Heat Exchanger Unit (HEU-T90) Power, Cooling, and Control System

HTM-010-A

Cray Research Proprietary

HEU-T90 Power, Cooling, & Cntrl
-010-A

Cray Research, Inc.

Record of Revision

REVISION	DESCRIPTION
	June 1995. Original printing.
A	September 1995. Revised to update diagrams.

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HEAT EXCHANGER UNIT (HEU-T90)
POWER, COOLING, AND CONTROL SYSTEM

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Overview

The heat exchanger unit (HEU-T90) removes heat generated within a module cabinet. The HEU-T90 consists of four basic systems: a dielectric-coolant system, a water system, a power system, and a control system.

NOTE: The HEU-T90 used with the CRAY T94, CRAY T916, and CRAY T932 is generally the same. The reservoir and heat exchanger sizes for the CRAY T94 computer system are smaller than those used with the CRAY T916 and CRAY T932 computer systems.

Dielectric coolant circulates through the module cabinet and absorbs heat generated by the modules and power supplies. This heated dielectric coolant then flows to the HEU-T90 where the heat is exchanged from the dielectric coolant to water.

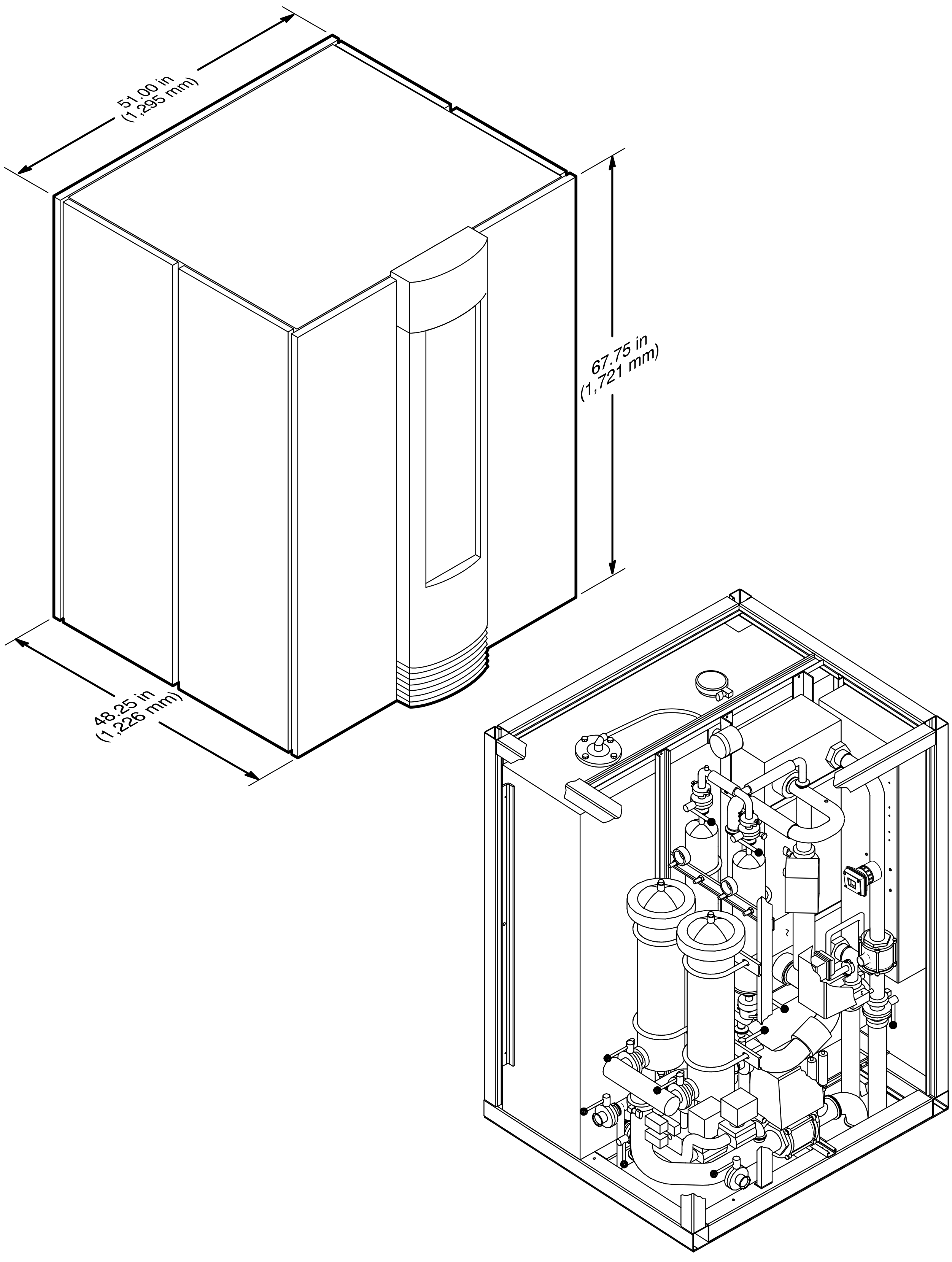
The control system monitors certain conditions within the HEU-T90 to ensure that they are within specific ranges. If the conditions are out of range, the control system either adjusts valves within the HEU-T90 to compensate for the out-of-range condition or shuts the computer system down to protect the equipment and computer room environment from damage.

Refer to Table 1 for the HEU-T90 physical, power, cooling, and control system specifications. Refer to Figure 1 for an illustration of the HEU-T90. (Refer to Figure 21 at the end of this document for an enlarged illustration of the HEU-T90 and a list of all the components.) The following subsection provides information about each of these components.

Table 1. HEU-T90 Specifications

Characteristic	Specification
Dimensions: Height Width Depth	 67.75 in. (1,721 mm) 51.00 in. (1,295 mm) 48.25 in. (1,226 mm)
Weight (with dielectric coolant):	5,600 lbs (2.520 kg)
Shipping weight (without dielectric coolant):	2,300 lbs (1,035 kg)
Dielectric coolant standard flow rate: CRAY T94 CRAY T94 with 600-series IOS CRAY T94 with 800-series IOS CRAY T916/T932	 100 gpm 125 gpm 150 gpm 200 gpm
Water/glycol mixture standard flow rate: CRAY T94 CRAY T916/T932	 50 gpm 100 gpm
Input power (to electrical control box): 50 Hz 60 Hz	 380 Vac, three phase 480 Vac, three phase

Figure 1. HEU-T90



Components

Refer to Figure 2, Part 1 for an illustration of the following HEU-T90 components.

Fluid–conditioning System

The fluid-conditioning system (FCS), which consists of two filters, performs chemical filtration. The filters are in parallel with the dielectric-coolant line going into the heat exchanger.

Each FCS filter has a glass indicator window that contains a combination of white and colored beads. If the filter has been expended, all the beads will be a uniform color, which means the filter needs to be replaced.

One filter should be isolated using the valves on either end during normal operation. Isolating this filter reserves it for a system failure. During a failure, both filters can be in use or the flow can be diverted through a single filter housing if a filter needs to be changed. This feature enables the system to keep running while the filters are changed.

Particulate Filters

Particulate filters remove any particles larger than 1.5 microns from the dielectric coolant. The HEU-T90 is equipped with two particulate filters. Each filter is a cylindrical stainless steel housing with three filter elements.

Dielectric coolant normally flows through both filter housings. The flow can be diverted through a single filter housing if a filter needs to be changed. This feature enables the system to keep running while the filters are changed.

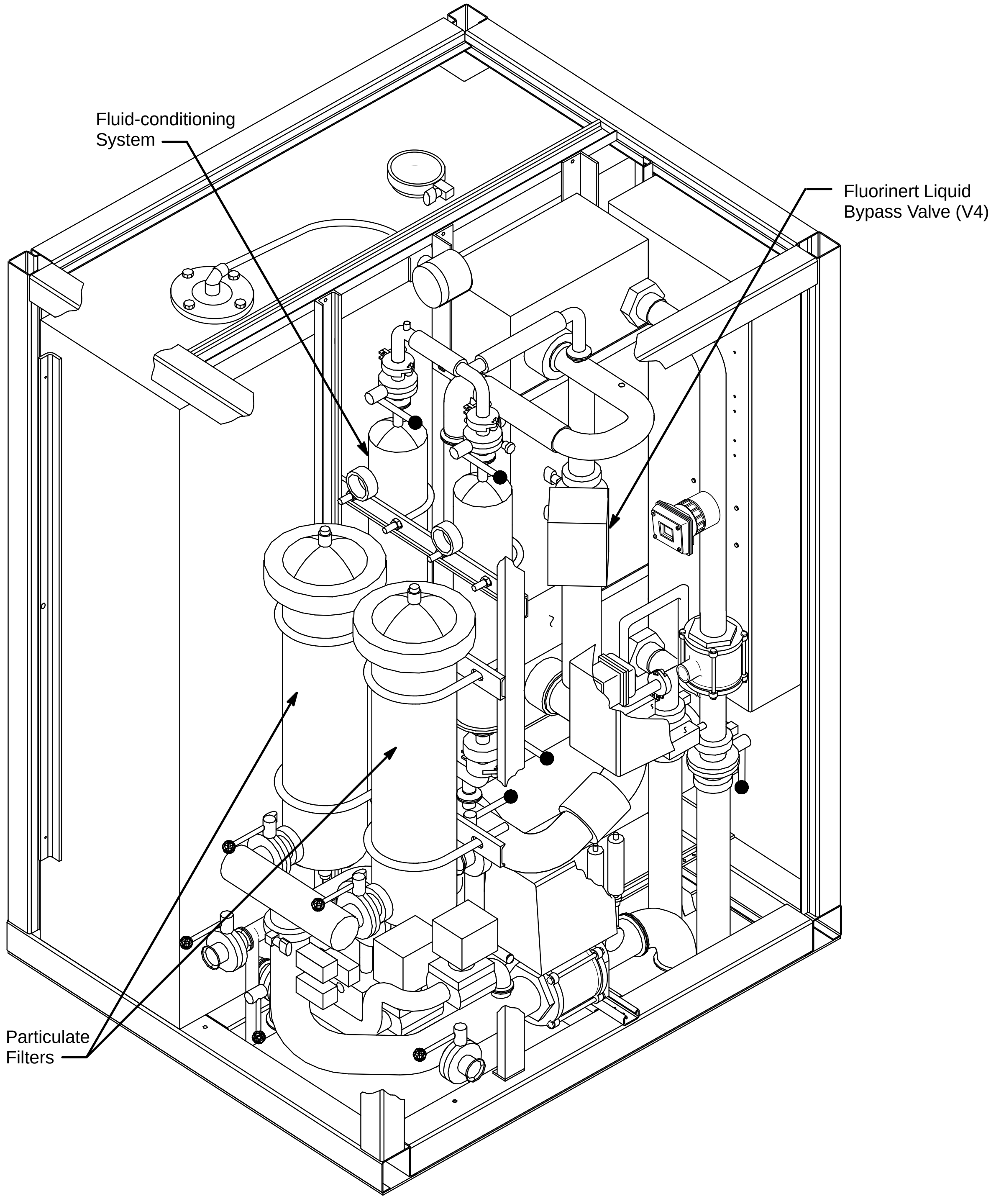
Fluorinert Liquid Bypass Valve

The Fluorinert liquid bypass valve routes warm dielectric coolant around the heat exchanger. This bypass valve maintains the flow rate of the water at a higher rate, which helps extend the life of the heat exchanger and also reduces water fouling problems.

Computer systems with smaller configurations generate smaller heat loads. The amount of water flow necessary to remove heat from the dielectric coolant in the heat exchanger is also less. However, reducing the amount of water flow also reduces the efficiency and the life span of the heat exchanger.

The Fluorinert liquid bypass valve helps maintain a higher water-flow rate by making the dielectric coolant coming out of the heat exchanger colder than it should be. The Fluorinert liquid bypass valve routes the warm dielectric coolant around the heat exchanger and mixes it with the colder dielectric coolant, which brings the temperature of the dielectric coolant up to standard temperature.

Figure 2. HEU-T90 Components (Part 1 of 5)



Refer to Figure 3, Part 2 for an illustration of the following HEU-T90 components.

Supply Valve (V1)

The supply valve is a control valve on the supply line that controls the flow rate of dielectric coolant to the module cabinet. This valve is controlled by the control system and is adjusted according to the measurements taken by the flow meter located on the discharge side of the pump. This supply valve is also used during the reservoir filling process, during which the supply valve is closed to prevent the dielectric coolant from flowing to the module cabinet. Instead, the dielectric coolant is routed to the reservoir.

Drain Valve (V2)

The drain valve is a solenoid control valve that is normally open. It provides make-up fluid from the reservoir to the circulation loop and maintains the net positive suction head pressure required for proper operation of the pump; this valve is also used to drain the HEU reservoir. During normal operation, the valve is open and enables the pump to suction the dielectric coolant through the pump to the rest of the HEU.

Fill Valve (V3)

The fill valve is a solenoid control valve that is normally closed. When activated, the valve opens, which allows the dielectric coolant to fill the HEU reservoir.

Drain Port

The drain port is used to drain the reservoir of dielectric coolant. A dielectric-coolant container can also be connected to this port. When the Drain/Fill switch is toggled to Drain, the HEU pump draws the dielectric coolant through the HEU-T90 to the drain port, which is located after the particulate filters, so that any dielectric coolant drained from the system is filtered.

