216324-000 rev1

INSTALLATION & OPERATION MANUAL

MODULAR DUAL FLUID CIRCULATING HEATING SYSTEM

MODEL

MODULAR DLV

HOTSTART®
ENGINE HEATING

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IDENTIFYING YOUR SYSTEM

The HOTSTART heating system is designed to heat fluids for use in marine propulsion, diesel-powered generator sets, locomotives, gas compression or any large-engine applications. Each heating system has an identification plate which includes the part number and serial number.

This operation manual describes the installation, operation and maintenance of the heating system. Model specifics, capabilities and features may vary. See part drawings for dimensions and specifications.

When ordering replacement parts, be sure to reference your heating system's **MODEL NUMBER** and **SERIAL NUMBER** found on the identification plate and following label:

HOTSTART.

SPOKANE, WA
U.S.A.

REF. SERIAL NUMBER WHEN ORDERING REPLACEMENT PARTS

MODEL _____
VOLTS _____ **HERTZ** _____
AMPS. _____ **PHASE** _____
CONTROL CIRCUIT VOLTS _____
CONTROL CIRCUIT AMPS. _____ **MAX**
SERIAL NUMBER _____

U.S. PATENTS 4,245,593, 4,249,491
CAN. PATENTS 1,087,473, 1,082,541

CAUTION
OPEN CIRCUITS BEFORE WORKING ON THIS EQUIPMENT OR REMOVING COVERS.
KEEP COVERS TIGHTLY CLOSED WHILE CIRCUITS ARE ALIVE.

NOTE: Typical heating system identification plate. Your identification plate may vary.

WARRANTY INFORMATION

Warranty information can be found at www.hotstart.com or by contacting our customer service department at **509.536.8660**. Have your **MODEL NUMBER** and **SERIAL NUMBER** ready when contacting the warranty department.

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IMPORTANT SAFETY INFORMATION

⚠ WARNING

Hazardous voltage: Before wiring, servicing or cleaning the heating system, turn off the power and follow your organization's lockout and tagout procedure. Failure to do so could allow others to turn on the power unexpectedly, resulting in harmful or fatal electrical shock.

Electrical hazard: All electrical work must be done by qualified personnel in accordance with national, state and local codes.

⚠ CAUTION

Read instructions carefully: The safety of any system incorporating this heater is the responsibility of the assembler. The safe and proper use of this heater is dependent upon the installer following sound engineering practices. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. All applicable electrical safety standards defined by local jurisdictions must be followed. (Reference EU directive 2006/95/EC in EU countries.)

- **Read carefully:** Installers and operators of this equipment must be thoroughly familiar with the instructions in this manual before commencing work.
- **Hot surfaces:** Avoid contact with the system while it is in service. Some surfaces may remain hot even if the system is not energized.
- **Proper lifting:** Proper rigging and safety equipment must be used to move this equipment. Do not lift the heating system by any cords, electrical conduit or cabling. Create a plan before attempting to move. Proper lifting locations are identified on each system; use these locations when lifting and mounting the system.
- **Rotating equipment:** The heating system can start automatically and without warning. Avoid contact unless a lockout at the service panel has been installed.
- **Grounding:** The heater must be connected to a suitable ground (protective earthing conductor).
- **Overcurrent limiting:** The power supply must be protected by a suitable overcurrent limiting device.
- **Power disconnection:** A means to disconnect the heater from the power supply is required. HOTSTART recommends that a power switch or circuit breaker be located near the heater for safety and ease of use.

NOTICE

EU Countries only: Equipment rated for the conditions listed in EN 601010-1 1.4.1 Ingress protection rating IP55. (Special conditions for specific applications may apply.)

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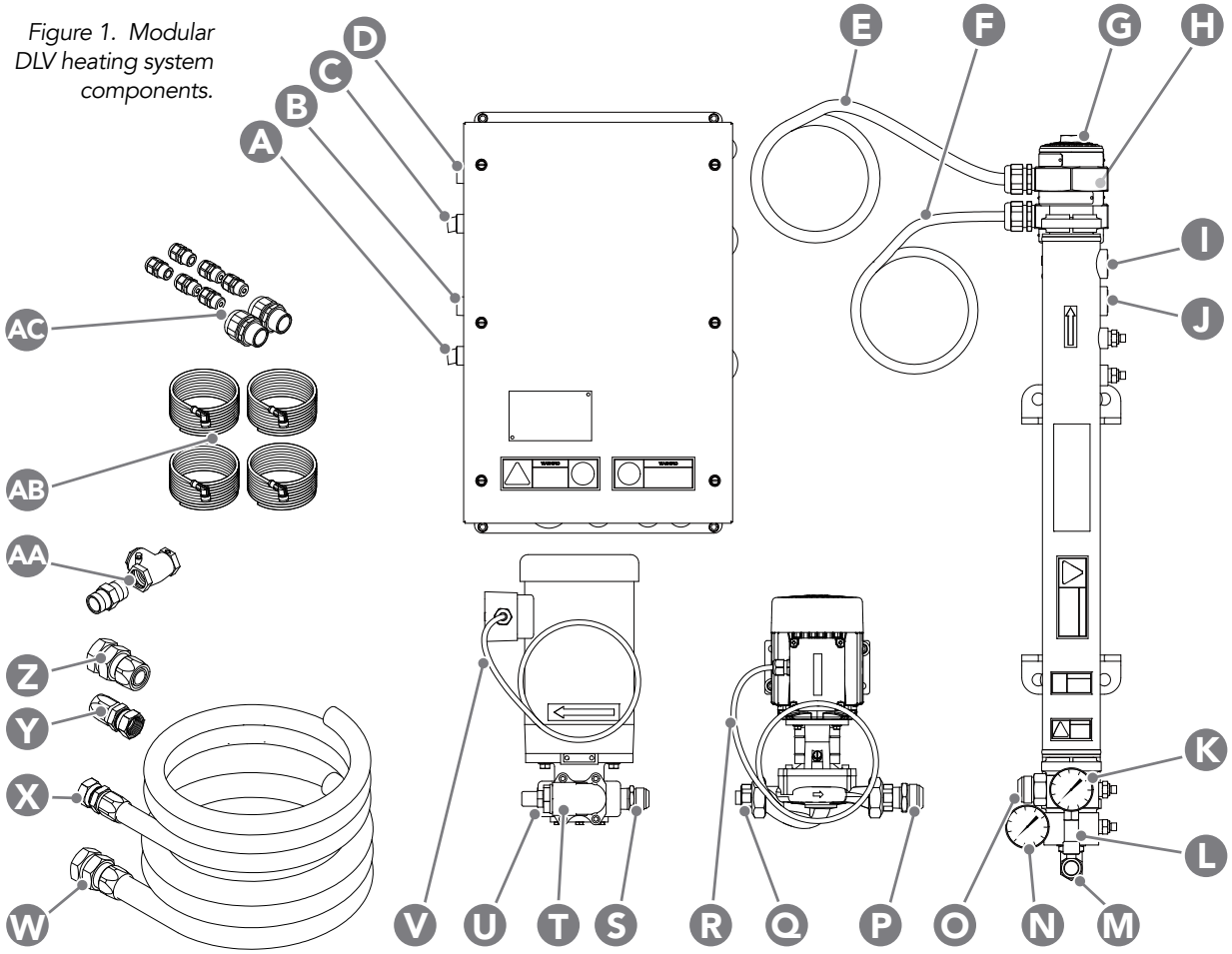
1 OVERVIEW

1.1 HEATING SYSTEM COMPONENTS

The heating system consists of the following main components: *See Fig. 1.*

NOTE: Component illustrations are for reference only and are not to scale. See part drawings for dimensions and specifications.

Figure 1. Modular DLV heating system components.



- **A.** *Oil ON/OFF/PRIME switch*
- **B.** *OIL FAULT light*
- **C.** *Coolant ON/OFF/PRIME switch*
- **D.** *COOLANT FAULT light*

- **E.** *Coolant element cable (40 ft. / 12.2 m)*
- **F.** *Oil element cable (40 ft. / 12.2 m)*
- **G.** *Coolant element assembly*
- **H.** *Oil element assembly (behind coolant tank)*
- **I.** *Coolant outlet (1.0" NPT)*
- **J.** *Oil outlet (1.0" NPT)*
- **K.** *Coolant pressure/ temperature gauge*
- **L.** *Coolant pressure relief valve (0.5" NPT)*
- **M.** *Oil tank inlet (#16 JIC)*
- **N.** *Oil pressure/temperature gauge*
- **O.** *Coolant tank inlet (#20 JIC)*

- **P.** *Coolant pump outlet (#20 JIC)*
- **Q.** *Coolant pump inlet (1.0" NPT)*
- **R.** *Coolant pump motor cable (40 ft. / 12.2 m)*

- **S.** *Oil pump outlet (#16 JIC)*
- **T.** *Oil pump pressure relief valve*
- **U.** *Oil pump inlet (1.0" NPT)*
- **V.** *Oil pump motor cable (40 ft. / 12.2 m)*

- **W.** *Coolant pump to tank hose (#20 JIC, 9 ft. / 2.7 m)*
- **X.** *Oil pump to tank hose (#16 JIC, 9 ft. / 2.7 m)*
- **Y.** *Adapter #16 JIC*
- **Z.** *Adapter #20 JIC*
- **AA.** *Check valve nipple and check valve (1.0" NPT)*
- **AB.** *RTD assembly × 4 (resistance temperature device) & cable (50 ft. / 15.2 m)*
- **AC.** *Strain relief*
  2 × 1 NPT
  (grip range .490 – .785)
  2 × 1/2 NPT
  (grip range .170 – .450)
  4 × 1/2 NPT
  (grip range .157 – .354)

1.2 OPERATION OVERVIEW

The Modular DLV heating system is intended to maintain an engine's optimal starting temperature and optimal lubrication oil temperature while the engine is shut down. The heating system may be activated locally or by optional remote control (*see* **SECTION 3.6**). The Modular DLV heating system should be deactivated upon engine start-up.

During heating system operation, a centrifugal pump takes coolant from the drain area low on the engine water jacket and forces it through the heating tank and into the coolant return line. Simultaneously, a rotary gear pump takes oil from the sump and forces it through the heating tank to the oil return line. The coolant pump and oil pump will continuously circulate fluid throughout the engine. To maintain consistent fluid temperature, the heating elements will cycle on and off at the user-selected temperature control point.

A return line check valve (included with the Modular DLV) and a supply line check valve (user-supplied, installed near the oil suction port) prevent backflow while the engine is operating. When the engine is shut down, the heating system should be activated locally or remotely to resume maintaining the engine's optimal starting temperature.

