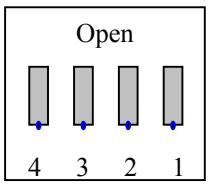


Figure 18 - LTCI Physical Layout
(G:\Technical Documents\MANUALS\W95900011- All)

3. Address and Subnet Switch Settings

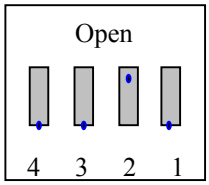
The LonWorks PCB has two DIP switches SW3 and SW4. Switch SW3, which has four switches, is the Subnet Switch. When the switches are in the CLOSE position, their value is 0. When they are in the OPEN position, their values from right to left are 1, 2, 4 and 8.

SW3



8 4 2 1

values

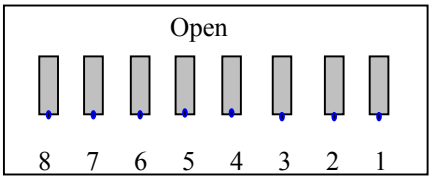


SW3 set to 2

The Subnet Switch default value is set at 2. Therefore switch 2 is in the open position. If SW3 is to be set at 3 then switch 1 and 2 should be in the OPEN position (1+2 = 3).
If SW3 is to be set at 5 then switch 1 and 3 should be in the OPEN position (1+4 = 5).

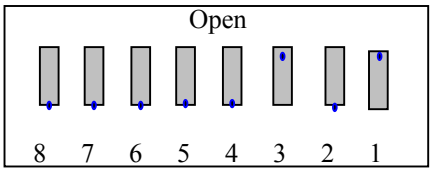
Switch SW4, which has 8 switches, is the Address Switch. When the switches are in the CLOSE position, their value is 0. SW4 address, when all the switches are in the CLOSE position, is 65. When they are in the OPEN position, their values from right to left are 1, 2, 4, 8, 16, 32, 64 and 128. The lowest address value that SW4 could be set at is 65 and highest address is 95.

SW4



128 64 32 16 8 4 2 1

values



SW4 set to 70

The Address Switch default value is set at 70. Therefore switch 1 and 3 are in the open position
(65 + 1 + 4 = 70)
If SW4 is to be set at 85 then switch 3 and 5 should be in the OPEN position
(65 + 4 + 16 = 85).
If SW4 is to be set at 95 then switch 2 through 5 should be in the OPEN position
(65 + 2 + 4 + 8 + 16 = 95).

4. Power Requirements

The LTCI requires a constant supply of ±15VDC & 5VDC at J2 for use as primary power. From this primary power source, the IM power conditioning circuitry provides the LTCI with two filtered DC voltages, +5VDC and +12VDC to support the signal conditioning and conversion functions.

5. General/Environmental Requirements

Physical Parameter	Limits
Operating Temperature	+10C to +50C
Humidity	80%

6. Functional Requirements

The LTCI supports the following TCU 40/80 *plus* control and monitoring functions:

1. Temperature Monitoring/Control
2. Start/Stop Control
3. Status Monitoring

The functional requirements associated with each of these capabilities are described in detail below. LTCI operation involves communication with the Lam Host Node using LonWorks network variables (NVs) and the following descriptions make a number of references to these NVs.

7. TCU 40/80 plus Temperature Monitoring/Control

The LTCI interfaces with the analog input and output interfaces of TCU 40/80 *plus*'s embedded temperature controller (ETC), allowing it to specify the process temperature setpoint and monitor the current process temperature respectively. Each of these analog interfaces uses a ±10V signal to linearly represent temperature in accordance with the specifications given in Table 16. During operation the LTCI samples the ETC voltage output, convert it to temperature, and, and transmit it to the Lam Host Node via the LonWorks interface in accordance with the protocol described in [1] and [2]. Table 16 specifies the process temperature-sampling rate used by the LTCI.

Table 16 - Analog Temperature Signal Characteristics

Signal	Sampling/Update Rate	Voltage/Temperature Conversion	Notes
ETC Input (Temp. Setpoint)	Updated upon receipt of value from Lam Host	Linear Mapping: ±10VDC => ±100°C	
ETC Output (Process Temp.)	Sampled at 1S period	Linear Mapping: ±10VDC => ±100°C	Sent to Lam Host as described in Text in accordance with host update and deadband specification.

Although the process temperature is sampled at regular intervals, not every sample is transmitted to the host. The LTCI provides two methods of limiting the rate of the temperature updates that it receives:

1. Specification of a minimum update period by the host using the `nviNodeConfig` network variable
2. Implementation of a temperature update deadband of ±1° C.

   The minimum update period specifies the minimum amount of time that must transpire between temperature updates. The LTCI ensures that temperature updates are not sent more frequently than the time specified by the minimum update period.

   The temperature update deadband specifies the minimum temperature change between host updates. The current process temperature must differ from the last host update by more than the amount specified by the update deadband in order for the LTCI to send it to the host. This function prevents the host from receiving unnecessary updates indicating identical temperatures or very small temperature changes. In order to provide the host with reasonably fresh process data, the LTCI ensures that a temperature update is sent to the host within at least 10 minimum update periods regardless of whether it exceeds the specified deadband.

   The TCU 40/80 *plus* may be operated in either Local Mode or Remote Mode, with selection made manually via a rear panel switch. The LTCI commands the TCU 40/80 *plus* to use either the local or remote temperature probes in accordance with the switch setting through connection to the TCU 40/80 *plus*'s Host Interface contacts controlling relay CR9. The network variable used to send the process temperature to the host, `nvoData,` will contain a flag indicating the temperature measurement source as well as the temperature.

   The LTCI will also be capable of commanding the TCU 40/80 *plus* to utilize either a Local or Analog Setpoint specification using the D/I interface of the ETC, replacing the functionality of CR14. The Local Setpoint is fixed and preprogrammed into the ETC, whereas the Analog Setpoint is generated by the LTCI in accordance with the `temperatureSetpoint` member of the `nviConfig` network variable, specified by the Lam Host Node. Upon receipt of an update to the `nviConfig` network variable, the LTCI sets its Analog Setpoint output in accordance with the specified temperature value without regard to the status of the `temperatureSetpoint` member. If `temperatureSetpoint` indicates selection of the Analog Setpoint, the LTCI ensures that the Analog Setpoint value is updated prior to selecting it.

On initial Power-up, prior to receiving a setpoint specification from the host, the LTCI will command a default setpoint of 25° C.

8. TCU 40/80 plus Start/Stop Control
The LTCI provides the Lam Host Node with the ability to start and stop chiller operation using the `nviControl` network variable. This is accomplished through connection to the TCU 40/80 *plus* Remote Start/Stop interface.

9. TCU 40/80 plus Status Monitoring

Note: *The specific TCU 40/80 plus status monitoring functions have not been finalized. The description contained within this section presumes the desire to monitor a variety of status conditions through connection to the status indicator panel at connector P1. Alternatively, TCU 40/80 plus status indications could be limited to the Host Fail and Host Warning indications.*

The LTCI provides the Lam Host Node with the ability to monitor a variety of TCU 40/80 *plus* status conditions. The LTCI monitors TCU 40/80 *plus* status through connection to the TCU 40/80 *plus* Status Indicator Panel connections within the TCU 40/80 *plus* drawer. In supporting these connections, the LTCI ensures that it does not present an excessive load to the panel drivers and will not affect the intensity of the existing LED displays.

The LTCI will poll the following status monitoring signals at the same time that it samples chiller temperature:
1. Host Fail Signal
2. High Reservoir Temperature
3. Local Mode
4. Low Reservoir Level Warning
5. Low Reservoir Level Fail
6. Low Fluid Flow Fail

Each of these conditions, except for Local Mode, will be mapped to a bit in the `error_codes` member of the `nvoStatus` network variable. In accordance with the protocols specified in [1] and [2], `nvoStatus` is sent to the Lam Host node upon receipt of an update to the `nviHeartbeat` network variable containing the LTCI node address or whenever there is a change in TCU 40/80 *plus* status.

If the Lam host issues a TCU 40/80 *plus* control command (START/STOP, Temperature Setpoint, or Temperature Alarm Setpoint) while the TCU 40/80 *plus* is in Local Mode, the LTCI will set the Local Mode bit within `error_codes` and send `nvoStatus` to the host.

10.1.4 Interfaces

1. LonWorks Interface

a. Physical Network Interface
The LonWorks network interface is provided on the LTCI CM utilizing a standard, transformer-coupled 1.25Mbps twisted-pair transceiver sold by Echelon Corporation (PN 50020-10). The transceiver supports connection to other approved 1.25Mbps transceivers, using standard signaling levels and power-down protection mechanisms. The LTCI will connect the output of the CM transceiver directly to the network interface. The transceiver output is transformer-coupled interface to the network, thus providing electrical isolation.

The LTCI will provide the ability to select one of three types of LonWorks network termination circuits through jumpers: (1) Twisted Pair bus termination, (2) FTT Bus Termination, and (3) FTT Free Topology Termination. Selection of a Termination Circuit is not required.

b. Interface Protocol

The LTCI LONWORKS interface communicates with the Lam Host node through the exchange of messages using LonWorks Network Variables (NVs). Each NV contains one or more parameters, is defined using a C syntax to include any valid C data type (i.e., ints, structures, enums, etc.), and is declared as either an input or output. In order to transmit a message to the host, the LTCI will update an associated output NV, causing the embedded LonTalk protocol stack to generate a message by adding appropriate addressing and message delivery information. The addressing will specify delivery to a corresponding input NV at the Lam Host node. Upon receipt of the message, the protocol stack at the host node will unpack the message to produce an update to the selected input NV. Communication from the Lam Host to the LTCI is handled identical.

The LTCI provides a set of network variables to meet the basic network interface requirements specified by Lam in [1] and to support specific TCU 40/80 plus control and monitoring functions described previously. Host control of TCU 40/80 plus operation is performed by writing to Host output network variables that are mapped to associated LTCI input network variables. Upon detection of a network variable update, the LTCI firmware translates the input network variables into corresponding TCU 40/80 plus commands. TCU 40/80 plus status is continuously monitored by the LTCI and is provided to the LonWorks interface by updating the values of appropriate output network variables in accordance with the protocol described by Lam in [1].

Table 18 defines the set of network variables implemented by the LTCI. Input network variables are sent from the host node to the LTCI and are named with an “nvi” prefix. Input network variables having their contents to be saved in nonvolatile EEPROM are named with an “nci” prefix. Output network variables are sent from the LTCI to the host node and are named with an “nvo” prefix. The LTCI firmware declares the network variables in the same sequence as shown in Table 18 and will use the self installation procedures described in [1] to assign the associated network variable selectors as indicated.

Table 17 - LTCI Network Variables

Network Variable	Type	Selector	Function	Notes
nviHeartbeat	uint[2,3]	0	Specifies address of node to respond with a nvoStatus update	Per Lam Specification
nvoStatus	status_struct[1]	1	Contains node status info: last reset cause heartbeat acknowledgment HW FAIL flag COMM FAIL flag HEARTBEAT FAIL flag Chiller errors	Per Lam Specification Chiller error codes adapted from Lam specification. See text for description
nviNodeConfig	nodeconfig_struct[1]	2	Specifies minimum update period, heartbeat time-out, and contains output force flag	Per Lam Specification
nviCommReset	uint[2]	3	Commands a transition from COMM FAIL state to NORMAL state	Per Lam Specification If the LTCI is not in a COMM FAIL state, this will be ignored
nviHWReset	uint[2]	4	Commands a hardware reset	Per Lam Specification
nvoNodeInfo	info_struct[1]	5	Specifies node type and firmware revision	Per Lam Specification For LTCI, node type is 245
nciNetConfig	SNVT_config_src[3]	6	Specifies whether node should perform self-installation	Per Lam Specification
nviControl	SNVT_lev_disc	7	Commands TCU 40/80 plus Start/Stop	BOC Edwards Specification ST_OFF => STOP ST_LOW-ST_ON => START other values are ignored
nviConfig	config_struct[1]	8	Specifies LTCI/Chiller operating configuration: LTCI Analog Setpoint High Temperature Alarm Setpoint Low Temperature Alarm Setpoint	BOC Edwards Specification
nvoData	data_struct[1]	9	Contains current coolant temperature and measurement source	Adapted from Lam Specification

Notes:
1: NEURON C structure definitions are contained in Appendix A.
2: Lam Specification defines these as unsigned short (8 bits). unit represents an unsigned, which NEURON C represents as 8 bits.
3: This nviHeartbeat definition is taken from the Lam SRS for the BOC Edwards Chiller [2].

c. Network Variables
This section describes the network variables provided by the LTCI. It should be remembered that the input/output sense of these NVs is defined in reference to the LTCI node.

`nviHeartbeat`
This input NV contains a Lam network node address and is broadcast periodically by the Lam host node to the entire subnet to determine the status of the network nodes. Upon receipt of the `nviHeartbeat` message, the LTCI will reset its local heartbeat timer and compare the supplied node address to its own node address. The LTCI node address is determined by reading the state of a 6-bit DIP switch contained on the LTCI module during power-up reset. If the addresses match, the LTCI will transmit the `nvoStatus` NV to the host.

nvoStatus

The nvoStatus NV contains the status information shown in Table 18. It is sent to the Lam Host node in response to receipt of a nviHeartbeat message containing the LTCI address and in response to a NEURON chip watchdog time-out.

Table18 - Definition of nvoStatus Network Variable

Status Parameter	Meaning	Notes
Reset Cause	A 4-bit indication of the cause of the last LTCI reset: 0 => Power-up Reset 1 => External Reset 2 => Watchdog Reset 3 => Software Reset	If reset is due to a watchdog time-out, the LTCI will forward the nvoStatus NV to the Lam Host at the end of reset processing. All other reset conditions will simply be saved for subsequent transmission in response to heartbeat polls or other status changes
Heartbeat Acknowledgment Flag	A single bit acknowledgment to a heartbeat poll.	Only set for heartbeat acknowledgments
Hardware Failure Flag	A single bit set to indicate an LTCI or TCU 40/80 plus hardware failure	Any hardware failure will result in immediate transmission of nvoStatus. The flag will be cleared upon removal of the hardware fault condition.
Communication Failure Flag	A single bit set to indicate an LTCI LonWorks communication failure	Any communication failure will result in immediate transmission of nvoStatus. This flag will not be reset until the LTCI receives nviCommReset having a value of "1"
Heartbeat Failure Flag	A single bit set to indicate that the LTCI heartbeat timer has timed out.	Detection of a heartbeat time-out will not result in transmission of nvoStatus. The flag will be cleared upon detection of the next heartbeat poll input.
TCU 40/80 plus Error Codes	A set of 8 bits indicating TCU 40/80 plus status: Bit 0: TCU 40/80 plus High Reservoir Temp. Fault Bit 1: TCU 40/80 plus Low Fluid Flow Fault Bit 2: TCU 40/80 plus Local Mode Bit 3: TCU 40/80 plus Low Reservoir Level Fault Bit 4: TCU 40/80 plus Low Reservoir Level Warning Bit 5: TCU 40/80 plus Temperature below Lo Temp Alm Setpt. Bit 6: TCU 40/80 plus Temperature above Hi Temp Alm Setpt. Bit 7: TCU 40/80 plus System Status (Summary Fault)	Detection of any Fault condition will result in immediate transmission of nvoStatus. Detection of any Warning condition will not result in immediate nvoStatus transmission. "0" indicates No Fault "1" indicates Fault

nviConfig

The nviConfig NV contains three parameters:

1. The minimum period between LTCI temperature updates (in milliseconds)
   The LTCI transmits TCU 40/80 *plus* temperature updates to the host whenever the temperature changes by an amount greater than the update deadband, but will not transmit at a rate faster than that specified by the minimum update period.
2. The Heartbeat time-out period (in seconds)
   The LTCI will immediately reset the heartbeat timer to the value specified. If the timer expires before the next heartbeat message is received, then the LTCI will declare a heartbeat fault.
3. The output condition force flag
   If the output condition force flag is set, the LTCI will set the analog and discrete output signals to default conditions.

nviCommReset
The LTCI will verify the successful transmission of each message from itself to the Lam Host as specified in [1]. Upon detection of a communication failure the LTCI will enter the COMM FAIL state and remain there until it receives an `nviCommReset` message having a value of "1". Upon receiving such a message, the LTCI will exit the COMM FAIL state and enter the NORMAL state. If the LTCI is in the NORMAL state it will not take any action upon receipt of a `nviCommReset` message.

nviHWReset
Upon receiving a `nviHWReset` message having a value of "1", the LTCI will initiate a hardware reset of the TCU 40/80 *plus* by pulsing the reset relay.

nvoNodeInfo
The `nvoNodeInfo` NV contains the LTCI node type specification and current LTCI firmware revision and is used by the Lam host to identify the individual nodes within the 300 mm system. The LTCI will report the node type as 245 and will report the software revision using the format X.YZ where X is the major version number and YZ are minor version numbers.

nciNetConfig
The `nciNetConfig` NV specifies whether the LTCI will perform self-installation functions. `nciNetConfig` is an enumerated Standard Network Variable Type (SNVT) and may have values of CFG_LOCAL ("0"), CFG_EXTERNAL ("1"), or CFG_NUL ("FF"). When reset, the LTCI firmware will read the value of the nciNetConfig NV. If the value is CFG_LOCAL, the LTCI will perform the self installation procedures specified in [1] to assign its own domain, subnet, and node address parameters and set up the address table used to communicate with the Lam Host node. If the value is not CFG_LOCAL, the LTCI will not perform any self-installation processing.

nvoData
1. The `nvoData` NV indicates the most recent TCU 40/80 *plus* temperature measurement and the measurement source (local or remote). Temperature will be specified in degrees C above -273°C with a resolution of 0.1°C in accordance with the NEURON C SNVT_temp network variable type definition. The measurement source will have a value of either "0" or "1". A "0" will indicate a local measurement and a "1" will indicate a remote measurement. The `nvoData` NV will be sent whenever the measured temperature has changed by greater than the specified temperature deadband.
For Condition 1, the LTCI will ensure that temperature updates are not transmitted with a period of less than that specified in the `nviConfig` NV. For both conditions, the LTCI will adjust the deadband to coincide with the most recently transmitted temperature.

nviConfig - Specifies the LTCI/Chiller operating configuration
The `nviConfig` NV is used by the Lam Host node to specify LTCI and TCU 40/80 *plus* operating parameters. `nviConfig` specifies the following LTCI and TCU 40/80 *plus* operating parameters:
1. LTCI Analog Setpoint Specification
2. High and Low Temperature Alarm Setpoints

nviControl
The `nviControl` NV is used to start and stop chiller operation. It utilizes the standard NEURON C enumerated type of SNVT_lev_disc for a two-state device, using ST_OFF to specify Chiller Stop. Receipt of any of the following specify Chiller Start: ST_LOW, ST_MED, ST_HIGH, ST_ON. All other values will be ignored.

LTCI Power Interface
The LTCI will require ±15VDC and +5VDC at CB1 for use as primary power. Power conditioning circuitry onboard the LTCI will re-regulate this to provide +5VDC and ±12VDC for use by the LTCI circuitry. The LTCI will not separately fuse the input power.

Analog Output Interface
Using a D/A and appropriate signal conditioning circuitry, the LTCI Analog Output Interface will be capable of generating output voltages between -10VDC and +10VDC into a 100KΩ load. The accuracy of the analog output will be 0.2% or better over the LTCI operating temperature range. The maximum analog update rate will be 10 updates per second.

