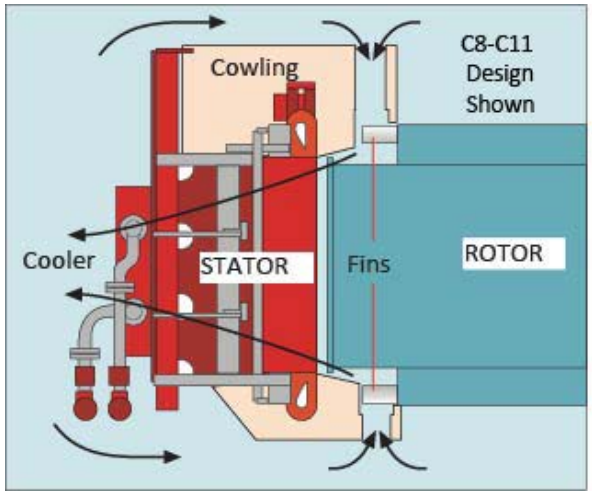
Generator Cooling Water System

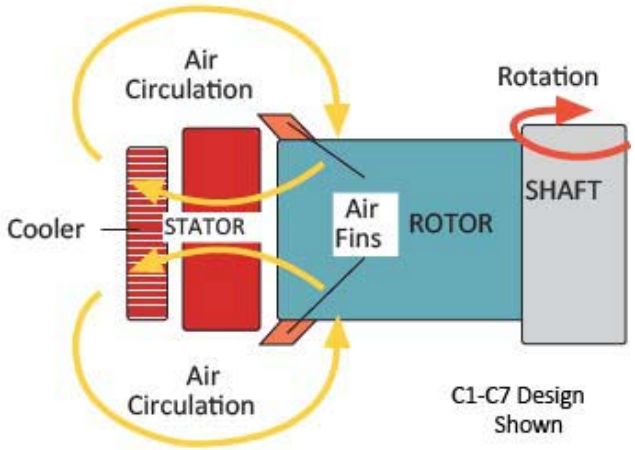
Rocky Reach

Table of Contents

OVERVIEW

The generator cooling system is designed to maintain generator stator temperatures with as small a differential as possible under varying load conditions between 50 MW and maximum output. River water delivered from the raw water header is circulated through a series of cooling coils installed around the stator. Fins on the top and bottom of the rotor circulate the air around the stator and cooling coils. Units C8-C11 have been retrofitted with new cowlings to focus air movement across the rotor and stator, as shown in the diagram below.

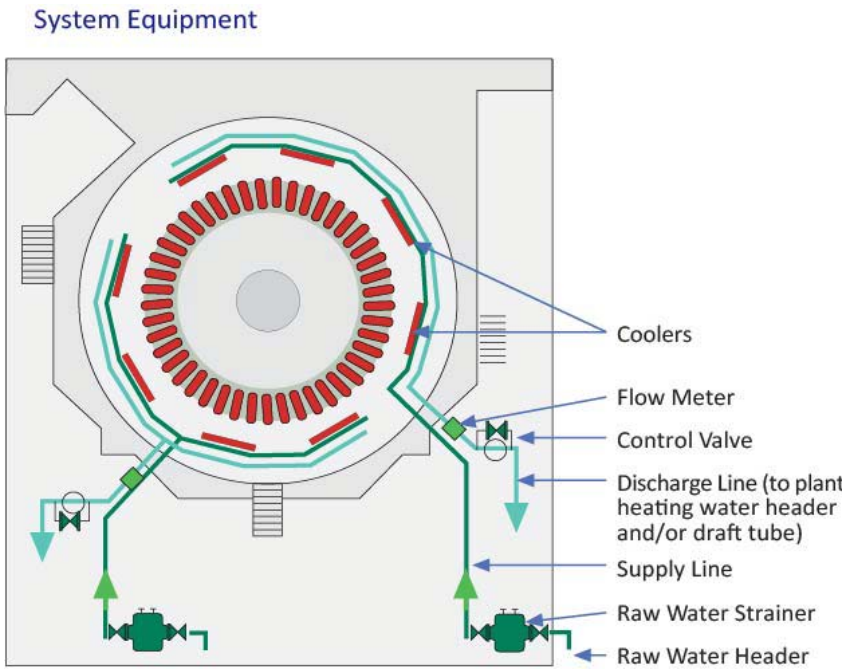




The degree of cooling supplied by the system depends on the temperature of the river water and the flow rate of the water through the cooling coils. Water flow rate is regulated by the position of automatically-controlled discharge valves. The unit PLC continuously monitors the stator outlet air temperature. The outlet temperature is compared to the target setpoint. Programming logic (a Proportional Integral Derivative Loop) determines the proper positions for the discharge valves to maintain the target temperature.

