ROBICON

LIQUID-COOLED PERFECT HARMONY™ COOLING SYSTEM

The standard liquid-cooled Perfect Harmony™ drive utilizes a pressurized, closed-loop cooling system where coolant circulates between the drive input transformer/power cell heat sinks/residual heat exchangers and a liquid-to-air or liquid-to-liquid heat exchanger.

COOLING SYSTEM PHILOSOPHY

The cooling system of a variable frequency drive is a critical element of the overall system. The effective thermal management of the heat producing components, combined with a system design which properly considers the ability to install, maintain, and monitor the system can substantially impact the reliability and availability of the drive, and as such, the customer process.

COOLING SYSTEM DESIGN OBJECTIVES

The following elements are considered essential to the design of a reliable, available, and maintainable cooling system:

- ☐ Effective cooling and thermal management of heat producing system components.
- ☐ Maintenance of low conductivity of the cooling fluid.
- ☐ Temperature control which not only addresses maximum temperature limits, but also considers minimum temperatures (low temperatures that can result in condensation and resultant fault and hazard).
- ☐ Effective early alarm indication and continuous monitoring capability, allowing the process operator to control and program potential process interruptions.
- ☐ Consideration of materials of construction and of air contamination in the cooling circuit, thereby eliminating electro-galvanic corrosion and reducing ion build-up.
- ☐ System design which considers redundancy of critical components.
- ☐ Ability to isolate and change out critical coolant monitoring probes and the coolant deionizer tank without interrupting the process.
- ☐ Protection schemes that assure critical coolant parameters are within tolerance (flow, temperature, and conductivity).
- ☐ Installation and maintenance capabilities that consider:

    - ➢ Ability to easily fill and drain the system and purge it of trapped air.
    - ➢ Ability to isolate and remove components without having to completely drain the system.

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ROBICON LIQUID COOLING SYSTEM DESIGN

Robicon Perfect Harmony™ Variable Frequency Drive Systems employing Size 5H and larger power cells utilize liquid-cooling. These drives have nominal output current ratings from 500 to 1250 amps RMS continuous, and nominal output line-to-line voltages from 2,400 to 7,200 volts RMS.

The liquid-cooled Robicon Perfect Harmony™ VFD System is a totally integrated system that typically includes the following system elements:

- Customer input and output medium voltage terminations
- Liquid-cooled dry-type input isolation transformer
- Liquid-cooled power converter (power cells)
- Control and cooling including customer control I/O and control power terminations
- System heat exchanger

The standard system includes all of these items, except a liquid-to-air type heat exchanger, housed in NEMA 12 cabinetry. A liquid-to-liquid system heat exchanger is typically supplied integral with the drive. A liquid-to-air system heat exchanger is typically supplied stand-alone for remote installation.

Small air-to-liquid heat exchangers are installed within the input isolation transformer and power cell cabinets to remove 'residual' heat produced by transformer stray losses, transformer-power cell interconnecting buswork, power cell input fuses, and power cell output cable.

A typical system flow diagram is attached for reference at the end of this document.

KEY POINTS OF DESIGN AND CONSTRUCTION

The coolant system utilizes copper pipe and non-conductive rubber hose. All drive piping and hosing is contained within the NEMA 12 cabinetry.

Fixed piping connections are soldered. Where flexible piping connections are required, non-conductive rubber hose, fastened with industrial grade clamps, is used.

Self-isolating quick-disconnect coolant connections are provided for each power cell.

Customer connections to the drive piping are typically via hose barb or AISI flange connection.

Pipe diameters are selected to ensure no particle erosion due to excessive coolant flow rates.

All system high points are fitted with a ball valve or auto-vent valve to purge air from the system.

Two (2) 100 percent redundant coolant pumps are provided standard with each drive system. These pumps are automatically cycled by the drive main microprocessor control to ensure availability and to prevent dry-up of the pump seals. Strainers are provided at the suction of each coolant pump.

A 3-Way Water Mix type valve is employed in each system to maintain the coolant inlet temperature to the drive at 35 degrees C. This valve is a self-actuating control valve that automatically maintains the desired set point without the use of external power.

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The normal operating pressure of the system is approximately 7 bars (100 PSI). The system is factory pressure tested at 8 bars (120 PSI) to check for leaks and assure all connections are proper. The system coolant tank provides space for the coolant volume to expand and contract, resulting in a nearly constant pressure throughout the system at all times.