Analog Input Interface
The LTCI Analog Input Interface will be capable of measuring analog input signals between -10VDC and +10VDC to a resolution of 12 bits. It will present a load of no less than 100KΩ to the analog driver circuit. The LTCI A/D will incorporate appropriate sample and hold functions to ensure accurate conversion in the presence of changes in input signal amplitude during conversion. The maximum A/D sampling rate will be 10 samples per second.

Contact Closure Interface
The LTCI will utilize solid-state devices to support all contact closure outputs. The selected devices will provide a closed contact resistance of less than 30Ω. The LTCI will be electrically coupled with the TCU 40/80 *plus* circuitry through its use of the same 24VDC and return that is used to support TCU 40/80 *plus* circuitry and its transformer-coupled isolation from the LonWorks Twisted Pair network. The LTCI contact closure interfaces will utilize optical isolation circuitry.

0/24VDC Interfaces
The LTCI will detect the state of the TCU 40/80 *plus* status monitor signals through direct coupling to the TCU 40/80 *plus* circuits that are used to drive the status indicating LEDs. The LTCI detection circuitry will provide input impedance of at least 10KΩ to avoid any degradation in indicator performance. All of the 0/24VDC status signals are uniquely mapped to fail-safe conditions. For these signals, absence of a 24VDC-signal level is an indication of the associated fault.

The TCU 40/80 *plus* uses relay ladder logic to implement the Reservoir fluid level warning and failure indicators, precluding the simple detection of the associated fault conditions. The LTCI will combine the detection of the two Low Reservoir Level signals to detect the Fail and Warning conditions as follows:

```
Reservoir Level Warning       =  A &  B
Reservoir Level Fail          = !A &  B
Reservoir Level Normal        =  A & !B
where:
A = TCU 40/80 plus P7-16
(TCU 40/80 plus Reservoir Normal Indication)
B = TCU 40/80 plus P7-18
(TCU 40/80 plus Reservoir Fail Indication)
```

Electrical Interconnections
The electrical connections between the LTCI and the TCU 40/80 *plus* are shown in Figure 22.

Rear Panel
Figure 18 shows the rear panel. Table 19 identifies the controls and indicators on the rear panel.

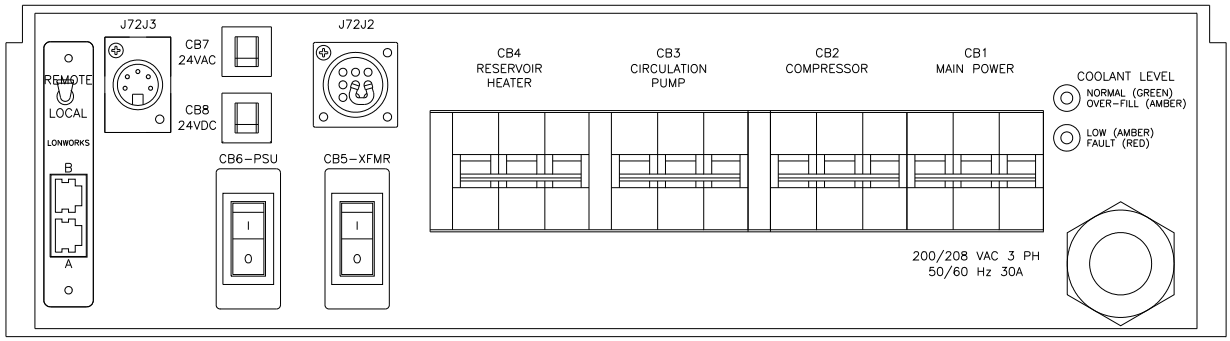


Figure 19 - Electrical Rear Panel
(G:\Technical Documents\MANUALS\W95900011- All)

Table 19 - Description of Rear Panel Components and Indicators

Label	Description
J72J3	Five-pin connector for remote RTD interface. See figure 16 on page 59 for pinouts.
CB7 24 VAC	1-pole, 2 Amp circuit breaker. Isolates the 24 VAC transformer. Normally on (in).
CB8 24 VDC	1-pole, 2 Amp circuit breaker. Isolates the 24 VDC power supply output. Normally on (in).
J72J2	Nine pin connector for remote EMERGENCY OFF, start-stop operation, and remote setpoint operation enable. See figure 16 on page 59 for pinouts.
CB4 reservoir heater	3-pole, 10 Amp circuit breaker. Normally on (up).
CB3 circulation pump	3-pole, 6 Amp circuit breaker. Normally on (up).
CB2 compressor	3-pole, 16 Amp circuit breaker. Normally on (up).
CB1 main power	3-pole, 25 Amp circuit breaker. Normally on (up).
normal/overfill	Normal, LED Green Overfilled, LED Amber
low/fault	Low, LED Amber Fault, LED Red
200/208 VAC 3 PH 50/60 Hz 30A	Mains input power connector.
CB5-XFMR	2-pole, 0.5 Amp circuit breaker. Isolates the equipment transformer.
CB6-PSU	2-pole, 0.3 Amp circuit breaker. Isolates the power supply.
LonWorks	Local/Remote Switch RJ-45 connectors for LonWorks communications

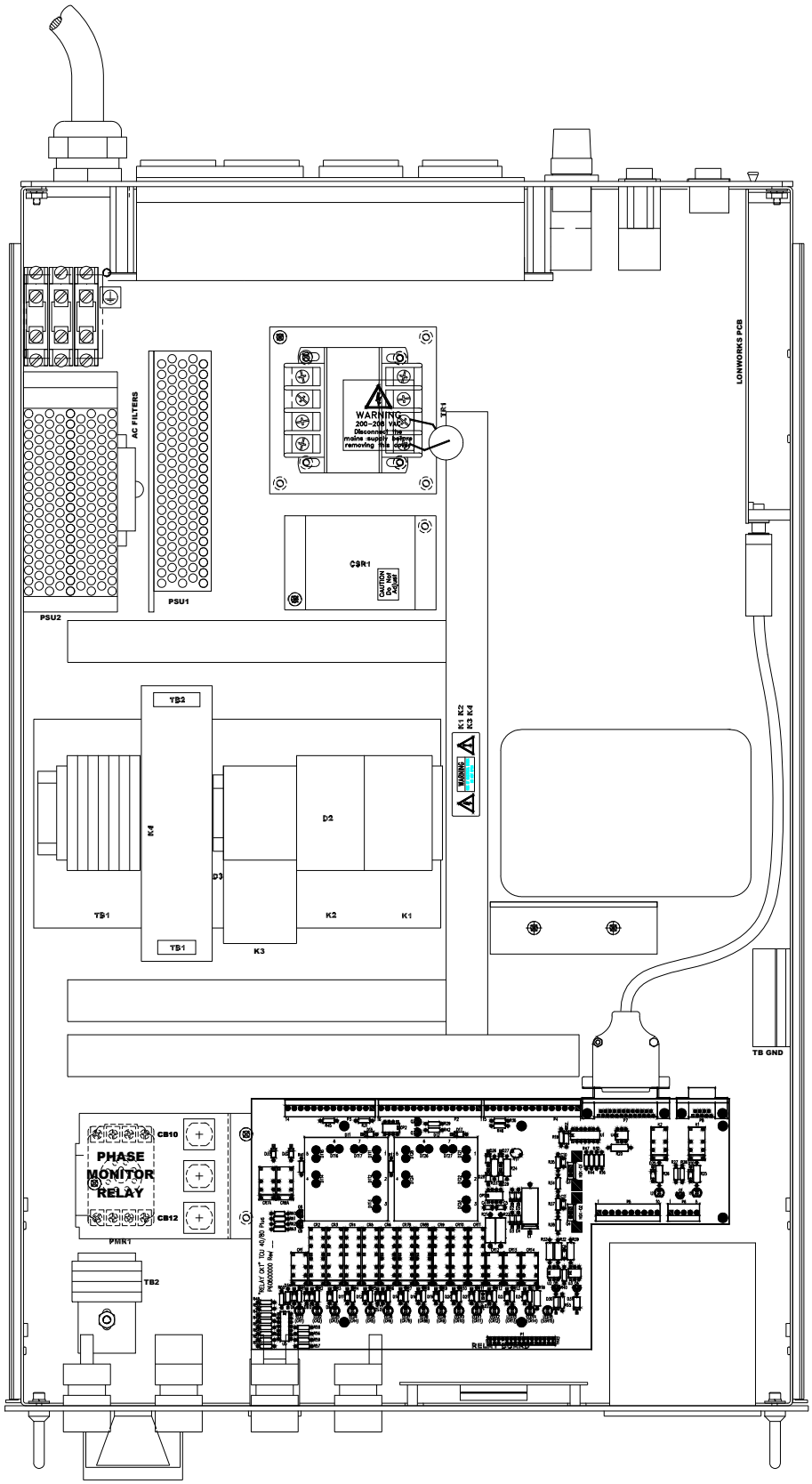
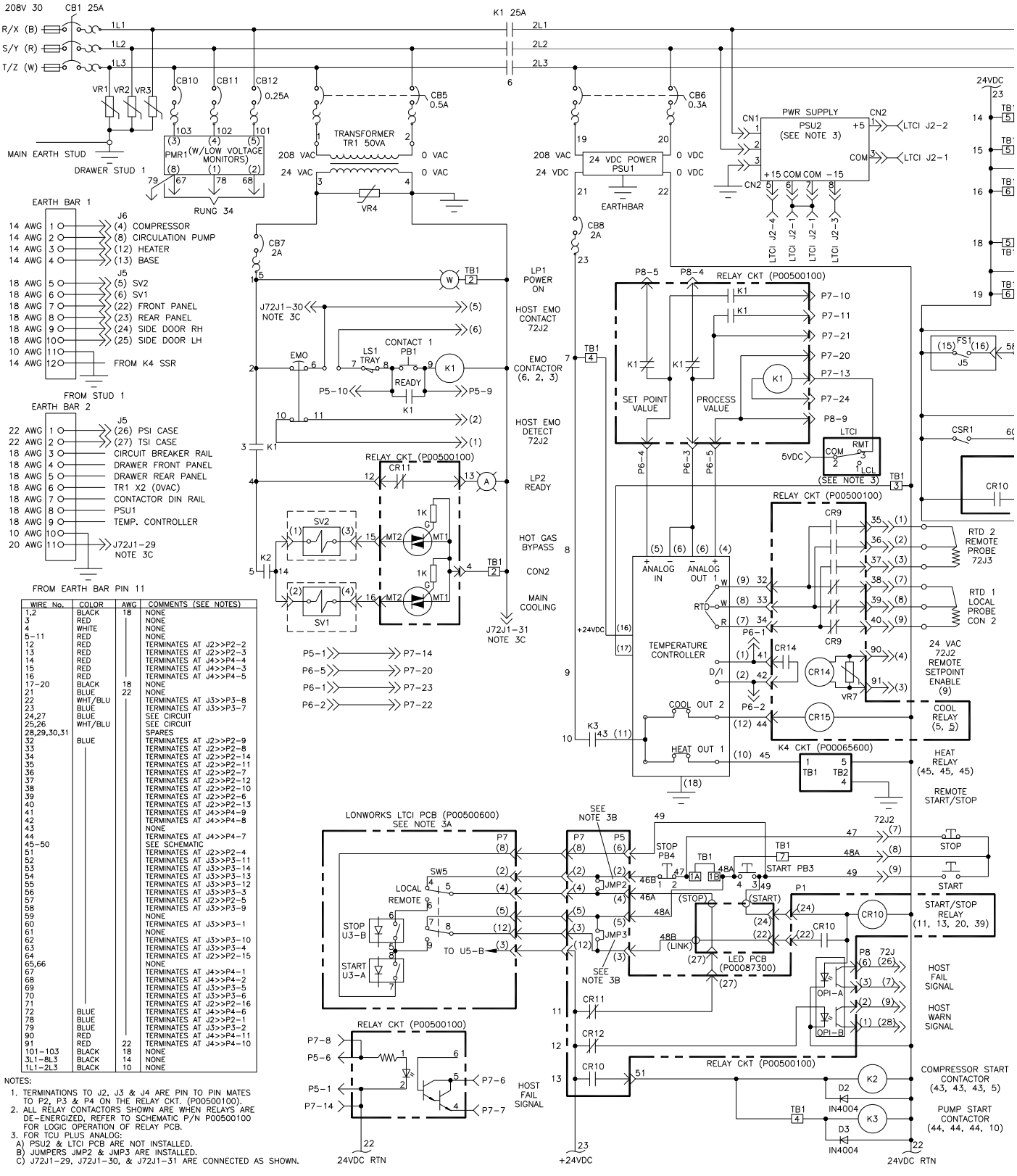


Figure 20 - Electrical Drawer LonWorks
(G:\Technical Documents\MANUALS\W95900011- All)

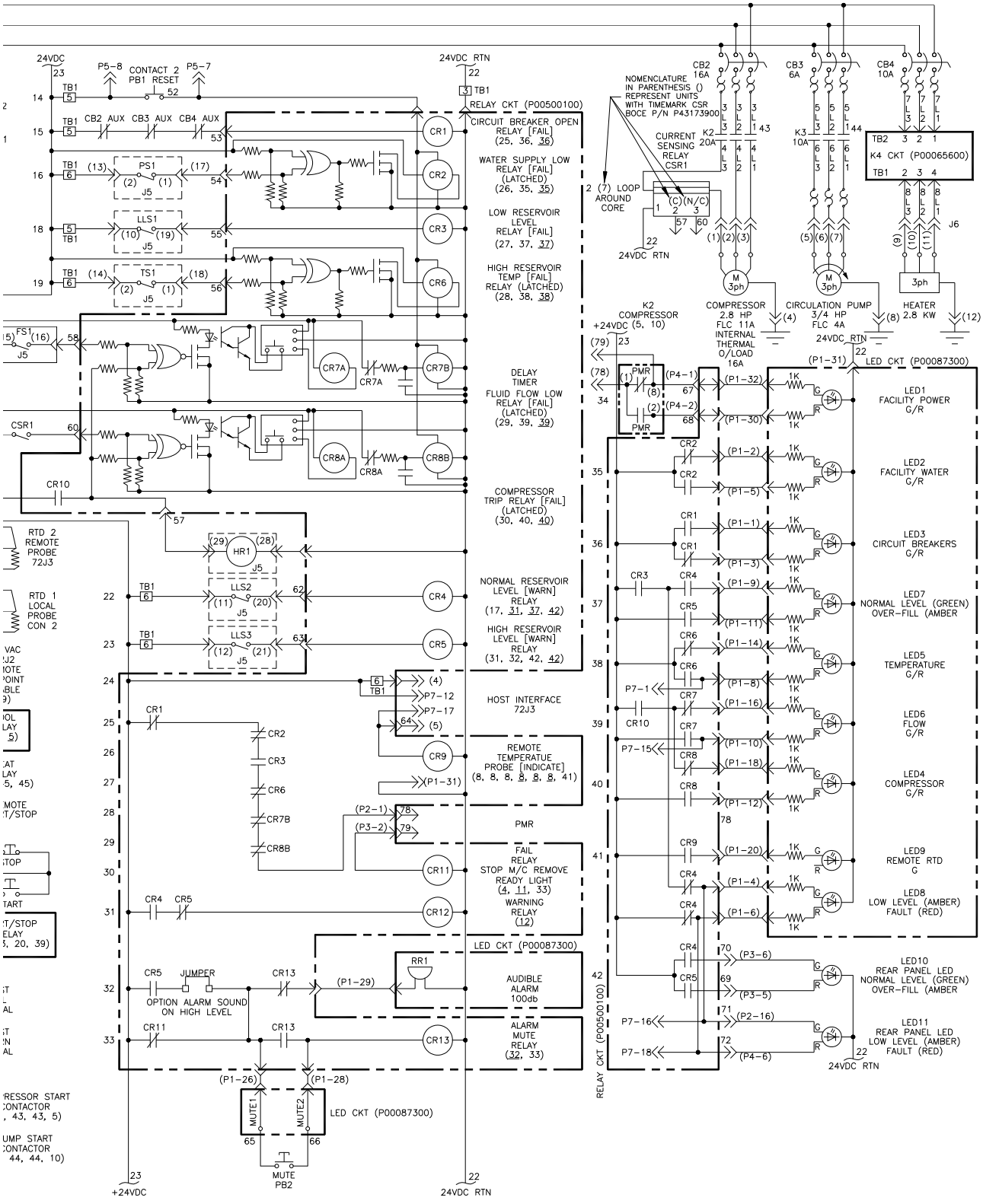
No Text



WIRE No.	COLOR	AWG	COMMENTS (SEE NOTES)
1,2	BLACK	18	NONE
3	RED		NONE
4	WHITE		NONE
5-11	RED		NONE
12	RED		TERMINATES AT J2>>P2-2
13	RED		TERMINATES AT J2>>P2-3
14	RED		TERMINATES AT J4>>P4-4
15	RED		TERMINATES AT J4>>P4-3
16	RED		TERMINATES AT J4>>P4-5
17-20	BLACK	18	NONE
21	BLUE	22	NONE
22	WHT/BLU		TERMINATES AT J3>>P3-8
23	BLUE		TERMINATES AT J3>>P3-7
24,27	BLUE		SEE CIRCUIT
25,26	WHT/BLU		SEE CIRCUIT
28,29,30,31			SPARES
32	BLUE		TERMINATES AT J2>>P2-9
33			TERMINATES AT J2>>P2-8
34			TERMINATES AT J2>>P2-14
35			TERMINATES AT J2>>P2-11
36			TERMINATES AT J2>>P2-7
37			TERMINATES AT J2>>P2-12
38			TERMINATES AT J2>>P2-10
39			TERMINATES AT J2>>P2-6
40			TERMINATES AT J2>>P2-13
41			TERMINATES AT J4>>P4-9
42			TERMINATES AT J4>>P4-8
43			NONE
44			TERMINATES AT J4>>P4-7
45-50			SEE SCHEMATIC
51			TERMINATES AT J2>>P2-4
52			TERMINATES AT J3>>P3-11
53			TERMINATES AT J3>>P3-14
54			TERMINATES AT J3>>P3-13
55			TERMINATES AT J3>>P3-12
56			TERMINATES AT J3>>P3-3
57			TERMINATES AT J2>>P2-5
58			TERMINATES AT J3>>P3-9
59			NONE
60			TERMINATES AT J3>>P3-1
61			NONE
62			TERMINATES AT J3>>P3-10
63			TERMINATES AT J3>>P3-4
64			TERMINATES AT J2>>P2-15
65,66			NONE
67			TERMINATES AT J4>>P4-1
68			TERMINATES AT J4>>P4-2
69			TERMINATES AT J3>>P3-5
70			TERMINATES AT J3>>P3-6
71			TERMINATES AT J2>>P2-16
72	BLUE		TERMINATES AT J4>>P4-6
78	BLUE		TERMINATES AT J2>>P2-1
79	BLUE		TERMINATES AT J3>>P3-2
90	RED		TERMINATES AT J4>>P4-11
91	RED	22	TERMINATES AT J4>>P4-10
101-103	BLACK	18	NONE
3L1-8L3	BLACK	14	NONE
1L1-2L3	BLACK	10	NONE

NOTES:
1. TERMINATIONS TO J2, J3 & J4 ARE PIN TO PIN MATES TO P2, P3 & P4 ON THE RELAY CKT. (P00500100).
2. ALL RELAY CONTACTORS SHOWN ARE WHEN RELAYS ARE DE-ENERGIZED, REFER TO SCHEMATIC P/N P00500100 FOR LOGIC OPERATION OF RELAY PCB.
3. FOR TCU PLUS ANALOG:
   A) PSU2 & LTCI PCB ARE NOT INSTALLED.
   B) JUMPERS JMP2 & JMP3 ARE INSTALLED.
   C) J72J1-29, J72J1-30, & J72J1-31 ARE CONNECTED AS SHOWN.