System Equipment

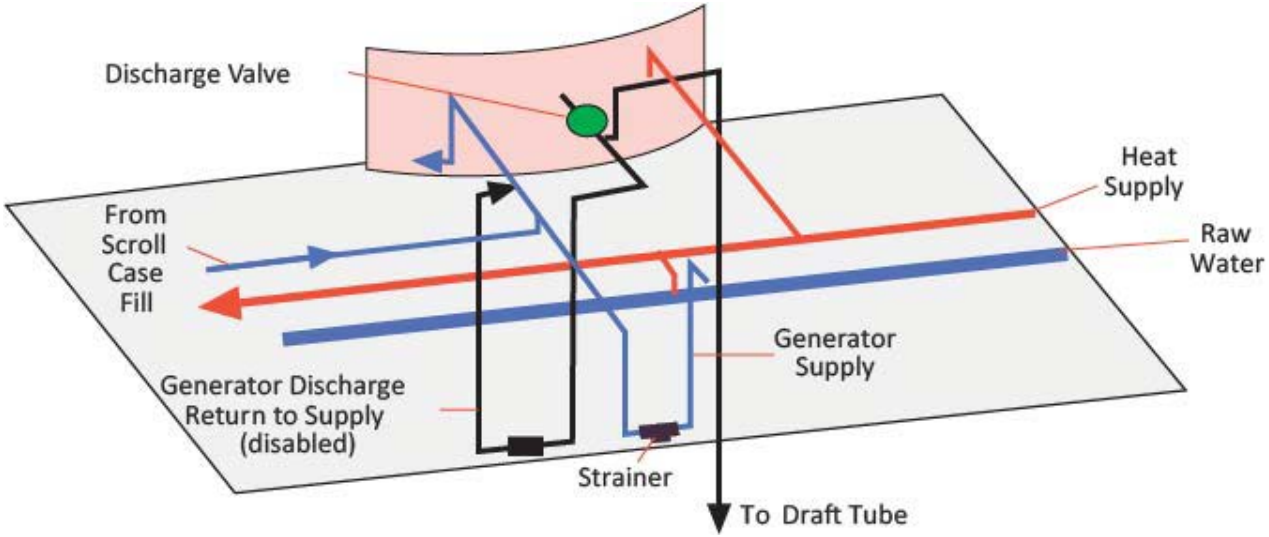
The generator cooling equipment on the small and large units was similar prior to the 1998-2001 rehabilitation. Units C8-C11 were retrofitted with a new stator and cooling system designed by ABB during rehab to improve cooling efficiency. The discharge control valves were replaced on units C8- C11. Similar Samson discharge valves will replace the ITT valves on C1-C7 over the next few years.



	C1-C7	C8-C11
Cooling Coils per Unit	8	12
Typical Target Temperature	27□C	29□C
Inlet Air RTDs per Unit	3	4
Outlet Air RTDs per Unit	3	4
Discharge Flow Meters	Yokogawa	ADMAG
Discharge Valves	ITT / Honeywell	Samson
Valve Positioning Mechanism	Hydraulic	Pneumatic

History:

Rocky Reach was originally designed as a run of the river plant. The original seven units were to be base loaded the majority of the time with little load fluctuation. The powerhouse heating system was designed to use the generator waste heat (discharge water) during the winter. To provide adequate heat some of the discharge water was recycled into the supply line using a recirculation pump. In the summer all the discharge water was spilled to the tailrace.



Modern operating practices demand more cooling capacity (to keep the stator cooler) and unit output is regularly adjusted based on power demand and water availability. The practice of recirculating discharge water into the generator cooling water supply line has been abandoned. Discharge water is still used to heat the powerhouse, but heating demands are not considered when controlling the system. More cooling coils and redesigned rotor fins and cowling were added to units C8-C11 to increase cooling capacity. This work was done by ABB as part of the stator and generator cooling system redesign. New discharge valves and monitoring equipment were installed on all units. Scroll case water is now added to the supply from the raw water header to meet the increased demand for cooling water on units C4-C11, and units C1-C3 are used to heat the powerhouse.

Operating Modes

Automatic - The controller adjusts the cooling water discharge valves to maintain the desired air outlet temperature. The setpoint is input by the operator using the unit PLC generator cooling water screen (or P.I.D. screen).

Manual - The operator can also control the cooling water valve position manually using the unit PLC generator cooling water screen.

Monitoring Equipment

The stator outlet air temperature is monitored for system control. The stator inlet air temperature and the generator cooling water pressure, temperature and flow rate are monitored to detect alarm conditions. There are fourteen PLC alarms associated with the generator cooling system.

Nameplate Information

C1-C7

Flow Meter
- Manufacturer: Yokogawa
- Model: 2300-AB1
- Size: 4 inch

Valve Positioner
- Manufacturer: ITT/Hydra-Motor
- Model #: H31A1221B1701F1M
- Oil Type: ML 856