Supply Line

The supply line provides the computer system with filtered dielectric coolant that is kept at a controlled temperature and flow rate.

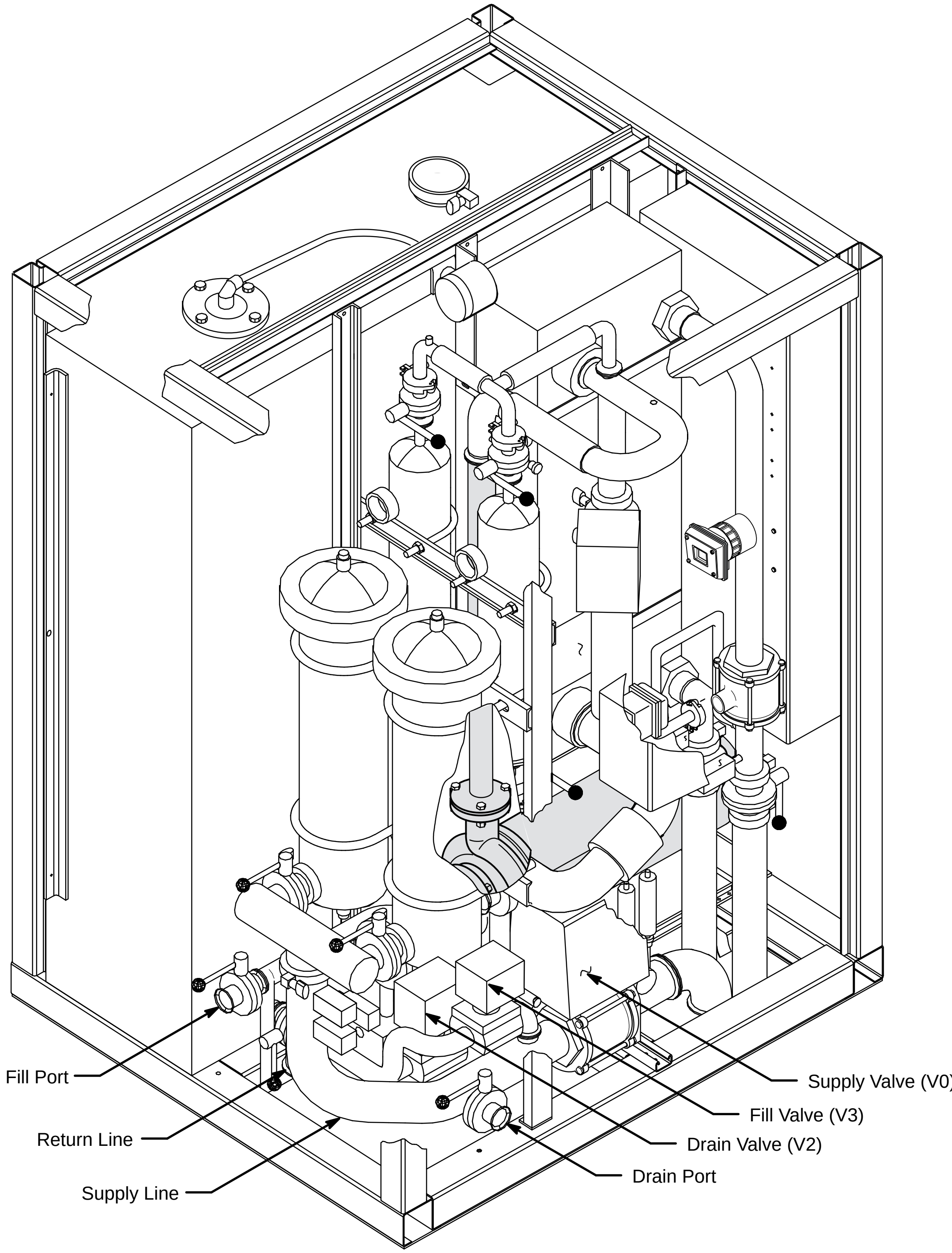
Return Line

The return line routes the dielectric coolant from the mainframe to the HEU. The return line connects to the HEU-T90 pump.

Fill Port

The fill port is used to fill the reservoir with dielectric coolant. A dielectric-coolant container can be connected to this port.

Figure 3. HEU-T90 Components (Part 2 of 5)



Refer to Figure 4, Part 3 for an illustration of the following HEU-T90 components.

Return Valve (V1)

The return valve is an on/off control valve on the return line that controls the flow of dielectric coolant during the reservoir draining process. Normally, the valve is open (on) and allows dielectric coolant to flow through the return line to the pump. During the reservoir draining process, this valve is closed (turned off), which causes the dielectric coolant to be suctioned from the reservoir through the pump and the rest of the HEU.

Reservoir

The reservoir can hold 225 gallons of dielectric coolant for the CRAY T94 system and 265 gallons of dielectric coolant for the CRAY T916 or CRAY T932 system. When the computer system is powered down, the dielectric coolant is drained from the module cabinet and stored in the reservoir. Dielectric coolant is pumped from the reservoir into the computer system when the computer system is running.

A 4-in. reservoir fill port is located on top of the reservoir. This port is used to add dielectric coolant when needed. The dielectric coolant is poured directly into the reservoir through this port. In addition, the reservoir has two lines coming into it: a drain/fill line and a vent/charge line.

Reservoir Fill Port

he reservoir fill port is used to fill the reservoir with dielectric coolant. A dielectric-coolant container is connected to this port, which is located before the pump. When the Drain/Fill switch is toggled to Fill, the HEU pump starts to pump and the dielectric coolant is suctioned into the reservoir.

Vent/Charge Line

The vent/charge line is used during the fill process. While the mainframe is being filled with dielectric coolant, any air in the lines and mainframe is forced through the vent/charge line back to the HEU reservoir. This line also ensures that the mainframe remains full during normal operation.

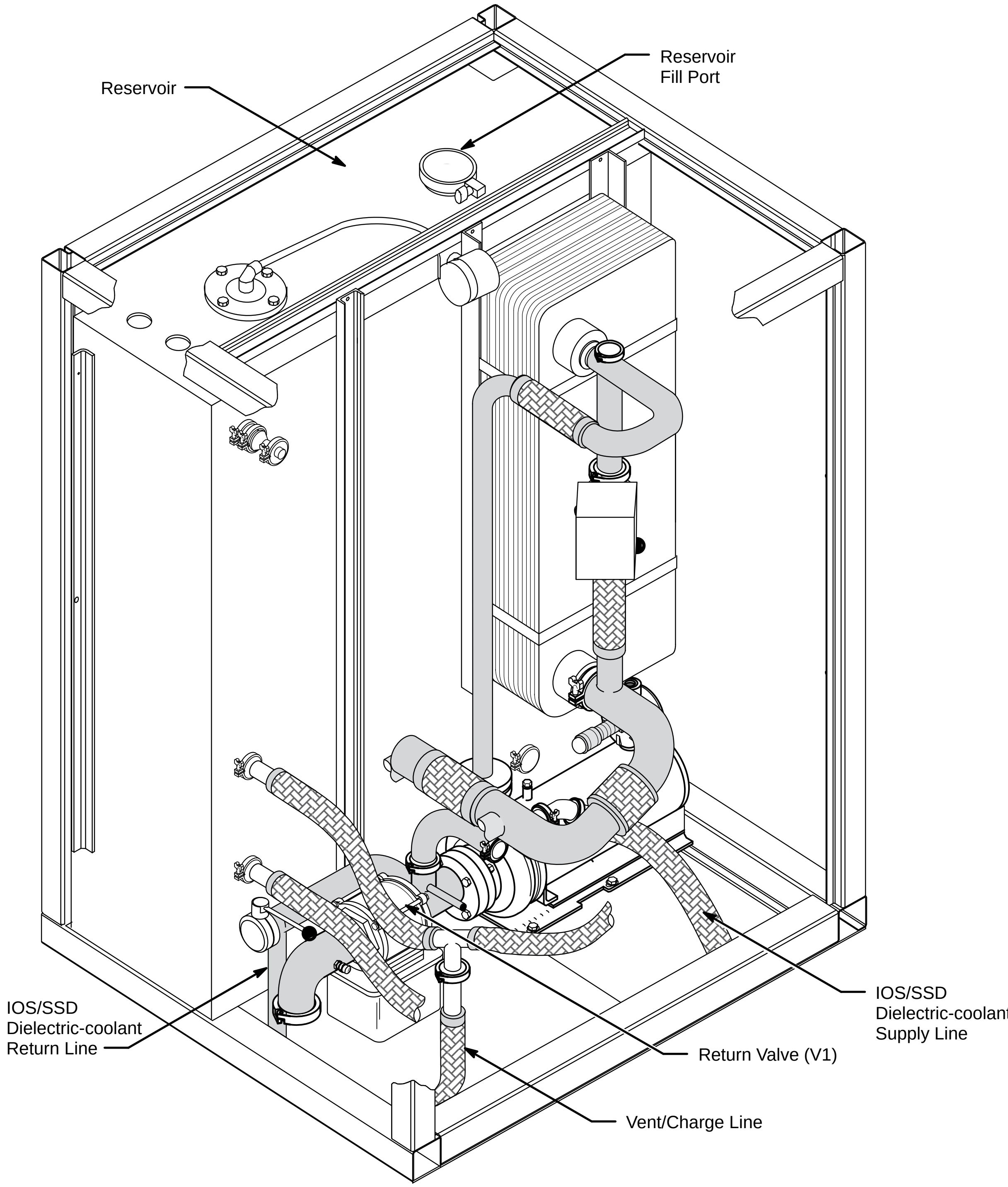
IOS/SSD Dielectric-coolant Supply Line

The IOS/SSD dielectric-coolant supply line provides the IOS/SSD chassis with cool dielectric coolant that is kept at a controlled temperature and flow rate. This supply line is located only on the HEU-T90 used with the CRAY T94 computer system that has an IOS/SSD configured.

IOS/SSD Dielectric-coolant Return Line

The IOS/SSD dielectric-coolant return line routes the warm dielectric coolant from the IOS/SSD chassis to the HEU where it mixes with the dielectric coolant coming from the mainframe chassis. This return line is located only on the HEU-T90 used with the CRAY T94 computer system that has an IOS/SSD configured.

Figure 4. HEU-T90 Components (Part 3 of 5)



Refer to Figure 5, Part 4 for an illustration of the following HEU-T90 components.

Heat Exchanger

The heat exchanger is where the heat exchange between the dielectric coolant and water takes place. The heat exchanger is a brazed assembly of thin corrugated metal plates stacked on top of each other.

The heated dielectric coolant enters the heat exchanger and flows through the channels formed by the stacked metal plates. Cold water also flows through the heat exchanger in channels adjacent to the dielectric-coolant channels. The dielectric coolant always flows in the opposite direction of the cold water. Heat is conducted from the warm dielectric coolant to the cold water.

Water Control Valve (V5)

The water control valve controls the amount and flow of the water entering the heat exchanger. This valve can be adjusted by the control system. The temperature transducers monitor the temperature of the dielectric coolant as it leaves the heat exchanger. If the temperature transducers detect an out-of-range temperature, the control system adjusts this valve accordingly.

Water Bypass Valve (V6)

The water bypass valve is a solenoid control valve that routes the water around the heat exchanger when the HEU is not operating. If desired, water is routed from the water supply line through the water bypass valve and through the water bypass line to the return line. The water flows at a reduced flow rate to reduce delays in system start-up time, which can be caused by stagnant water loops warming to room temperature.