Figure 21 - Electrical Drawer Schematic
(G:\Technical Documents\MANUALS\W95900011- All)



(continued …..) Figure 21 - Electrical Drawer Schematic
(G:\Technical Documents\MANUALS\W95900011- All)

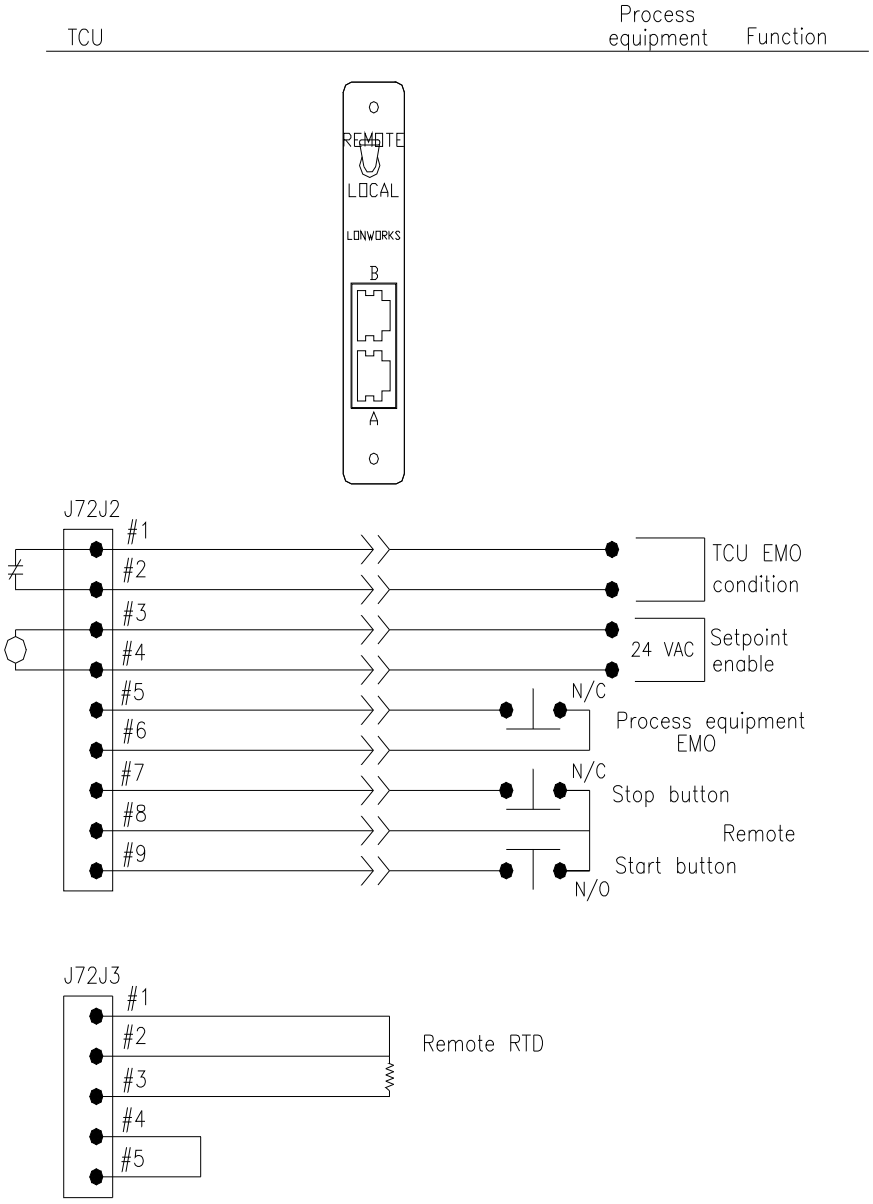
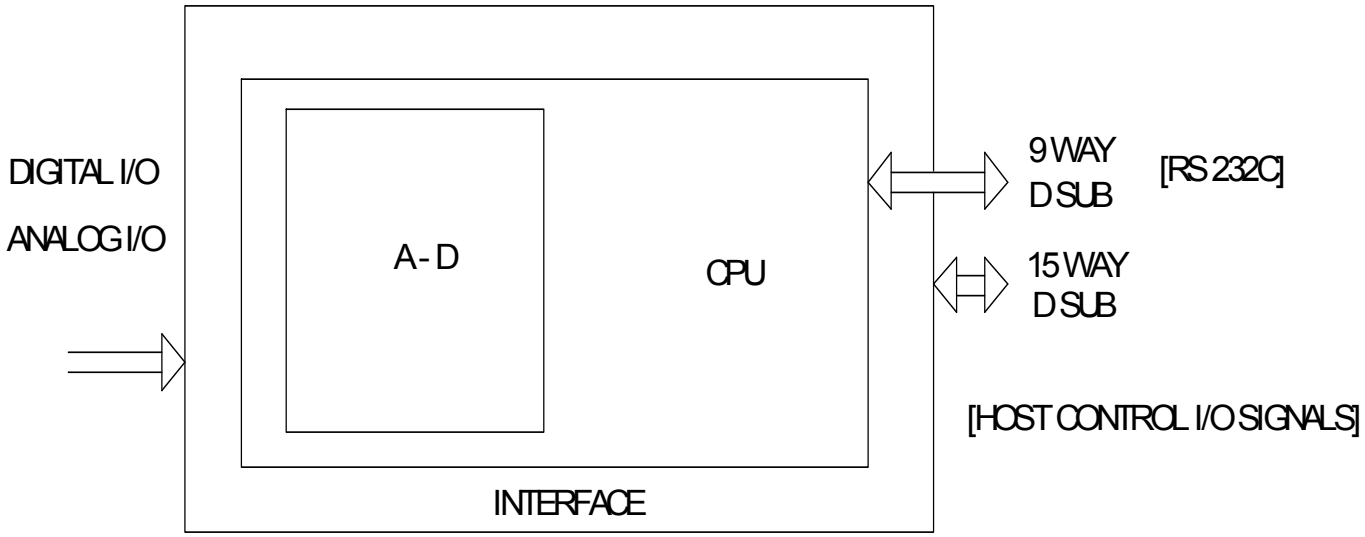


Figure 22 - Remote Interface
(G:\Technical Documents\MANUALS\W95900011- All)

10.2 RS 232 TEL

10.2.1 Block Diagram

The signals comprises contact I/O signals and an RS-232C communication function. See Figure 23.



BLOCK DIAGRAM
FIG 23

(G:\Technical Documents\MANUALS\W95900011- All)

10.2.2 Operation Modes and Contents of Function

The modes include local operation mode and remote operation mode. The Functions available differ in each mode.

1. Local operation mode
   In this mode of operation, the TCU can only be controlled from the front control panel. System status and Process Temperature maybe monitored by the external host device. In the case of power shut down, the set point will default to 25°C upon the next system power up.
2. Remote operation mode
   In this mode the unit can be operated by a signal generated from the external host device. "Run" and "Stop" of the unit, temperature set point is only available from the external host device.

Note: *The alarm may only be reset at the front control panel of the TCU.*

3. Set point retention during mode switching
   If the unit is switched from Local to Remote operation, the temperature set point will be set by the external host device. If the unit is switched for Remote to Local operation, the temperature set point will be set by the last value retained in the temperature controller.
4. Available functions in each mode
   The functions available in each mode are listed in Table 20

Table 20 – Available Functions

	Operation	At the TCU	At the Host	RS-232
Local operation mode	Run	C	M	M
	Stop	C	M	M
	Temperature Setting	C	M	M
	BAND Setting	M	M	M
	Alarm reacting	C	----------	----------
	Reading of set temperature	C (with display)	M	C
	Reading of BAND set value	M (with display)	M	C
	Reading of process temperature	C (with display)	M	C
	Reading of Status	C (with display)	M	C
Remote operation mode	Run	M	C	C
	Stop	M	C	C
	Temperature setting	M	M	C
	BAND setting	M	M	C
	Alarm reading	C	----------	----------
	Reading of set point temperature	C	C	C
	Reading of BAND set value	M	M	C
	Reading of process temperature	C (with display)	C	C
	Reading of status	C (with display)	C	C

C: Control M: Monitor

Additional description of the functions and terms used in Table 20

1. Band
   The term denotes the range between the upper limit and the lower limit of the temperatures corresponding to the generation of a "TEMPERATURE OK" message and signal. It can be set over a range of from ± 0.5 °C to ± 5.0°C. The setting is done only on the positive side, the negative side is automatically set.

   Example: When the set value of BAND is selected to 1.0°C, the message "TEMPERATURE OK" and a signal is generated when the process temperature becomes within a range from –1.0°C to +1.0°C of setting temperature.

2. Temperature Ok
   When the process temperature enters into the BAND range during operation of the unit, the message "TEMPERATURE OK" appears on the screen of the Control Display Panel and signal is generated at the same time. If an offset has been set, the temperature range of "TEMPERATURE OK" (BAND) adopts the offset display temperature.

10.2.3 Description of External Control and Monitoring Signals

Two methods of communication are used together, these are:
1. Contact I/O Signals
2. RS 232 Communication

A. Contact I/O Signals

1. Host control signals (Signals to and from an external host device to the TCU)

   a. "Run" / "Stop" Signal

2. Monitoring signals (Signals from the TCU to an external host device)

   a. "Operation mode" signal (remote operation mode/local operation mode)
   b. "Run" Signal
   c. "Stop" Signal (Not Used)
   d. "TEMPERATURE OK" signal
   e. "Fault" Signal (TCU will shut down)
   f. "Warning" Signal (TCU will continue to operate)
   g. "EMO" Signal

A description and the functions of the contact I/O signals are as follows:

Host control signals (Signals to and from the external host device)
1. "Run" / "Stop" Signal
   In remote operation mode, a momentary signal with contact ON (close)
   Initiates "Run" and "Stop" of the specified channel in the unit.

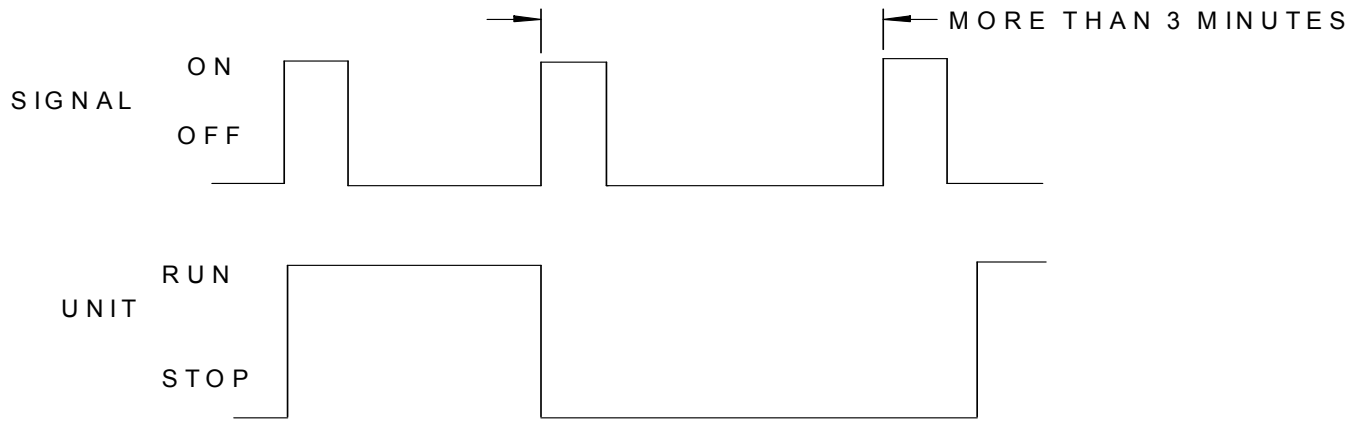


FIG 24 - "RUN" / "STOP" SIGNAL

(G:\Technical Documents\MANUALS\W95900011- All)

3. Input signal state (common to all signals)
   a. The input signals shall be momentary (instantaneous) work mode.
   b. The input time shall be set as illustrated below.

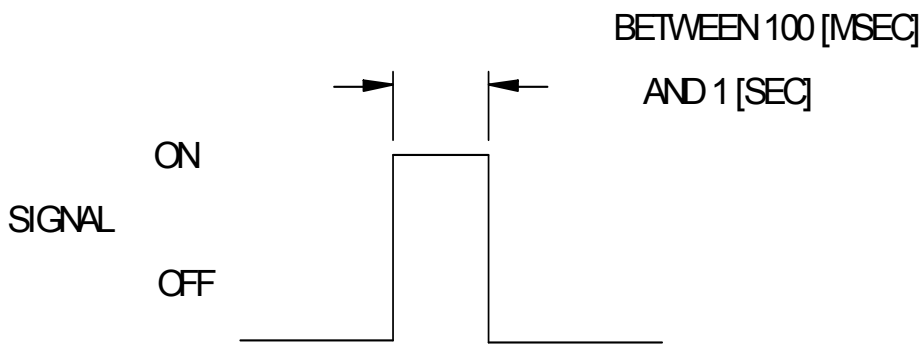


Fig 25 - Control Signal State
(G:\Technical Documents\MANUALS\W95900011- All)

c. Input impedance: 3.0 kΩ
Host monitoring signals (Signals from the TCU to an external host device)

1. "Operation mode" signal
   When in remote operation mode, the contact is set to ON.
   In local operation mode, the contact is set to OFF.
2. "RUN" signal
   The contact is ON (for each channel) during operation
3. "STOP signal (Not Used)
   The contact is ON (for each channel) during stop.
4. "TEMPERATURE OK" signal
   When the recirculating fluid temperature is within the range of BAND, the contact is set to ON (for each channel).
5. "FAULT" signal (impossible to sustain operation)
   If a major system fault occurs that is likely to cause damage to the TCU, Host, or endanger life, then the TCU will stop, setting the contact to the ON position (for each channel).
6. "WARNING" signal (possible to sustain operation)
   If a system fault occurs that will not cause damage to the TCU, Host, or endanger life, then the TCU will continue to operate, setting the contact to the ON position (for each channel).
7. "EMO" signal
   If the emergency stop switch on the operation panel of the unit is pressed, the power to the unit is shut off and EMO signal is set to OFF (open).

Note: *The capacity of the output signals:*

- *Contact closure (solid state) capacity of 100 (ma) at 50 volts DC*
- *The unit shall be operated within the above-specified range Operation outside of this range may damage the unit.*
- *All warning & fault signals can only be reset on the unit and cannot be reset from an external device.*

Table 21 - Pin Assignments at the TCU Host Connection (15 way D sub)

Pin #	Function/Use	Comment
1	Operation Mode	Isolated Solid State
2	Operation Mode Return	Contact Closure
3	Run	Contact Closure to Common
4	Stop (Not Used)	Contact Closure to common
5	Fault	Contact Closure to common
6	Warning	Contact Closure to common
7	Temperature OK	Contact Closure to common
8	Run/Stop Input Command	Contact closure to common to Toggle Run/Stop
9	System Status Common (return)	24 volt Common

B. RS-232C Communication

1. Outline of RS-232C communication functions
   RS-232C communication provides the following functions.
   a. Reading of data
      - Reading of set temperature
      - Reading of BAND set value
      - Reading of process temperature
      - Reading of status

   b. Writing of data
      - Writing of set temperature
      - Writing of BAND set value

NOTE: *For Dual Channel operation the signals are independent in each channel except for the "operation mode" signal. The RS-232C port is also independent for each channel.*

2. Pin Assignment for RS-232C communication connectors
   - Connector No. (TBA): for channel 1 (CH1) RS-232C communication
   - Type of connector: D-sub 9 pin, socket (female connector)
   - Pin assignment for connectors see Figure 24.

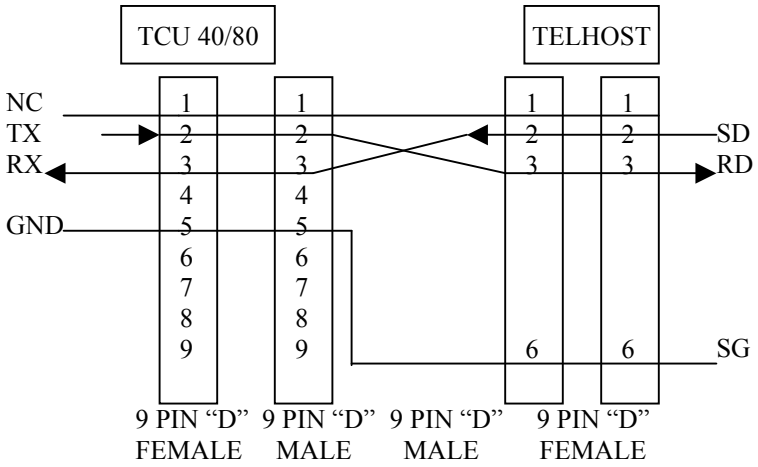


Fig. 26 - Pin Assignment for TCU-Tel Cable
(G:\Technical Documents\MANUALS\W95900011- All)

NOTE: *A Personal Computer with appropriate software can be used to simulate a Host. In this case a Pin1 to Pin 1, 9 Pin male to female cable can connect the TCU to the P.C.*

3. RS-232C Specifications

- Standard----------RS-232C (EIA)
- Communication Method----------Half-Duplex
- Synchronous Type----------Start-stop
- Baud Rate----------9600bps
- Character Code----------ASCII
- Parity----------Non
- Start Bit----------1 bit
- Data Length----------8 bit
- Stop Bit----------1 bit
- Block Check----------See page 80

4. Description Of Transmission/Reception Of Messages

1. Control Code

Table 22 - Control Code

Control Code	ASCII Code	Function
STX	02_H	Start of text
ETX	03_H	End of text
ENQ	05_H	Enquiry
ACK	06_H	Acknowledge
NAK	15_H	Negative acknowledge
CR	OD_H	Carriage Return

1. Header Code

Table 23 - Header Code

Header Code (Hex)	Function
31_H	Reading/Writing of setpoint temperature
32_H	Reading/Writing of BAND set value
34_H	Reading of process temperature
36_H	Reading of Status 1
37_H	Reading of Status 2
38_H / 39_H	Run CMD / Stop CMD
$3A_H$	Select Remote RTD
$3B_H$	Select Local RTD

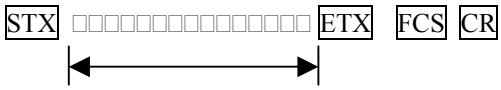
Note: *The external host device has priority of communication. Communication begins from the host, and the TCU answers to the host. Therefore, a response from the TCU must be confirmed after transmitting a signal from the host. If there is no response from the TCU within 3 seconds, the host will transmit the signal again. No data is accepted during the period of response from the TCU.*

5. Block Check (Frame Check Sequence)

FCS is calculated in accordance with the following steps:

Calculation Procedure
By putting 3 to the head of each value, this translates each byte into its ASCII Hex code.
Add the target of calculation per byte. This will give a 2-byte answer in Hex, which will be FCS.

(Follow the following example of calculation.)



Target of calculation

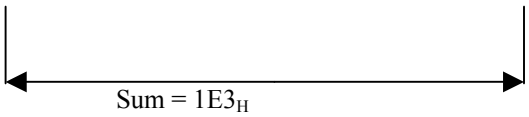
The FCS Calculation is the sum of the bytes between, but not including [STX] to [ETX].

Note: *$2B_H$ is the Hex value representing the ASCII code for a + sign.*

Example: (Writing of set point temperature 25°C)

STX	31_H	+25	000	000	ETX	FCS	CR

STX 31_H, $2B_H$, 32_H, 35_H, 30_H, 30_H, 30_H, 30_H, 30_H, 30_H, ETX…


Sum = $1E3_H$

Then, FCS will be [$3E_H$, 33_H], that is, 3 is added to the head of each figure of [E][3] $_H$, the
First place 1 byte. (If A—F are included in the calculation result, it will be 3A--- and 3F and
Different from ASCII Code.) Note: The most significant byte is dropped.