Discharge Valve
- Manufacturer: Honeywell
- Model: D4534-1
- Size: 6 inch

Nameplate Information

C8-C11

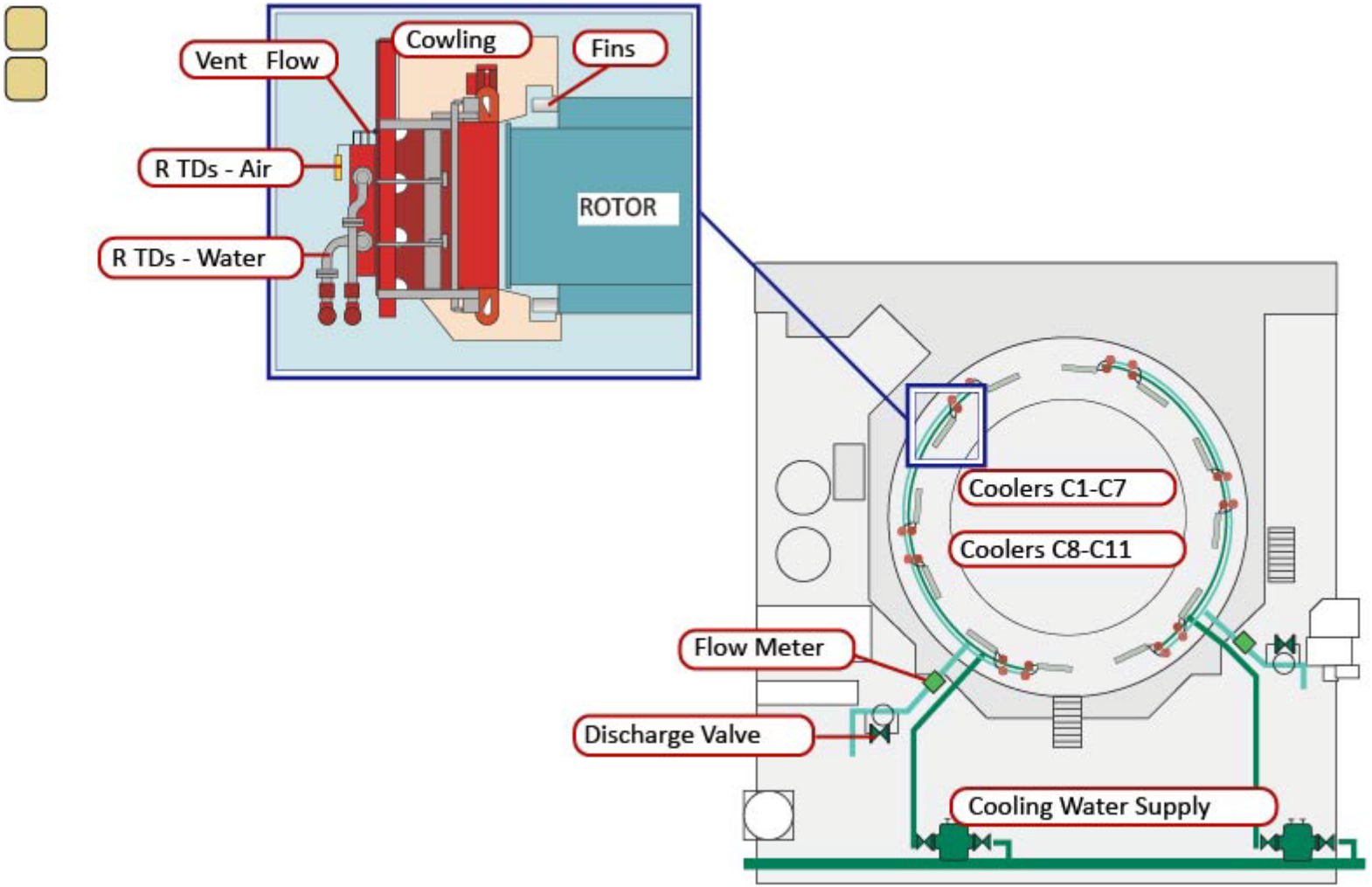
Flow Meter
- Manufacturer: ADMAG
- Model: RE210MN
- Style: S1

Valve Positioner
- Manufacturer: Samson
- Model #: 3277-907
- Serial #: 9028
- Stroke: 30mm

Discharge Valve
- Manufacturer: Samson
- Model: CL150
- Size: 6 inch

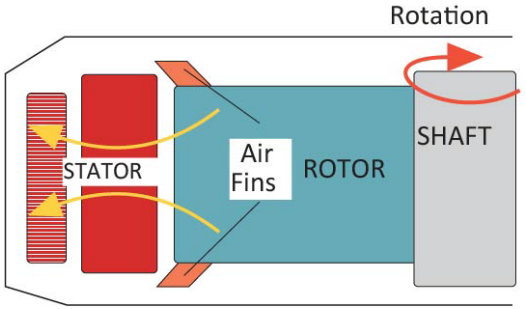
COMPONENTS

System Components



Rotor Fins and Cowling

As the rotor spins, the fins attached to the top and bottom edges of the rotor circulate the air around the rotor, stator, and generator coolers. On units C8- C11, the fins are curved to direct air flow rather than just stir up the air. The large units are also equipped with a fiberglass cowling that fits tightly around the top and bottom of the stator and contains air channels to direct air movement. These revisions were made by ABB as part of the new stator package (1998-2001 rehab).



Air Fins Mounted on the Rotor: C8-C11

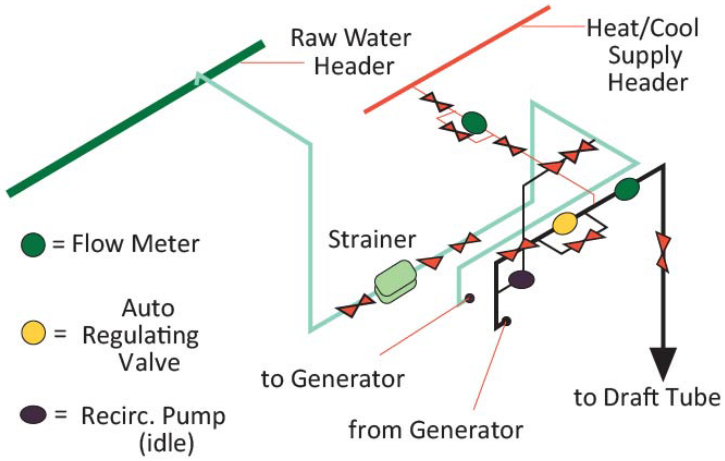
Air Channels Built into the Cowling: C8-C11

Cooling Water Supply

The primary source of cooling water is the raw water header. It runs the full length of the powerhouse along the roof of the turbine floor (elevation 630 feet). River water is drawn through an intake strainer behind the stoplogs at unit 11 (elevation 682 feet) to pressurize the raw water header. Pressure in the raw water header is roughly 30 psig.