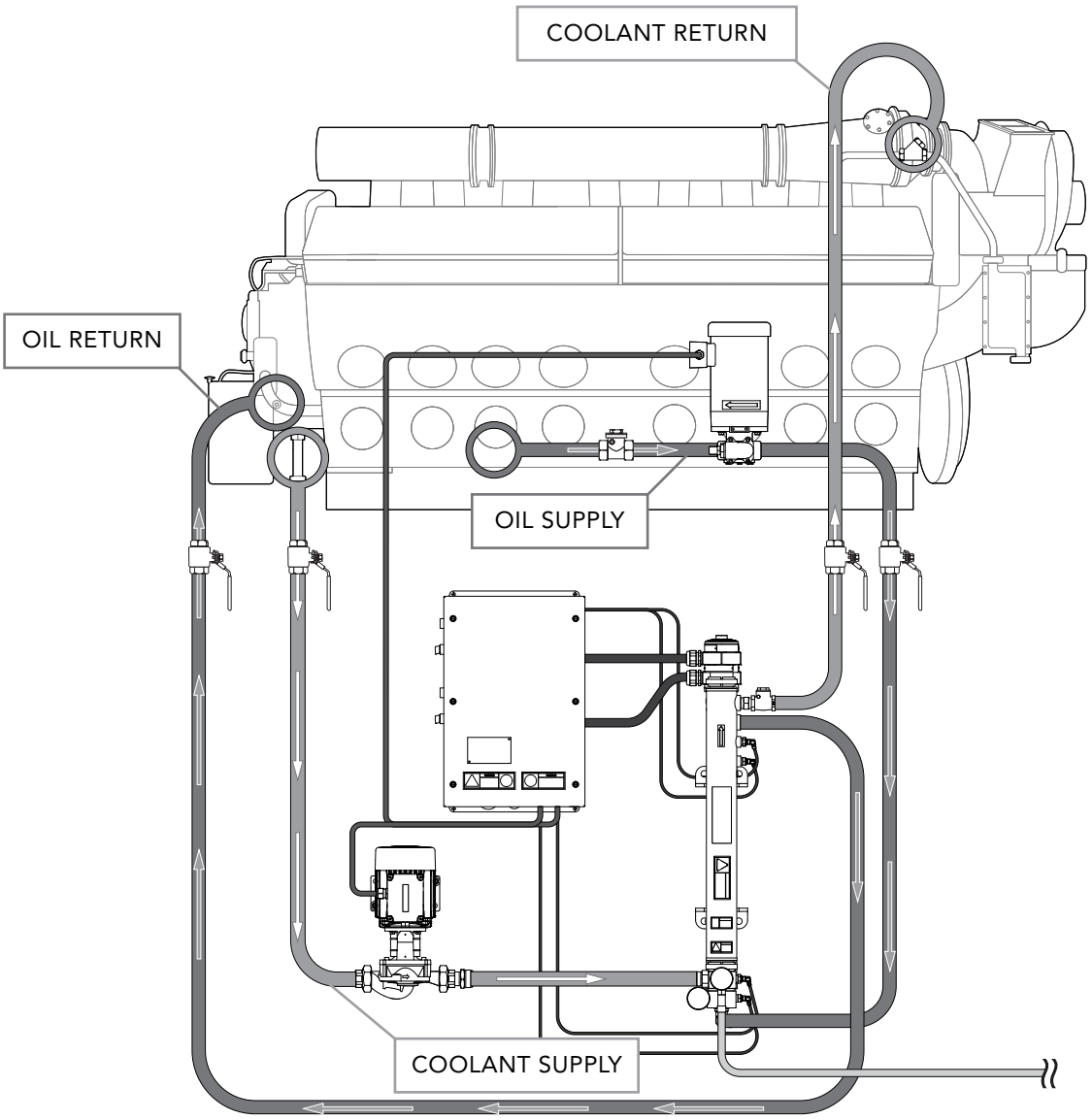


Figure 2. Modular DLV operation overview, showing oil circulation. While the heating elements cycle on and off to maintain the preset temperature, the pump circulates fluid continuously during operation.

Component illustrations are for reference only and are not to scale. See part drawings for dimensions and specifications.

2 COMPONENT INSTALLATION

Before installing the Modular DLV components, plan connections and routing for coolant and oil plumbing. For coolant plumbing requirements, *see* **SECTION 3.2**. For oil plumbing requirements, *see* **SECTION 3.1**.

2.1 HEATING TANK ASSEMBLY INSTALLATION

NOTICE

Overheating hazard: When mounting the heating tank assembly, position the tanks so that they are completely full of fluid while in operation.

Heating tank orientation: heating tank assembly may be mounted in a vertical orientation or horizontal orientation with the tank outlets positioned at the top of the tank or pointing directly upward. *(See Fig. 3)*. Do not mount the tank assembly at an angle or in any other orientation.

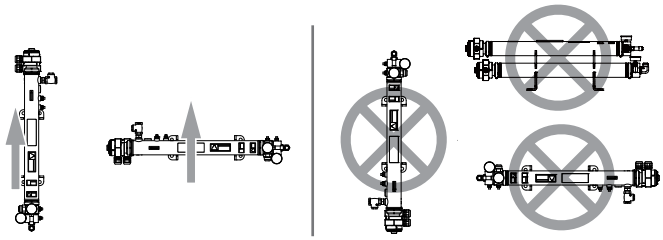


Figure 3. Correct heating tank assembly mounting orientations (left) and incorrect orientation (right). Incorrect positions show tank outlets positioned at bottom of tank or pointing downward.

When installing the heating system, note that the tank requires a minimum of 30 inches (63.5 cm) of clearance to remove each element for maintenance. *See* **SECTION 5.2.12**.

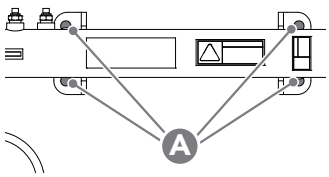


Figure 4. Modular DLV tank assembly .4 inch (10 mm) diameter mounting holes × 4 **(A)**.

2.1.1 COOLANT CHECK VALVE ASSEMBLY

NOTICE

Check valve assembly: Check valve must be installed prior to heating system activation. If check valve is absent during heating system activation or engine activation, damage may occur to coolant heating system.

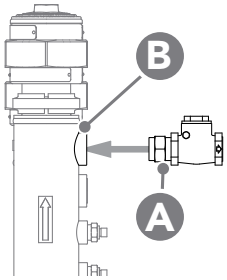


Figure 5. Modular DLV check valve and nipple assembly **(A)** *and coolant tank outlet* **(B)**.

1. Attach supplied check valve nipple to check valve.

2. Attach check valve and nipple assembly **(A)** to coolant tank outlet **(B)**. *See Fig. 5.*

2.1.2 RTD ASSEMBLY

1. Note positions of coolant and oil RTD locations. *See Fig. 6.*

2. Fit RTD plug to RTD. Ensure plug is aligned correctly with notch. Push plug in firmly. Screw RTD plug to RTD to secure in place.

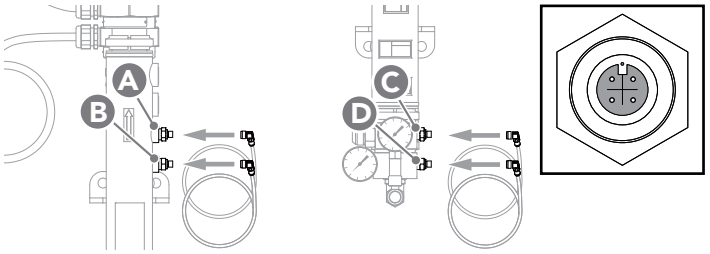


Figure 6. Tank assembly showing coolant high-limit RTD **(A)**, *oil high-limit RTD* **(B)**, *coolant control RTD* **(C)**, *and oil control RTD* **(D)**. *Note RTD notch position (inset).*

3. Mark each RTD cable end with the RTD location. *See Fig. 9 on following page.*

2.2 PUMP INSTALLATION

NOTICE

Pump/motor assembly damage: Engine vibration will damage the heating system; isolate the heating system from vibration. Never mount the heating system or components directly to the engine. If the heating system is installed using rigid pipe, use a section of flexible hose to the supply and return ports to isolate the heating system from engine vibration.

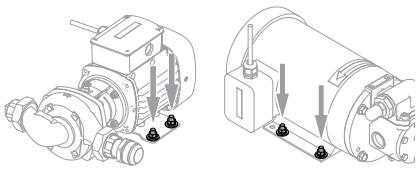


Figure 7. Coolant pump assembly and oil pump assembly showing .38 inch (10 mm) × 4 diameter mounting holes.

When installing the Modular DLV oil pump/motor assembly, refer to the following HOTSTART guidelines:

- HOTSTART recommends mounting the oil pump/assembly no more than 20 feet (6 meters) from the oil suction port.

2.3 CONTROL BOX INSTALLATION

NOTICE

Water ingress: Control box must be mounted in a vertical orientation. Do not mount control box on back or in any other orientation.

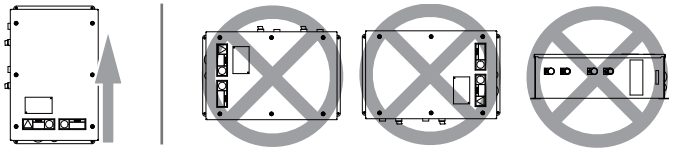


Figure 8. Correct control box orientation (left) and incorrect control box mounting orientations (right).

2.3.1 CONTROL BOX CONNECTIONS

1. Route pump motor cables and heating tank assembly cables to control box. Using supplied strain relief, connect all cables to control box. *See Table 1 and Fig. 9.*
2. Using supplied wire markers, label each wire before connecting wire. *(See Fig. 10 on following page).*
3. Connect **coolant high-limit RTD** cable wires to temperature control relay **TCR2**:
    1. Connect blue wire to TCR2:T1
    2. Connect brown wire to TCR2:T2
    3. Connect black wire to TCR2:T3
4. Connect **oil high-limit RTD** cable wires to temperature control relay **TCR4**:
    1. Connect blue wire to TCR4:T1
    2. Connect brown wire to TCR4:T2
    3. Connect black wire to TCR4:T3
5. Connect **coolant element** cable wires to temperature contactor **K1**:
    1. Connect #1 wire L1 to K1:T1
    2. Connect #2 wire L2 to K1:T2
    3. Connect #3 wire L3 to K1:T3
    4. Connect ground wire to ground terminal
6. Connect **oil element** cable wires to temperature contactor **K3**:
    1. Connect #1 wire L1 to K3:T1
    2. Connect #2 wire L2 to K3:T2
    3. Connect #3 wire L3 to K3:T3
    4. Connect ground wire to ground terminal
7. Connect **coolant pump motor** cable wires to contactor **K2**.
    1. Connect #1 wire U to K2:T1
    2. Connect #2 wire V to K2:T2
    3. Connect #3 wire W to K2:T3
    4. Connect ground wire to ground terminal
8. Connect **oil pump motor** cable wires to contactor **K4**:
    1. Connect #1 wire L1 to K4:T1
    2. Connect #2 wire L2 to K4:T2
    3. Connect #3 wire L3 to K4:T3
    4. Connect ground wire to ground terminal

	CABLE		BOX SIDE
	COMPONENT	LENGTH	
A	Oil Pump Motor	40 ft. (12.2 m)	Bottom
B	Coolant Pump Motor	40 ft. (12.2 m)	Bottom
C	Coolant Element	40 ft. (12.2 m)	Right
D	Oil Element	40 ft. (12.2 m)	Right
E	Coolant High-Limit RTD	50 ft. (15.2 m)	Right
F	Oil High-Limit RTD	50 ft. (15.2 m)	Right
G	Coolant Control RTD	50 ft. (15.2 m)	Bottom
H	Oil Control RTD	50 ft. (15.2 m)	Bottom

Table 1. Modular DLV pump, element and RTD connections.