In this case, the transmission data will be:

02	31	2B 32 35	30 30 30 30 30 30	03	3E 33	OD
STX	Header Code	Date	Dummy Code	ETX	FCS	CR

6. Description of the Read Command

a. Reading of Set Temperature

Command format [Transmission from host (external device) to the unit

ENQ	Header	ETX	FCS		CR
02_H	31_H	03_H	33_H	31_H	OD_H

Response format [Response from the unit to the host (external device)

STX	Header	±	9	9	Dummy Code		
02_H	31_H	Set Temp.			30_H	30_H	30_H

Dummy Code			ETX	FCS		CR
30_H	30_H	30_H	03_H	*	*	OD_H

Set Point Temperature Data

2 digits ASCII code with +/- sign (-30°C--+90°C)

Example: +10°C: $2B_H$, 31_H, 30_H
0°C: $2B_H$, 30_H, 30_H
-20°C: $2D_H$, 32_H, 30_H

b. Reading of BAND Set Value

Command format [Transmission from host (external device) to the unit]

ENQ	Header	ETX	FCS		CR
05_H	32_H	03_H	33_H	32_H	OD_H

Response format [Response from the unit to the host (external device)

Equal Box

STX	Header	9	9	9	Dummy code		
02_H	32_H	BAND setvalue			30_H	35_H	30_H

Dummy Code			ETX	FCS		CR
30_H	35_H	30_H	03_H	*	*	OD_H

BAND Set Value

3 digits ASCII code without +/- sign (0.5°C—5.0°C)

Example: 0.5°C: 30_H, 30_H, 35_H
5.0°C: 30_H, 35_H, 30_H

c. Reading of Process Temperature

Command format [transmission from host (external device) to the unit]

ENQ	Header	ETX	FCS		CR
05_H	34_H	03_H	33_H	34_H	OD_H

Response format [Response from the unit to the host (external device)]

STX	Header	+	9	9	9	9	Dummy Code				
02_H	34_H	Process Temp					30_H	30_H	30_H	30_H	30_H

Dummy Code					ETX	FCS		CR
30_H	30_H	30_H	30_H	30_H	03_H	*	*	OD_H

Process Temperature Data

4 digits ASCII code with +/- sign (-40.0°C--+100.0 °C)

Example: +90.0°C: $2B_H$, 30_H, 39_H, 30_H, 30_H
0.0°C: $2B_H$, 30_H, 30_H, 30_H, 30_H
-30.0°C: $2D_H$, 30_H, 33_H, 30_H, 30_H

d. Reading of Status 1

Command format [Transmission from host (external device) to the unit]

ENQ	Header	ETX	FCS		CR
05_H	36_H	03_H	33_H	36_H	OD_H

Response format [Transmission from host (external device) to the unit]

STX	Header	1	2	3	4	5	6	7	8
02_H	36_H								

9	10	11	ETX	FCS		CR
			03_H	*	*	OD_H

1.

3 0011	0	0	0	0

Not used	(0 fixed)
Not used	(0 fixed)
Not used	(0 fixed)
Not used	(0 fixed)

2.

3 0011	0	0	0	

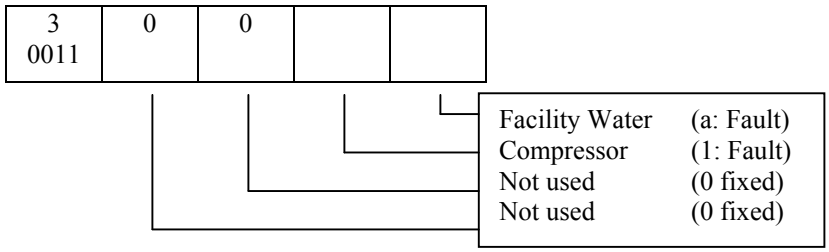
"Run" Status	(1: RUN 0: STOP)
Not used	(0 fixed)
Not used	(0 fixed)
Not used	(0 fixed)

3.

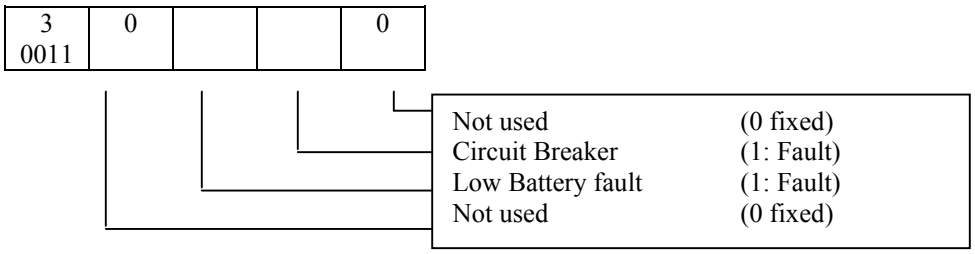
3 0011	0	0		0

Not used	(0 fixed)
Operation mode status	(1: Remote 0: Local)
Not used	(0 fixed)
Not used	(0 fixed)

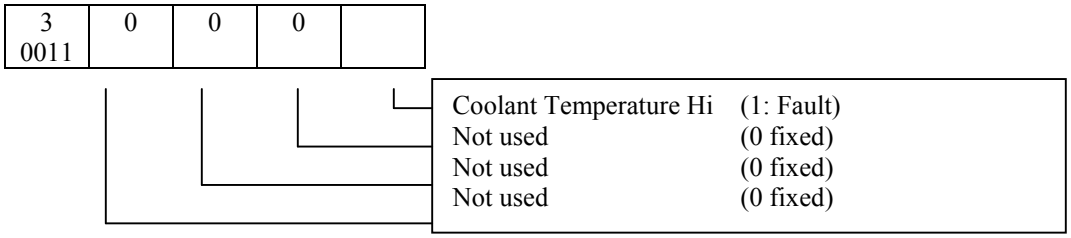
4.


3
0011
0
0
Facility Water (a: Fault)
Compressor (1: Fault)
Not used (0 fixed)
Not used (0 fixed)

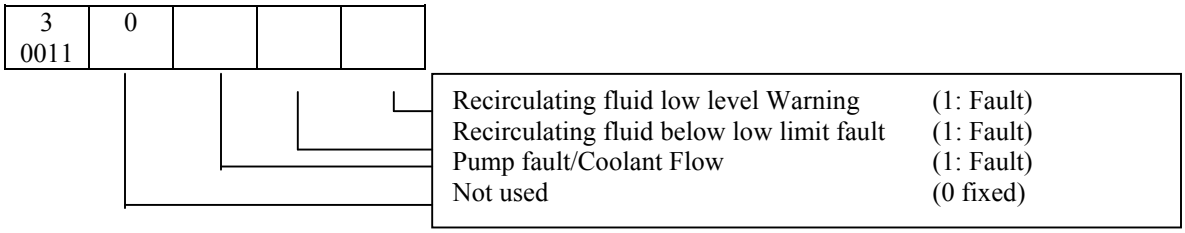
5.


3
0011
0
0
Not used (0 fixed)
Circuit Breaker (1: Fault)
Low Battery fault (1: Fault)
Not used (0 fixed)

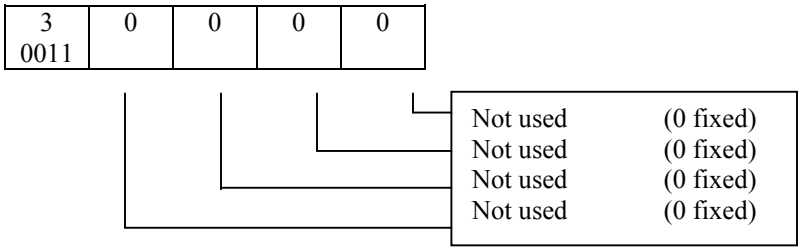
6.


3
0011
0
0
0
Coolant Temperature Hi (1: Fault)
Not used (0 fixed)
Not used (0 fixed)
Not used (0 fixed)

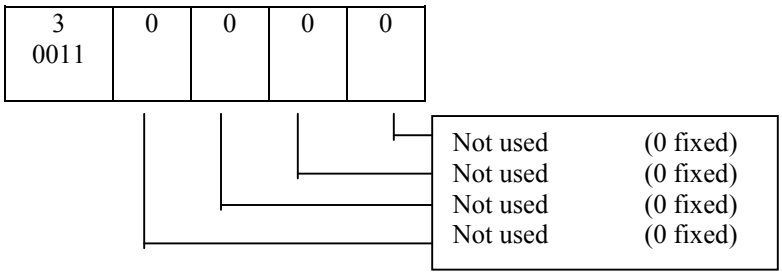
7.


3
0011
0
Recirculating fluid low level Warning (1: Fault)
Recirculating fluid below low limit fault (1: Fault)
Pump fault/Coolant Flow (1: Fault)
Not used (0 fixed)

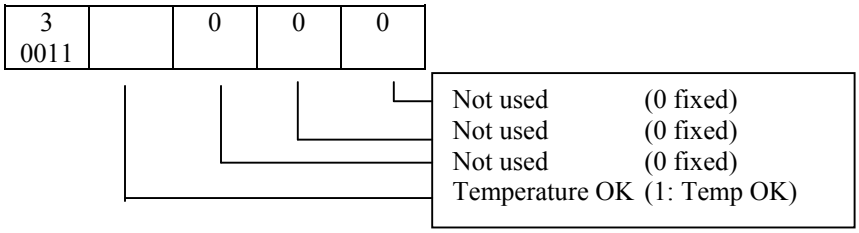
8.


3
0011
0
0
0
0
Not used (0 fixed)
Not used (0 fixed)
Not used (0 fixed)
Not used (0 fixed)

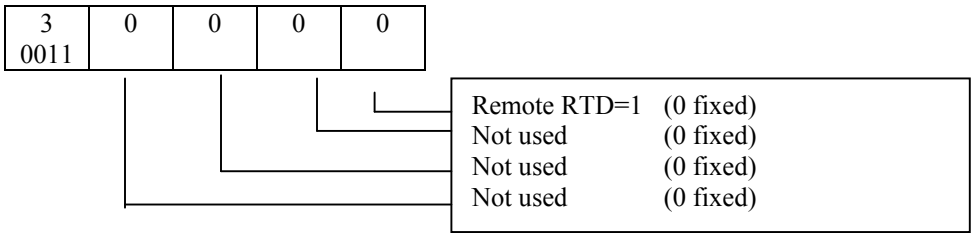
9.


3
0011
0
0
0
0
Not used (0 fixed)
Not used (0 fixed)
Not used (0 fixed)
Not used (0 fixed)

10.


3
0011
0
0
0
Not used (0 fixed)
Not used (0 fixed)
Not used (0 fixed)
Temperature OK (1: Temp OK)

11.


3
0011
0
0
0
0
Remote RTD=1 (0 fixed)
Not used (0 fixed)
Not used (0 fixed)
Not used (0 fixed)

e. Reading of Status 2

Command format [Transmission from host (external device) to the unit]

ENQ	Header	ETX	FCS		CR
05_H	37_H	03_H	33_H	37_H	OD_H

Response format [response from the unit to the host (external device)]

STX	Header	1	2	3
02_H	37_H			

ETX	FCS		CR
03_H	*	*	OD_H

1.

3 0011	0	0		

"RUN"/ "STOP signal	(1: RUN 0: STOP)
Not used	(0 fixed)
Not used	(0 fixed)
Not used	(0 fixed)

2.

Warning signal	(1: Warning condition)
Fault signal	(1: Fault condition)
Not used	(0 fixed)
Not used	(0 fixed)

3 0011	0	0		

3.

3 0011	0	0		0

N/A	
Operation mode status	(1: Remote 0: Local)
Not used	(0 fixed)
Not used	(0 fixed)

7. Description of Write Command
The write command is effective only when the unit is in remote operation mode. If the unit is in local operation mode, [ACK] is returned but the command is neglected.

A. Writing of Set Temperature

Command format [Transmission from the host] (external device to the unit]

STX	Header	±	9	9	Dummy code		
02_H	31_H	Set Point Temp			30_H	30_H	30_H

Dummy code			ETX	FCS		CR
30_H	30_H	30_H	03_H	*	*	OD_H

Response format [Response from the unit to the host (external device)]

STX	ACK	ETX	FCS		CR
02_H	06_H	03_H	30_H	36_H	OD_H

Set Temperature Data

2 digits ASCII code with + / - sign (-30°C--+90°C)

Example: +10°C: $2B_H$, 31_H, 30_H
0°C: $2B_H$, 30_H, 30_H
-20°C: $2D_H$, 32_H, 30_H

Note: *If the setpoint temperature is set that is outside of the temperature range, the following occurs. If the value is higher than the upper limit then the temperature is set to that value. If the value is lower than the lower limit then the temperature is set to that value. [NAK] is not returned.*

B. Writing of BAND Set Value

Command format [Transmission from the host (external device) to the unit]

STX	Header	9	9	9	Dummy Code		
02_H	32_H	BAND Set Value			30_H	30_H	30_H

Dummy Code			ETX	FCS		CR
30_H	35_H	30_H	03_H	*	*	OD_H

Response format [Response from the unit to the host (external device)]

STX	ACK	ETX	FCS		CR
02_H	06_H	03_H	30_H	36_H	OD_H

BAND Set Value

3 digits ASCII code without +/- sign A(0.5°C—5.0°C)

Example: 0.5°C: 30_H, 30_H, 35_H
5.0°C: 30_H, 35_H, 30_H

Note: *If the BAND value is set outside the available range the following occurs. Below the lower limit, the value will be set to the lower limit. Above the higher limit the value will be set to the higher limit. [NAK] is not returned.*

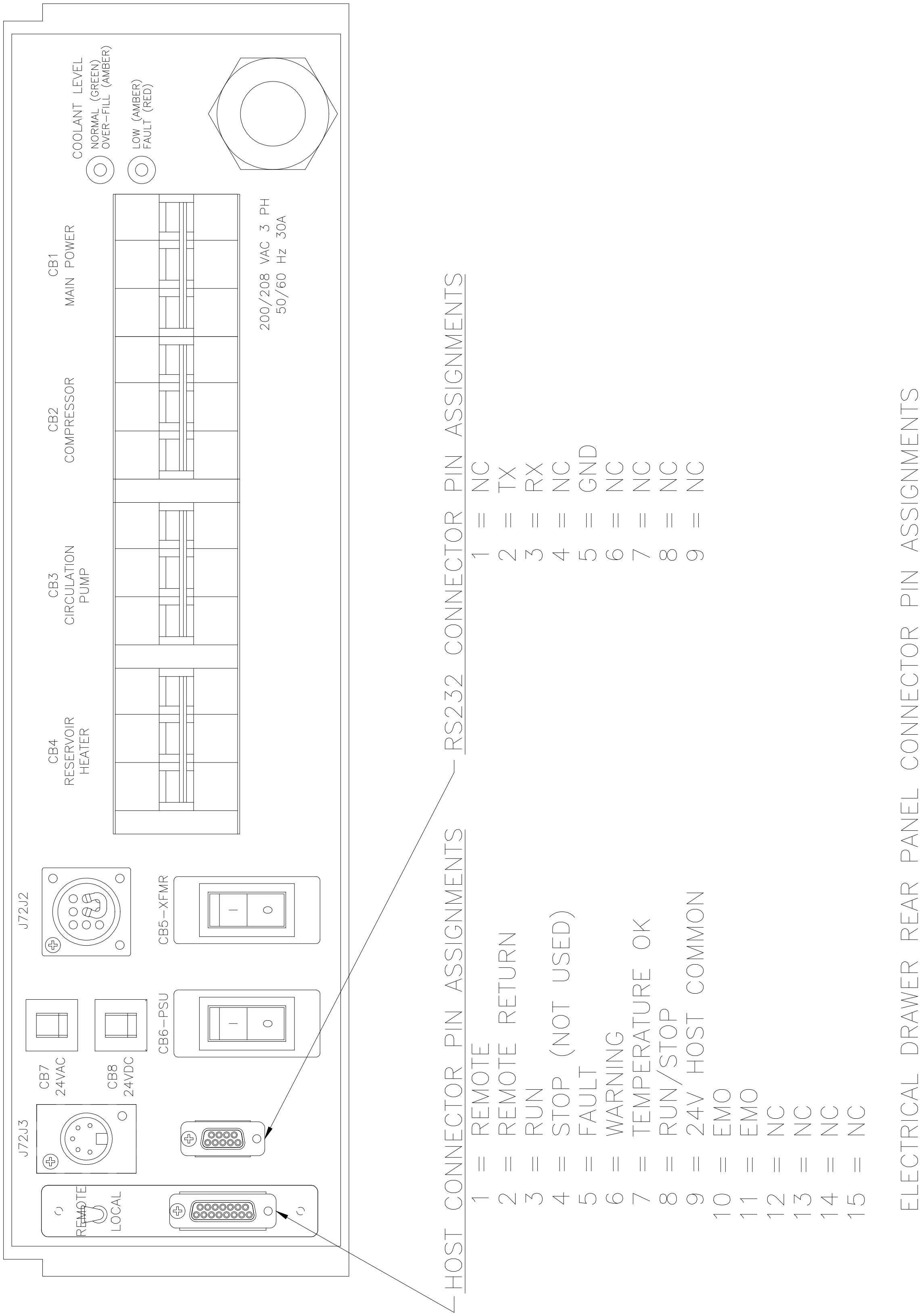


Fig 27 – Electrical Rear Panel
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Table 24 - Description of Rear Panel Components and Indicators

Label	Description
J72J3	Five-pin connector for remote RTD interface. See Figure 31 on page 98 for pin outs.
CB7 24 VAC	1-pole, 2 Amp circuit breaker. Isolates the 24 VAC transformer. Normally on (in).
CB8 24 VDC	1-pole, 2 Amp circuit breaker. Isolates the 24 VDC power supply output. Normally on (in).
J72J2	Nine pin connector for remote EMERGENCY OFF, start-stop operation, and remote setpoint operation enable. See Figure 31 on page 98 for pin outs.
CB4 reservoir heater	3-pole, 10 Amp circuit breaker. Normally on (up).
CB3 circulation pump	3-pole, 6 Amp circuit breaker. Normally on (up).
CB2 compressor	3-pole, 16 Amp circuit breaker. Normally on (up).
CB1 main power	3-pole, 25 Amp circuit breaker. Normally on (up).
normal/overfill	Normal, LED Green Overfilled, LED Amber
low/fault	Low, LED Amber Fault, LED Red
200/208 VAC 3 PH 50/60 Hz 30A	Mains input power connector.
CB5-XFMR	2-pole, 0.5 Amp circuit breaker. Isolates the equipment transformer.
CB6-PSU	2-pole, 0.3 Amp circuit breaker. Isolates the power supply.
DB9	RS 232 Communications
DB15	Analog Host Interface