At each unit there are two six inch taps from the raw water header, one supplying the north set of generator cooling coils and one supplying the south set of coils. Piping and recirculation pumps permit the return water to be reintroduced to the generator cooling supply lines, but this option is no longer used.

Scroll case water is used to supplement water in the raw water header. A ten inch pipe connects the raw water header to the scroll case fill pipe on the south side of each unit. The scroll case fill valve (traditionally called the actuator fill valve) separates the two systems. It is standard practice to leave the actuator valve open on units C4-C11. If demand for raw water reduces the water header pressure, scroll case water will flow into the header to supplement the supply. A high level of impurities can often introduced from units C1-C3, so these valves are kept closed.

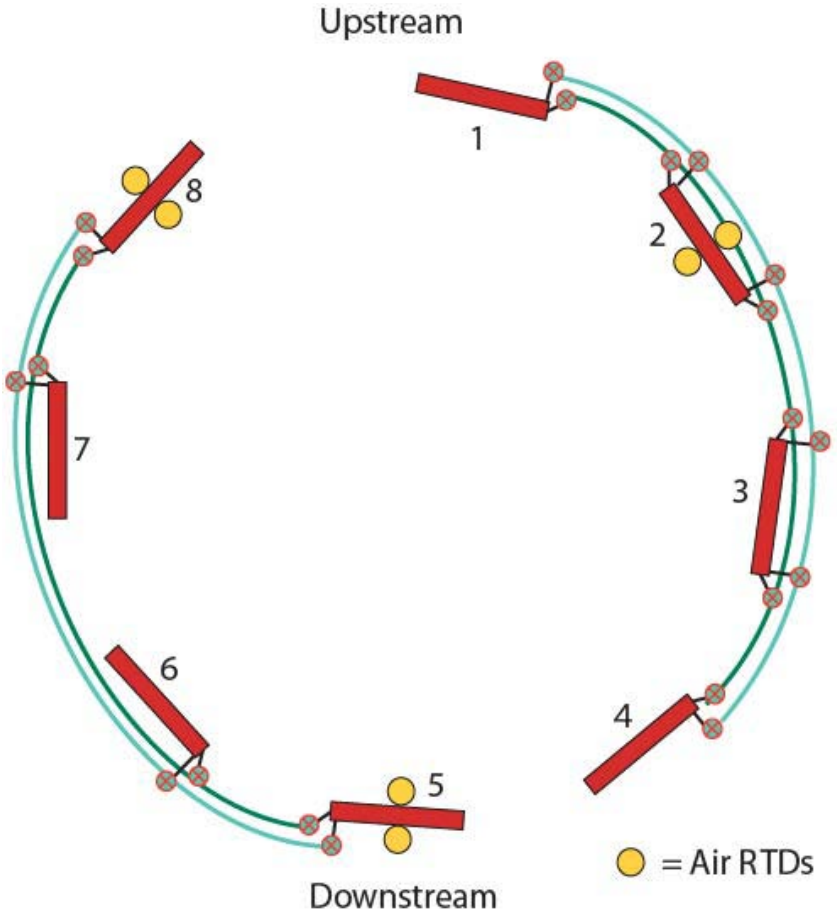


For more information, see the OMI titled, “Raw Water (Unit Service Water)”.

Coolers C1-C7

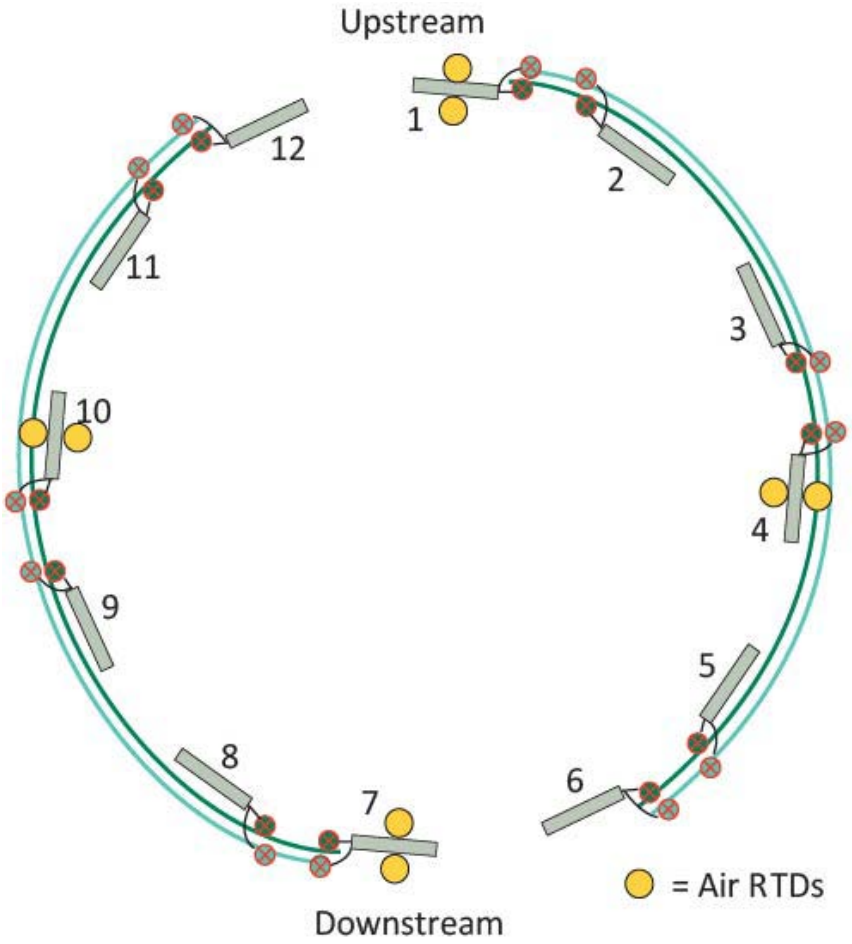
There are eight cooling coil radiators surrounding the C1-C7 stators, divided into north and south halves. Each cooler can be individually isolated from the supply and return lines for maintenance. They were manufactured by Westinghouse Corporation and installed as original plant equipment.