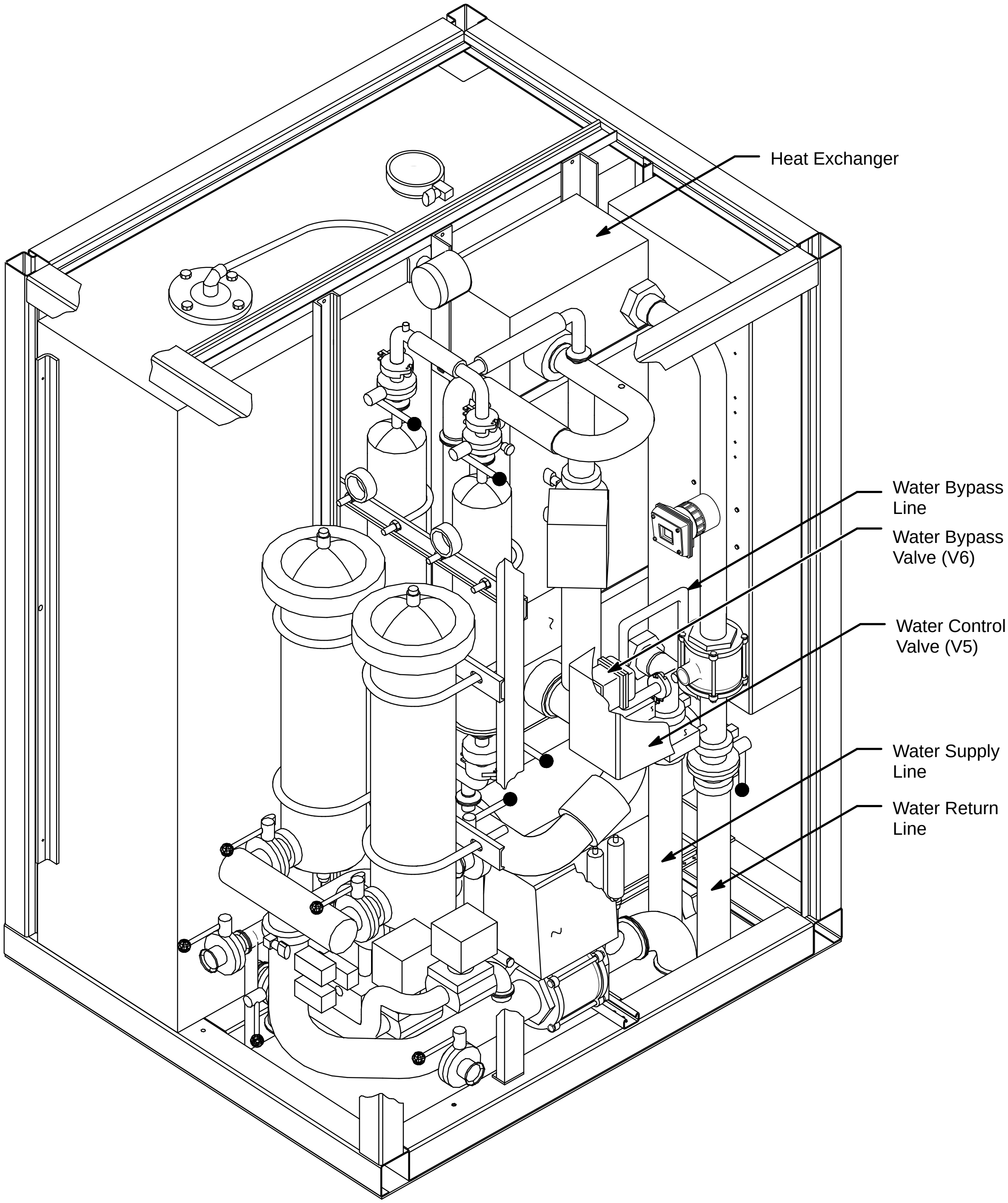
Water Supply Line

The water supply line provides cool water from the customer’s water source to the heat exchanger.

Water Return Line

The water return line routes the heated water from the heat exchanger to the customer’s water source.

Figure 5. HEU-T90 Components (Part 4 of 5)



Refer to Figure 6, Part 5 for an illustration of the first three HEU-T90 components described below.

Centrifugal Pump

The centrifugal pump circulates dielectric coolant through the computer system. The pump draws dielectric coolant through the HEU-T90 and module cabinet. This pump operates on 50-Hz, 3-phase, 380-Vac or 60-Hz, 3-phase, 480-Vac power supplied by the 4-pole male connector connected to the electrical control box. The pump is protected by a contactor and overload relay. It also has overtemperature circuitry that protects the pump from damage if an overload causes the temperature to become too high.

Electrical Control Box

The electrical control box contains the main circuit breaker, transformer, power on/off switch, and electrical connections for the HEU-T90. Refer to the “Power System” subsection in this document for more information about the electrical control box.

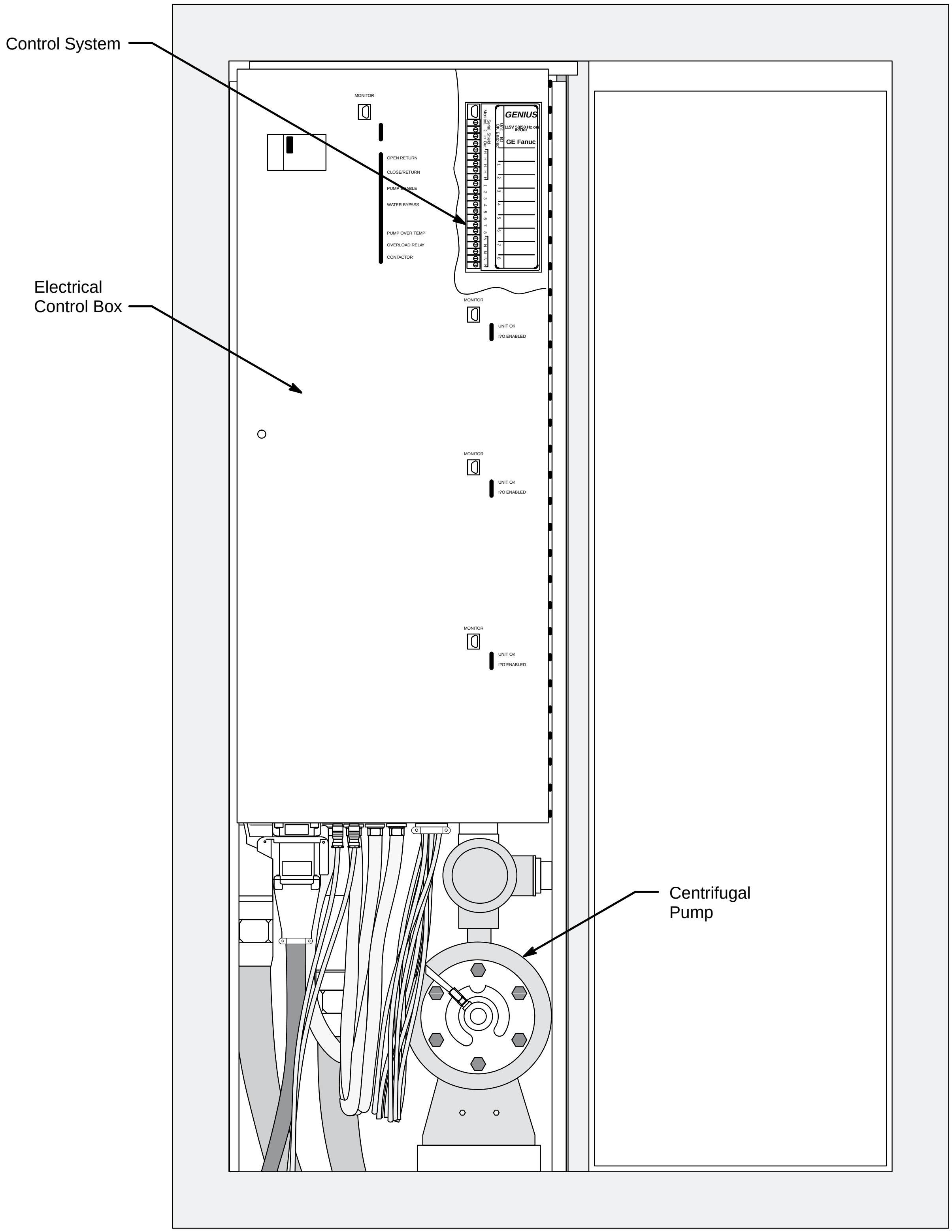
Control System

The control system (GE Fanuc Genius I/O System) monitors flow, temperature, pressure, and dielectric-coolant levels within the HEU-T90. The HEU-T90 contains five remote monitoring blocks that provide an interface between the controller on the mainframe and the sensors within the HEU-T90. Refer to the “Control System” subsection for more information about the HEU-T90 control system.

Butterfly Valves (Not Shown)

Butterfly valves are manual valves that are used to isolate pieces or areas of equipment within the HEU-T90.

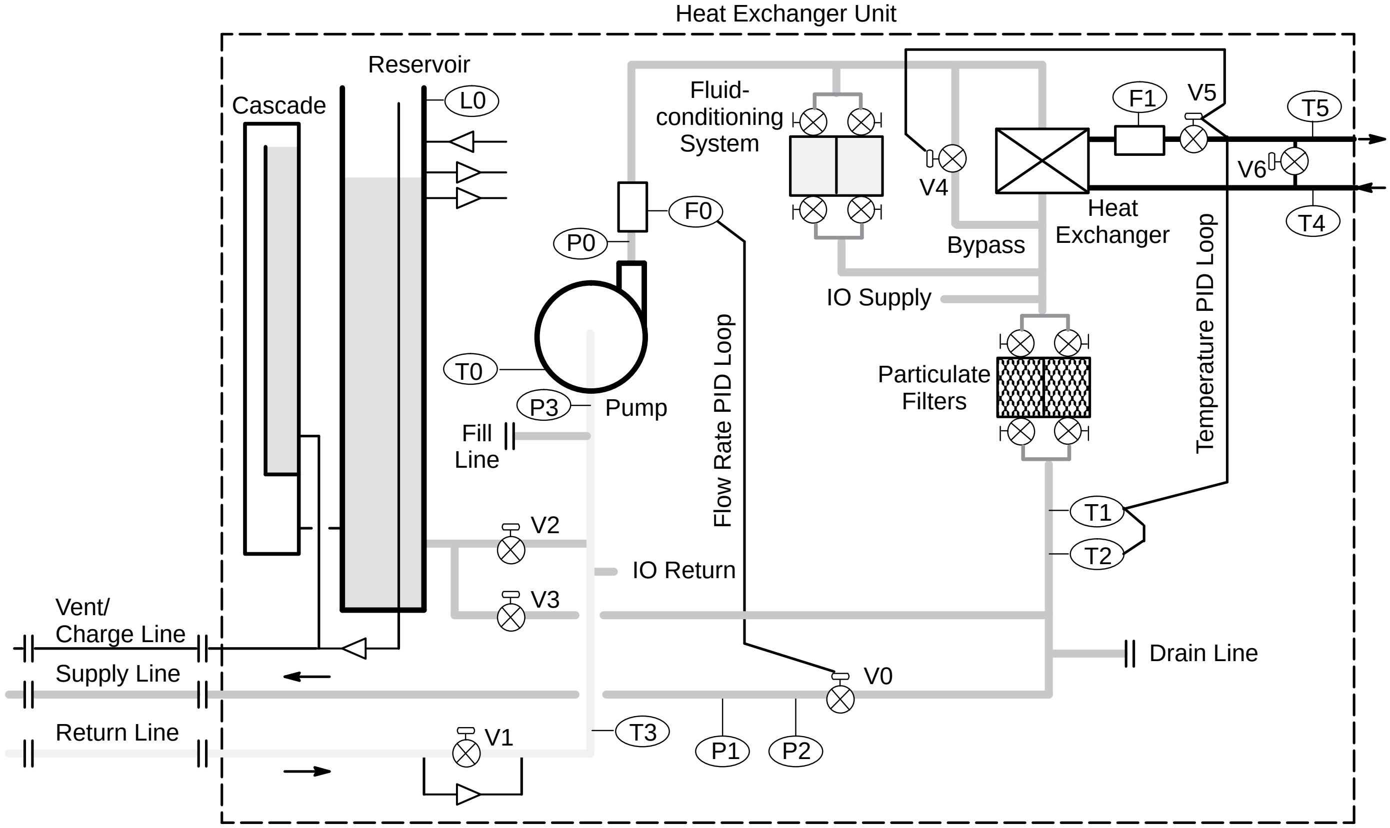
Figure 6. HEU-T90 Components (Part 5 of 5)



Dielectric-coolant Flow Circuit

Refer to Figure 7 for a simplified block diagram of the HEU-T90 flow circuit. The following subsections provide information about the dielectric-coolant flow during various operations.

Figure 7. HEU Block Diagram



Sensors

ID	Description
L0	Level Sensor
P0	Discharge Pressure Sensor
P1	Primary Supply Line Pressure Sensor
P2	Backup Supply Line Pressure Sensor
T0	Pump Temperature Sensor
T1	Primary Supply Line Temperature Sensor
T2	Backup Supply Line Temperature Sensor
T3	Return Line Temperature Sensor
T4	Water Supply Line Temperature Sensor
T5	Water Return Line Temperature Sensor
F0	Discharge Flow Rate Sensor
F1	Water Flow Rate Sensor

KEY

= Manual Valve

= Control Valve

Valves

ID	Control	Description
V0	Analog	Supply Valve
V1	On/Off	Return Valve
V2	Solenoid	Drain Valve
V3	Solenoid	Fill Valve
V4	Analog	Bypass Valve
V5	Analog	Water Control Valve
V6	Solenoid	Water Bypass Valve

Normal Operation

Refer to Figure 8 for an illustration of the HEU-T90. The shaded areas indicate components that are part of the dielectric-coolant flow circuit. The following description includes circled numbers that correspond with the numbers shown in Figure 8.