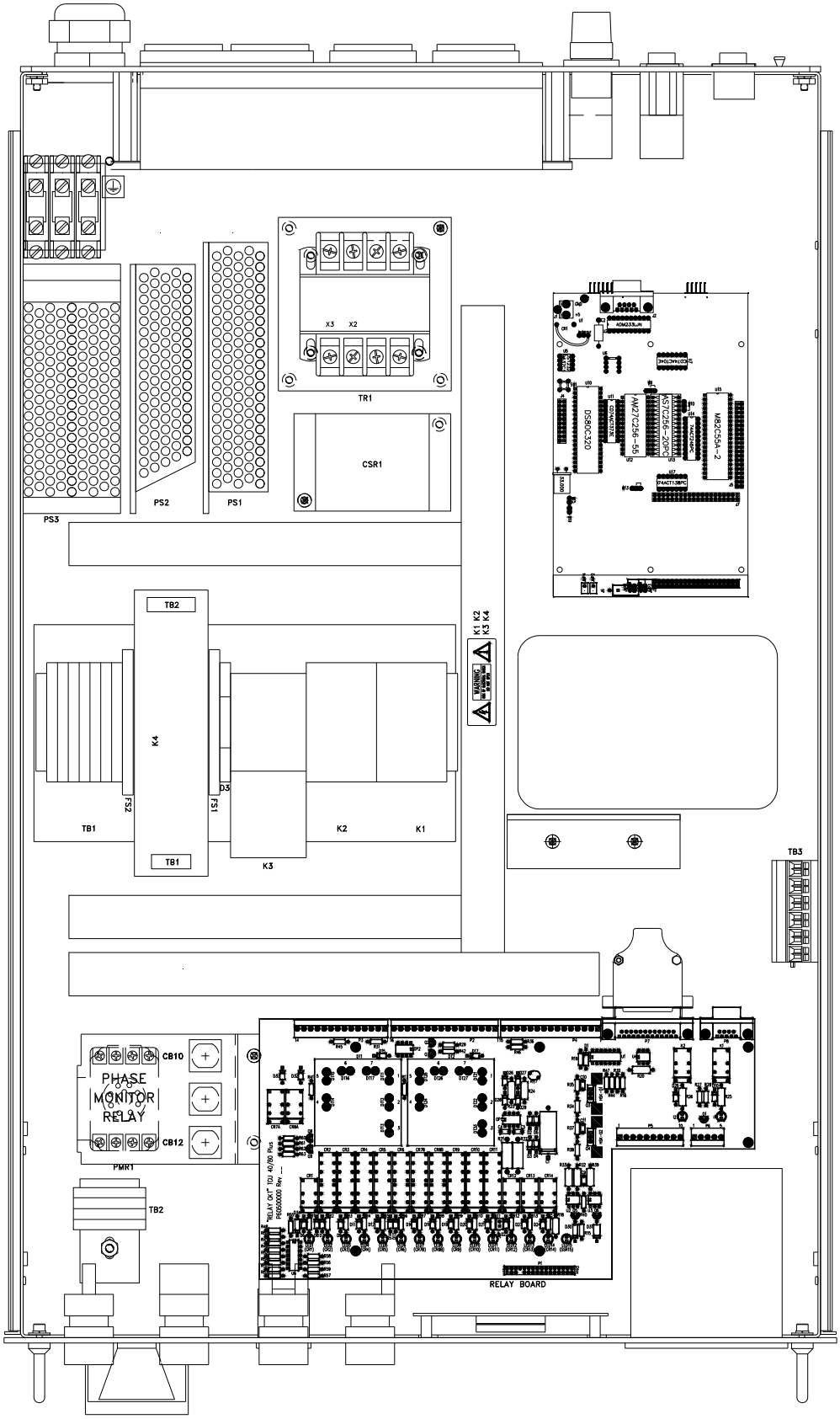

Fig 28 – RS232 Electrical Drawer
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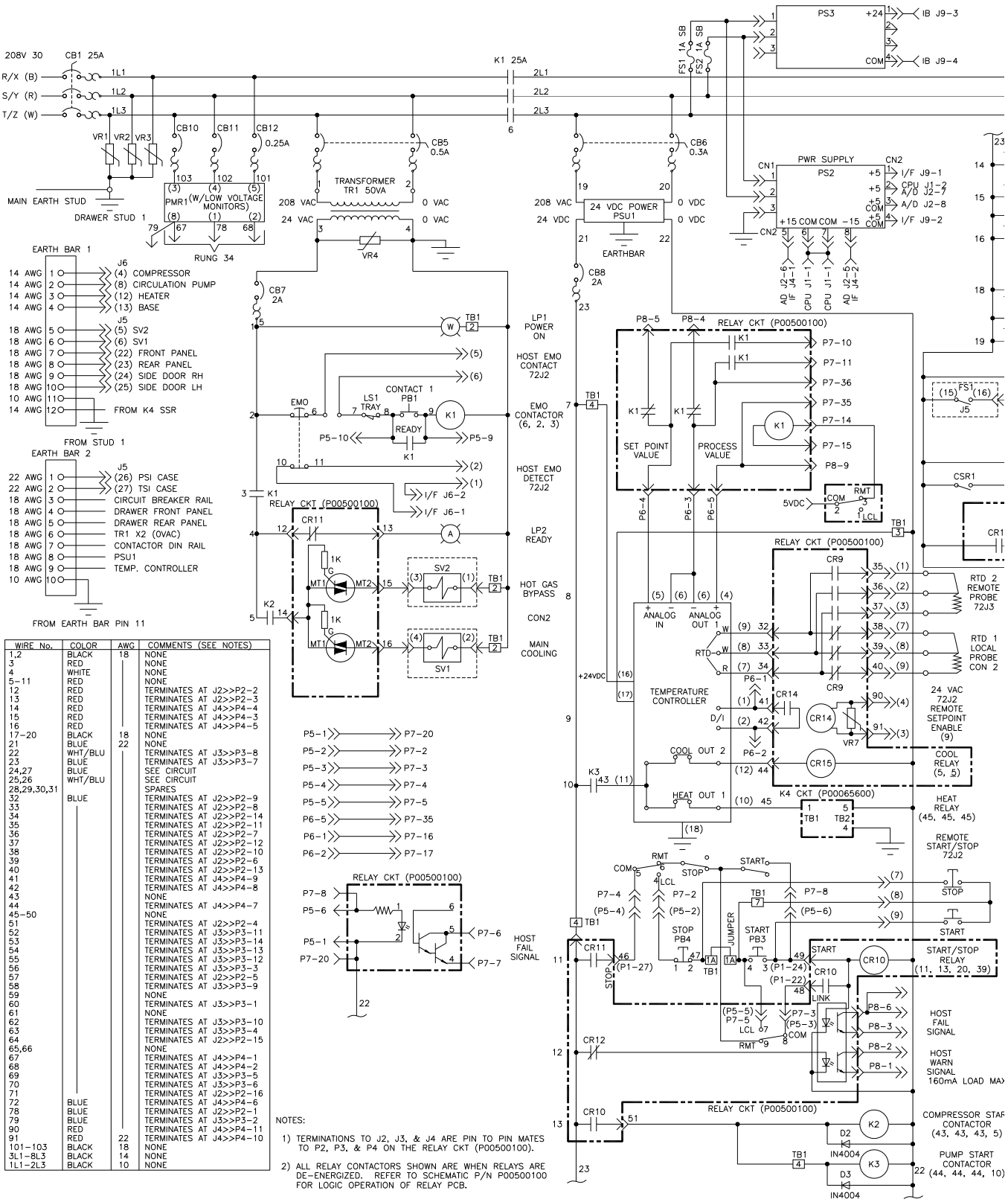
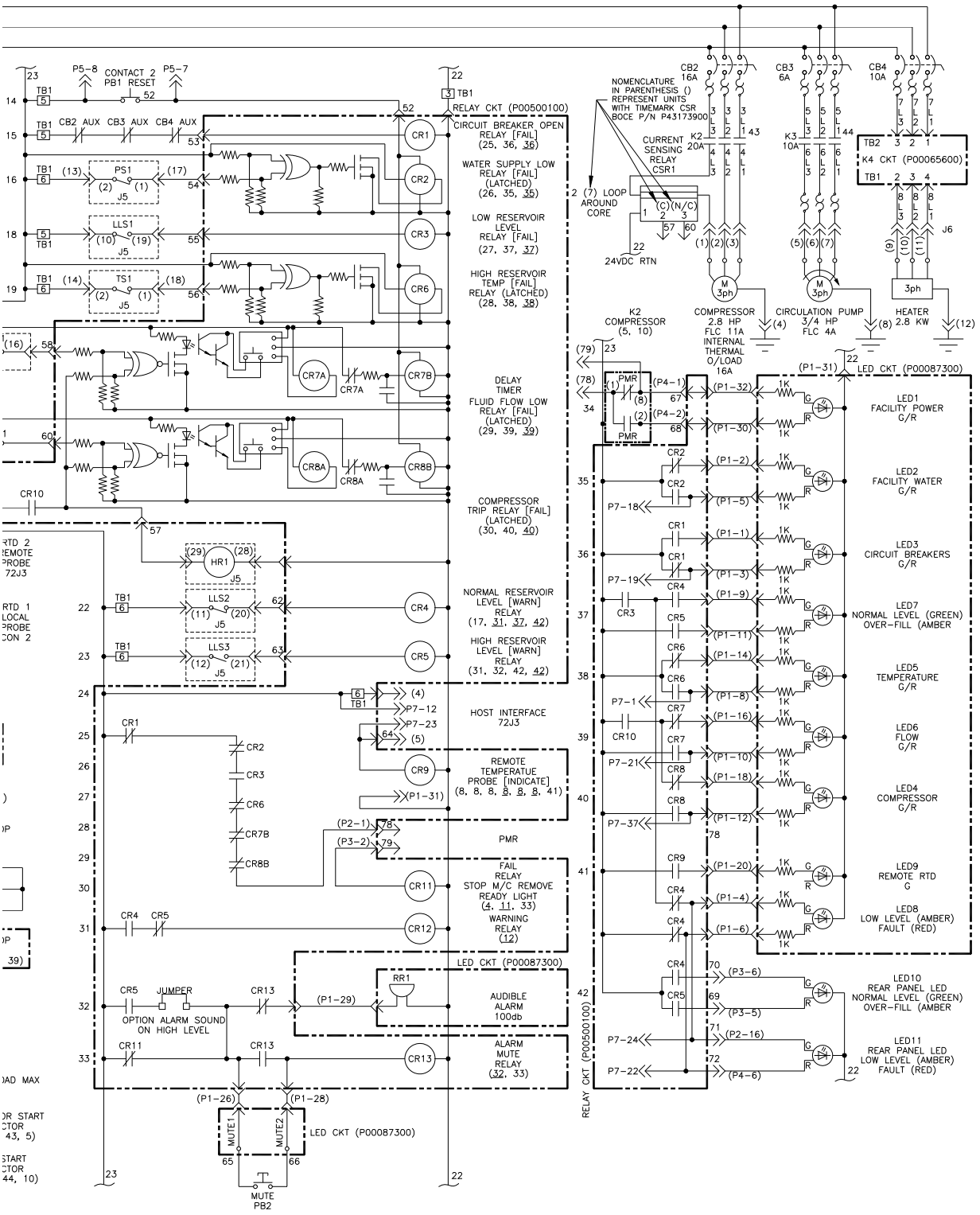
No Text



WIRE No.	COLOR	AWG	COMMENTS (SEE NOTES)
1,2	BLACK	18	NONE
3	RED		NONE
4	WHITE		NONE
5-11	RED		NONE
12	RED		TERMINATES AT J2>>P2-2
13	RED		TERMINATES AT J2>>P2-3
14	RED		TERMINATES AT J4>>P4-4
15	RED		TERMINATES AT J4>>P4-3
16	RED		TERMINATES AT J4>>P4-5
17-20	BLACK	18	NONE
21	BLUE	22	NONE
22	WHT/BLU		TERMINATES AT J3>>P3-8
23	BLUE		TERMINATES AT J3>>P3-7
24,27	BLUE		SEE CIRCUIT
25,26	WHT/BLU		SEE CIRCUIT
28,29,30,31			SPARES
32	BLUE		TERMINATES AT J2>>P2-9
33			TERMINATES AT J2>>P2-8
34			TERMINATES AT J2>>P2-14
35			TERMINATES AT J2>>P2-11
36			TERMINATES AT J2>>P2-7
37			TERMINATES AT J2>>P2-12
38			TERMINATES AT J2>>P2-10
39			TERMINATES AT J2>>P2-6
40			TERMINATES AT J2>>P2-13
41			TERMINATES AT J4>>P4-9
42			TERMINATES AT J4>>P4-8
43			NONE
44			TERMINATES AT J4>>P4-7
45-50			NONE
51			TERMINATES AT J2>>P2-4
52			TERMINATES AT J3>>P3-11
53			TERMINATES AT J3>>P3-14
54			TERMINATES AT J3>>P3-13
55			TERMINATES AT J3>>P3-12
56			TERMINATES AT J3>>P3-3
57			TERMINATES AT J2>>P2-5
58			TERMINATES AT J3>>P3-9
59			NONE
60			TERMINATES AT J3>>P3-1
61			NONE
62			TERMINATES AT J3>>P3-10
63			TERMINATES AT J3>>P3-4
64			TERMINATES AT J2>>P2-15
65,66			NONE
67			TERMINATES AT J4>>P4-1
68			TERMINATES AT J4>>P4-2
69			TERMINATES AT J3>>P3-5
70			TERMINATES AT J3>>P3-6
71			TERMINATES AT J2>>P2-16
72	BLUE		TERMINATES AT J4>>P4-6
78	BLUE		TERMINATES AT J2>>P2-1
79	BLUE		TERMINATES AT J3>>P3-2
90	RED		TERMINATES AT J4>>P4-11
91	RED	22	TERMINATES AT J4>>P4-10
101-103	BLACK	18	NONE
3L1-8L3	BLACK	14	NONE
1L1-2L3	BLACK	10	NONE

Fig 29 - RS 232 Power Distribution Schematic
(G:\Technical Documents\MANUALS\W95900011- All)



(continued …..) Fig 29 - RS 232 Power Distribution Schematic
(G:\Technical Documents\MANUALS\W95900011- All)

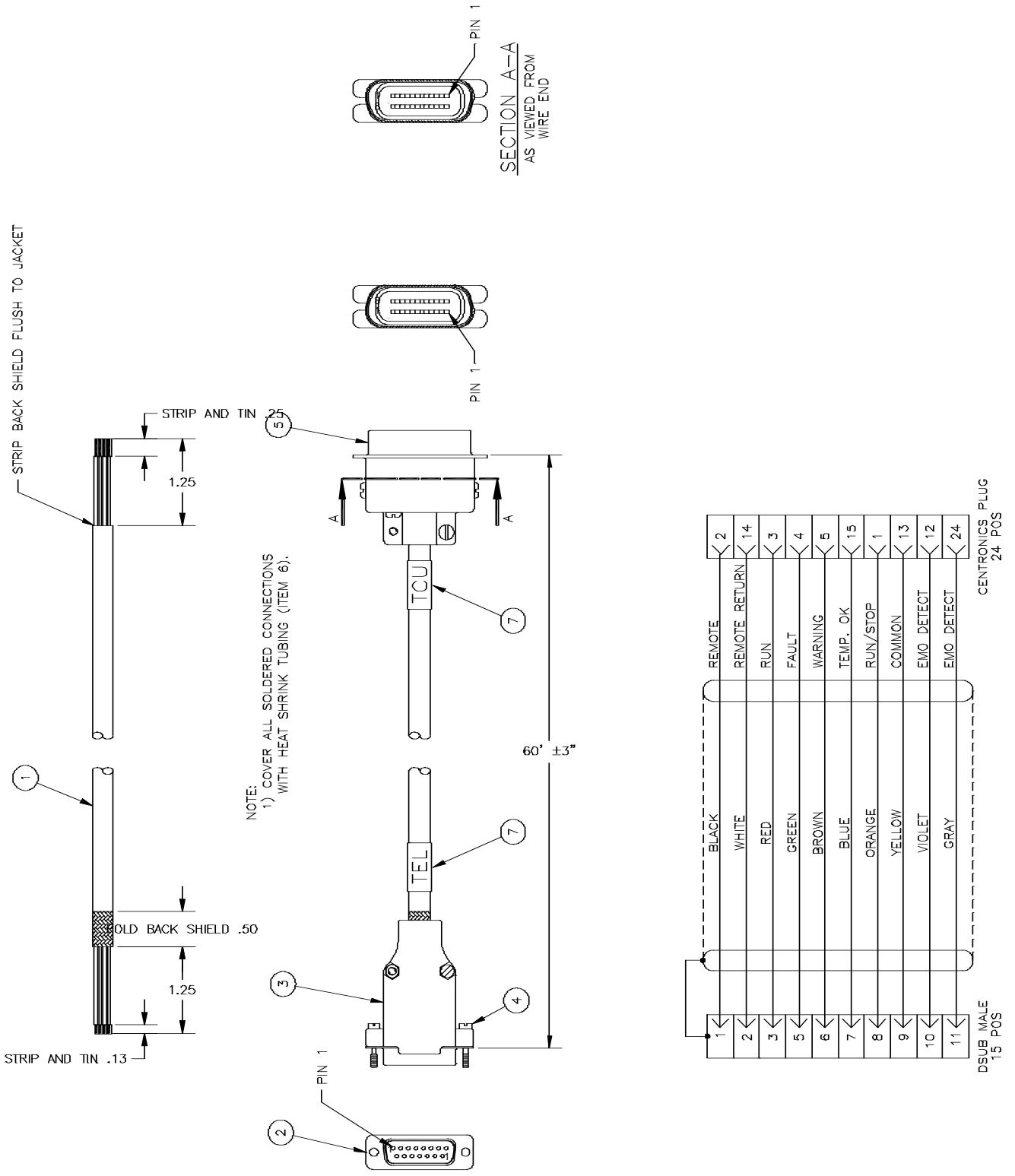


Fig 30 - Assy,Cable,TCU Host Comm
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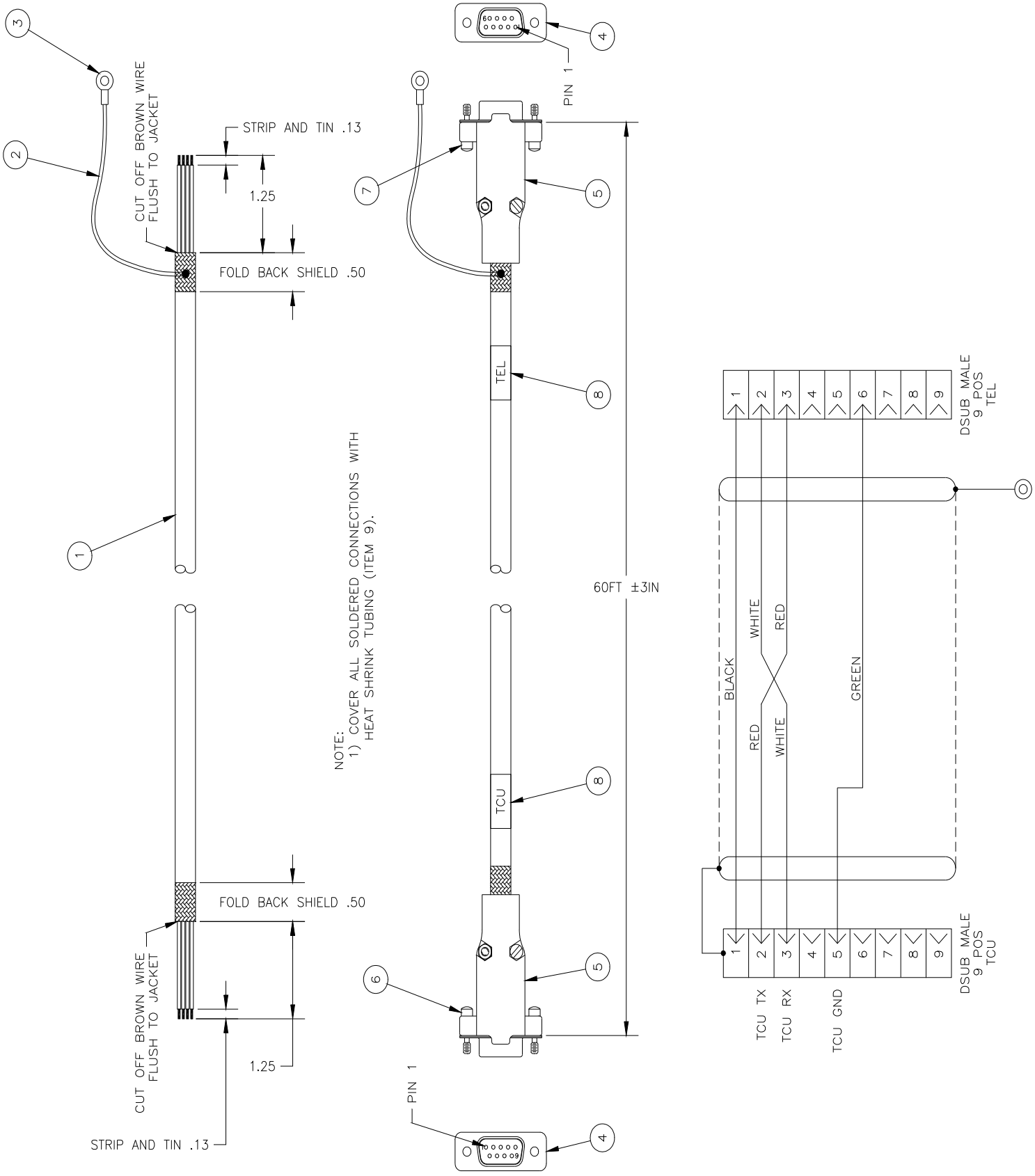

Fig 31 - Assy,Cable,TCU RS232 Comm
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10.3. RS485 Serial Communication

The RS485 Interface Box Assembly was designed specifically to install only on the BOC Edwards model TCU 40/80 with RS485, BOC Edwards P.N. NW9501194. The TCU 40/80 with RS485 communications consists of two major components:

1. TCU 40/80 with modified electrical controls drawer,
2. External RS485 Interface Box Assembly

10.3.1 Modified Electrical Controls Drawer

Modifications to the standard TCU 40/80 electrical controls drawer include the addition of a dedicated RS485 low voltage power supply (labeled "PSU2"), and wiring to convey all standard chiller monitor and control functions to connector J72J1 with revised pin-out designations. The revised component layout for this modified electrical drawer is shown in Figure 32 on page 100; this drawing supercedes Figure 14 on page 55, Electrical Drawer for the standard TCU 40/80. The Electrical Drawer Schematic revised for RS-485 is given in Figure 33 on page 102; this drawing supercedes Figure 15 on page 57, Electrical Drawer Schematic for the standard TCU 40/80. The revised pin designation for rear panel connector J72J1 (See Section 4.6 Figure 5 on page 18) is defined in Table 7 page 18.