Supply and Return Water Headers and Shutoff Valves



Coolers C8-C11

There are twelve cooling coil radiators surrounding the C1-C7 stators, divided into north and south halves. Each cooler can be individually isolated from the supply and return lines for maintenance. All this equipment was replaced as part of the 1998-2001 rehab project.



Radiator Vent Flow

Air entrapped in the radiators impedes water flow and cooling efficiency. Radiators are equipped with vents to purge air in the system after maintenance.

Vent Pipe and Header: C1-C7

The radiators on C1-C7 are equipped with a vent flow header to prevent air blockage in the coolers. The vent flow valve on each radiator is left cracked open to permit continuous flow and eliminate air blockage.

Vent Pipe: C8-C11

The radiators on C8-C11 do not have a header so the valve must be manually operated to bleed entrapped air.

RTDs – Water Temperature Sensors

RTDs (Remote Temperature Detectors) record the water temperature flowing into and out of the radiators. These RTD's are strategically located to indicate problems in water circulation or generator overheating due to MW or MVAR loading. RTD signals are sent to the PLC and monitored for alarm conditions.

Water Temperature Sensor: C1-C7

C-1 through C-7

There are eight outgoing water temperature RTD's (one for each cooler) and two incoming water temperature RTD's (one each at the last cooler on the north and south headers.

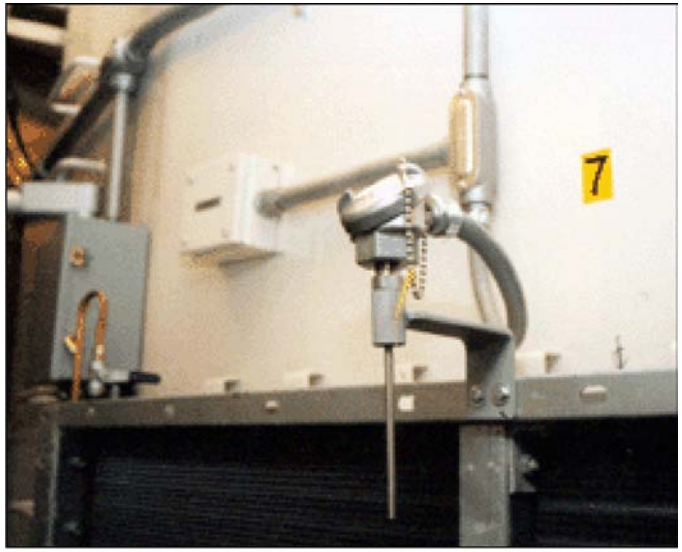
C-8 thru C-11

There are twelve outgoing water temperature RTD's (one for each cooler) and two incoming water temperature RTD's (one each at the last cooler on the north and south headers.

RTDs – Air Temperature Sensors

RTDs (Remote Temperature Detectors) record the air temperature flowing into and out of the radiators. Three of the eight radiators on units C1-C7 are monitored. Four of the twelve radiators on C8-C11 are equipped with RTDs. The generator air output RTDs (pictured below) provide the values used by the PLC to control cooling water flow and are also used for alarming. The generator air inlet readings are used only for alarming. RTDs embedded in the generator stators are also used for alarming.

Air Temperature Sensor: C1-C7



Air Temperature Sensor: C8-C11

To see the specific coolers equipped with RTD, see the previous screens describing the **C1-C7 Coolers** and the **C8-C11 Coolers**.

Water Flow Meters

Water flow meters are installed on both cooling water discharge lines on all units. Units C1-C7 use Yokogawa flow meters, while C8-C11 have ADMAG flow meters. In all cases the flow meters are installed upstream of the discharge control valves just after the discharge lines exit the generator cylinder wall. The cooling water flow rate is continuously monitored by the unit PLC. If the flow rate drops below a preset amount, a low flow alarm is annunciated.

Water Flow Meter: C1-C7

Water Flow Meter: C8-C11

Water Discharge Valves

The discharge water control valves are installed downstream of the discharge water flow meters. These globe valves are remotely controlled to vary the flow of cooling water through the coolers to match a target temperature for the air adjacent to the generator stator.

The ITT/Honeywell valves (now owned by Asco) use a hydraulic mechanism to control the position of the valve. Parts for these valves have become difficult to obtain, and the valves will be replaced with Samson valves as the old valves fail. The Samson valves are equipped with a pneumatic valve positioning mechanism. This mechanism maintains a pre-selected relationship between the valve stem position and an output signal sent from the unit PLC. Wiremen are responsible for ***valve calibration***.