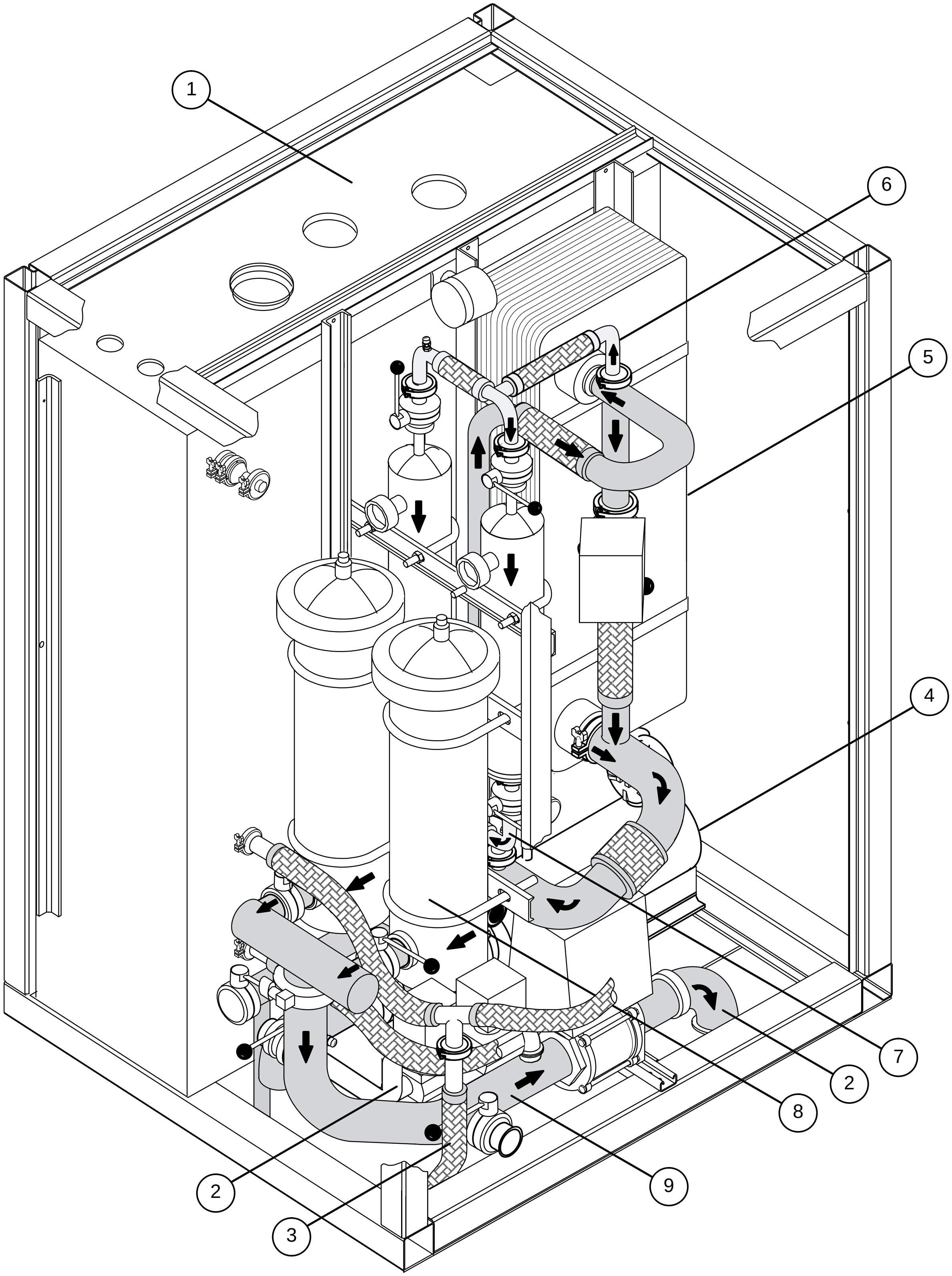
Dielectric coolant is pumped through the computer system to absorb heat and through the HEU-T90 where the heat is removed and transferred to water. When the computer system is powered down, all dielectric coolant is removed from the computer system. This dielectric coolant is stored in the reservoir ① within the HEU-T90.

When the computer system is powered up, dielectric coolant flows through the supply line ② from the HEU-T90 reservoir to the module cabinet. As the module cabinet is filling, any air that was in the module cabinet or supply line is forced through the vent/charge line into the HEU-T90 reservoir.③

Dielectric coolant absorbs heat in the module cabinet and then flows to the HEU-T90. The pump ④ suctions the dielectric coolant through it and then pumps it to the heat exchanger ⑤, where the heat is transferred from the dielectric coolant to water through a heat exchange process. The pipe leading to the heat exchanger is in a slip stream ⑥ with the fluid-conditioning system (FCS). Some dielectric coolant flows directly to the heat exchanger while the rest flows through the FCS. Once the dielectric coolant has been filtered in the FCS, the dielectric coolant flows through a pipe that joins the pipe coming from the heat exchanger. ⑦

After the heat has been removed from the dielectric coolant in the heat exchanger, the dielectric coolant flows through the particulate filters ⑧, where any particles that may have been picked up during the cooling process are filtered out. From the particulate filters, the dielectric coolant flows out of the HEU-T90 through the supply line ⑨ and back to the module cabinet.

Figure 8. HEU-T90 Dielectric-coolant Flow Circuit



Refer to Figure 9 for an illustration of the HEU-T90 IOS/SSD dielectric-coolant flow circuit. The following description includes circled numbers that correspond with the numbers shown in Figure 9.

On CRAY T94 computer systems, the HEU-T90 cools an IOS/SSD cabinet in addition to the mainframe. In this instance, the flow of dielectric coolant is increased by the control system. The pump suctions the dielectric coolant through the IOS/SSD dielectric-coolant return line ① and then mixes with the dielectric coolant coming from the mainframe. ②

The dielectric coolant flows through the heat exchanger where it is cooled ③; the dielectric coolant flows out of the heat exchanger towards the particulate filters ④. Before the dielectric coolant reaches the particulate filters, some of the dielectric coolant flows through the IOS/SSD dielectric-coolant supply line ⑤ back to the IOS/SSD chassis. Because the IOS/SSD chassis does not use an immersion cooling technique, the dielectric coolant does not have to be filtered for PFIBs or particles.

A lighted cascade is located on the front of the HEU-T90. This cascade is connected to dielectric coolant coming from the reservoir. The front of the cascade has clear plastic and a light at the top so that the dielectric coolant can be viewed as it cascades to the bottom of the cascade plenum. The only purpose of this cascade is aesthetics; no cooling is accomplished using this circuit. Refer to Figure 10 for an illustration of the HEU-T90 cascade circuit and connections.

The cascade supply line connects to the reservoir. The dielectric coolant comes from the reservoir and enters the top of the cascade plenum. The dielectric coolant cascades down through the cascade plenum where it flows through an exit hole back to the reservoir.

Figure 9. IOS/SSD Dielectric-coolant Flow Circuit

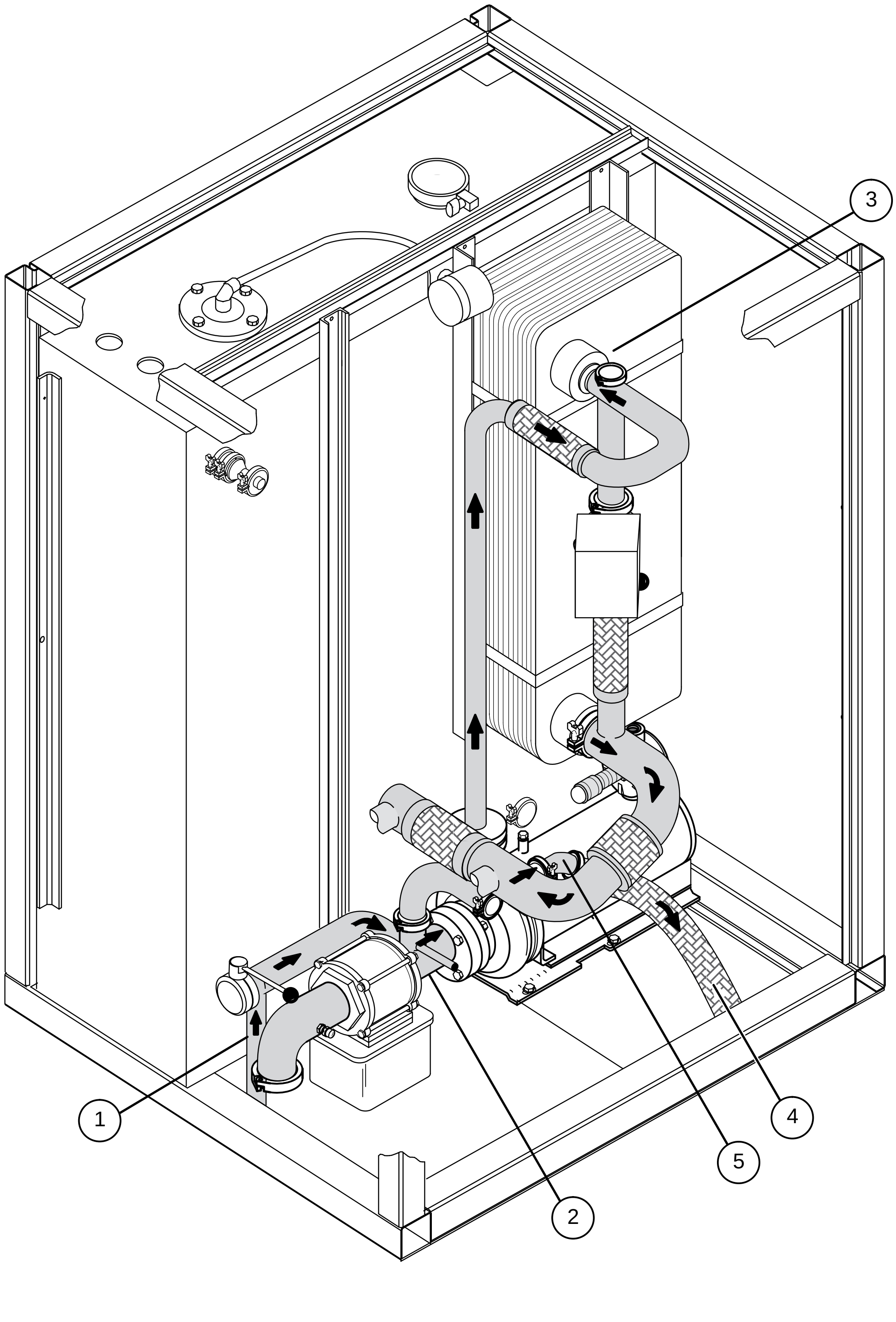
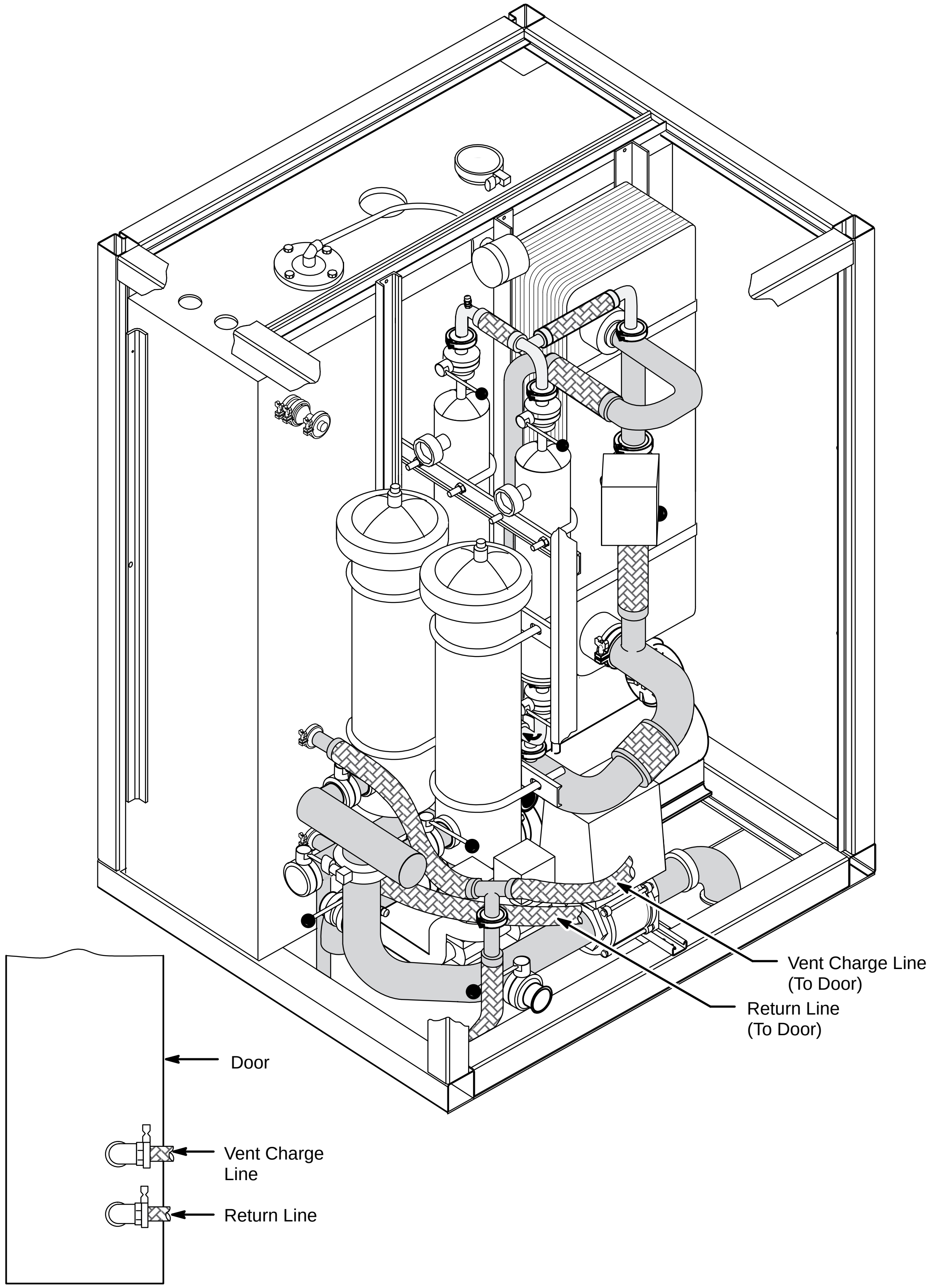


Figure 10. Cascade Circuit



Sequence of Events

The HEU-T90 sequence of events depends upon the following conditions:

- Computer system configuration
- Command sent by the control system (`nwacs` program)

The types of equipment that the HEU-T90 cools affect the sequence of events. If the HEU-T90 cools an input/output subsystem and SSD solid-state storage device (IOS/SSD) in addition to the mainframe, the sequence of events can be different than if the HEU-T90 cooled only the mainframe.