10.3.2 RS485 Interface Box Assembly

The physical dimensions and appearance of the Box Assembly are illustrated in Figure 34 on page 104. A top view of the box with top cover removed is given in Figure 35 on page 105. This assembly includes a Chiller Interface Cable assembly, a host RS485 communication connector, a sheet metal enclosure, a Remote/Local selector switch, and three printed circuit board assemblies (PCA's).

The Chiller Interface Cable assembly is composed of a 37-pin male plug connector (labeled "RS-485 Interface P72J1") with 1-meter long cable harness wired directly to the screw terminal headers on the Interface PCA located inside the box. The pin designation for P72J1 is identical to that defined in Table 7 on page 18 for the mating J72J1 connector.

The host RS485 communication connector is a 9-pin D-subminiature connector with female socket contacts. The pin designation for this connector is defined in Table 25 on page 106. The mating host serial RS485 communication cable assembly provided by the customer must be plugged into this connector.

The sheet metal enclosure shields and protects the three PCA's that compose the BOC Edwards serial interface electronics, and provides a rigid mounting surface for the Chiller Interface Cable strain relief fitting, the 9-pin host RS485 interface connector, and the Remote/Local selector switch.

The Remote/Local selector switch is used by the Local Operator (at the chiller) to manually control the Remote enable function of the TCU 40/80. When this switch is initially set to the "REMOTE" position, control of the chiller is transferred from the local user, to the Host via RS485 serial communication; the Microprocessor PCA is programmed to send a factory default remote set point temperature of 25C to the chiller until the Host controller commands a change.

The three PCA's housed within the sheet metal enclosure include the Microprocessor board, Analog-to-Digital (A/D) board, and the Interface board. The Microprocessor PCA is mounted directly above the A/D PCA; the Interface PCA is physically larger and mounted beside these stacked boards. The Microprocessor and A/D board set monitor and report to the tool Host controller (via the 9-pin host RS485 communication connector) both chiller process value temperature and system status; it also relays Host commands for remote set point temperature value to the chiller. All analog and digital input/output signals transferred between the chiller and the RS485 Interface Box Assembly are relayed and conditioned by the Interface PCA (via the 37-pin Chiller Interface Cable assembly).

10.3.3 Installation and Set-up of RS485 Interface Box Assembly

Supplement to Remote Connections, Section 5.4.4:

The following installation and set-up procedure is intended to supplement related procedures given in Remote Connections section 5.4.4 of this instruction manual.

1. Place the box on the top surface of the TCU; position the box so that the cable connectors are facing toward the rear of the TCU.
2. Depress the EMO button on the TCU front panel to remove power.
3. The customer must determine the required RS485 address for the TCU and verify the need for the termination jumper installed by BOC Edwards during Interface Box manufacture and test. If the required address is not 6 and/or the termination jumper is not required, then open the Interface Box top cover; i.e., turn the Box upside-down, remove the 4 bottom-side corner screws, turn the Box right side up and lift open top cover to exposed the internal components.

ADDRESS SETTING: The Interface Box is manufactured and tested by BOC Edwards with the Interface PCA Address Switch S1 (8-position, DIP switch) set to 6 (in hexadecimal code). As mentioned above, the Address Switch S1 is located on the Interface PCA as shown in Figure 35 on page 105. Reset each of the eight switches as required to achieve the required hexadecimal address value.

TERMINATION JUMPER SETTING: As mentioned above, the Interface Box is manufactured and shipped by BOC Edwards to the customer with the termination jumper installed. This jumper is designated "JP7" on the Microprocessor PCA, as shown in Figure 35 on page 105. Pin designation and functions for JP7 are defined in Figure 36 on page 105. JP7 enables a termination register across the twisted pair host communication cable, and is required whenever the TCU is at the end of a chain of RS-485 devices or is used as a stand-alone device. If for a given application, the TCU does not meet these criteria, then remove JP7 from across the two pins and re-install on one pin only (for future use).

When both the Address and Termination Jumper positions meet the application requirements, then reassemble the Interface Box top cover onto the base assembly; fasten all four corner screws; then orient the Box on the TCU as defined in step 1, above.

4. Push the Interface Box Remote/Local toggle switch downward to the LOCAL position.
5. Install Interface Box plug P72J1 into mating J72J1 connector located on TCU rear panel.
6. Install Host RS-485 Communication Cable connector (9-pin male D-subminiature; provided by customer) in mating RS485 9-pin female connector on Interface Box rear panel.
7. Complete all other Installation procedures as defined in chapter 5 of this manual.

Supplement to Operation, Chapter 6:

The following procedure is intended to supplement similar procedures given in Operation, Chapter 6 of this manual.

1. Restore power to the TCU; i.e., reset the EMO switch and depress RESET button, both on TCU front control panel.
2. Verify proper TCU operation in LOCAL mode.
3. Push the Interface Box Remote/Local toggle switch downward to the REMOTE position.
4. Verify proper RS485 serial communication between the process tool Host Controller and the TCU.

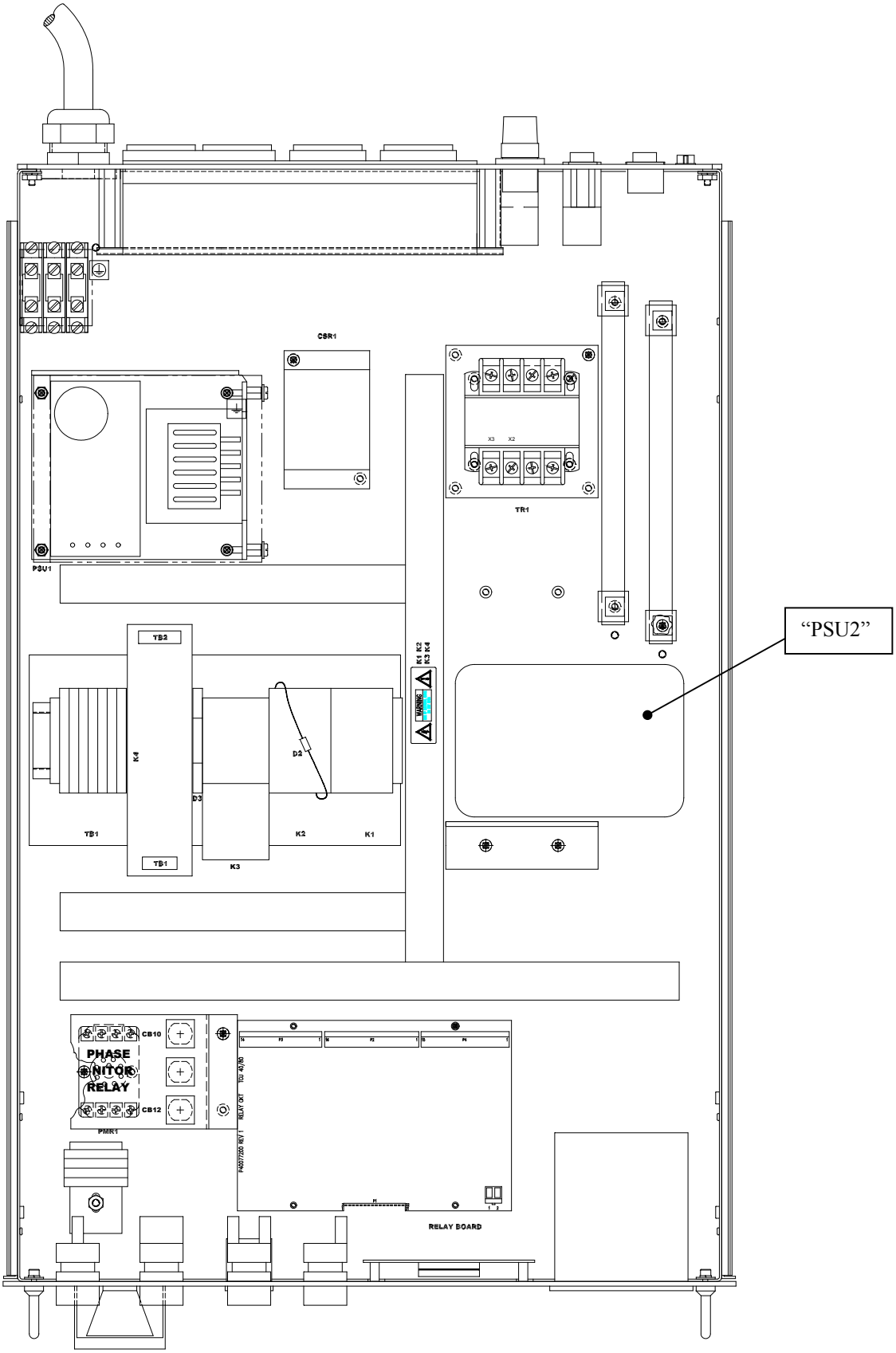

Figure 32 - RS-485 Electrical Drawer Component Layout
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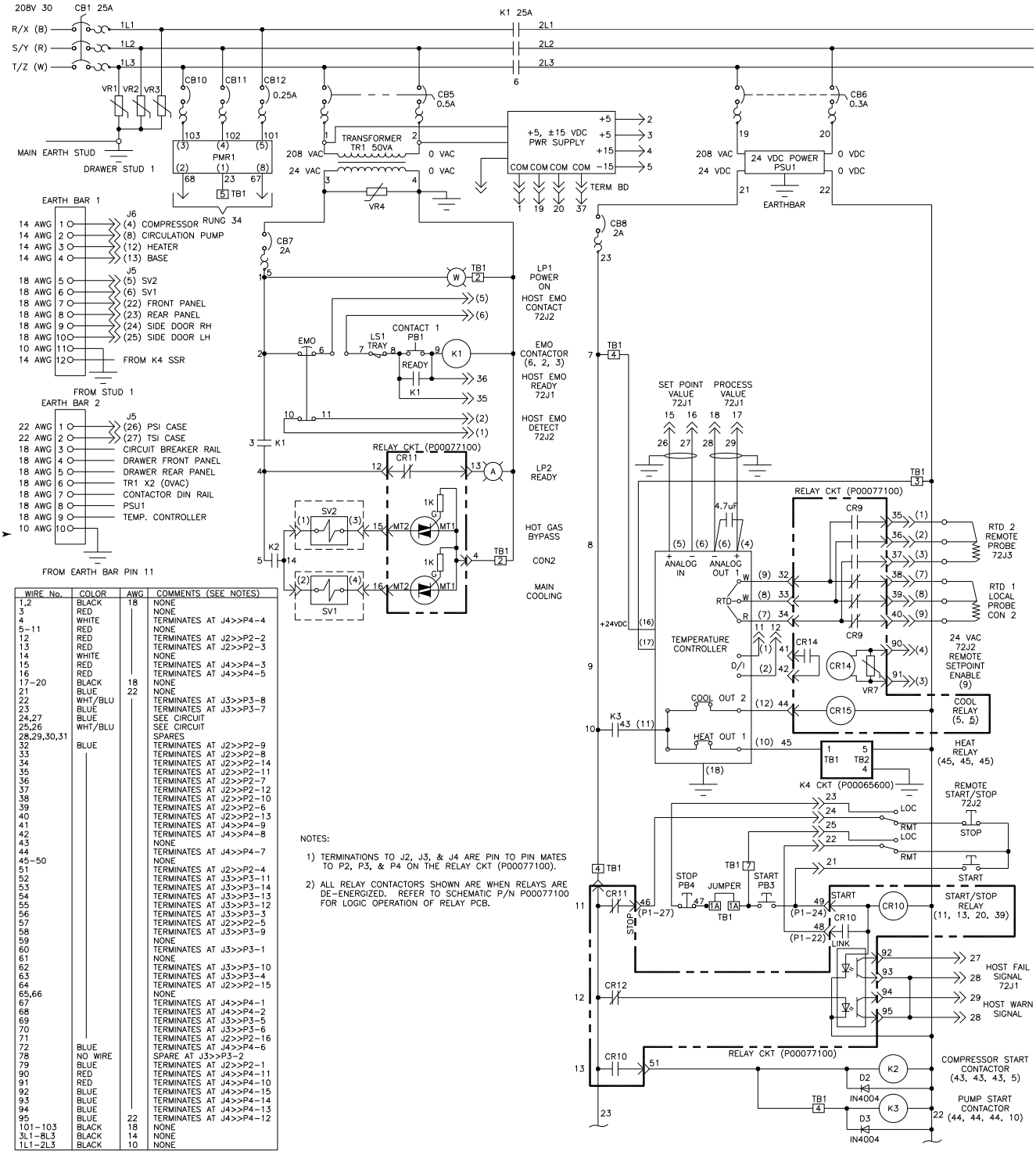
No Text



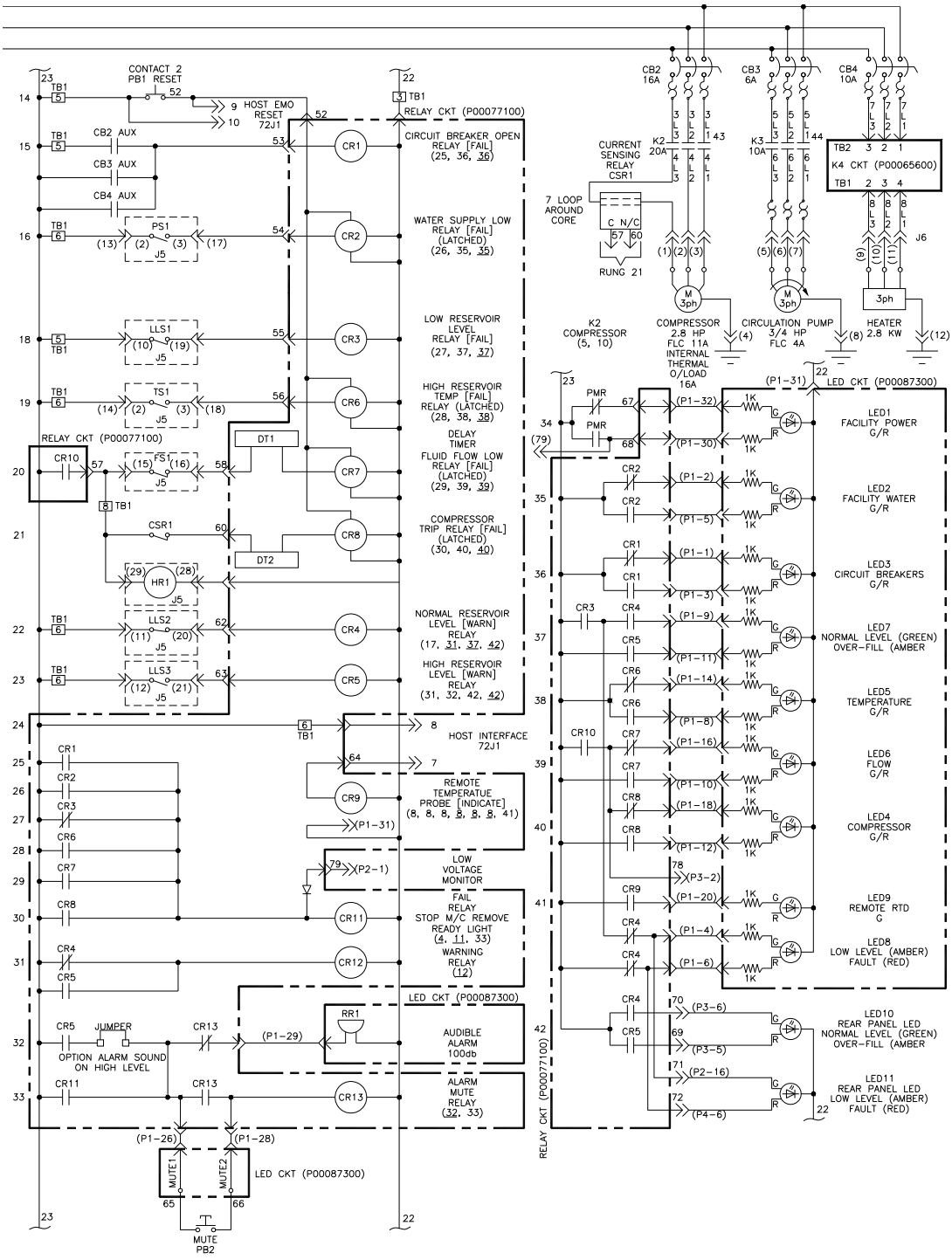
WIRE No.	COLOR	AWG	COMMENTS (SEE NOTES)
1,2	BLACK	18	NONE
3	RED		NONE
4	WHITE		TERMINATES AT J4>>P4-4
5-11	RED		NONE
12	RED		TERMINATES AT J2>>P2-2
13	RED		TERMINATES AT J2>>P2-3
14	WHITE		NONE
15	RED		TERMINATES AT J4>>P4-3
16	RED		TERMINATES AT J4>>P4-5
17-20	BLACK	18	NONE
21	BLUE	22	NONE
22	WHT/BLU		TERMINATES AT J3>>P3-8
23	BLUE		TERMINATES AT J3>>P3-7
24,27	BLUE		SEE CIRCUIT
25,26	WHT/BLU		SEE CIRCUIT
28,29,30,31			SPARES
32	BLUE		TERMINATES AT J2>>P2-9
33			TERMINATES AT J2>>P2-8
34			TERMINATES AT J2>>P2-14
35			TERMINATES AT J2>>P2-11
36			TERMINATES AT J2>>P2-7
37			TERMINATES AT J2>>P2-12
38			TERMINATES AT J2>>P2-10
39			TERMINATES AT J2>>P2-6
40			TERMINATES AT J2>>P2-13
41			TERMINATES AT J4>>P4-9
42			TERMINATES AT J4>>P4-8
43			NONE
44			TERMINATES AT J4>>P4-7
45-50			NONE
51			TERMINATES AT J2>>P2-4
52			TERMINATES AT J3>>P3-11
53			TERMINATES AT J3>>P3-14
54			TERMINATES AT J3>>P3-13
55			TERMINATES AT J3>>P3-12
56			TERMINATES AT J3>>P3-3
57			TERMINATES AT J2>>P2-5
58			TERMINATES AT J3>>P3-9
59			NONE
60			TERMINATES AT J3>>P3-1
61			NONE
62			TERMINATES AT J3>>P3-10
63			TERMINATES AT J3>>P3-4
64			TERMINATES AT J2>>P2-15
65,66			NONE
67			TERMINATES AT J4>>P4-1
68			TERMINATES AT J4>>P4-2
69			TERMINATES AT J3>>P3-5
70			TERMINATES AT J3>>P3-6
71			TERMINATES AT J2>>P2-16
72	BLUE		TERMINATES AT J4>>P4-6
78	NO WIRE		SPARE AT J3>>P3-2
79	BLUE		TERMINATES AT J2>>P2-1
90	RED		TERMINATES AT J4>>P4-11
91	RED		TERMINATES AT J4>>P4-10
92	BLUE		TERMINATES AT J4>>P4-15
93	BLUE		TERMINATES AT J4>>P4-14
94	BLUE		TERMINATES AT J4>>P4-13
95	BLUE	22	TERMINATES AT J4>>P4-12
101-103	BLACK	18	NONE
3L1-8L3	BLACK	14	NONE
1L1-2L3	BLACK	10	NONE

NOTES:

1) TERMINATIONS TO J2, J3, & J4 ARE PIN TO PIN MATES TO P2, P3, & P4 ON THE RELAY CKT (P00077100).