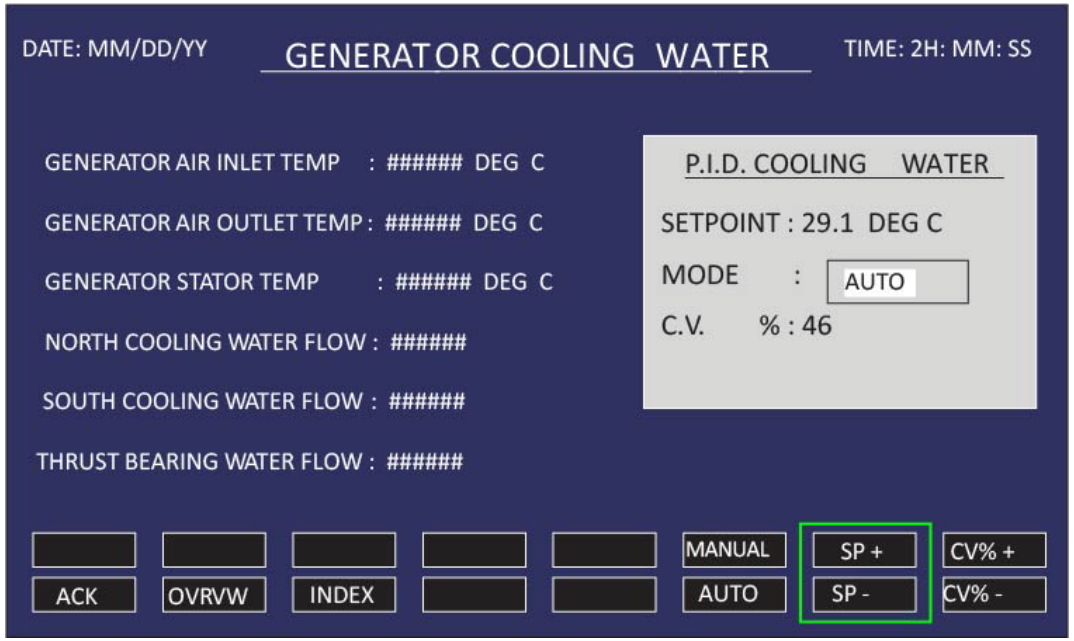
ITT/Honeywell Globe Valve with Hydraulic Positioner : C1-C7

Samson Globe Valve with Pneumatic Positioner : C8-C11

OPERATIONS

Automatic Control

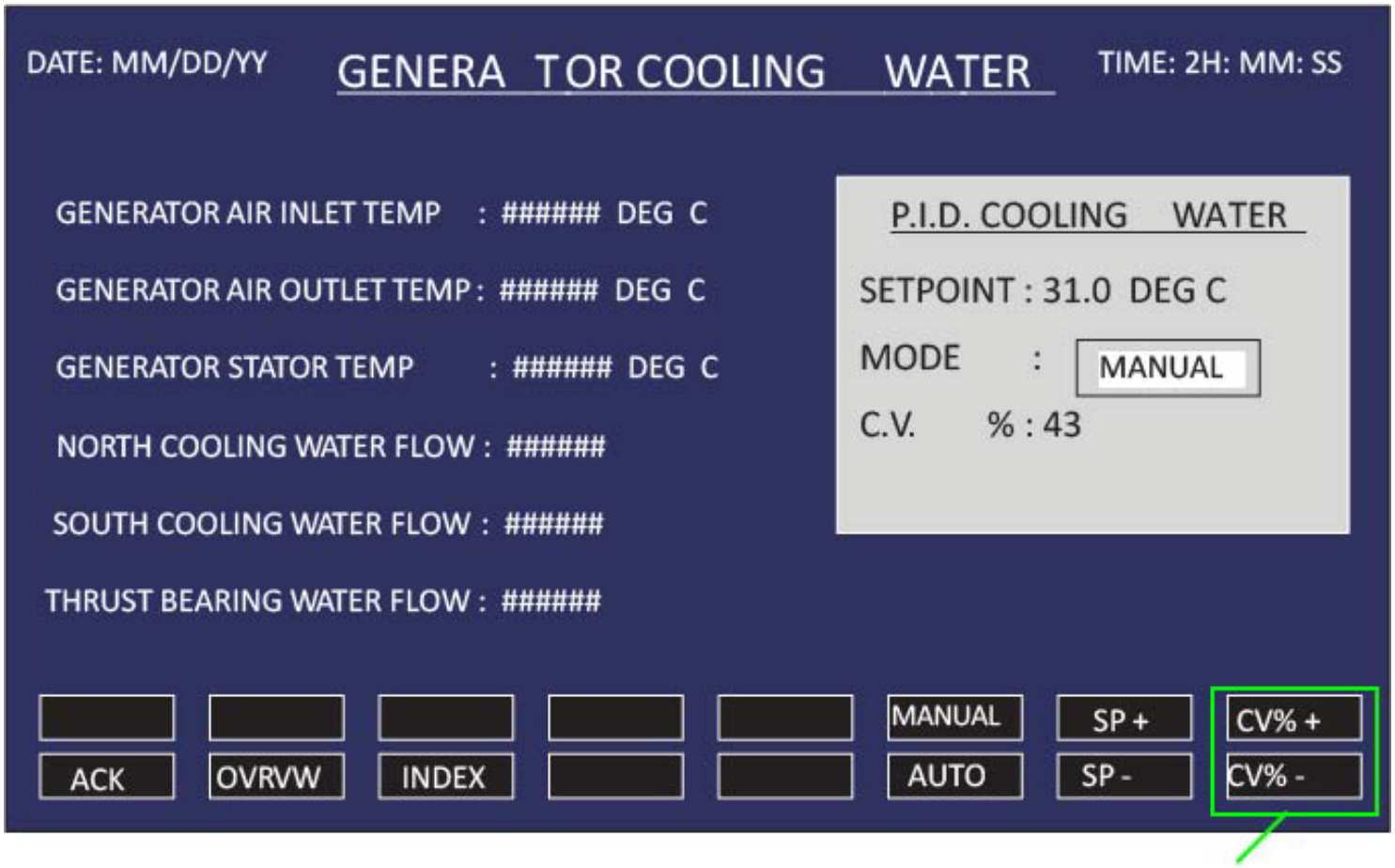
The generator cooling system is designed to operate without intervention from the operator. The equipment is not included in the operator's daily inspection. However, there are occasions when the operator needs to control the cooling water discharge valve manually. For both automatic and manual discharge valve control, the unit PLC's Panelview Generator Cooling Water screen is used.