In addition to the computer system configuration, the commands sent by the control system (`nwacs` program) also affect the sequence of events. Refer to the mainframe power, cooling, and control system document for specific information about the `nwacs` commands and the associated sequence of events.

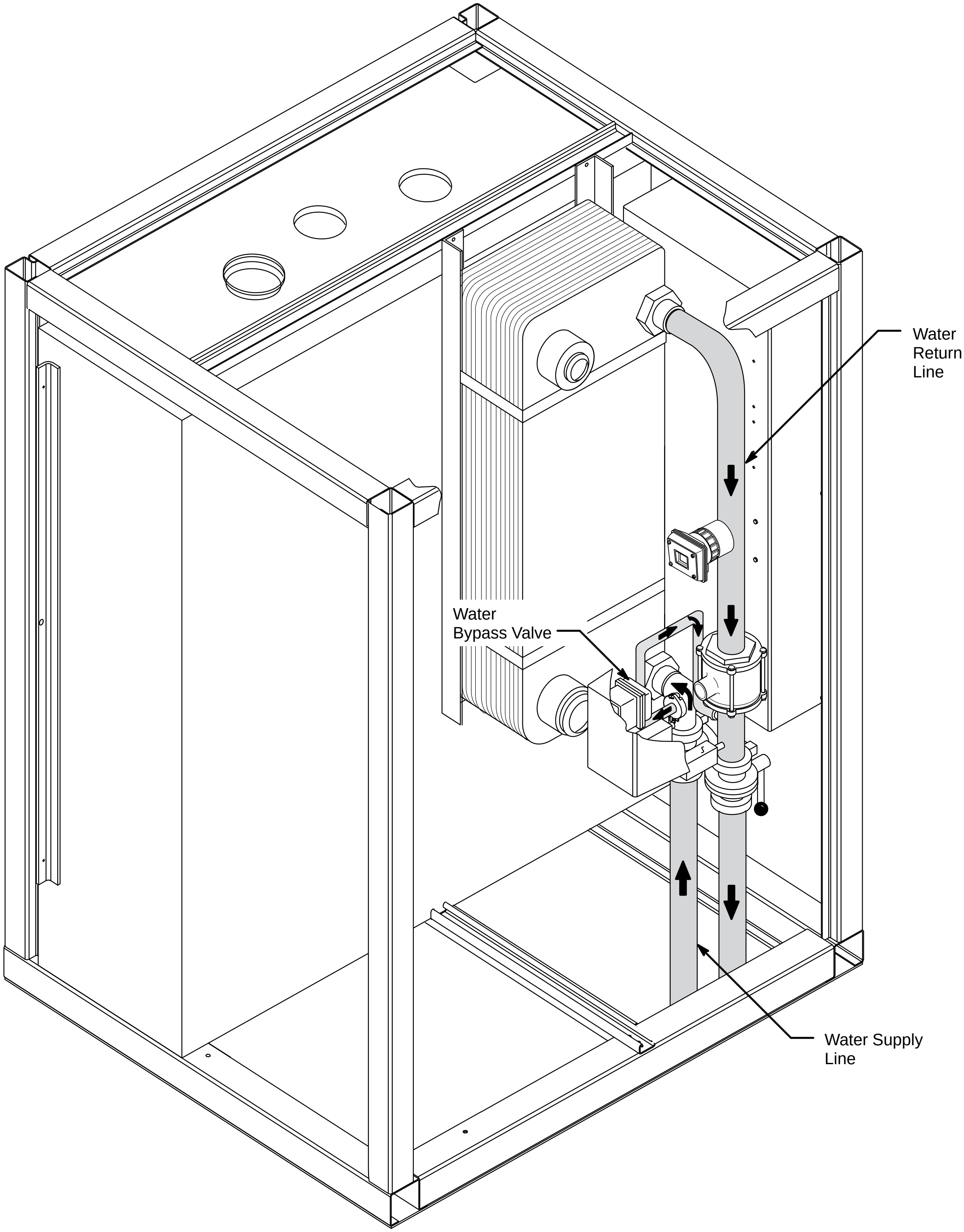
Water Flow Circuit

Water is used in the HEU-T90 to remove heat from the dielectric coolant. The shaded areas in Figure 11 indicate the water-flow circuit components.

Water flows from the customer-supplied cooling water source to the HEU-T90 through piping under the computer room floor. The water supply line enters the HEU-T90 and flows to the heat exchanger. A temperature transducer monitors this water supply line.

The water flows through the heat exchanger in channels formed by stacked metal plating. The water flows through these channels in the opposite direction of the dielectric-coolant channels. The water absorbs the heat from the dielectric coolant in the heat exchanger and then flows through the water return pipe, which is monitored with a flow meter and temperature transducer. The water flows back to the customer chiller where the water is cooled for reuse.

Figure 11. HEU-T90 Water Flow Circuit



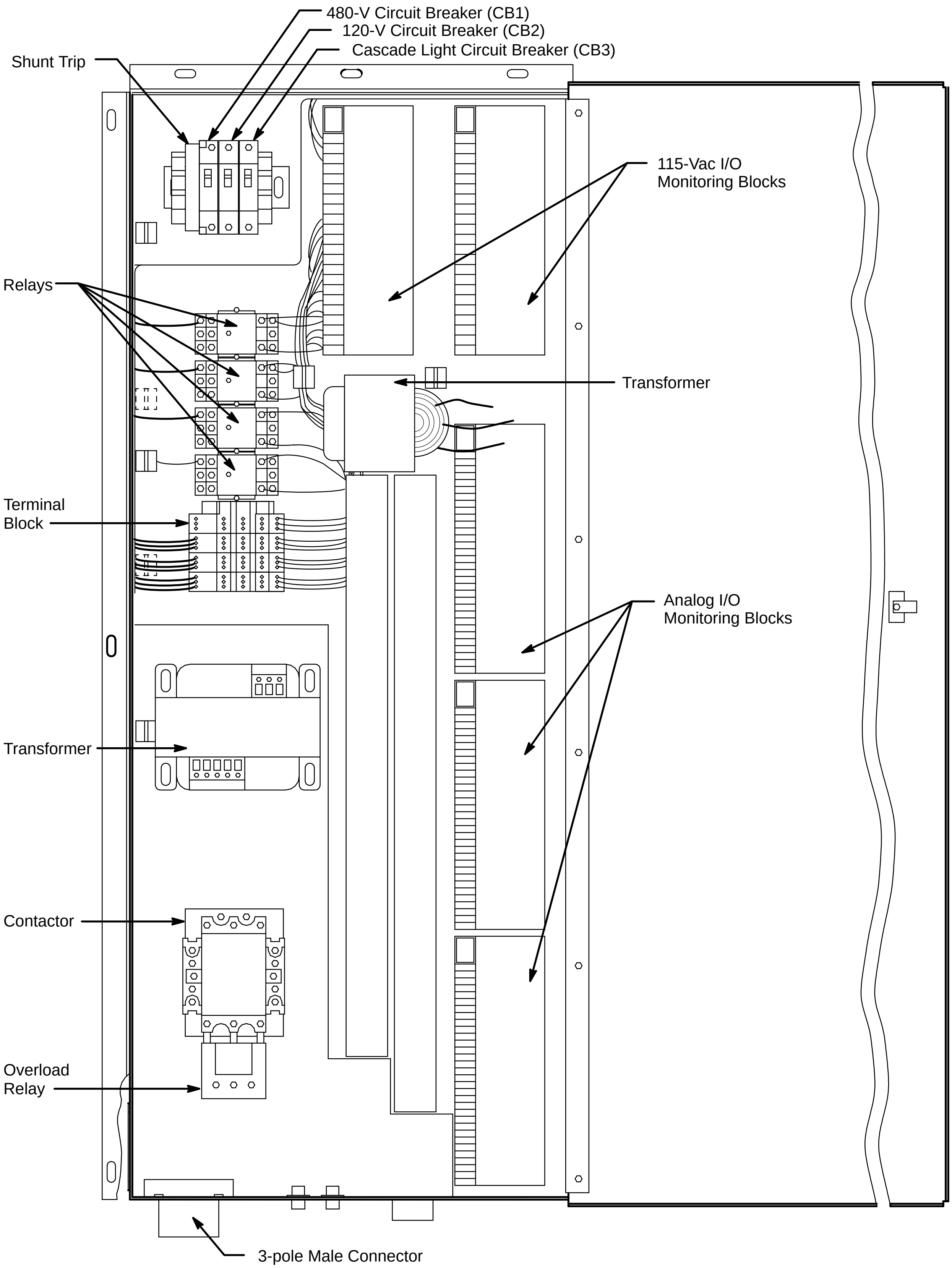
Power System

The HEU-T90 has an electrical control box (refer to Figure 12) that receives the 50-Hz, 3-phase, 380-Vac or 60-Hz, 3-phase, 480-Vac power from the uninterruptable power source (UPS) through the high-voltage DC (HVDC) cabinet.

Components

- Three-pole male connector (rated for 480 V, 50 A)
- Contactor (3 phase, rated for 480 V, 80 A)
- Step-down control transformer (480 to 120 V, 500 VA)
- Step-down transformer (120 to 12 V, 120 VA)
- Overload relay
- Circuit breaker (rated for 480 V)
- Circuit breaker [(120 V, 3 A) housekeeping]
- Circuit breaker [(120 V, 1 A) cascade lights]
- Terminal block
- Relays
- 115-Vac remote monitoring blocks
- Analog I/O monitoring blocks

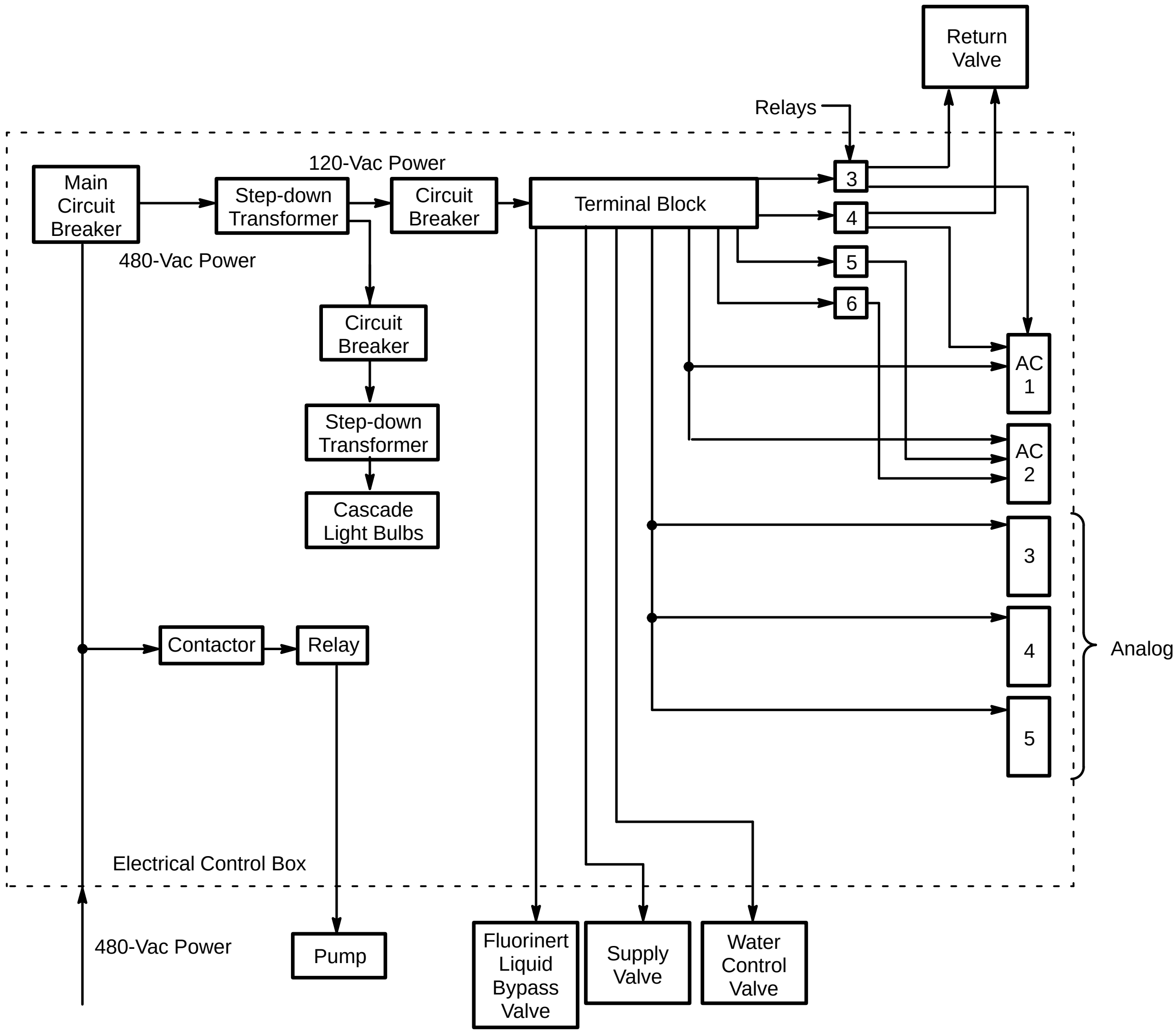
Figure 12. Electrical Control Box



Distribution

Figure 13 is an electrical block diagram of the HEU-T90.