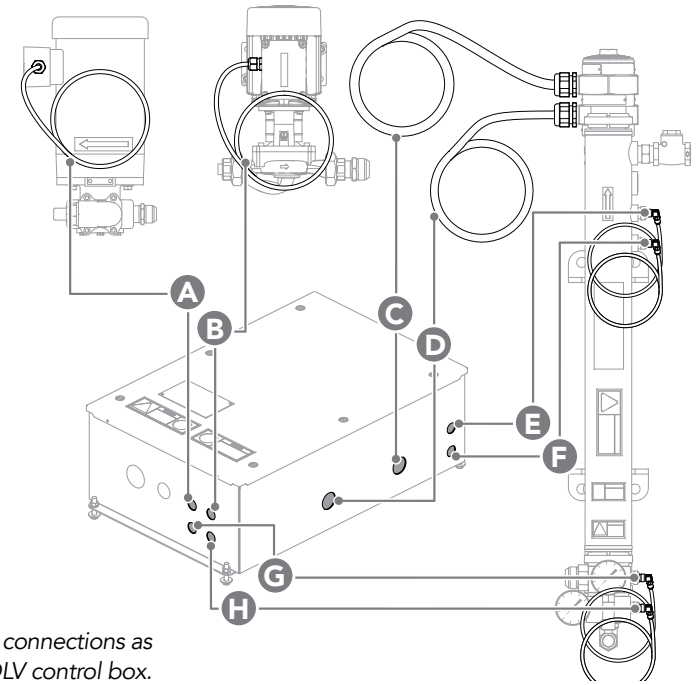


Figure 9. Pump, element and RTD connections as shown in the Modular DLV control box.

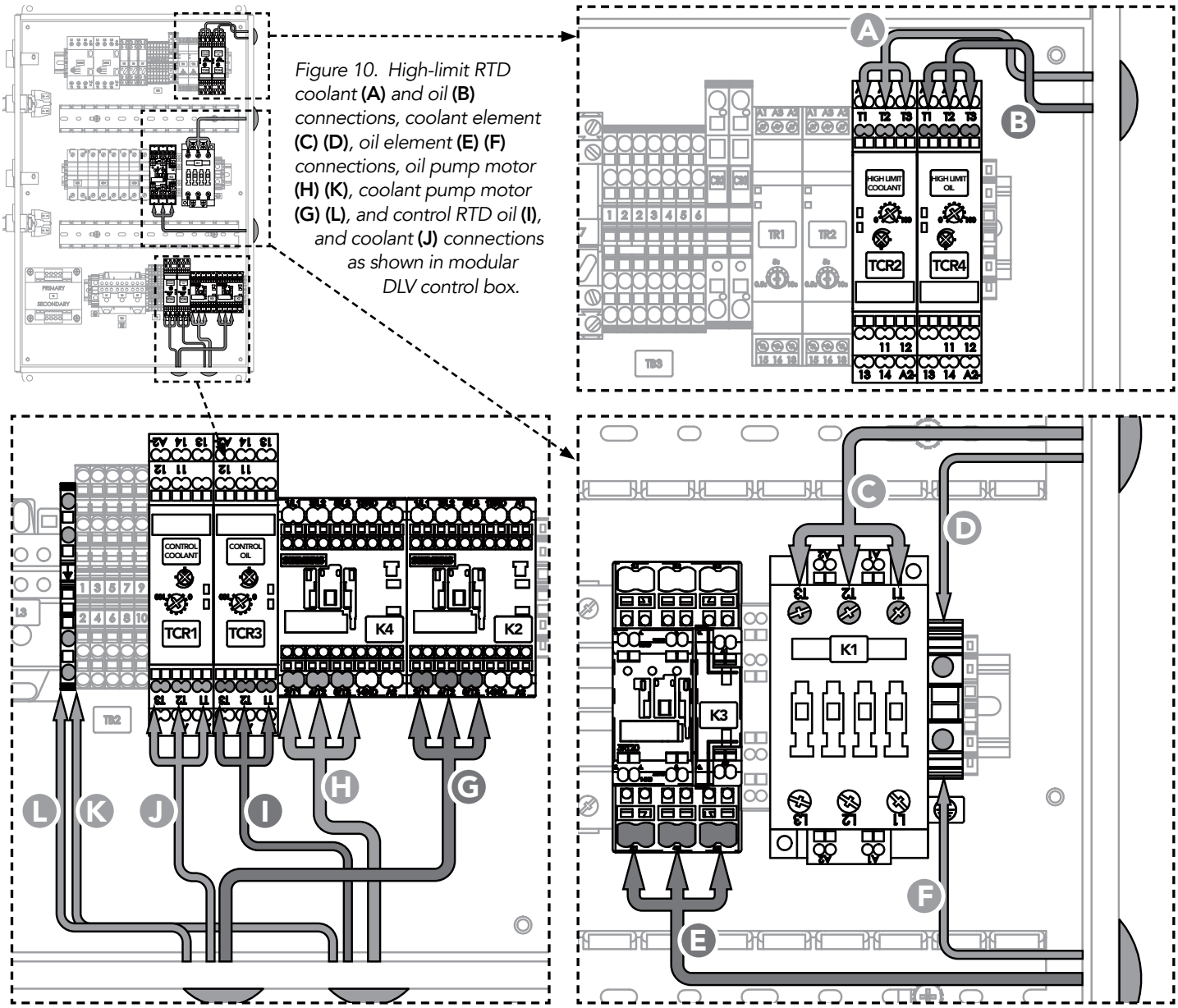


Figure 10. High-limit RTD coolant **(A)** *and oil* **(B)** *connections, coolant element* **(C) (D)**, *oil element* **(E) (F)** *connections, oil pump motor* **(H) (K)**, *coolant pump motor* **(G) (L)**, *and control RTD oil* **(I)**, *and coolant* **(J)** *connections as shown in modular DLV control box.*

9. Connect **oil control RTD** cable wires to temperature control relay **TCR3**:
   1. Connect blue wire to TCR3:T1
   2. Connect brown wire to TCR3:T2
   3. Connect black wire to TCR3:T3

10. Connect **coolant control RTD** cable wires to temperature control relay **TCR1**:
    1. Connect blue wire to TCR1:T1
    2. Connect brown wire to TCR1:T2
    3. Connect black wire to TCR1:T3

	FROM		TO	TO
	COMPONENT	WIRES	LOCATION	TERMINAL
A	Coolant High-Limit RTD	blue, brown, black	TCR2	T1, T2, T3
B	Oil High-Limit RTD	blue, brown, black	TCR4	T1, T2, T3
C	Coolant Element	L1, L2, L3	K1	T1, T2, T3
D	Coolant Element Ground	green/yellow	ground	–
E	Oil Element	L1, L2, L3	K3	T1, T2, T3
F	Oil Element Ground	green/yellow	ground	–
G	Coolant Pump Motor	U, V, W	K2	T1, T2, T3
H	Oil Pump Motor	blue, brown, black	K4	T1, T2, T3
I	Oil Control RTD	blue, brown, black	TCR3	T1, T2, T3
J	Coolant Control RTD	blue, brown, black	TCR1	T1, T2, T3
K	Oil Pump Motor Ground	green/yellow	ground	–
L	Coolant Pump Motor Ground	green/yellow	ground	–

Table 2. Modular DLV wiring connections.

3 PLUMBING INSTALLATION

⚠ CAUTION

Pressure hazard: Power must be turned off and locked out at the service panel when the isolation valves are in the closed position. Failure to do so may cause damage to heating system components, damage to lubrication oil, fluid leaks and unexpected release of heated coolant.

Overheating hazard: After completing line installation, top off the fluid levels to compensate for the fluid used to fill the lines and heating tank. Do not operate the heating system without the presence of fluid. Position the heating tank to ensure it is completely full of fluid while in operation.

Pump priming: Fill each supply line with fluid. Pump is not self-priming. Fluid must be present in the pump before start-up. Trapped air inside the pump will cause pump and seal damage.

Pump seal damage: Do not reduce the coolant supply line or oil supply line to an inner diameter smaller than the corresponding pump inlet; pump seal damage will occur.

Check valve: HOTSTART recommends installing a customer-supplied swing-type or full-flow check valve to prevent oil from flowing back into the oil sump. If the pump is installed above the minimum oil level, a check valve **must** be installed.

Isolation valves: HOTSTART recommends installing full-flow ball valves to isolate the heating system in order to perform service on the system or engine without draining oil or coolant.

Pressurized steam hazard: Coolant pressure relief valve outlet must be vented to the atmosphere in case an over-pressure release of heated coolant occurs. Do not connect pressure relief plumbing to coolant system.

⚠ CAUTION

Lifting hazard: Proper rigging and safety equipment must be used to move this equipment. Do not lift the heating system by any cords, electrical conduit or cabling. Create a plan before attempting to move. Proper lifting locations are identified on each system; use these locations when lifting and mounting the system.

NOTICE

Heating system damage: Engine vibration will damage the heating system; isolate the heating system from vibration. Never mount the heating system or components directly to the engine. If the heating system is installed using rigid pipe, use a section of flexible hose to the supply and return ports to isolate the heating system from engine vibration.

Improper mounting hazard: Reference heating system component drawings before mounting the system. Unless mounted properly, the heating system will be unstable.

3.1 OIL PLUMBING

3.1.1 OIL SUPPLY

Installing a short, straight oil supply line with a minimum of flow restriction is the most important step toward ensuring heating system longevity. When installing the Modular DLV oil supply line, refer to the following HOTSTART guidelines:

PUMP INLET	HOSE INNER DIAMETER	MAX. LINE LENGTH	MAX. ELBOW COUNT
1 inch NPT	1-1/2 inch	20 feet (6 meters)	4

Table 3. HOTSTART recommended hose inner diameters, line lengths and elbow counts for Modular DLV oil supply lines. Note that the maximum line length is the sum of both the line length from the port to the pump and the pump to the tank.

- Due to the increased viscosity of oil, the oil supply line must be as short and as straight as possible. Any 90° elbows will reduce the maximum recommended oil supply length. *See Table 3* for HOTSTART Modular DLV oil supply recommendations:

  NOTE: Each additional pair of 90° elbows will reduce the maximum recommended line length by five feet (1.5 meters). To minimize flow restriction, HOTSTART recommends using sweeping bends or 45° fittings.

- At a minimum, size the oil supply line per the pump inlet. **NOTICE!** Do not reduce the supply line inner diameter; pump seal damage will occur.

  NOTE: To maximize flow and allow the longest possible supply line, install the largest practical inner diameter hose; for most installations, HOTSTART recommends using a hose with a size larger inner diameter than the pump inlet.