In Automatic Mode, the controller adjusts the cooling water discharge valves to maintain the desired air outlet temperature. The operator uses F7 (SP+) and F15 (SP-) to set the temperature target. The normal setpoint for units C1-C7 is 29°C and for units C8-C11 is 27°C.

Manual Control

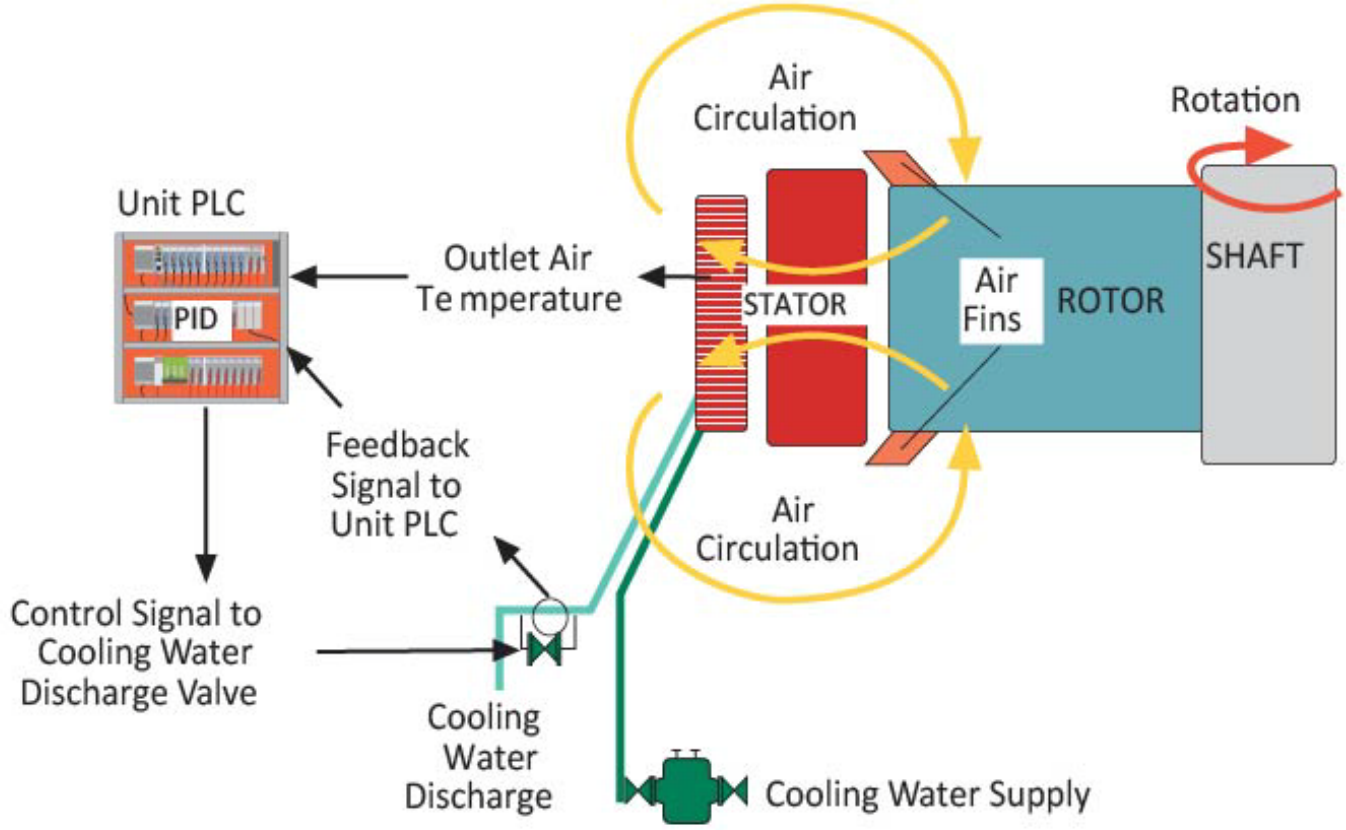
In Manual Mode, the operator can control the cooling water valve position by pressing F8 (CV%+) or F16 (CV%-) to open or close the valve.



Control Theory

The unit PLC continuously monitors the stator outlet air temperature. The outlet temperature is compared to the target setpoint. Programming logic (a Proportional Integral Derivative Loop) determines the proper positions for the discharge valves to maintain the target temperature.