Figure 13. Electrical Block Diagram (AC)



The 3-phase, 480-Vac power is connected to the electrical control box with the 3-pole male connector. This power is routed to an 80-A contactor, through an overload relay, and then to the pump; this power from the connector is also routed through the main shunt-trip circuit breaker (power on/off switch) and then to a multitap step-down transformer. The transformer steps down the 360- to 480-Vac power to 120-Vac power.

From this step-down transformer, the 120-Vac power is routed to two circuit breakers. The first circuit breaker is a 1-amp circuit to a step-down transformer which reduces the 120-Vac power to 12-Vac power. This stepped-down power is then routed to the cascade light assembly. (These bulbs are wired in parallel so that if one burns out, the other lights will still function.)

The stepped-down 120-Vac power is also routed through a 3-A circuit breaker and then to 2-pole bus bar terminal blocks. The terminal blocks provide power to the remote monitoring blocks and four relays contained within the electrical control box. (Refer to the “Control System” subsection in this document for more information about the remote monitoring blocks.)

Two terminal blocks provide power for the relays and remote monitoring blocks. A blue terminal block provides the neutral connections for the relays and the remote monitoring blocks. The other terminal block is gray and is located under the blue terminal block. This gray terminal block provides power for the relays and remote monitoring blocks. Figure 14 provides an illustration of the terminal blocks. Table 2 provides signal information for each terminal block.

Figure 14. Terminal Block Connections

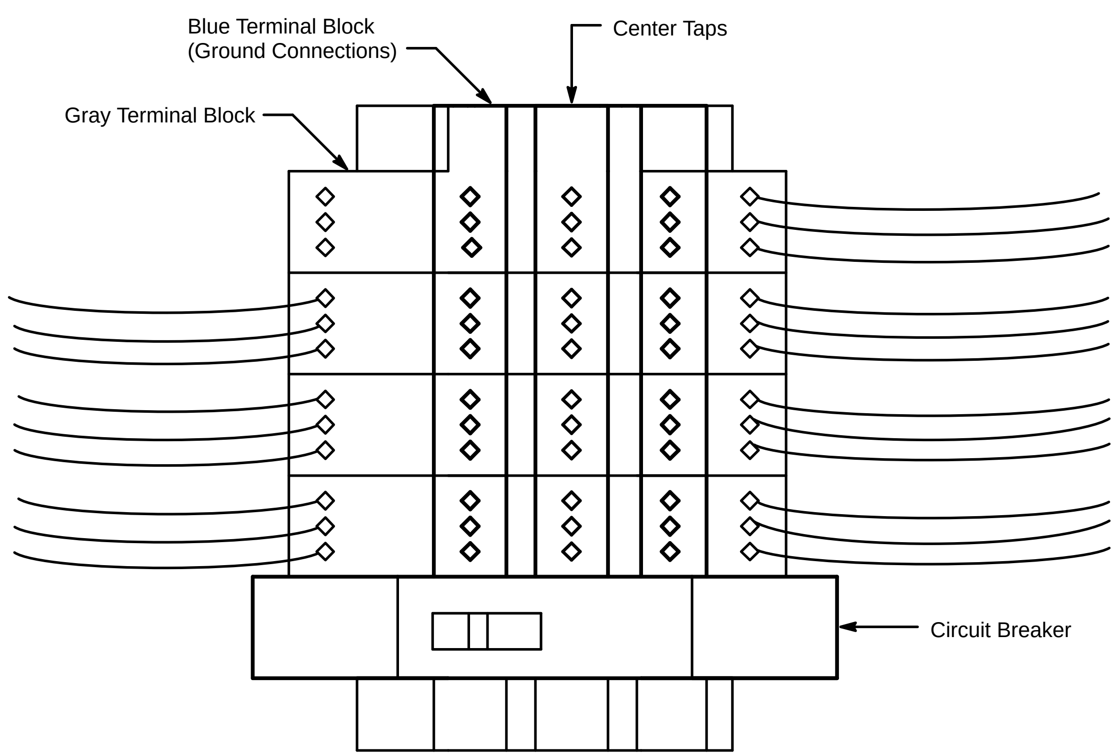


Table 2. HEU-T90 Terminal Block Connections

Terminal Block	Connection Number	Connected To
Gray (Line Connections)	1	CB2
	2	Contactor
	3 through 18	Not used
	19	115-Vac remote monitoring blocks (1 and 2), connection #5
	20	Analog remote monitoring blocks (3, 4, and 5), connection #6
	21	Supply valve (V0)
	22	Fluorinert liquid bypass valve (V4)
	23	Water control valve (V5)
	24	Relays K3 and K4
Blue (Neutral Connections)	1	Not used
	2	Not used
	3 through 13	Not used
	14	115-Vac remote monitoring blocks (1 and 2), connection #18
	15	Analog remote monitoring blocks (3, 4, and 5) connection #7
	16	Water bypass valve (V6)
	17	Drain valve (V2)
	18	Fill valve (V3)
	19	Return valve (V1)
	20	Supply valve (V0)
	21	Fluorinert liquid bypass valve (V4)
	22	Water control valve (V5)
	23	Relays (K3, K4, K5, and K6)
	24	Not used

The 115-Vac I/O remote monitoring blocks receive power from the terminal blocks and control the relays and solenoid valves. Figure 15 illustrates the four relays and the component to which each relay is connected. Table 3 provides information about each relay connection.

Figure 15. Relay Connections

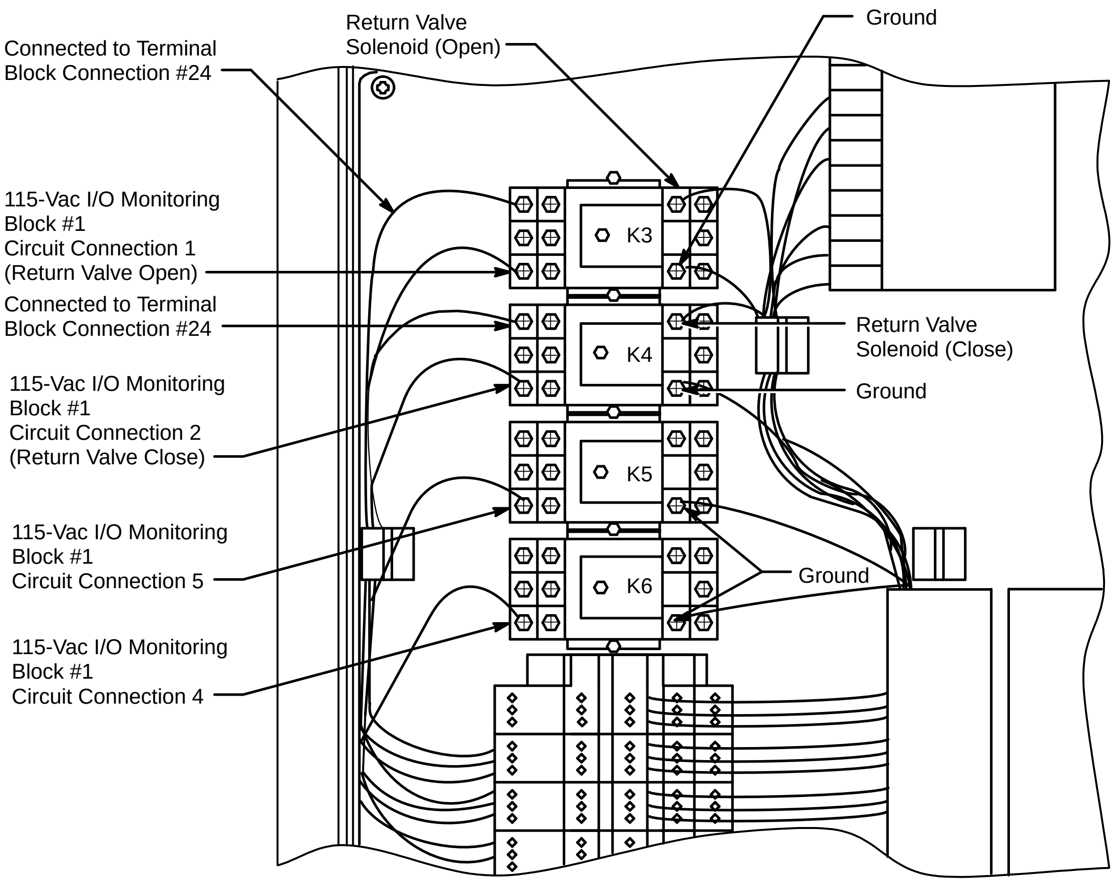


Table 3. Relay Connections

Connection Number	Relays			
	K3	K4	K5 (Not used)	K6 (Not used)
1				
7	Gray terminal block connection #24	Gray terminal block connection #24		
4	Return valve (open)	Return valve (close)		
3				
9				
6				
A	115-Vac monitoring block #1, circuit #1, connection #10	115-Vac monitoring block #1, circuit #2, connection #11	115-Vac monitoring block #2, circuit #5, connection #14	115-Vac monitoring block #1, circuit #4, connection #13
B	Blue terminal block connection #23	Blue terminal block connection #23	Blue terminal block connection #23	Blue terminal block connection #23

Control System

The control system monitors the HEU-T90 for acceptable water and dielectric-coolant temperatures, pressures, and flow rates. The control system also monitors the dielectric-coolant level in the reservoir, drain line, and fill line. This system controls the power-up and power-down process of the HEU-T90 as well as the draining and filling processes of the mainframe and reservoir. Refer to Figure 16 for a block diagram of the control system.

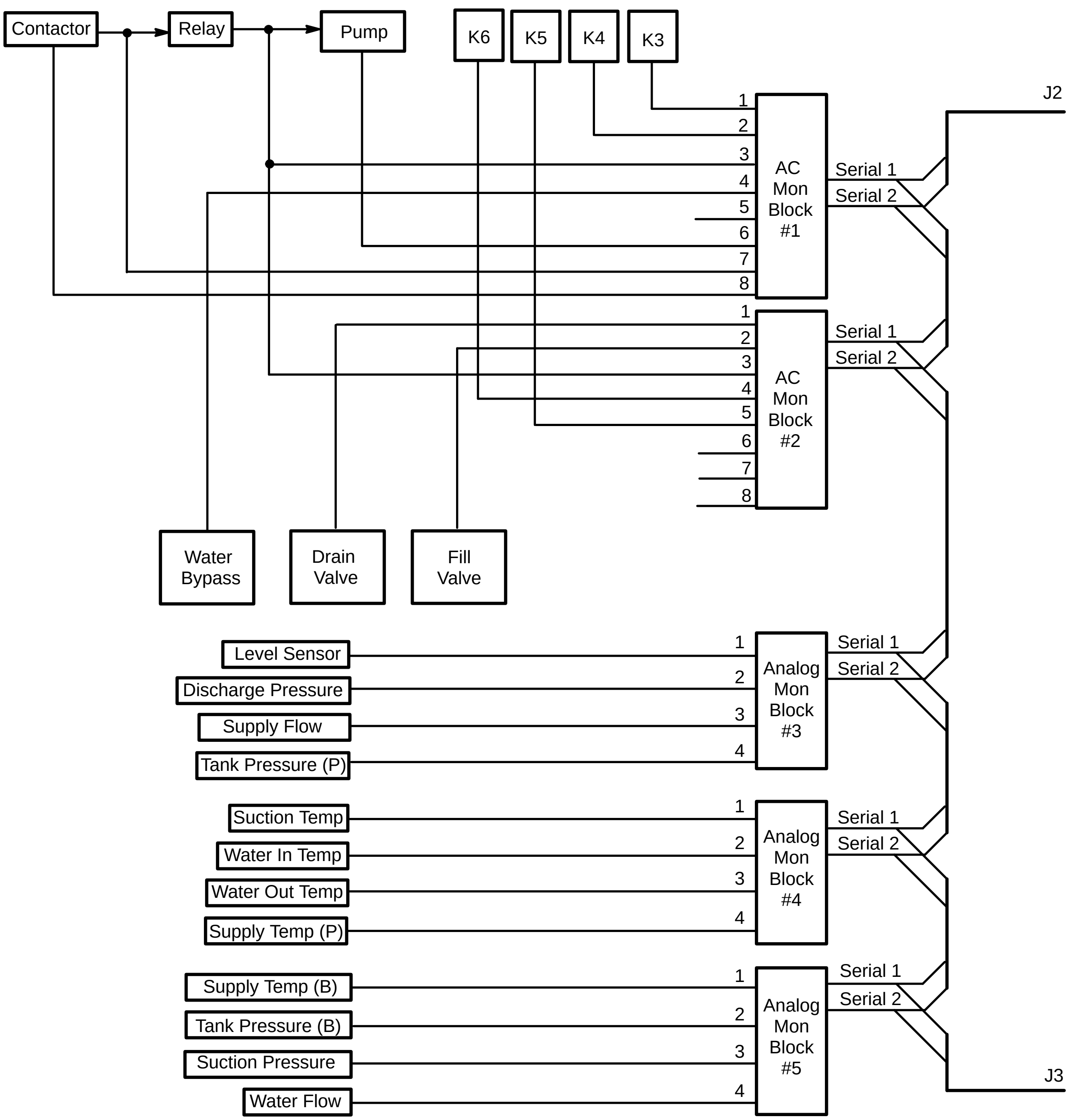
NOTE: This document does not explain the theory of operation for the control system. Only information specific to the HEU-T90 is provided. Refer to the *Control System Overview* document, Cray Research publication number HTM-065-0, for more information about the control system.