A mixed bed deionizer bottle is constantly in service 'polishing' the coolant. This bottle can be isolated and replaced with the system in service.

The standard liquid-to-air heat exchanger is designed for stand-alone service remote from the drive. This exchanger is a force-air cooled, multiple-row, aluminum finned copper tube type unit employing TEFC motors with an integral control package. The standard arrangement is for the exchanger to be supplied with N-1 cooling fans. Piping/hosing and any control wiring between the drive and this exchanger is typically the customer's responsibility.

The standard liquid-to-liquid heat exchanger is supplied in a NEMA 12 cabinet integral with the drive system. This exchanger is a stainless steel plate/carbon steel frame type.

COOLANT

The coolant is a mix of deionized water and industrial grade ethylene or propylene glycol. The glycol must contain no additives or inhibitors. Robicon typically supplies both the deionized water and glycol as part of the drive system scope of supply.

INSTALLATION, MAINTENANCE, AND REPAIR

The following items are typically furnished with each drive system:

- Deionized water and glycol.
- A spare mixed bed deionizer bottle.
- A lift to handle the power cells.
- A hose clamp and plug kit to minimize coolant spillage/loss should it become necessary to remove an individual power cell for maintenance. Note self-isolating quick-disconnect coolant connections are also provided for each power cell.

All drive systems are delivered dry [no coolant in the system].

Strainers are provided at the suction of each coolant pump.

All system high points are fitted with a ball valve or auto-vent valve to purge air from the system.

In the event it becomes necessary to remove/replace a system component, strategically located isolation valves limit the loss of coolant, greatly reduce the risk of cooling system contamination, and minimize the mean time to complete repairs. Based on detailed instructions provided in the Robicon User's Manual, system components can be readily removed, cooling fluid levels restored, and air purges completed without the need to fully drain the system.

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CONTROL

Robicon Perfect Harmony™ liquid-cooled drive systems are typically furnished with ProToPS© [Process Tolerant Protection Strategy] control. This is inherent software built into the drive that the customer can configure based on his or her own unique process requirements. With ProToPS©, the drive reacts to drive system alarm and trip conditions based on the unique requirements of the process being served.

The typical ProToPS© setup for liquid-cooled drive systems is as follows:

Condition			ProToPS Category			
Category	**Problem Detected**	**Drive Response**	**Alarm Modbus address**	**Process Alarm Modbus address**	**Trip Alarm Modbus address**	**Trip Modbus address**
MV Input Transformer	Winding hot spot overtemperature	Process Alarm, Trip Alarm, & Trip		Temp >65 °C Register 6074 Bit 6	Temp > 82 ° C Register 6074 Bit 7	Temp > 65 & 82° C for 30 seconds Register 6050 Bit 8
Converter/ Inverter Power Cell	Overtemperature alarm Cell heat sink > 80 ° C	ProcessAlarm		Cell overtemp alarm Register 6071 Bit 3		
	Overtemperature trip Cell heat sink > 90 ° C	Alarm Automatic cell bypass	Cell overtemp fault Register 6047 Bit 4			
Liquid-cooled Drive	Loss of one internal HEX fan	Alarm	Loss of one HEX fan Register 6075 Bit 1			
	Loss of internal HEX fan 120VAC power	Process Alarm		Loss of all HEX fans Register 6075 Bit 2		
	Loss of one coolant pump	Alarm	Loss of one pump Register 6074 Bit 9			
	Loss of both coolant pumps	Trip Alarm			Loss of both pumps Register 6074 Bit 10	
	Coolant conductivity high	Process Alarm & Trip Alarm.		Conductivity > 3 uS Register 6074 Bit 11	Conductivity > 4 uS Register 6074 Bit 12	
	Coolant temperature at drive inlet high	Process Alarm & Trip Alarm.		Temp > 45 ° C Register 6074 Bit 13	Temp > 50 ° C Register 6074 Bit 14	
	Coolant temperature at drive inlet low	Alarm	Temp < 33 ° C Register 6074 Bit 15			
	Coolant temperature at drive outlet high	Process Alarm & Trip Alarm.		Temp > 55 ° C Register 6078 Bit 1	Temp > 60 ° C Register 6078 Bit 2	
	Coolant tank level low	Process Alarm & Trip Alarm.		Level < 30 inches Register 6078 Bit 3	Level < 20 inches Register 6078 Bit 4	
	Low coolant flow	Alarm	Loss of coolant flow Register 6078 Bit 5			
				↑ **INHIBIT ANY INCREASE OF VFD LOAD**	↑ **REDUCE VFD LOAD BY 10 % MINIMUM**	