- Install the oil suction port as low as possible in the oil tank. **NOTICE!** Avoid installing the oil suction port in a location that may allow debris or sediment to enter the heating system.

- HOTSTART recommends installing a user-supplied, swing-type or full-flow check valve to prevent oil flowing into the sump. Install the check valve as close to the oil supply port as possible.

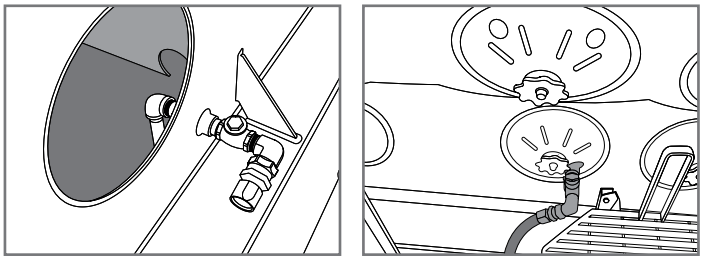


Figure 11. Typical oil suction port installations for railroad applications: near third inspection cover (left) and through cover (right).

3.1.2 OIL RETURN

When installing the Modular DLV oil return line, refer to the following HOTSTART guidelines:

- At a minimum, size the oil return line per the heating system outlet. **NOTICE!** Do not reduce the return line inner diameter.
- Install the oil discharge port near the engine oil pump, the opposite end of the oil sump or at the lower P-pipe for railroad applications.

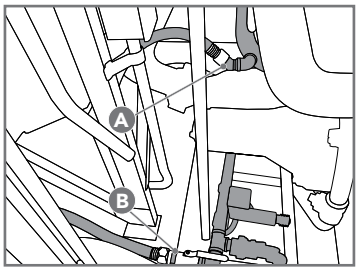


Figure 12. Typical oil discharge port **(A)** *installed at locomotive engine lower P-pipe. Note coolant suction port* **(B)** *located at locomotive main engine drain.*

3.1.3 OIL PRESSURE RELIEF VALVE

The oil pump pressure relief valve is internal to the pump and releases pressure from the discharge side of the pump to the suction side of the pump at 75 psi (525 kPa). No plumbing for this component is required.

3.2 COOLANT PLUMBING

3.2.1 COOLANT SUPPLY

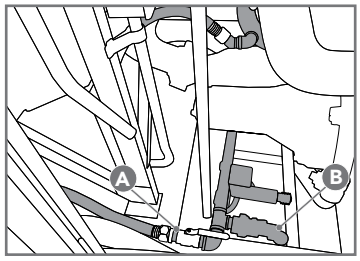
When installing the Modular DLV coolant supply line, refer to the following HOTSTART guidelines:

- At a minimum, size the coolant supply line per the pump inlet. **NOTICE!** Do not reduce the supply line inner diameter; pump seal damage will occur.

  NOTE: To maximize flow and allow the longest possible supply line, install the largest practical inner diameter hose; for most installations, HOTSTART recommends using a hose with a size larger inner diameter than the pump inlet.

- Install the coolant suction port as low as possible on the engine's water jacket, typically near the main water drain. *See Fig. 13.*

Figure 13. Coolant suction port installed at main locomotive engine drain. Note suction port **(A)** *has been installed at the same level as the drain* **(B)***, ensuring DLV pump will draw water from the cooling system's lowest point.*



- To minimize flow restriction, the coolant supply line must be as short and as straight as possible. Use elbow fittings sparingly; HOTSTART recommends using sweeping bends or 45° fittings.

3.2.2 COOLANT RETURN

When installing the DLV coolant return line, refer to the following HOTSTART guidelines:

- Size the coolant return line per the pump outlet. **NOTICE!** Do not reduce the return line inner diameter.
- Install the coolant discharge port as high as possible on the engine's water jacket on the opposite end of the suction port; typically near the aftercooler water line discharge port.

  NOTE: To ensure even heat distribution, the coolant return line may be split and routed to two return ports. Size both return lines per the outlet of the heating system. For engines without an aftercooler, typical installation points are along the water line from the radiator to the engine block. *See Fig 14.*

3.2.3 COOLANT PRESSURE RELIEF

To safeguard personnel and equipment, attach an appropriately sized pipe to the pressure relief valve and route to a safe area, bucket or catch-basin. **CAUTION!** Coolant pressure relief valve outlet must be plumbed to a safe area in case an over-pressure release of heated coolant occurs. Do not connect pressure relief plumbing to coolant system.

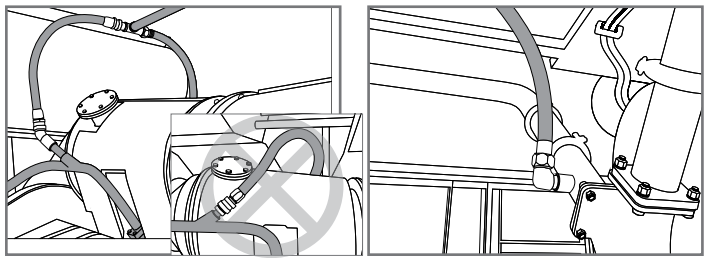
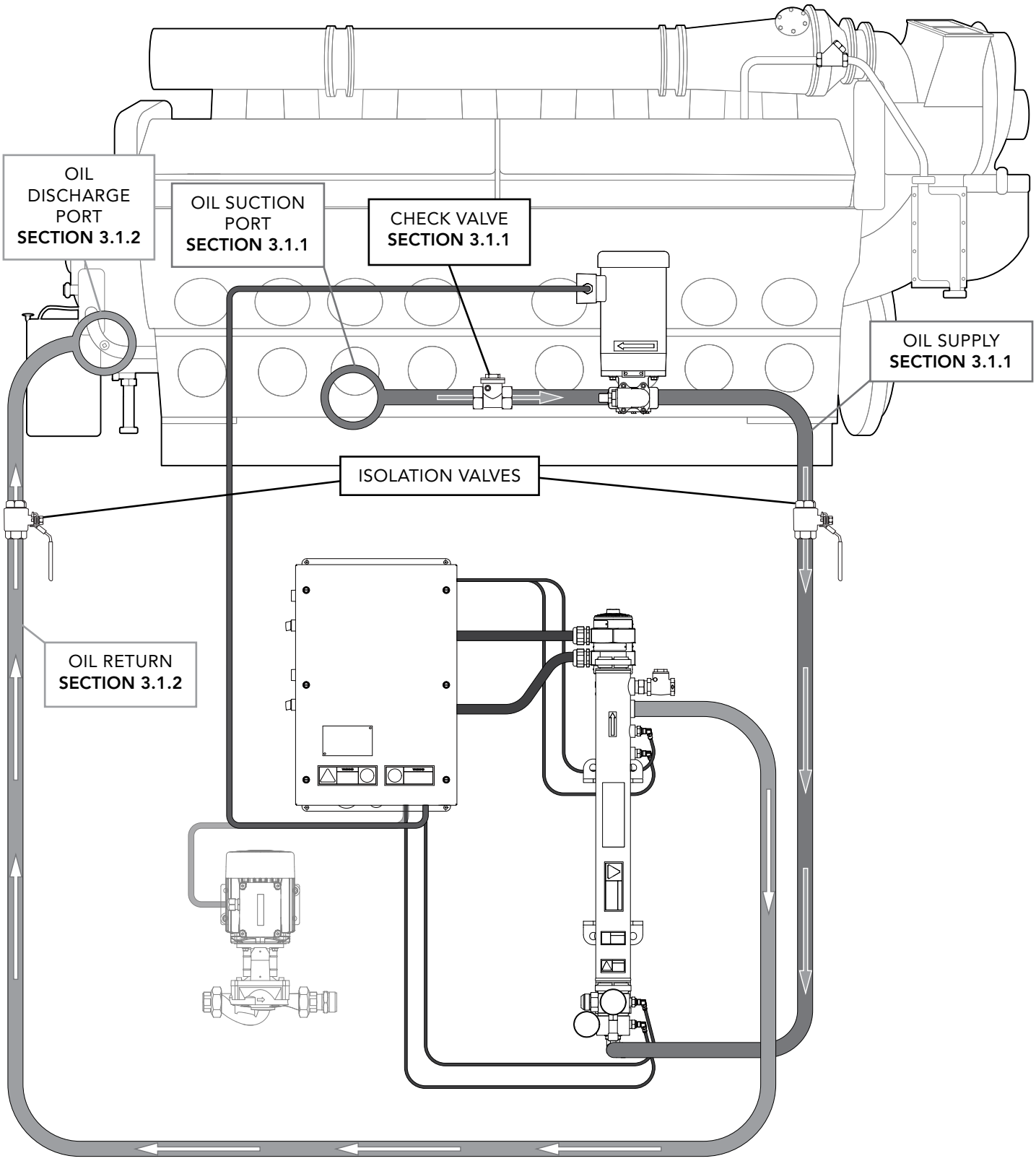


Figure 14. Typical coolant discharge ports installed on a turbocharged locomotive engine (left) and supercharged engine at Y-pipe (right). To distribute heat evenly, the return line is split into two discharge ports. Each port is installed at a welded 45° fitting, angled to ensure majority of heated coolant is transferred directly to engine block. Note incorrectly oriented fitting (inset). This fitting should be angled in the opposite direction to allow flow toward the engine.