2) ALL RELAY CONTACTORS SHOWN ARE WHEN RELAYS ARE DE-ENERGIZED. REFER TO SCHEMATIC P/N P00077100 FOR LOGIC OPERATION OF RELAY PCB.

Figure 33 - RS-485 Electrical Drawer Schematic
(G:\Technical Documents\MANUALS\W95900011- All)



(continued …) Figure 33 - RS-485 Electrical Drawer Schematic
(G:\Technical Documents\MANUALS\W95900011- All)

Fig 34 - RS485 Interface Box – Physical Dimensions
(G:\Technical Documents\MANUALS\W95900011- All)

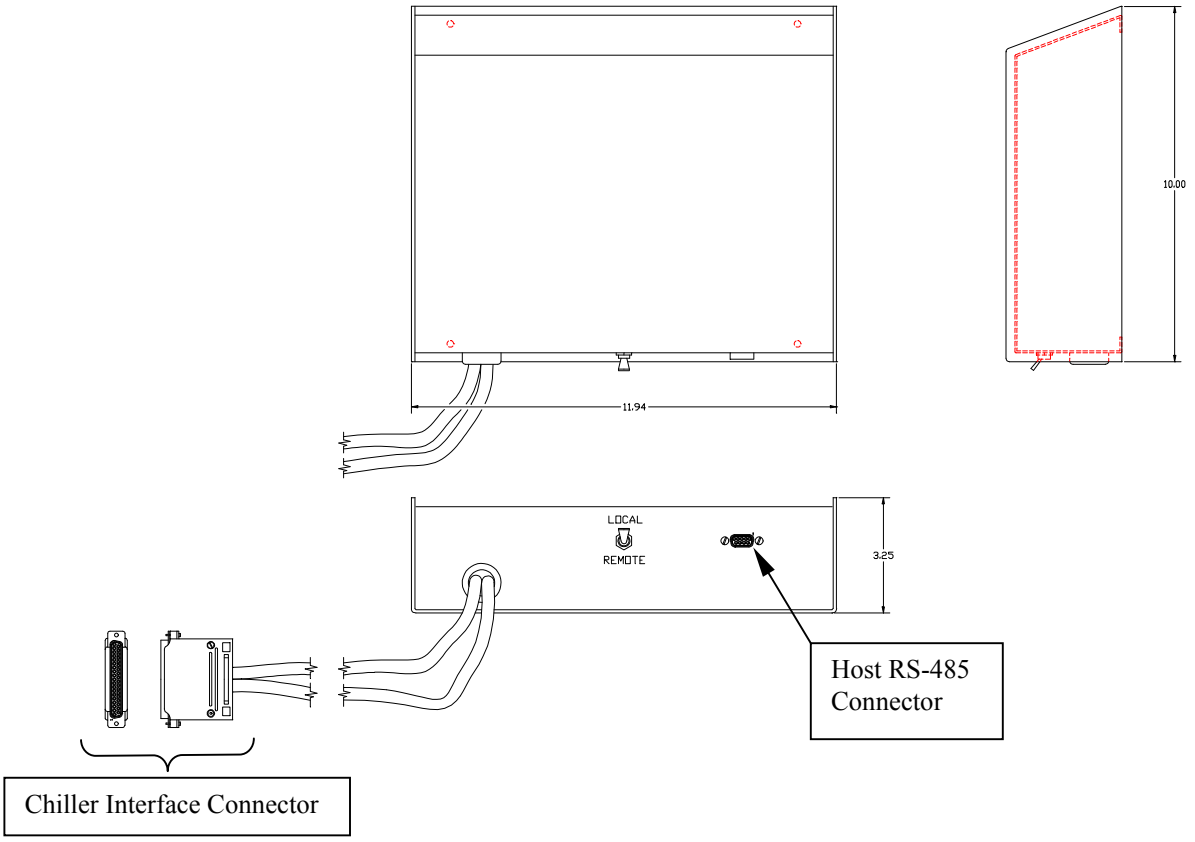


Fig 35 - RS485 Interface Box with Top Cover Removed
(G:\Technical Documents\MANUALS\W95900011- All)

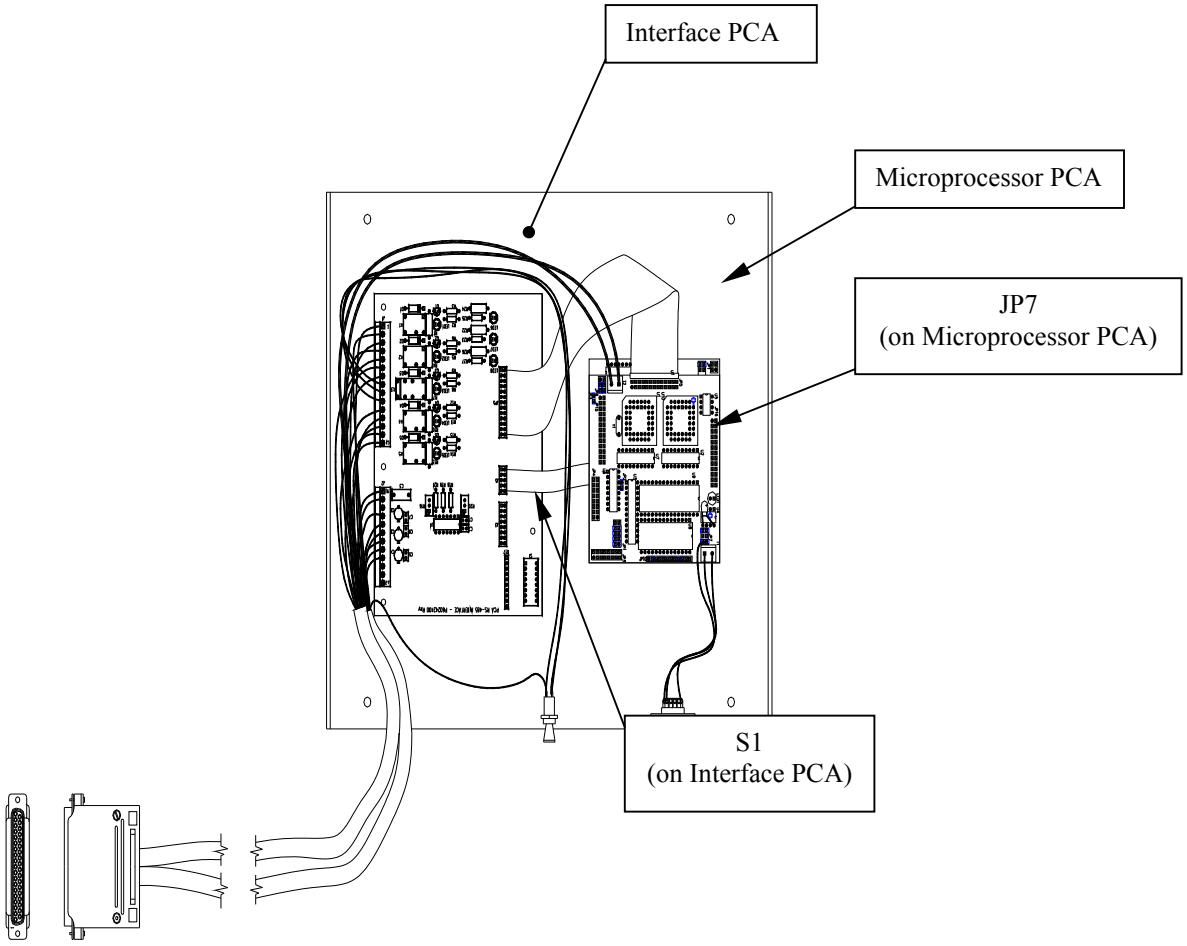
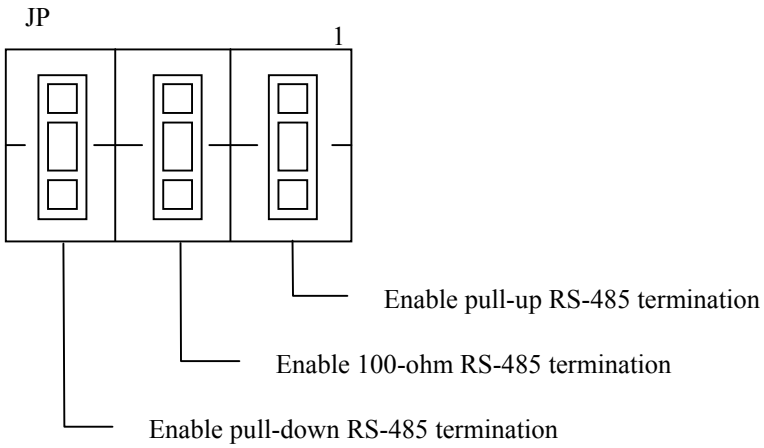
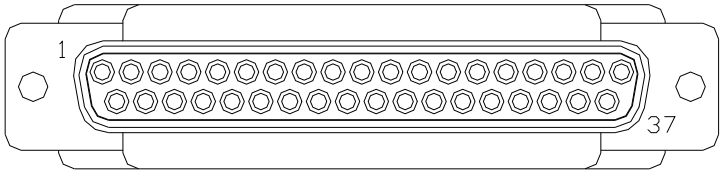


Figure 36 - Microprocessor PCA – JP7 Pin Description and Function
(G:\Technical Documents\MANUALS\W95900011- All)



JP7 shows termination of the RS-485 lines enabled

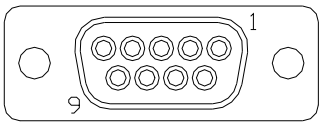
Table 25 - TCU 40/80 “J72J1” Connector Modified for RS-485 (37-Pin D-subminiature Female)



Note: Same pin designation applies to mating “P72J1” male connector

PIN #	ID #	DESCRIPTION	TO
1	5V COM		I/F PCB, J2-8
2	+5 V		I/F PCB, J2-9
3	+5 V		Processor PCB, P2-1
4	+15 V		I/F PCB, J2-4
5	-15 V		I/F PCB, J2-6
6	GND		RS 485 Box chassis
7	64	Remote RTD enable	I/F PCB, J1-1
8	23	+24 Vdc to Remote RTD relay R9	I/F PCB, J1-2
9	52	Reset	I/F PCB, J1-5
10	23	+24 Vdc for Reset	I/F PCB, J1-6
11	41	Remote Set Point Enable	I/F PCB, J1-3
12	42	Remote Set Point Enable	I/F PCB, J1-4
13	GND	Temperature Set Point Shield	I/F PCB, J2-7
14	GND	Temperature Process Value Shield	I/F PCB, J2-7
15	26	Temperature Set Point (+)	I/F PCB, J2-1
16	27	Temperature Set Point (-)	I/F PCB, J2-5
17	28	Process Value (+)	I/F PCB, J2-2
18	29	Process Value (-)	I/F PCB, J2-3
19	±15 COM		I/F PCB, J2-3
20	±15 COM		CPU PCB, J1-1
21	49	Start Relay CR10 (+24 Vdc signal)	I/F PCB, J1-9
22	48	Start, N.O. contact, CR10 (+24 Vdc)	To common of L/R Switch “C”
23	46	Stop “Local”	To Local of L/R Switch “B”
24	46	Stop (+24 Vdc signal)	To common of L/R Switch “B”
25	48	Start “Local”	To Local of L/R Switch “C”
26			Not Connected
27	92	Chiller “Fail” signal	I/F PCB, J1-13
28	93 & 95	Fail/Remote COM	I/F PCB, J1-15
29	94	Chiller “Warning” signal	I/F PCB, J1-14
30			Not Connected
31			Not Connected
32			Not Connected
33			Not Connected
34			Not Connected
35	8	Remote Ready (+24 Vac signal)	I/F PCB, J1-7
36	9	Remote Ready (+24 Vac to K1)	I/F PCB, J1-8
37	COM		Processor PCB, P2-2

Table 26 - Host RS-485 Communication Connector (9-Pin D-Subminiature Female)



Note: Connection type is 2-wire half-duplex multi-drop RS-485

Pin	Signal Type	Function
1		(-)
2		
3		
4		
5		SG
6		
7		
8		
9		(+)

10.3.4 RS485 Modicon Modbus Protocol Specification for TCU 40/80

1. Purpose:
   The purpose of this document is to define the RS485 transmission characteristics using the Modicon protocol.

2. References:
   Modicon Modbus Protocol Reference Guide PI-MBUS-300 Rev J dated June 1996.

3. RS485 Transmission Characteristics:
   The Modbus protocol implemented is ASCII mode (1 start bit, 7 data bits, 1 even parity bit, 1 stop bit), Longitudinal Redundancy Check (LRC), and operation at 9600 baud. All hex characters are transmitted upper case ASCII.

   If an incomplete message is received or if the time between characters exceeds a millisecond the partial message will be ignored. The unit will receive and respond to messages only when in Remote Mode.

4. RS485 Line Control, Tri State Control.
   The TCU 40/80 powers up with the line ready to receive, i.e. the RS485 driver is off and the receiver is enabled. Note: the unit will receive and respond to messages only when in Remote Mode.
   When a valid message is received or a message that contains an error that can be responded to, the unit will respond in approximately 2 to 3 millisecond.
   After the 2 to 3 milliseconds the unit will drive the line to a stop condition for at least 0.2 msec and then begin transmitting the return message.
   Upon completion of the message the unit will keep the line in a stop condition for at least 0.2 msec. After the 0.2 millisecond the line will be left in a high impedance state.
   These times allow the line to settle and any character errors to be flushed out.

5. RS485 Message Structure:
   All characters transmitted and received are ASCII characters. I.e. if the RS485 address is 172 decimal (AC hex) the two ASCII characters for the address will be 41 hex & 43 hex.

   The structure of a message frame is as follows:
   Start of Message: Colon (:); ASCII 3A hex
   RS485 Address..: Two ASCII characters 00 to FF hex
   Function…….: Two ASCI characters
   Data……...: Variable number of ASCII chars, fcn dependent
   LRC check…….: Two ASCII characters
   Termination…...: CRLF

   The LRC characters are the 2's complement of the sum of the ASCII characters following the Start of Message character through the characters preceding the LRC characters.

6. Modbus Commands Implemented:
   Only two Modbus commands are implemented:
   Mask Write 4X Register, code 22 (16 hex).
   This command is used to set or clear individual bits in a register.

   Read/Write 4X Registers, code 23 (17 hex).
   This command can be used to read a series of registers and write a series of registers.

7. 4X Memory Map:
The memory-mapped registers are 16 bits in length and for purposes of discussion the least significant bit is b0 and the most significant bit is b15.

The registers written to or read from are organized in a memory map. The memory map starts at location 0100 hex and runs through location 010E hex. These locations contain process data or receive data and commands. They are organized in two groups, a read only group and a read write group.

The read only addresses start at 0100 hex and end at 0108 hex. The write/read addresses start at 0109 hex and end at 010E hex. Not all addresses (4X Memory) contain valid data. Many are reserved for future use.

8. Message Error Response:
When a valid message is received but cannot be implemented an error message is returned. The function field of the message gets returned with the most significant bit set. I.e. function 17 becomes 97 hex and function 16 becomes 96 hex.

There are three types of errors identified. The error codes are as follows:
01: Illegal Function, (function not available)
02: Illegal Data Address, (out of range or illegal command)
03: Illegal Data Value, (out of range etc)

10.3.5 RS485 4X Memory Map for TCU 40/80 Heat Exchanger

4X Address b15 b14 b13 b12 b11 b10 b09 b08 b07 b06 b05 b04 b03 b02 b01 b00

0x0100	1 2 (bits b13 to b00 not used)	Digital Input	Read Only
0x0101	Temperature	Analog Input	Read Only
0x0102	Reserved	Digital Input	Read Only
0x0103	Reserved	Digital Input	Read Only
0x0104	Reserved	Analog Input	Read Only
0x0105	Reserved	Analog Input	Read Only
0x0106	Reserved	Analog Input	Read Only
0x0107	Reserved	Analog Input	Read Only
0x0108	Reserved	Analog Input	Read Only
0x0109	3 (bits b14 to b00 not used)	Digital Output	Read/Write
0x010A	Temperature Set Point	Analog Output	Read/Write
0x010B	Reserved	Digital Output	Read/Write
0x010C	Reserved	Analog Output	Read/Write
0x010D	Reserved	Analog Output	Read/Write
0x010E	Reserved	Analog Output	Read/Write

Notes:
Read Base: 0x0100
Write Base: 0x0109
1: Unit Fault; 1 = fault.
2: Unit Warning; 1 = warning
3: On / Off Control; 0 = off, 1 = on
Scaling for Temperature & Temperature Set Point is as follows:
-60 degree C is scaled at 0 counts, 160 degree C is scaled at 0xFFFF counts. All other values are scaled linearly between these counts. A set point value outside the operating range of the unit will return an error.