Components

The control system receives inputs from temperature transducers, pressure transducers, flow meters, and level sensors. These transducers and sensors send the monitored information to the remote monitoring blocks, which send the information to the programmable logic controller (PLC) on the mainframe. Refer to Figure 17 for the locations of the control system components. The following list describes each sensor.

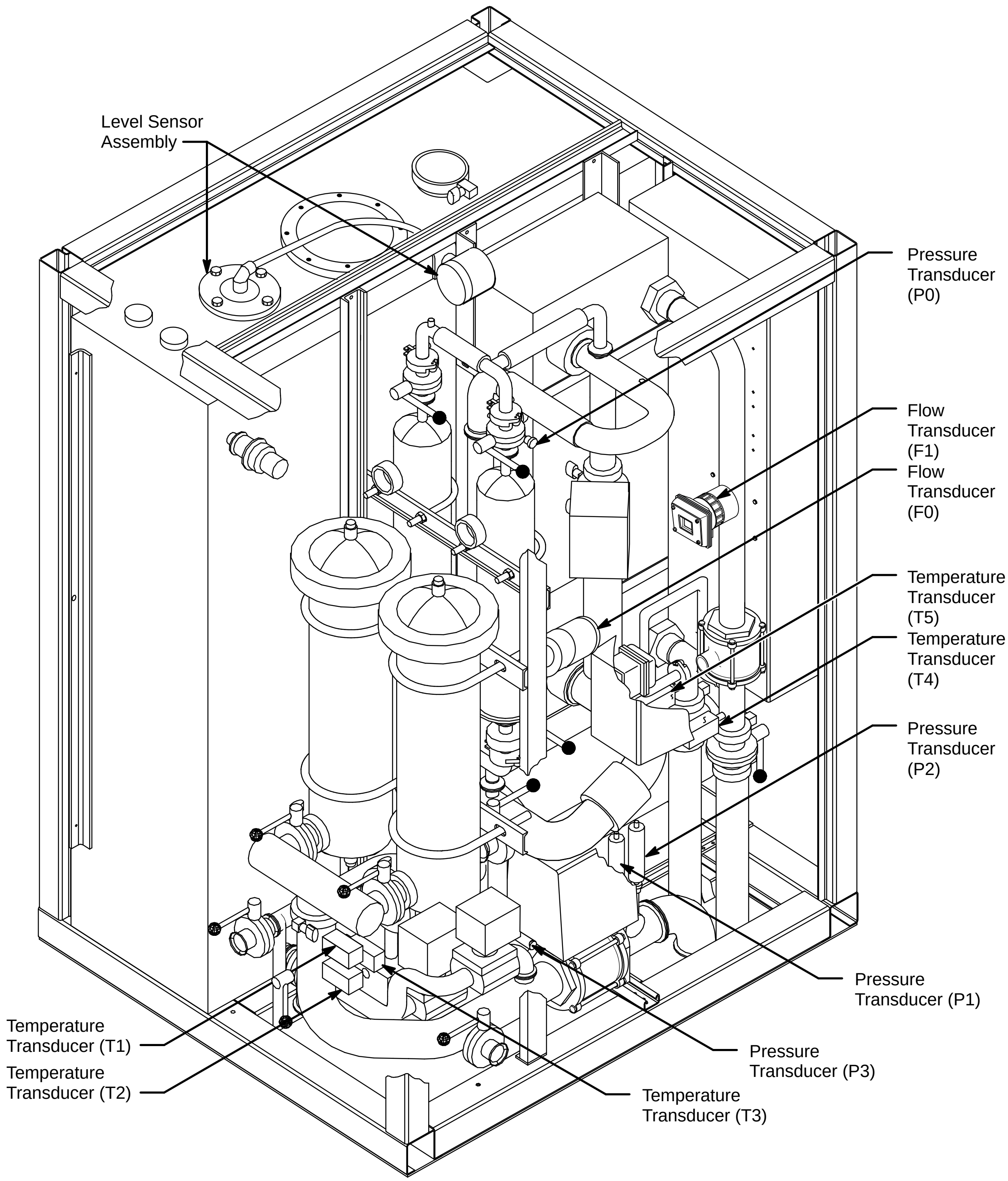
NOTE: Each sensor is labeled with an alphanumeric designator; for example, T1, T2, etc.

Figure 16. Control System Block Diagram



NOTE: The numbers on the lines indicate the circuit numbers on the remote monitoring blocks.

Figure 17. HEU-T90 Control System Component Locations



NOTE: T0 is located on the pump.

Two types of remote monitoring blocks are used in the HEU-T90: three analog I/O monitoring blocks and two 115-Vac monitoring blocks. These remote monitoring blocks are located within the electrical control box (refer to Figure 18).

The remote monitoring blocks are numbered 1 through 5 in Figure 18. (These are the block ID numbers.) Refer to Figure 19 and Figure 20 for more detailed illustrations of these remote monitoring blocks. Table 4 and Table 5 provide information about the 115-Vac monitoring block channels and LED indications. Table 6 provides information about the analog I/O monitoring block channels.

Table 4. 115-Vac I/O Monitoring Block #1 Channel Descriptions

Channel	Condition	LED	Description
1	Return Valve (Open)	On	Return valve is opening; LED is illuminated briefly while valve opens.
		Off	Valve is idle.
2	Return Valve (Close)	On	Return valve is closing; LED is illuminated briefly while valve closes.
		Off	Valve is idle.
3	Pump Enable	On	Pump is enabled.
		Off	Pump is idle.
4	Water Bypass Valve	On	Valve is energized (open).
		Off	Valve is not energized (closed).
5	Not used	On	
		Off	
6	Pump Overtemp	On	Pump is operating normally.
		Off	If HEU is supposed to be running and this LED is not illuminated, a pump overtemperature condition exists.
7	Overload Relay	On	Overload relay is OK.
		Off	If HEU is supposed to be running and this LED is not illuminated, an overload condition exists.
8	Contactor	On	Contactor is OK.
		Off	Contactor has failed.

Table 5. 115-Vac I/O Monitoring Block #2 Channel Descriptions

Channel	Condition	LED	Description
1	Drain Solenoid	On	Valve is energized (closed).
		Off	Valve is not energized (open).
2	Fill Solenoid	On	Valve is energized (open).
		Off	Valve is not energized (closed).
3	Pump Enable (Overload Relay/Pump)	On	Pump is enabled.
		Off	Pump is not enabled.
4	Relay K6	On	Not used; could be illuminated during normal operation.
		Off	
5	Not used	On	
		Off	
6	Not used	On	
		Off	
7	Drain Reservoir	On	Reservoir is draining.
		Off	Idle.
8	Fill Reservoir	On	Reservoir is filling.
		Off	Idle.

Table 6. Analog I/O Monitoring Block Channel Descriptions

Channel	Analog I/O Block #3	Analog I/O Block #4	Analog I/O Block #5
Output 1	Supply Valve	Water Control Valve	Not Used
Output 2	Fluorinert Bypass Valve	Not Used	Not Used
Input 1	Reservoir Level	Suction Temperature	Supply Temperature (B)
Input 2	Discharge Pressure	Water In Temperature	Tank Pressure (B)
Input 3	Supply Flow	Water Out Temperature	Suction Pressure
Input 4	Tank Pressure (P)	Supply Temperature (P)	Water Flow