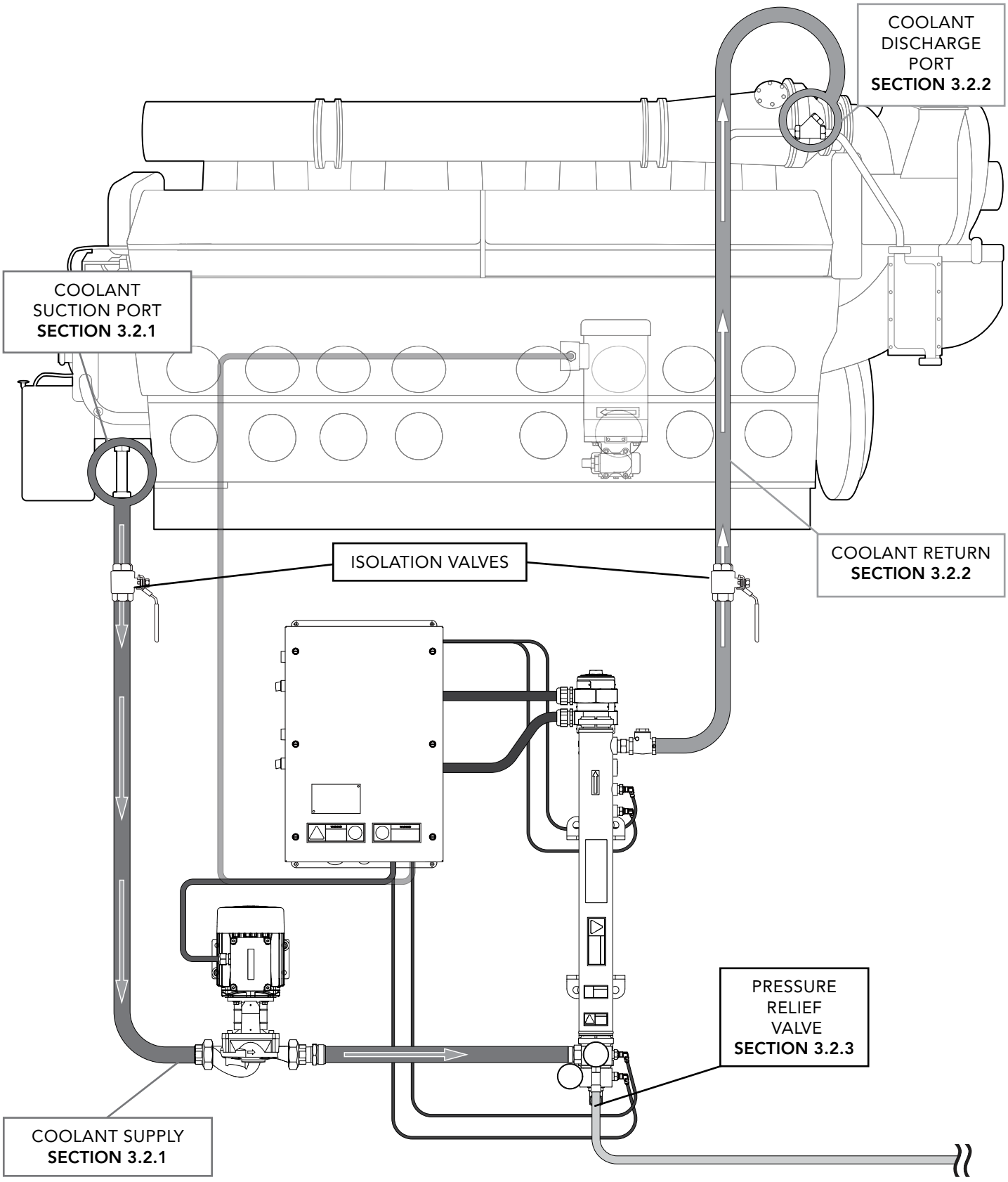
3.3 OIL PLUMBING ILLUSTRATION

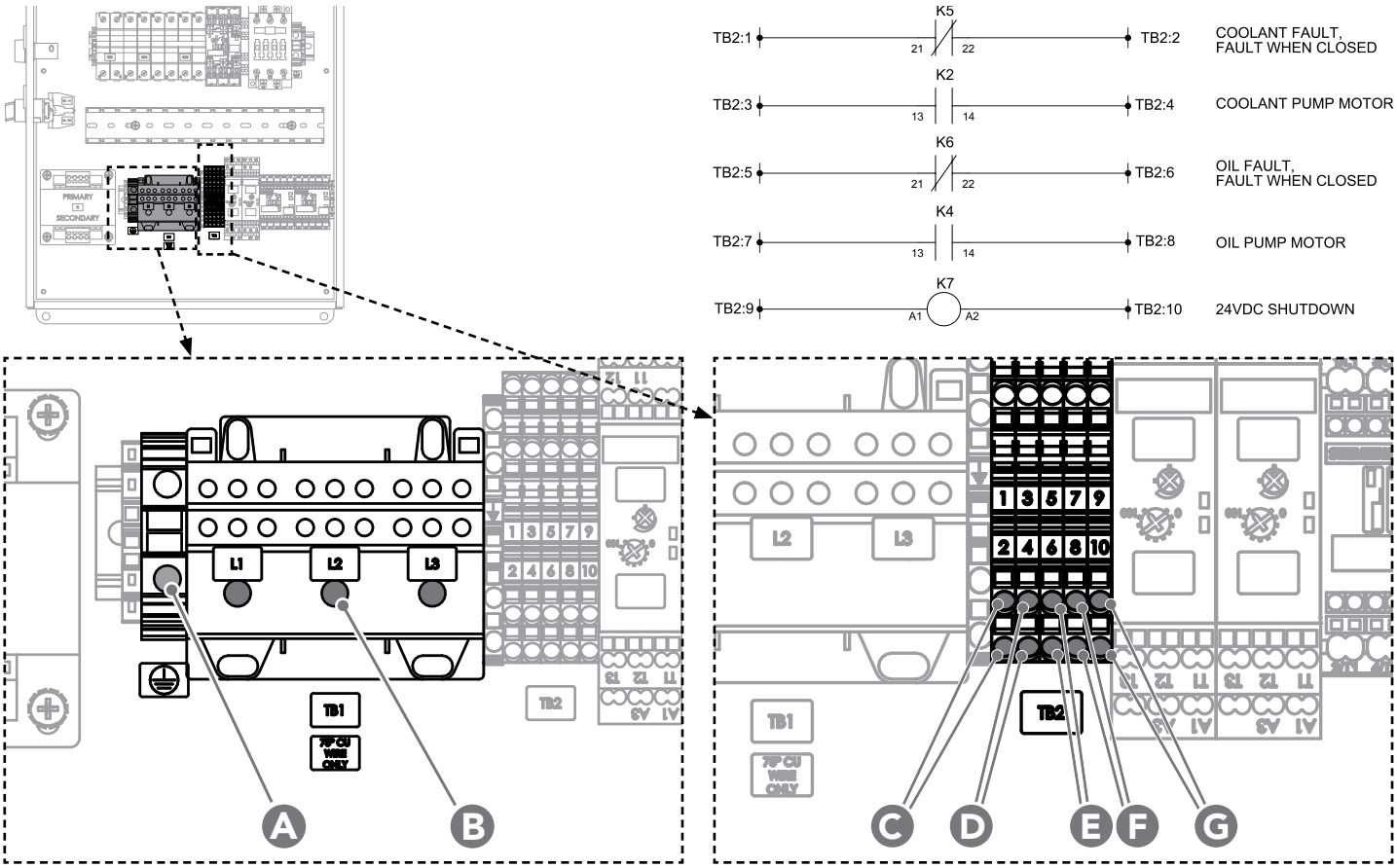
NOTE: Installation illustrations are for reference only and are not to scale. See part drawings for dimensions and specifications.



3.4 COOLANT PLUMBING ILLUSTRATION

NOTE: Installation illustrations are for reference only and are not to scale. See part drawings for dimensions and specifications.





A. *Main power ground block*

B. *Main power terminal block*

C. *Coolant fault signal*

D. *Coolant motor run signal*

E. *Oil fault signal*

F. *Oil motor run signal*

G. *Remote On/Off 24 V DC shutdown*

Figure 15. Main power supply and customer interface connections as shown in the Modular DLV control box. Reference electrical schematic drawing for proper wiring locations; the following illustrations are typical customer interface locations.

3.5 MAIN POWER SUPPLY

⚠ WARNING

Hazardous voltage: Before wiring, servicing or cleaning the heating system, turn off the power and follow your organization's lockout and tagout procedure. Failure to do so could allow others to turn on the power unexpectedly, resulting in harmful or fatal electrical shock.

Electrical hazard: All wiring shall be done by qualified personnel in accordance with national, state and local codes. Each system shall be grounded in accordance with the National Electrical Code. Failure to properly ground the system may result in electrical shock.

11. Connect the specified power from the user-supplied circuit breaker to the terminal blocks located in the main control box.

NOTE: The specified power source must be within plus or minus 10% of the rated voltage.

NOTE: The circuit breaker must be near the heating system and easily accessible. HOTSTART recommends connecting the heating system to a circuit breaker rated for 125% of the system's maximum load.

NOTE: The main power supply operates the heating elements and the circulating pumps. A transformer is used to operate the control circuit. The transformer and control circuits are overload-protected.

- For **three-phase applications**, the terminal blocks are labeled **L1**, **L2** and **L3**.
- For **single-phase applications**, use the terminal blocks labeled **L1** and **L2** or **L** and **N**. *See Fig. 15.*

12. Connect the main power ground wire to the ground lug or ground block on the electrical panel located inside the electrical box.

3.6 CUSTOMER INTERFACE CONNECTIONS

⚠ WARNING

Hazardous voltage: Before wiring, servicing or cleaning the heating system, turn off the power and follow your organization's lockout and tagout procedure. Failure to do so could allow others to turn on the power unexpectedly, resulting in harmful or fatal electrical shock.

Electrical hazard: All wiring shall be done by qualified personnel in accordance with national, state and local codes. Each system shall be grounded in accordance with the National Electrical Code. Failure to properly ground the system may result in electrical shock.

Reference electrical schematic drawing for proper wiring locations; the following illustrations are typical customer interface locations. *See Fig. 15 on previous page*.

The **coolant fault signal** or **oil fault signal** will indicate a heating system shutdown, triggered by either the corresponding high-limit temperature control relay or the corresponding motor protection switch (*see* **SECTION 5.1**). The **coolant motor run signal** or **oil motor run signal** indicates the corresponding pump is running. When provided, the **24 V DC shutdown** connection operates the heating system. When 24 V DC is present, the system will not operate. Use this connection for remote operation of the heater when the **ON/OFF/PRIME** switch is turned to **ON**.

NOTE: The **24 V DC shutdown** connection is wired **NC (normally closed)** from the factory; see system wiring schematic for directions to switch to NO (normally open) operation.

4 SYSTEM COMPONENTS AND OPERATION

The following is an operation description for the standard parts located in the system.

NOTE: Parts in the control box may vary depending on the particular system configuration purchased.

4.1 ON/OFF/PRIME SWITCH

- **ON** – The system is **on**. In this state, the 24 V DC shutdown may be used to activate or deactivate the system.
- **OFF** – The system is shut **off**.
- **PRIME** – Turn and hold the switch to **PRIME** to energize the corresponding pump motor in order to remove any air in the heating system without energizing the elements.

4.2 PRESSURE/TEMPERATURE GAUGES

The Modular DLV model features a temperature/pressure gauge mounted at the outlet of each heating tank. The gauge will indicate a pressure increase when the pump motor is engaged by turning and holding the **ON/OFF/PRIME** switch to **PRIME** or during normal operation. The gauge will also indicate the current fluid temperature.

NOTE: Your system's operating pressure may vary depending on the configuration of the engine.

4.3 PRESSURE RELIEF VALVES

⚠ CAUTION

Pressurized steam hazard: Coolant pressure relief valve outlet must be plumbed to a safe area in case an over-pressure release of heated coolant occurs.

The coolant pressure relief valve is mounted at the coolant heating tank outlet and is set to relieve at 100 psi (690 kPa). During normal operation, pressure release events are rare. To safeguard personnel and equipment, attach an appropriately sized pipe to the pressure relief valve outlet and direct flow to a safe area, bucket or other catch-basin.

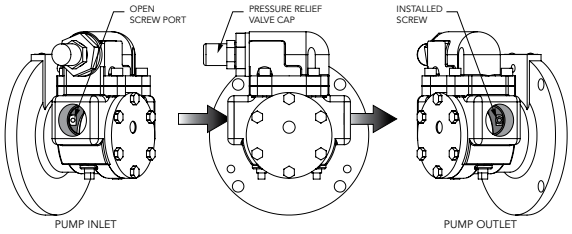


Figure 16. Modular DLV oil pump assembly. Note that the pressure relief valve cap must always point toward the inlet side of pump. Screw is installed on outlet side of pump.