10.3.6 RS485 TCU 40/80 Message Example

QUERY MESSAGE & Response Message:

Field	Hex	ASCII Code
Start Character		":" = 0x3A
Unit Address	0x05	"0" = 0x30 "5" = 0x35
Function	0x16	"1" = 0x31 "6" = 0x36
Reference Address Hi	0x01	"0" = 0x30 "1" = 0x31
Reference Address Lo	0x09	"0" = 0x30 "9" = 0x39
And Mask Hi	0x7F	"7" = 0x37 "F" = 0x46
And Mask Lo	0xFF	"F" = 0x46 "F" = 0x46
Or Mask Hi	0x00	"0" = 0x30 "0" = 0x30
Or Mask Lo	0x00	"0" = 0x30 "0" = 0x30
LRC Check	0x5D	"5" = 0x35 "D" = 0x44
Message Termination	CR/LF	CR= 0x0D LF = 0x0A

ERROR RETURN MESSAGE:

Field	Hex	ASCII Code
Start Character		":" = 0x3A
Unit Address	0x05	"0" = 0x30 "5" = 0x35
Function	0x96	"9" = 0x39 "6" = 0x36
Error Code	0x02	"0" = 0x30 "2" = 0x32
LRC Check	0x63	"6" = 0x36 "3" = 0x33
Message Termination	CR/LF	CR= 0x0D LF = 0x0A

Appendix

Return of BOC Edwards Equipment - Procedure (Form HS1)

Introduction

Before you return your equipment you must warn your supplier if the substances you used (and produced) in the equipment can be dangerous. You must do this to comply with health and safety at work laws.

You must complete the Declaration (HS2) on the next page and sent it to your supplier before you dispatch the equipment. If you do not, your supplier will assume that the equipment is dangerous and he will refuse to accept it. If the Declaration is not completed correctly, there may be a delay in processing your equipment.

Guidelines

Take note of the following guidelines:

- Your equipment is '**uncontaminated'** if it has not been used or if it has only been used with substances that are not dangerous. Your equipment is '**contaminated'** if it has been used with any dangerous substances.
- If your equipment has been used with radioactive substances, you must decontaminate it before you return it to your supplier. You must send independent proof of decontamination (for example a certificate of analysis) to your supplier with the Declaration (HS2). Phone your supplier for advice.
- We recommend that contaminated equipment is transported in vehicles where the driver does not share the same air space as the equipment.

PROCEDURE

Use the following procedure:

1. Contact your supplier and obtain a Return Authorization Number for your equipment.
2. Turn to the next page(s), photocopy and then complete the Declaration (HS2).
3. Drain all fluids from the equipment and its accessories.
4. Disconnect all accessories, such as levelers and host connectors, from the equipment.
5. Close the drain, supply and return valves.
6. Ensure that the electrical drawer and all access doors are fastened securely.
7. Coil the main power cord and secure.
8. Wrap the TCU 40/80 *plus* in bubble, polythene, or shrink-wrap and enclose in the original or replacement shipping crate (BOC Edwards part number P90150100).
9. If the equipment is contaminated, label the pallet (or box) in accordance with laws covering the transport of dangerous substances.
10. Fax or post a copy of the Declaration (HS2) to your supplier. The Declaration must arrive before the equipment.
11. Give a copy of the Declaration to the carrier. You must tell the carrier if the equipment is contaminated.
12. Seal the original Declaration in a suitable envelope attach the envelope securely to the outside of the equipment package. **WRITE YOUR RETURN AUTHORIZATION NUMBER CLEARLY ON THE OUTSIDE OF THE ENVELOPE OR ON THE OUTSIDE OF THE EQUIPMENT PACKAGE.**

Return of BOC Edwards Equipment - Declaration (FormHS2)

Return Authorization Number:

You must:

- Know about all of the substances which have been used and produced in the equipment before you complete this Declaration
- Read the Procedure (HS1) on the previous page before you attempt to complete this Declaration
- Contact your supplier to obtain a Return Authorization Number and to obtain advice if you have any questions
- Send this form to your supplier before you return your equipment

SECTION 1 : EQUIPMENT

FOR SEMICONDUCTOR APPLICATIONS ONLY:

Equipment model _____

Serial Number_____Hours_____

Has the equipment been used, tested, or operated?

yes ☐ Go to Section 2 no ☐ Go to Section 4

Tool Reference Number _____

Process _____

Failure Date _____

Serial Number of Replacement TCU_____

SECTION 2 : SUBSTANCES IN CONTACT WITH THE EQUIPMENT

Are any of the substances used or produced in the equipment

- Radioactive yes ☐ no ☐
- Biologically active yes ☐ no ☐
- Dangerous to human health and safety? yes ☐ no ☐

If you have answered "no" to all of these questions, go to Section 4.

Your supplier will not accept delivery of any equipment that is contaminated with radioactive substances, unless you:

- Decontaminate the equipment
- Provide proof of decontamination

YOU MUST CONTACT YOUR SUPPLIER FOR ADVICE BEFORE YOU RETURN SUCH EQUIPMENT

SECTION 3 : LIST OF SUBSTANCES IN CONTACT WITH THE EQUIPMENT

Substance Name	Chemical Symbol	Precautions Required (For Example, Use Protective Gloves, Etc.)	Action Required After Spillage Or Human Contact.
1			
2			
3			
4			
5			
6			

SECTION 4 : RETURN INFORMATION

Reason for return and symptoms of malfunction:_____

_____

If you have a warranty claim:

- Whom did you buy the equipment from ? _____
- Give the supplier's invoice number _____

SECTION 5 : DECLARATION

Print your name:_____ Print your job title:_____

Print your organization: _____

Print your address: _____ _____

Telephone number: _____ Date of equipment delivery:_____

I have made reasonable inquiry and I have supplied accurate information in this Declaration. I have not withheld any information. I have followed the Return of BOC Edwards Equipment Procedure (HS1) on the previous page.

Signed: _____ Date: _____

Legal Notices, Limitations and Disclaimers

For a period of twelve (12) months from the date of original shipment to Purchaser, the apparatus and each part of component manufactured be BOC Edwards High Vacuum International (BOC Edwards) is warranted to be free from functional defects in materials and workmanship. The foregoing warranty is subject to the condition that regular periodic maintenance and service be performed or replacements made in accordance with instructions provided by BOC Edwards. The foregoing warranty shall not apply to any apparatus, part, or component that has been repaired other than by BOC Edwards or an authorized BOC Edwards representative or in accordance with written instructions provided by BOC Edwards, that has been altered by anyone other than BOC Edwards or that has been subject to improper installation or abuse, misuse, negligence, accident, or corrosion.

Purchaser's sole and exclusive remedy under the above warranty is limited to, at BOC Edwards option, repair or replacement of defective parts of components or return to Purchaser of the price of the apparatus. The defect must be promptly reported to BOC Edwards or Purchaser must return the part or component with a statement of the observed deficiency no later than seven (7) days after the expiration date of the warranty to the address designated by BOC Edwards, transportation charges prepaid. In the event that BOC Edwards elects to refund the purchase price, the apparatus shall be the property of BOC Edwards and shall be shipped to BOC Edwards at BOC Edwards expense. This Mechanical Warranty shall be void and the apparatus shall be deemed to be purchased AS IS in the event that the entire purchase price has not been paid within thirty (30) days of original shipment of apparatus.

THERE ARE NO EXPRESS OR IMPLIED WARRANTIES THAT EXTEND BEYOND THE WARRANTY HEREIN ABOVE SET FORTH. THERE IS NO PARTICULAR WARRANTY OF MERCHANT ABILITY OR FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE APPARATUS OR ANY PART OR COMPONENT THEREOF AND NO WARRANTY SHALL BE IMPLIED BY LAW.

Items not of BOC Edwards manufacture but resold by BOC Edwards are the products of other manufacturers and their warranty, if any, shall apply. THERE ARE NO WARRANTIES OF ANY KIND ON PRODUCTS OF OTHER MANUFACTURERS RESOLD BY BOC EDWARDS EXCEPT THE WARRANTY OF TITLE. AND NO WARRANTIES SHALL BE IMPLIED BY LAW. THERE IN NOT EXPRESS OR IMPLIED WARRANTY OF MERCHANT ABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO PRODUCTS OF OTHER MANUFACTURERS.

In no event shall the Purchaser be entitled to any special, indirect, or consequential damages.

MSDS (material safety data sheet) - “SUVA” HP62

MATERIAL SAFETY DATA SHEETS

Du Pont Chemicals

6002FR Revised 15-JUL- 1993 Printed 16-DEC-1993

“SUVA” HP62”

CHEMICAL PRODUCT/COMPANY IDENTIFICATION

Material Identification

"SUVA” is a registered trademark of DuPont.
Corporate MSDS Number DUO05612

Company Identification

Manufacturer/Distributor

DuPont
1007 Market Street
Wilmington, DE 19898

Phone Numbers

Product Information	1-800-441-9442
Transport CHEMTREC	1-800-424-9300
Medical Emergency	1-800-441-3637

COMPOSITION/INFORMATION ON INGREDIENTS

Components

Material	CAS Number	%
PENTAFLUOROETHANE (HFC-125)	354-33-6	44
ETHNE, 1,1,1 - TRIFLUORO- (HFC-143a)	420-46-2	52
		811-97-2
ETHANE, 1,1,1,2 - TETRAFLUORO. (HFO-134a)		4

Hazards Identification

Potential Health Effects

Inhalation of high concentrations of vapor is harmful and may cause heart irregularities, unconsciousness, or death. Intentional misuse or deliberate inhalation may cause death without warning, Vapor reduces oxygen available for breathing and is heavier than air. Liquid contact can cause frostbite.

(Continued)

Human Health Effects:

Overexposure to the vapors by inhalation may include temporary nervous system depression with anesthetic effects such as dizziness, headaches, confusion, incoordination, and loss of consciousness. Higher exposures to the vapors may cause temporary alteration of the heart's electrical activity with irregular pulse, palpitations, or inadequate circulation; or fatality from gross overexposure. Contact with the liquid may cause frostbite.

Individuals with preexisting diseases of the central nervous or cardiovascular system may have increased susceptibility to the toxicity of increase exposures.

Carcinogenicity Information

None of the components present in this material at concentrations equal to or greater than 0.1% are listed by IARC, NTP, OSHA or ACGIH as a carcinogen.

FIRST AID MEASURES

First Aid

INHALATION

If high concentrations are inhaled, immediately remove to fresh air. Keep person calm. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

SKIN CONTACT

Flush skin with water for at least 15 minutes after excessive contact. Treat for frostbite if necessary by gently warming affected area. Call a physician if irritation is present.

EYE CONTACT

In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Call a physician.

INGESTION

Ingestion is not considered a potential route of exposure.

Notes to Physicians

Because of possible disturbances of cardiac rhythm, catecholamine drugs, such as epinephrine, should only be used with special caution in situations of emergency life support.

FIRE FIGHTING MEASURES

Flammable Properties

Flash Point	will not burn
Method	TOC
Flammable limits in Air	% by Volume
LEL	Not applicable
UEL	Not applicable
Auto-ignition	Not determined

Fire and Explosion Hazards:

Cylinders may rupture under fire conditions. Decomposition may occur.

Potential Combustibility:

"SUVA" HP62 is not *flammable* at temperatures up to 80ºC (176ºF) and at atmospheric pressure. Data are not available at higher temperatures and pressures. However, one of the components, HFC-143a is flammable. Another, HFC-134a, has been shown in tests to be combustible at pressures as low as 60 psig at ambient temperature when mixed with air at concentrations of 65 volume % air. Therefore, "SUVA" HP82 should not be mixed with air for leak testing. In general, it should not be used or allowed to be present with high concentrations of air above atmospheric pressures. Experimental data have also been reported which indicate combustibility of HFC-134a in the presence of certain concentrations of chlorine.

Extinguishing Media

As appropriate for combustible in area.

Fire Fighting Instructions

Cool cylinder with water spray or fog. Self-contained breathing apparatus (SCBA) is required if cylinders rupture and contents are released under fire conditions.

ACCIDENTAL RELEASE MEASURES

Safeguards (Personnel)

NOTE: Review FIRE FIGHTING MEASURES and HANDLING (PERSONNEL) sections before proceeding with clean up. Use appropriate PERSONAL PROTECTIVE EQUIPMENT during clean up.

Accidental Release Measures

Ventilate area, especially low or enclosed places where heavy vapors might collect. Remove open flames. Use self-contained breathing apparatus (SCBA) for large spills or releases.

HANDLING AND STORAGE

Handling (Personnel)

Avoid-breathing vapor. Avoid liquid contact with eyes and skin. Use with sufficient ventilation to keep employees exposure below recommended limits. Contact with chlorine or other strong oxidizing agents should also be avoided. See Fire and Explosion Data section.

Storage

Clean, dry area. Do not heat above 52°C (125°F).

EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls

Avoid breathing vapors. Avoid contact with skin or eyes. Use with sufficient ventilation to keep employee exposure below the recommended exposure limit. Local exhaust should be used if large amounts are released. Mechanical ventilation should be used in low or enclosed places.

Personal Protective Equipment

Impervious gloves should be used to avoid prolonged or repeated exposure. Chemical Splash goggles should be available for use as needed to prevent eye contact. Under normal manufacturing conditions, no respiratory protection is required when using this product. Self-contained breathing apparatus (SCBA) is required if a large release occurs.

Exposure Guidelines

Applicable Exposure Limits

PENTAFLUOROETHANE (HFC-125)		
PEL	(OSHA)	None Established
TLV	(ACGIH)	None Established
AEL *	(Du Pont)	1000 ppm, 8 & 12 Hr. TWA
ETHANE. 1, 1, 1-TRIFLUORO- (HFC-143a)		
PEL	(OSHA)	None Established
TLV	(ACGIH)	None Established-.
AEL *	(Du Pont)	1000 ppm, 8 & 12 Hr. TWA
ETHANE, 1, 1, 1, 2-TETRAFLUORO- (HFC-134a)		
PEL(OSHA) None Established		
TLV	(ACGIH)	None Established
AEL *	(Du Pont)	1000 ppm, 8 & 12 Hr. TWA
WEEL	(AIHA)	1000 ppm, 8 Hr. TWA

* AEL is DuPont's Acceptable Exposure Limit. Where governmental imposed occupational exposure limits which are lower than the AEL are in effect, such limits shall take precedence.

PHYSICAL AND CHEMICAL PROPERTIES

Physical Data

Boiling Point	-46.7ºC (-52, 1ºF) Average
Vapor Pressure	182.1 psig at 25°C (77°F)
% Volatiles	100 WT%
Evaporation Rate	(CL4 = 1) Greater than 1
Solubility in Water	Not determined
Odor	slight ethereal
Form	Liquefied gas
Color	Clear, colorless
Specific Gravity	1.05 @ 25ºC (77ºF)

STABILITY AND REACTIVITY

Chemical Stability

Material is stable. However, avoid open flames and high temperatures.

Incompatibility with Other Materials

Incompatible with active metals, alkali or alkaline earth metals - powdered Al, Zn, Be, etc.

Polymerization

Polymerization will not occur.

Other Hazards

Decomposition	Decomposition products are hazardous. “SUVA" HP62 can be decomposed by high temperatures (open flames glowing metal surfaces, etc.) forming hydrochloric and hydrofluoric acids, and possibly carbonyl halides.

TOXICOLOGICAL INFORMATION

Animal Data

The blend is untested.

HFC-125

Inhalation 4-hour ALC: >709,000 ppm in rats

Single high inhalation exposures caused decreased activity, labored breathing and weight loss. Cardiac sensitization occurred in dogs exposed to concentrations of 10-30% in air and given an intravenous epinephrine challenge; no cardiac sensitization occurred at a concentration of 7.5%.

No animal data are available to define carcinogenic hazards. HFC-125 did not cause embryotoxicity or developmental toxicity in rats or rabbits at inhalation concentrations up to 50,000 ppm. HFC-126 does not produce genetic damage in bacterial or mammalian call cultures or when tested in animals.

(Continued)

HFC-134a

Inhalation 4-hour LC50: 567,000 ppm in rats

A 5 or 10 second spray of vapor produced very slight eye irritation and a 24-hour occlusive application produced slight skin irritation in rabbits. The compound is not a skin sensitizer in animals. No toxic effects were seen in animals from exposures by inhalation to concentrations up to 81,000 ppm. Lethargy and rapid respiration were observed at a vapor concentration of 305,000 ppm and pulmonary congestion, edema, and central nervous system effects occurred at a vapor concentration of 750,000 ppm. Cardiac sensitization occurred in dogs at 75,000 ppm following an epinephrine challenge. No effects in animals occurred from repeated inhalation-exposures to 99,000 ppm for two weeks or higher concentrations to 50,000 ppm for three months. Repeated exposures to higher concentrations caused transient tremors, incoordination and some organ weight changes. Long-term exposures produced increased testes weights and increased urinary fluoride levels. No adverse effects were observed in male and female rats fed diets containing 300 mg/kg/day of HFC-134a for 52 weeks. Animal testing indicates that this compound does not have carcinogenic or mutagenic effects. Inhalation of 50,000 ppm for two years caused an increase in benign testicular tumors in male rats. No effects were observed at lower concentrations. The tumors were late occurring and were judged not to be life threatening. Embryotoxic activity has been observed in some animal tests but only at high concentrations that were also maternally toxic.

HFC-143a

Inhalation 4-hour LC50: >540,000 ppm in rats

Single exposures by inhalation to 500,000 ppm caused anesthesia but no mortality at 540,000 ppm. Cardiac sensitization occurred in dogs at 600,000 ppm following an intravenous challenge with epinephrine. Two, 4-week inhalation have been conducted. In the first study, pathological changes in the testes were observed at all exposure concentrations; no effects were observed in females. The testicular effect was considered related to the method used to expose the rats to HFC-143a. In the second study using the same exposure concentrations, no effects were noted in males at any concentration. Data from a 90-day study revealed no effects in male or female rats at exposures up to 40,000 ppm. Long-term exposure caused significantly decreased body weights in male rats fed 300 mg/kg for 52 weeks, but there was no effect on mortality. Tests in rats demonstrated no carcinogenic activity when administered orally 300 mg/kg/day for 52 weeks and observed for an additional 73 weeks. Tests in bacterial cell cultures demonstrated mutagenic activity, but the compound did not induce transformation of mammalian cells in culture or in the whole animal. Tests in animals demonstrate no developmental toxicity.

ECOLOGICAL INFORMATION

Ecotoxicological Information

Aquatic Toxicity

HFC 143a

96-hour LC50, rainbow trout: >40 mg/L

DISPOSAL CONSIDERATIONS

Waste Disposal

Comply with Federal, State, and local regulations. Reclaim by distillation or remove to a permitted waste disposal facility.

TRANSPORTATION INFORMATION

Shipping Information
D /IMO

Proper Shipping Name	LIQUEFIED GAS, N.O.S. (CONTAINS PENTAFLUORDETHANE AND TETRAFLUOROETHANE)
Hazard Class 2.2	
UN No.	1956
DOT/IMO Label	NON-FLAMMABLE GAS
Shipping Containers Tank Cars, Cylinders Ton Tanks	

REGULATORY INFORMATION

US Federal Regulations

TSCA Inventory Status Reported/Included.
TITLE III HAZARD CLASSIFICATIONS SECTIONS 311, 312

Acute:	No
Chronic:	No
Fire:	No
Reactivity:	No
Pressure:	Yes

LISTS:

SARA Extremely Hazardous Substance	No
CERCLA Hazardous Material	No
SARA Toxic Chemicals	No

OTHER INFORMATION

NFPA, NPCA-HMIS

NPCA-HMIS Rating

Health	1
Flammability	0
Reactivity	1

Personal Protection rating to be supplied by user depending on use conditions.

Additional Information

HFC-125 and HFC 143a are TSCA listed, and are controlled by a TSCA Section 5 Consent Order.

The date in this Material Safety Data Sheet relates only to the specific material designated herein and does not relate to use in combination with any other material or in any process.
Responsibility for MSDS DuPoint Chemicals:

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End of MSDS

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