Figure 18. I/O Remote Monitoring Block Locations

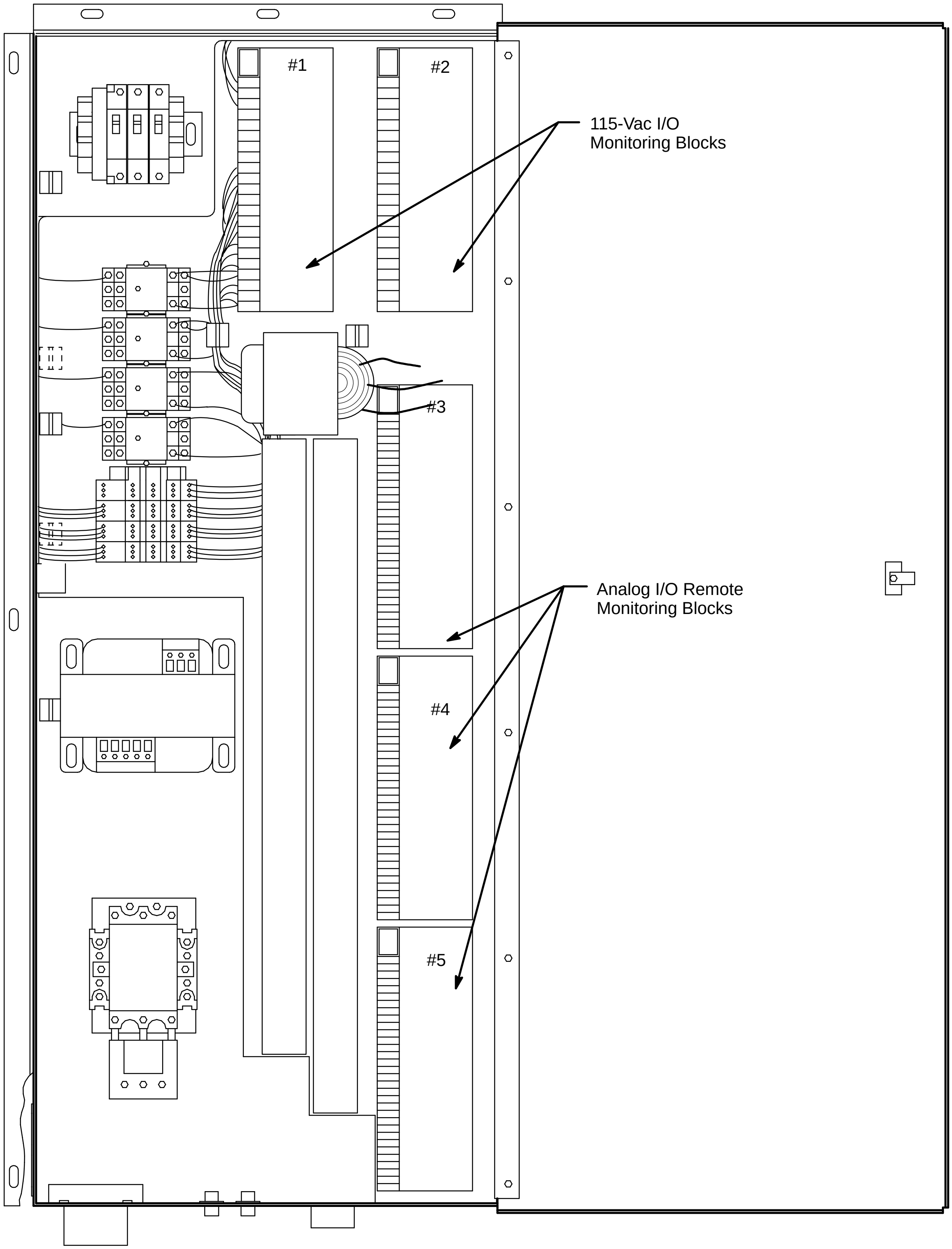


Figure 19. 115-Vac I/O Monitoring Blocks #1 and #2

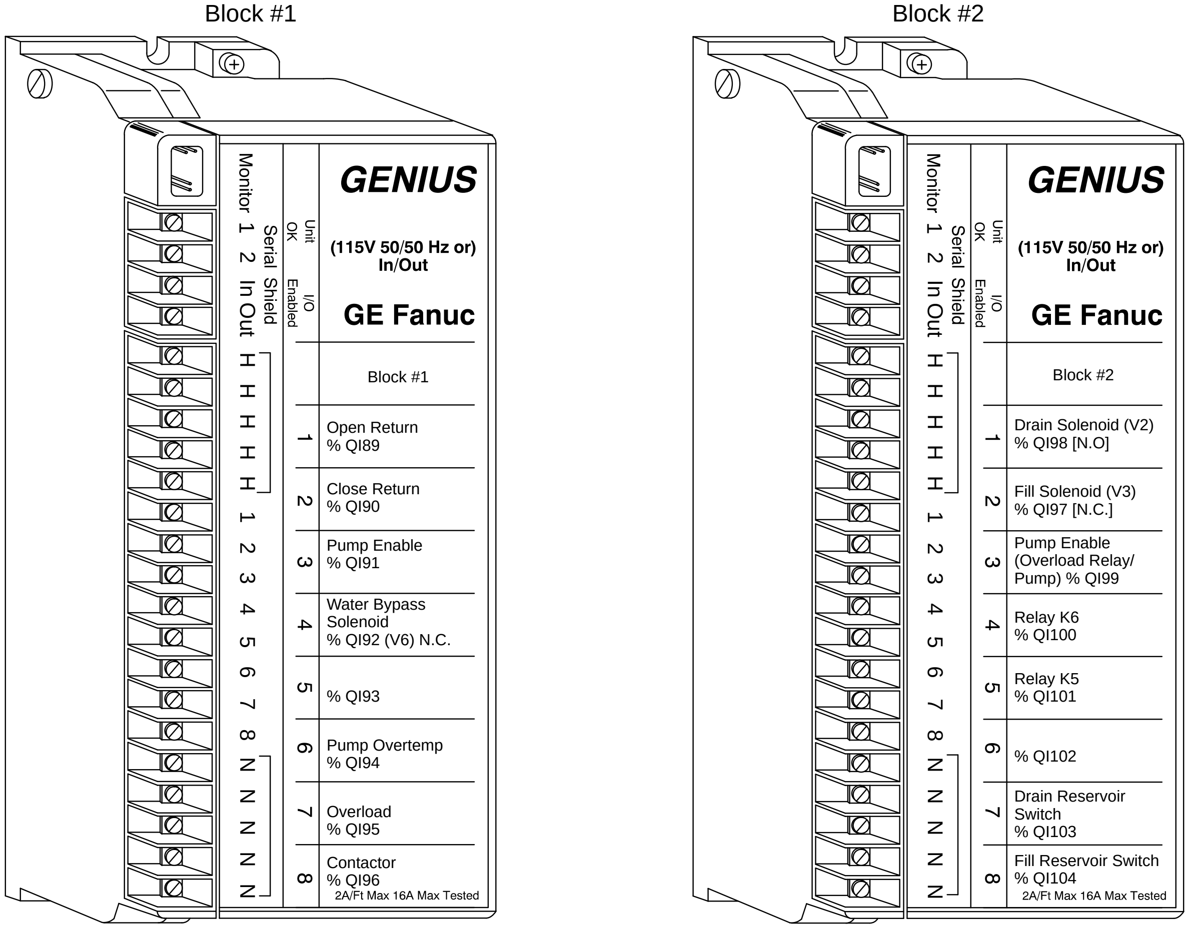
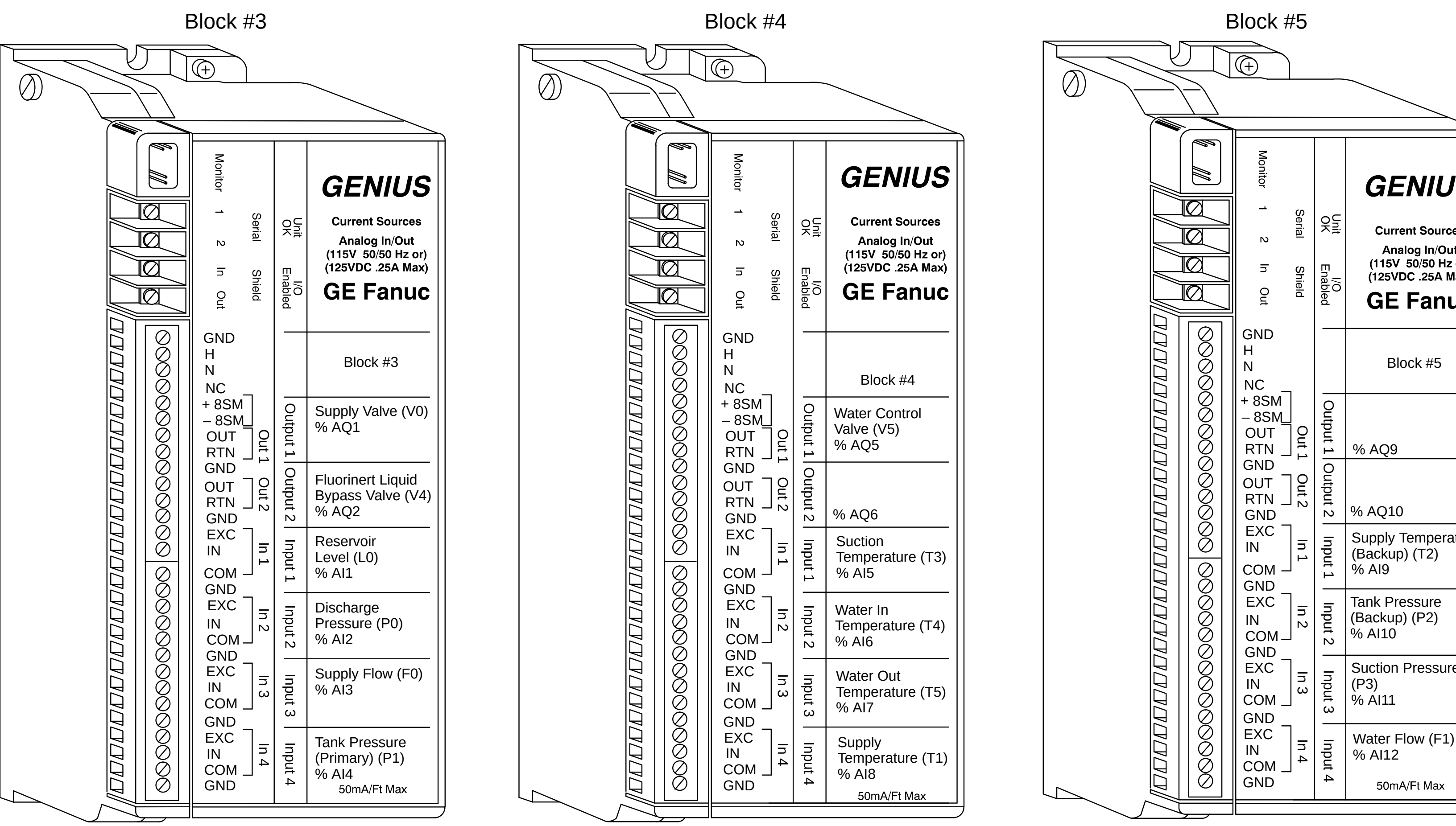


Figure 20. Analog I/O Monitoring Blocks #3, #4, and #5



Monitored Conditions and Limits

Sensors within the HEU-T90 monitor the water and dielectric coolant for certain conditions and ranges. Table 7 provides the sensor type, function, and limits for each monitored condition.

Table 7. Monitored Conditions and Limits

Monitored Condition	Label	Sensor Type	Function	Limits	
				High	Low
Discharge pressure	P0	Pressure transducer	Monitors the discharge pressure of dielectric coolant from the pump	N/A	N/A
Suction pressure	P3	Pressure transducer	Monitors the suction pressure of dielectric coolant before the pump	N/A	N/A
Tank pressure †	P1 and P2	Pressure transducer	Monitors the pressure of dielectric coolant going through the supply line to the mainframe tank	35 psi	19 psi
Suction temperature	T3	Temperature transducer	Monitors the temperature of the dielectric coolant before the pump	N/A	N/A
Water-in temperature	T4	Temperature transducer	Monitors the temperature of water going into the heat exchanger	N/A	N/A
Water-out temperature	T5	Temperature transducer	Monitors the temperature of water coming out of the heat exchanger	N/A	N/A
Supply temperature †	T1 and T2	Temperature transducer	Monitors the temperature of dielectric coolant leaving the heat exchanger	71 ^{o}F 22 ^{o}C	59 ^{o}F 15 ^{o}C
Supply flow ‡	F0	Flow meter	Monitors the flow of dielectric coolant leaving the pump	+6 gpm above normal	–5 gpm below normal
Water flow	F1	Flow meter	Monitors the flow of water leaving the heat exchanger	N/A	N/A
Reservoir level	L0	Level sensor	Monitors the level of dielectric coolant in the reservoir	N/A	Warning at 5%
Pump temperature	T0	Temperature transducer	Monitors for pump overtemperature condition	N/A	N/A

† Primary and backup sensors are used for this monitored condition.
‡ Supply flow depends on the IOS/SSD type.

Self-monitoring Features

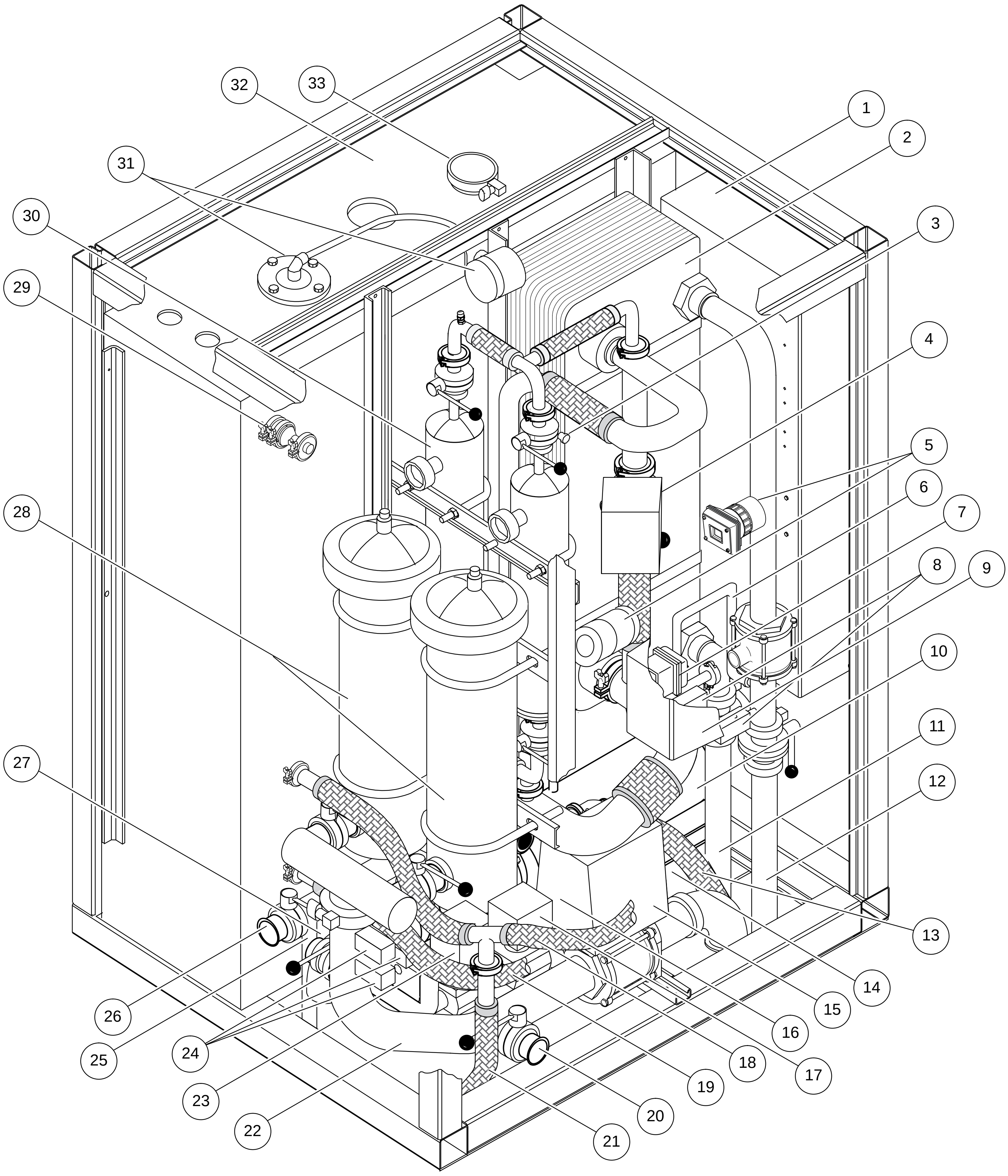
The control system uses monitored values to control the actuated valves in the HEU-T90. Two PID (proportional plus integral plus derivative) systems control and monitor the following conditions:

- Temperature of the dielectric coolant leaving the heat exchanger
- Flow rate of the dielectric coolant entering the mainframe

Two temperature transducers (primary and backup) monitor the temperature of the dielectric coolant leaving the heat exchanger. If the temperature is warmer or colder than the desired temperature (+1 to –3 °C), signals are sent to the bypass valve (V4) or the water control valve (V5) to adjust the amount of warm dielectric coolant bypassing the heat exchanger or the amount of water going through the exchanger.

The flow rate of the dielectric coolant leaving the pump is also monitored. If the flow rate is too low or too high, the control system sends a signal to the actuated supply valve that controls the rate of flow going to the mainframe. The control system adjusts the supply valve to regulate the amount of dielectric coolant flowing to the module cabinet.

Figure 21. Enlarged View of the HEU-T90 Component Locations



No	Description	No	Description
1	Electrical Control Box	18	Cascade Supply Line
2	Heat Exchanger	19	Cascade Return Line
3	Pressure Transducer	20	Drain Port
4	Fluorinert Liquid Bypass Valve	21	Vent/Charge Line
5	Flow Transducer	22	Mainframe Supply Line
6	Water Bypass Line	23	Drain Valve
7	Water Bypass Valve	24	Temperature Transducer (3)
8	Temperature Transducer	25	IOS/SSD Dielectric-coolant Return Line (Only on HEU used with CRAY T94 Systems with an IOS/ SSD Chassis.)
9	Water Control Valve	26	Fill Port
10	Pump	27	Particulate Filters
11	Water Supply Line	28	Return Valve (Under Particulate Filter)
12	Water Return Line	29	Check Valve
13	IOS/SSD Supply Line (Only on HEU used with CRAY T94 Systems with an IOS/SSD Chassis.)	30	Fluid-conditioning System
14	Pressure Transducers (2) (Behind Supply Valve)	31	Reservoir
15	Supply Valve	32	Level Sensor Assembly
16	Pressure Transducer (Behind Fill Valve)	33	Reservoir Fill Port
17	Fill Valve		