The oil pump pressure relief valve is internal to the pump and releases pressure from the discharge side of the pump to the suction side of the pump at 75 psi (525 kPa). No plumbing for this component is required. The pressure relief valve cap must always point toward the inlet side of the pump. When examining the pump, note that the outlet will be designated by an installed screw. *See Fig. 16*.

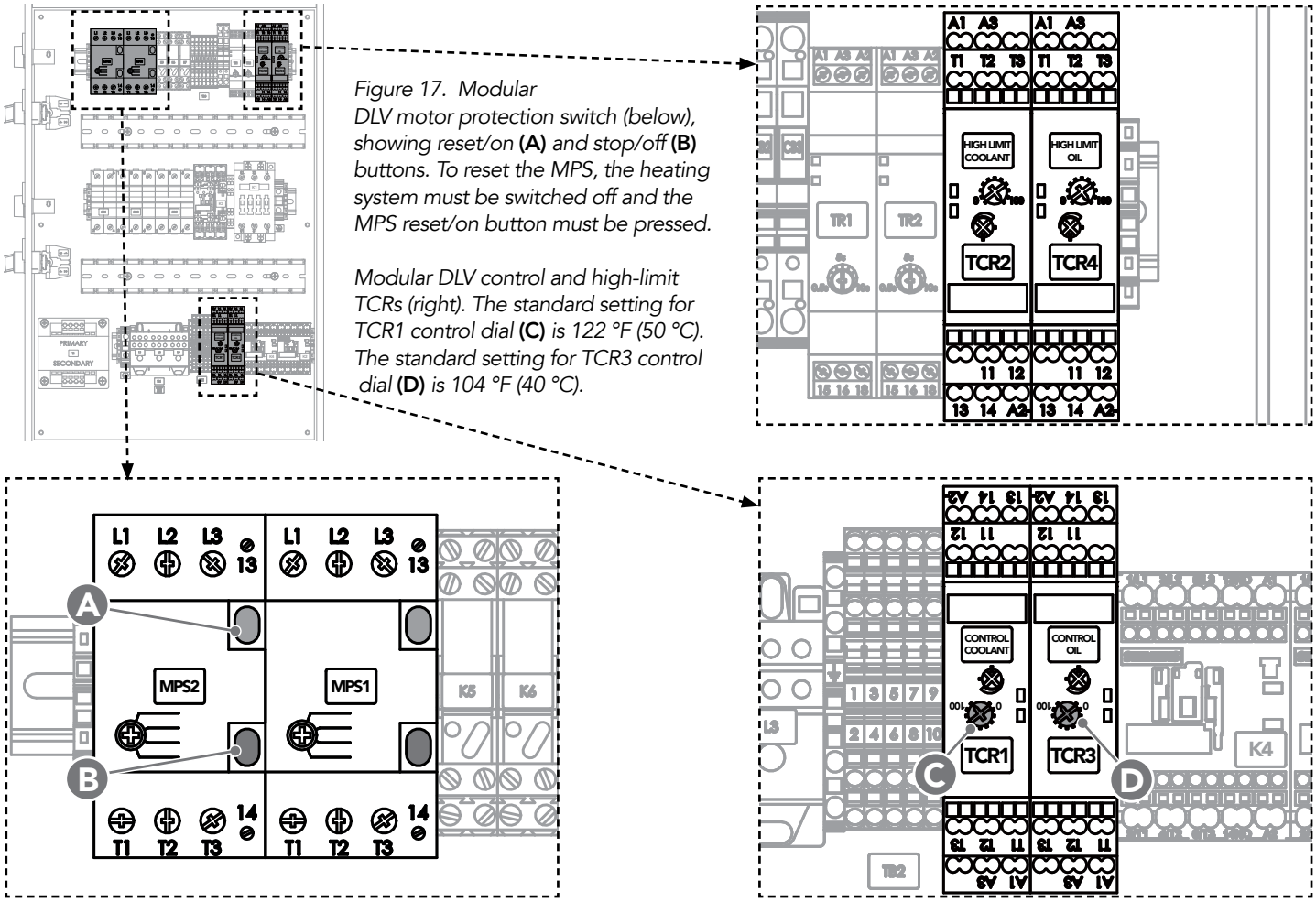


Figure 17. Modular DLV motor protection switch (below), showing reset/on **(A)** *and stop/off* **(B)** *buttons. To reset the MPS, the heating system must be switched off and the MPS reset/on button must be pressed.*

Modular DLV control and high-limit TCRs (right). The standard setting for TCR1 control dial **(C)** *is 122 °F (50 °C). The standard setting for TCR3 control dial* **(D)** *is 104 °F (40 °C).*

4.4 MOTOR PROTECTION SWITCH (MPS)

The motor protection switch (MPS) protects the pump motor from overloads. *See Fig. 17.* The MPS will be set at the full load amperage of the motor when shipped from the factory. To reset the MPS, the **ON/OFF/PRIME** switch must be switched to **OFF** and the operator must press the MPS reset/on button. *See* **SECTION 5.1**.

4.5 HIGH-LIMIT TCR (TEMPERATURE CONTROL RELAY)

The high-limit TCRs (TCR2, TCR4) are protection devices to prevent fluid overheating. The high-limit TCR uses a resistance temperature device (RTD) located near each tank outlet. The default setting for the coolant and oil high-limit TCRs is 194 °F (90 °C) at 0% hysteresis and should always be at least 18 °F (10 °C) higher than the corresponding control TCR set point. The high-limit TCR hysteresis is not used in the high-limit control. *See Fig. 17.*

4.6 CONTROL TCR (TEMPERATURE CONTROL RELAY)

The control TCRs (TCR1, TCR3) are used to control the temperature of the respective fluids. The control TCRs use a resistance temperature device (RTD) to sense the temperature of the fluid as it enters the heating tank. The standard setting for the coolant control temperature relay (TCR1) is 122 °F (50 °C) at 10% hysteresis. The standard setting for the oil control temperature relay (TCR3) is 104 °F (40 °C) at 10% hysteresis. *See Fig. 17.*

5 HEATING SYSTEM START-UP

⚠ WARNING

Hazardous voltage: Before wiring, servicing or cleaning the heating system, turn off the power and follow your organization's lockout and tagout procedure. Failure to do so could allow others to turn on the power unexpectedly, resulting in harmful or fatal electrical shock.

NOTICE

Pump damage: Do not run the motor/pump assembly dry for more than a few seconds. Running a pump that is not completely filled with fluid will cause damage to the pump seal.

Proper heating operation: The high-limit temperature control relays (TCR2, TCR4) must be set at least 18 °F (10 °C) higher than the corresponding control temperature control relay for proper heating operation. This will prevent nuisance tripping of the high-limit circuit.

1. Check and tighten all electrical and plumbing connections.

2. Ensure isolation valves are **open** before energizing the system.

3. Check the pump for proper rotation. **NOTICE!** Do not run the motor/pump assembly dry for more than a few seconds.

   - For three-phase heating systems, turn and hold the **ON/OFF/PRIME** switch to **PRIME** while observing the rotation of the pump motor fan at the rear of the motor. If the pump motor is not rotating in the correct direction, switch any two electrical leads at the main power terminal block. *See* **SECTION 3.5**. Repeat this procedure for both pump motors.

   - Single-phase systems are prewired to ensure the pump motors rotate in the correct direction.

4. Bleed all trapped air from the heating system by opening a plug or pipe fitting at or near the pump. Turn and hold the **ON/OFF/PRIME** switch to **PRIME** to evacuate any remaining air in the lines.

   NOTE: When priming the pump, the pressure gauge should indicate an increase in pressure. Your system's operating pressure may vary depending on the configuration of the engine.

5. Turn the **ON/OFF/PRIME** switch to **ON** to energize the heating system.

6. Once operation is satisfactory, turn the control dial on the temperature control relay TCR1 to the desired temperature setting for engine coolant. Turn the control dial on the temperature control relay TCR3 to the desired temperature setting for engine oil. HOTSTART recommends a control temperature on TCR1 of 122 °F (50 °C) and a control temperature on TCR3 of 104 °F (40 °C). The high-limit temperature setting on TCR2 and TCR4 should be set at 194 °F (90 °C). *See* **SECTION 4.6** *and* **SECTION 4.7**.

6 MAINTENANCE, REPAIR AND TROUBLESHOOTING

6.1 FAULTS

The coolant fault light will display if:

- The coolant pump motor protection switch is tripped (MPS1).
- The coolant high-limit temperature is exceeded (TCR2).

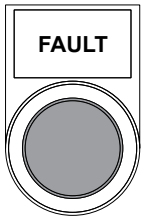


Figure 18. Fault light as shown on Modular DLV control box.

The oil fault light will display if:

- The oil pump motor protection switch is tripped (MPS2).
- The oil high-limit temperature is exceeded (TCR4).

A failure in the pump motor that causes the motor protection switch (MPS1 or MPS2) to trip will shut down the corresponding heating system. A fault signal will be transmitted and the coolant or oil fault light will illuminate. If this failure occurs, the **ON/OFF/PRIME** switch must be switched to **OFF** and the operator must press the MPS reset/on button to reset the fault. (*See* **SECTION 4.4.**)

If there is a failure that causes a high temperature to occur, the high-limit temperature controller (TCR2 or TCR4) will shut down the coolant or oil heating system, including the pump motor. A fault signal will be transmitted and the coolant or oil fault light will illuminate. To restart the system, the **ON/OFF/PRIME** switch must be switched to **OFF** and then back to **ON** to resume operation once the fluid temperature drops below the high-limit preset (*See* **SECTION 4.5**.)

NOTE: A high-limit fault can only occur when the respective heating element is energized. A fault in one fluid system will not cause the other fluid system to shut down.

For additional troubleshooting, *see* **SECTION 6.5**.

6.2 SYSTEM MAINTENANCE

⚠ WARNING

Hazardous voltage: Before wiring, servicing or cleaning the heating system, turn off the power and follow your organization's lockout and tagout procedure. Failure to do so could allow others to turn on the power unexpectedly, resulting in harmful or fatal electrical shock.

Instructions for the following maintenance procedures are provided to ensure trouble-free operation of your heating system. Replacement parts must meet or exceed original part requirements in order to maintain the compliance level of the original heating system.

NOTE: After maintenance is performed, *refer to* **SECTION 5** for system start-up procedures.

6.2.1 PLUMBING CONNECTIONS

Periodically check plumbing connections for leaks and, if necessary, tighten connections. A loose connection on the suction side will cause a loss of flow and cavitation in the pump. It can also pull air into the heating tank and cause an element failure.

6.2.2 ELECTRICAL CONNECTIONS

Vibration may cause terminals to loosen. At start-up, tighten electrical connections. Check connections again in a week. Tighten all electrical connections every three months.

6.2.3 SYSTEM MOUNTING

Vibration may cause mounting bolts to loosen. Periodically check and tighten all mounting bolts.