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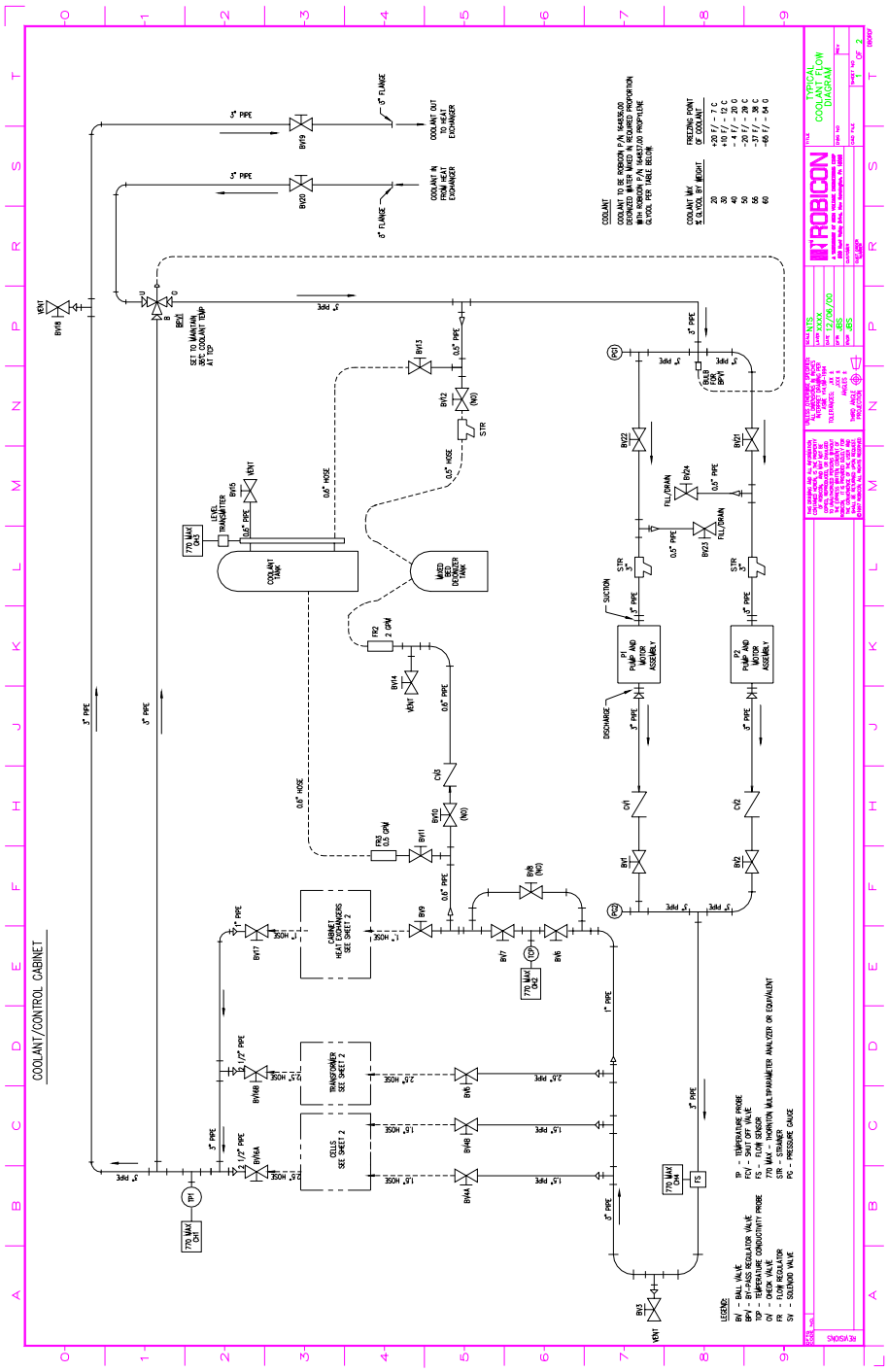

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