6.2.4 MAGNETIC CONTACTORS

Magnetic contactors are used as voltage switching controls for motors and heating elements in HOTSTART heating systems. The contactors use 120 volt or 240 volt coils. To test for failure, check for continuity across the coil connections; an open or direct-short reading indicates a failed contactor coil.

The contacts on the magnetic contactor should be inspected periodically for welding, arc erosion and mechanical wear. If any of these conditions exist, replace the magnetic contactor. HOTSTART recommends contactors be replaced every five years.

6.2.5 PUMP SEAL

Pump mechanical seals are **controlled leakage devices** and are not intended to create a zero leak seal. Some leaking from the seal is expected during normal operation. If seal becomes worn, replacement pump seals are available for oil pumps. To ensure pump seal longevity, ensure the supply lines do not restrict flow excessively (*see* **SECTION 3.1.1** *and* **SECTION 3.1.2**) and run the heating system for 20 minutes monthly during offseason periods (*see* **SECTION 6.4**).

NOTE: Instructions to replace the pump seals are included with replacement seals.

6.2.6 MOTOR LUBRICATION

Motors are installed with initial lubrication. If your motor has provisions for relubrication, refer to the motor manufacturer for recommended relubrication schedule intervals. For recommended lubrication type, refer to the motor nameplate.

NOTE: New motors installed on heating systems placed in extended storage for a year or longer may require relubrication. *See* **SECTION 6.4**.

6.2.7 OIL PRESSURE RELIEF VALVE

The oil pump pressure relief valve is internal to the pump and releases pressure from the discharge side of the pump to the suction side of the pump. No maintenance for this part is required.

6.2.8 PRESSURE/TEMPERATURE GAUGES

The oil pressure/temperature gauge will indicate a pressure increase when the pump motor is engaged by turning and holding the **ON/OFF/PRIME** switch to **PRIME** or during normal heater operation. The gauge will also indicate the current temperature of the fluid. No maintenance for this part is required.

6.2.9 VOLATILE CORROSION INHIBITOR (VCI)

A volatile corrosion inhibitor (VCI) is provided with each control box and should be replaced once a year.

NOTE: Heating systems placed in extended storage will require that the VCI is replaced at six month intervals. *See* **SECTION 6.4**.

6.2.10 TEMPERATURE CONTROL RELAY (TCR)

⚠ WARNING

Hazardous voltage: Before wiring, servicing or cleaning the heating system, turn off the power and follow your organization's lockout and tagout procedure. Failure to do so could allow others to turn on the power unexpectedly, resulting in harmful or fatal electrical shock.

If the DLV heating system does not maintain the desired preset control temperature or signals a high-limit temperature fault immediately upon system start-up, the TCR (temperature control relay), the RTD (resistance temperature device), or the RTD cable may require replacement. To perform this troubleshooting, you will need:

- Ohmmeter

1. De-energize the heating system. Verify fluid is present and flow is not restricted. Check temperature gauge to ensure the liquid in the tank is below 122 °F (50 °C).

2. Verify the control TCR is set correctly. Verify that high-limit TCR is set at least 18 °F (10 °C) higher than the control TCR set point.

3. Using the ohmmeter, measure the resistance between TCR terminals **T1** and **T2** *(See Fig. 12)*:
   - ➤ If the measured resistance is **between 80 and 120 ohms** continue troubleshooting. *Proceed to step 4.*
   - ➤ If the resistance is **lower than 80 ohms** or **higher than 120 ohms**,contact HOTSTART for further assistance.

4. Using the ohmmeter, test for continuity between TCR terminals **T2** and **T3**:
   - ➤ If there **is continuity** between TCR terminals **T2** and **T3**, the TCR, RTD and RTD cable are functioning correctly. Close control panel. Allow fluid to cool below high-limit preset temperature. Perform system start-up *(see* **SECTION 4***)*. If fault or temperature problems persist after start-up, contact HOTSTART for further assistance.
   - ➤ If there **is no continuity** between TCR terminals **T2** and **T3**, locate connected RTD on the heating tank. Unscrew the RTD plug from RTD. *See Table 2 and Fig. 14, Fig. 16* on following page.

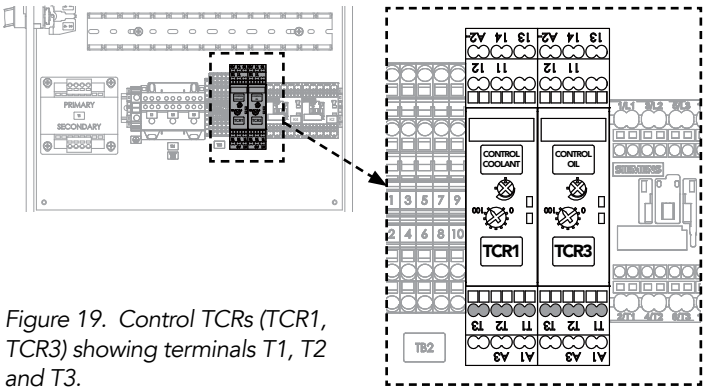


Figure 19. Control TCRs (TCR1, TCR3) showing terminals T1, T2 and T3.

TCR		TYPE		RTD Position
TCR1	Coolant	Control	50 °C	Coolant Tank Inlet
TCR2	Coolant	High-limit	90 °C	Coolant Tank Outlet
TCR3	Oil	Control	40 °C	Oil Tank Inlet
TCR4	Oil	High-limit	90 °C	Oil Tank Outlet

Table 4. TCR types, default temperature settings and corresponding RTD positions.

5. Using the ohmmeter, touch the probes to RTD **pin 1** and **pin 3**. *See Fig. 13.* Note the resistance. Touch the probes to RTD **pin 1** and **pin 4** to check for continuity:
   - ➤ If the resistance between RTD **pin 1** and **pin 3** is **between 80 and 120 ohms** and there **is continuity** between RTD **pin 1** and **pin 4**, the RTD is functioning properly. Replace the RTD cable.
   - ➤ If the resistance between RTD **pin 1** and **pin 3** is **not between 80 and 120 ohms** or there is **no continuity between pin 1** and **pin 4**, the RTD is malfunctioning. Replace the RTD. *See* **SECTION 5.2.11**

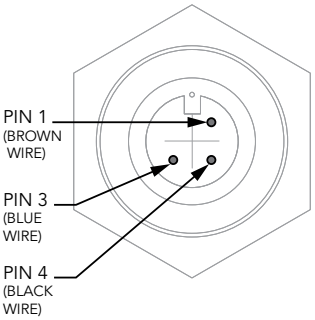


Figure 20. RTD pins 1, 3 and 4. The resistance between pin 1 and pin 3 should measure between 80 and 120 ohms. There should be continuity between pin 1 and pin 4.

6.2.11 RESISTANCE TEMPERATURE DEVICE (RTD)

⚠ WARNING

Hazardous voltage: Before wiring, servicing or cleaning the heating system, turn off the power and follow your organization's lockout and tagout procedure. Failure to do so could allow others to turn on the power unexpectedly, resulting in harmful or fatal electrical shock.

High-limit or control resistance temperature devices (RTDs) sense temperature to either control fluid temperature or protect the system and fluid from overheating. To replace a resistance temperature device (RTD), use the following procedures.

NOTE: Before removing and replacing an RTD, ensure the RTD is malfunctioning. *See* **SECTION 6.2.10**.

1. De-energize the heating system. Allow fluid to cool.
2. Close isolation valves. Drain fluid from the oil heating tank. Locate the RTD that requires replacement. *See Fig. 21.*
3. Unscrew RTD plug. Remove plug. *See Fig. 21.*
4. Unscrew RTD from tank. *See Fig. 22.*
5. Screw replacement RTD to tank. When tightening, ensure plug is aligned with notch toward top of tank. *See Fig. 23.*
6. Fit RTD plug to RTD. Ensure plug is aligned correctly with notch. Push plug in firmly. Screw RTD plug to RTD to secure in place.
7. To ensure proper installation and temperature regulation, re-energize and operate heating system. *Refer to* **SECTION 4** *for system start-up procedures.*

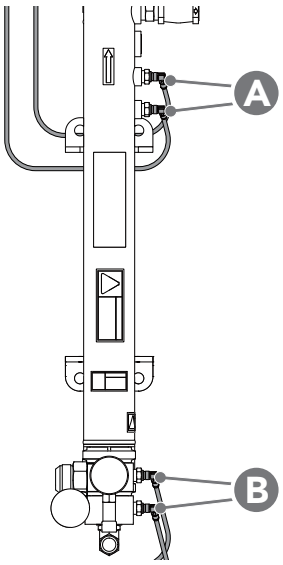
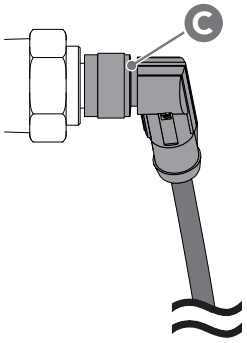


Figure 21. Modular DLV high-limit RTDs **(A)**, *control RTDs* **(B)** *and RTD plug detail* **(C)**.



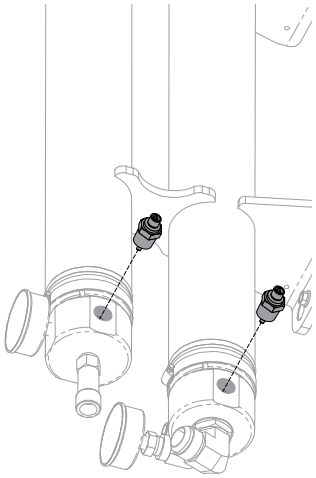


Figure 22. RTD plugs shown removed from DLV heating tanks.

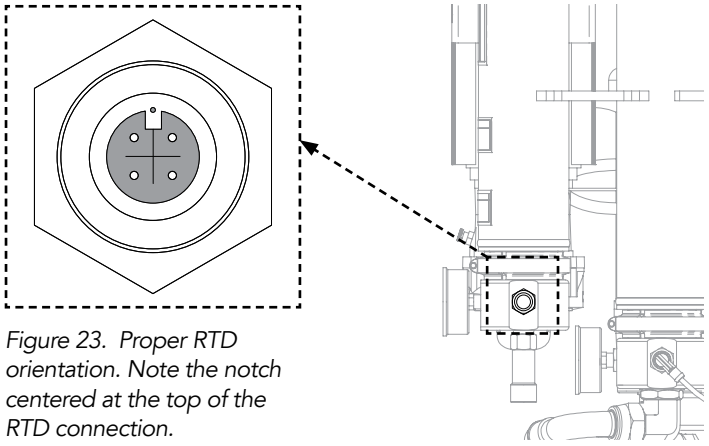


Figure 23. Proper RTD orientation. Note the notch centered at the top of the RTD connection.

6.2.12 HEATING TANK/ELEMENT

⚠ WARNING

Hazardous voltage: Before wiring, servicing or cleaning the heating system, turn off the power and follow your organization's lockout and tagout procedure. Failure to do so could allow others to turn on the power unexpectedly, resulting in harmful or fatal electrical shock.

At least once per year, clean the interior of the heating tank and the heating element with a wire brush and/or damp cloth. Periodically check the sediment build-up around the element loops. Any scaling or build-up will shorten element life.

To replace the heating element or perform routine maintenance, use the following procedures. *See Fig. 24.* The wattage and phase of the heating element are listed on the identification plate on the outside of the element **(B)**. Reference this label for the replacement part number.

1. De-energize the heating system. Allow fluid to cool.
2. Close isolation valves.
3. Drain the fluid from the heating tank **(F)**.
4. Remove the cap **(A)** from the heating element service entrance enclosure.
5. The wire connections inside the enclosure correspond to one of the phase configurations shown on the following page. Note your unit's phase configuration. *See Fig. 26.*

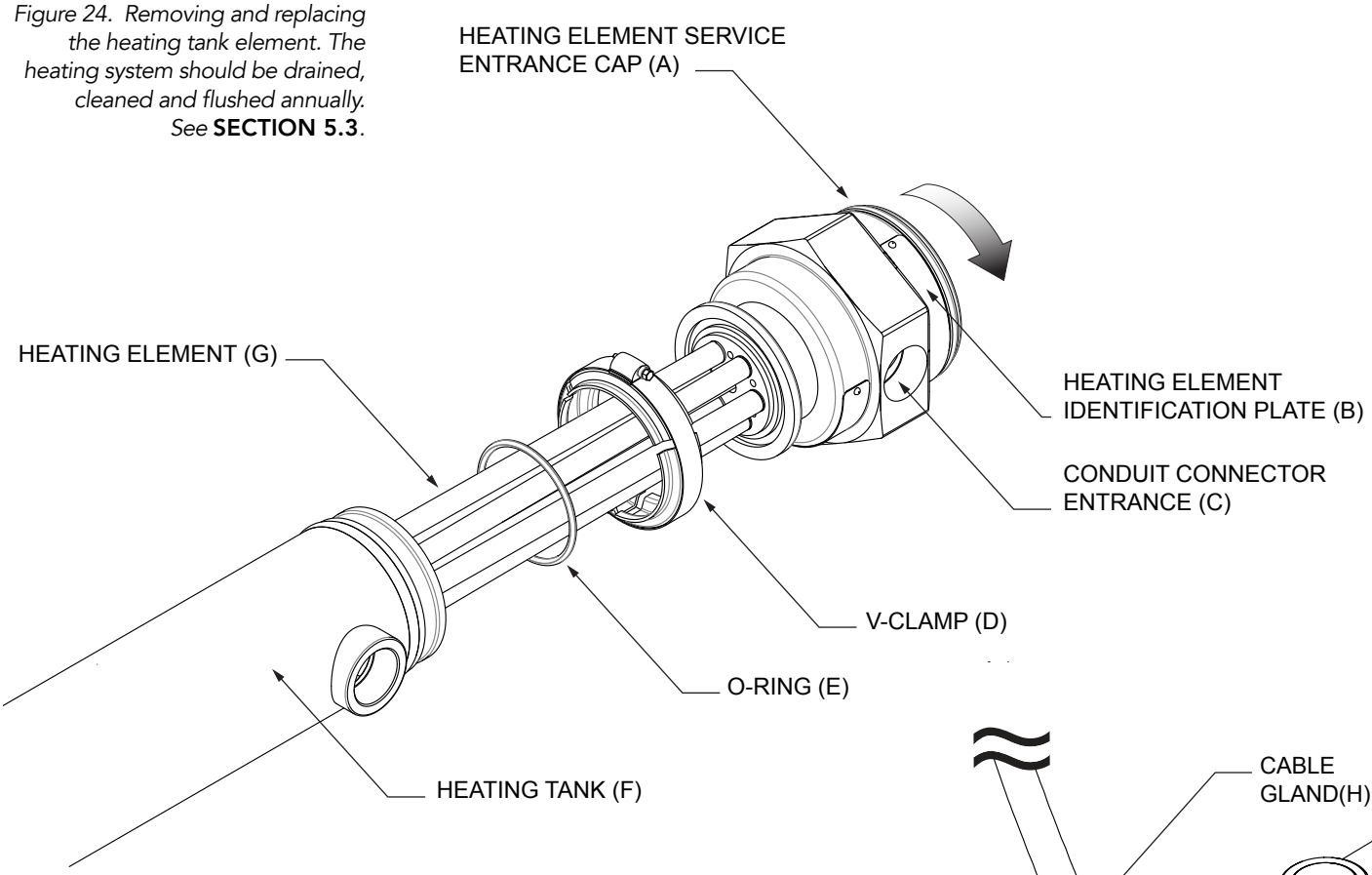
   NOTE: Replacement elements may be a different phase configuration.

6. Disconnect the ground (green/yellow) and power electrical wires from the posts inside the cap.
7. Unscrew cable gland **(H)** from conduit connector entrance **(C)**. Remove electrical cable and wires from the heating element. *See Fig. 25.*
8. Loosen V-clamp screw to remove V-clamp **(D)** Detach the heating element from the tank as shown.
9. Replace the heating element **(G)** or perform the necessary cleaning procedure. Ensure the O-ring **(E)** is in place.

6.2.13 REASSEMBLY OF HEATING ELEMENT AND TANK

To reassemble the heating element and tank, follow the steps listed in **SECTION 6.2.12** in **reverse order**. Make sure the ground and power electrical wires are properly reconnected using the provided washers, cup washers and nuts.

Figure 24. Removing and replacing the heating tank element. The heating system should be drained, cleaned and flushed annually. See **SECTION 5.3**.



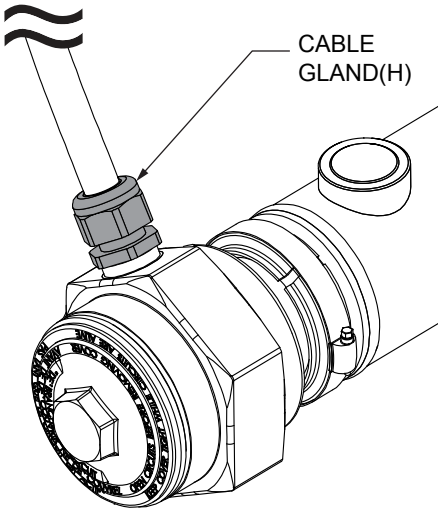


Figure 25. The cable gland as shown connected to the element assembly. Unscrew to remove element wiring.

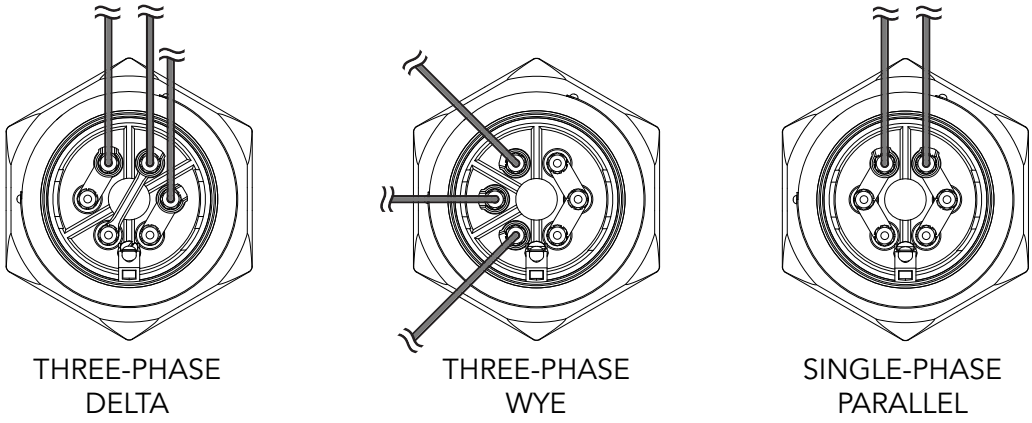


Figure 26. Heating tank element phase configurations. Replacement elements may be a different phase configuration.

6.3 RECOMMENDED MAINTENANCE

INTERVAL	MAINTENANCE TASK
At initial start-up	Tighten electrical connections. *See* **SECTION 4.5**.
One week after initial start-up	Check and tighten electrical connections. *See* **SECTION 6.2.2**.
Every three months	Tighten electrical connections.
Annually	Drain, clean and flush heating system.
	Check for cracked or weakened hoses and replace if necessary.
	Check electrical wiring and connections for wear and excessive heat.
	Check mounting bolts and tighten if necessary.
	Remove element and clean element and tank. *See* **SECTION 6.2.12**.
Every five years	Replace magnetic contactors. *See* **SECTION 6.2.4**.

6.4 STORAGE REQUIREMENTS

If long-term storage is necessary, precautions must be taken to ensure that the heating system is operational for start-up. Steps must be taken to ensure that water ingress is mitigated at all locations. All plugs and caps must remain tight and a suitable cover must be provided for the system. The cover must shield the system from direct rain and protect from any directed spray that may occur.

For any storage longer than three months, desiccant bags must be placed next to the system if it is still in the original packaging and inside the control box. If the storage duration will be one year or longer, the volatile corrosion inhibitor inside the control box must be replaced at six month intervals.

New pump motors placed in long-term storage for a year or longer may require relubrication before initial use. If your pump motor has provisions for relubrication, refer to the pump motor manufacturer's relubrication recommendations. Refer to the pump motor nameplate for lubrication type.

During the offseason, or during periods in which the heating system is not active for a month or longer, HOTSTART recommends running the heating system for a minimum of 20 minutes each month. Circulating and heating fluid at regular intervals will reduce pump seal wear and promote pump seal longevity.

6.5 TROUBLESHOOTING

SYMPTOM	POSSIBLE CAUSES	SOLUTION
Heating system fault	Pump not primed properly	Bleed all trapped air from lines. Restart system.
	Isolation valves may be closed	Open valves. Restart system.
	Hose kinked or crushed	Remove obstruction. Restart system.
	Leak in suction line	Repair leak. Restart system.
	Pump motor turning backwards	Reverse any two leads on power (in three-phase system). Restart system. *See* **SECTION 5**.
	Control TCR failure: closed	Check and replace if necessary. *See* **SECTION 6.2.10**.
	Motor failure	Check and replace if necessary. Restart system.
	Motor contactor failure	Check contacts and replace if needed. Restart system.
	Motor protection switch tripped	Check and reset switch. If problem occurs again, check motor. Restart system.
	RTD failure	Check TCR and RTD. See **SECTION 6.2.10**.
	RTD cable failure	Check TCR and RTD. See **SECTION 6.2.10**.
Fluid temperature too low	Motor failure	Check motor. Replace if necessary.
	Heating element failed	Check elements for continuity. Replace element if necessary.
	Element breaker tripped	Check for element short to ground. If no short, reset breaker.
	Element contactor failed	Check contacts and coil. Replace if necessary.
	Motor contactor failed	Check contacts and coil. Replace if necessary.
	Control TCR failure: open	Check and replace if necessary. *See* **SECTION 6.2.10**.
	Control TCR set point too low	Adjust set point for control TCR. *See* **SECTION 4.6.**
	RTD failure	Check TCR and RTD. See **SECTION 6.2.10**
	RTD cable failure	Check TCR and RTD. See **SECTION 6.2.10**.