To read more about control theory and how PID loops work, click here. View Process Control Abstract.



ALARMS

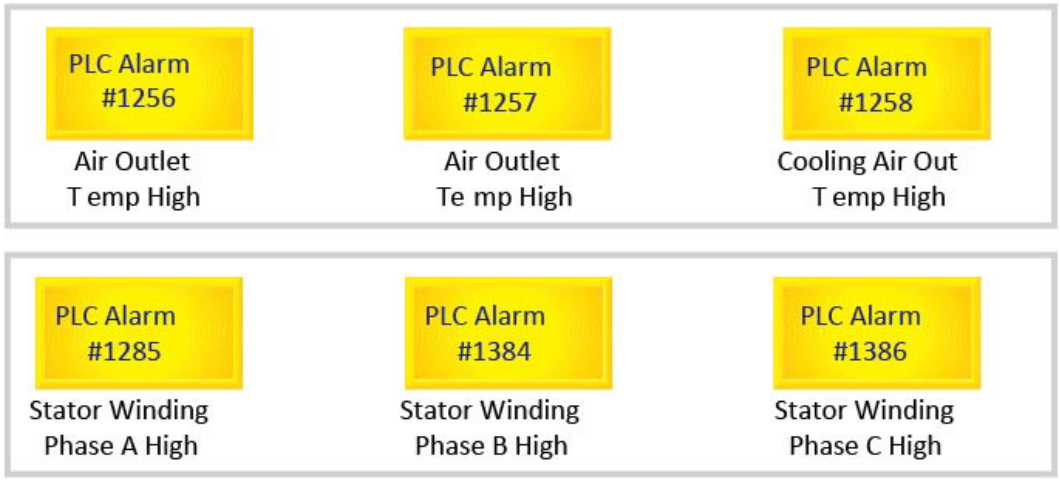
Alarm Signaling

There are 14 alarms associated with the generator cooling system. The alarms alert the operator of conditions which may result in overheating and subsequent damage to the generator stator and rotor.

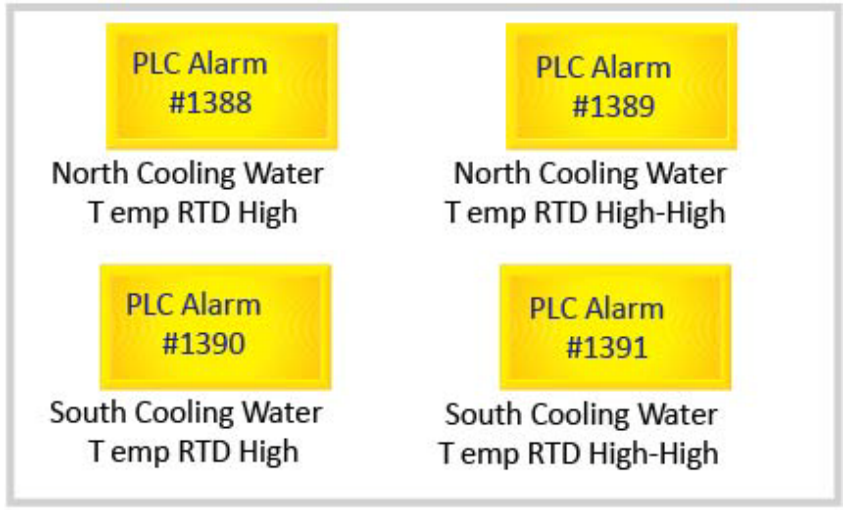
Alarms initiated by sensors associated with the cooling system are sent to the unit PLC. The unit PLC alerts workers in the local unit area with a red light and an alarm message on the PanelView monitor. A duplicate PanelView monitor displays the same alarm message in the control room. The unit PLC also sends the alarm to the plant Scada control system.

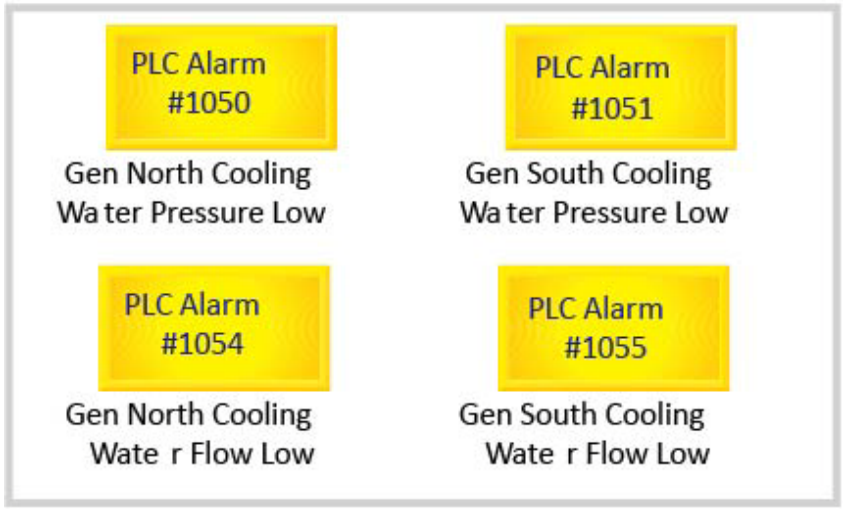
Individual Alarm Summary

The on line alarm program provides source, cause and response information for each alarm individually. See the alarm program for alarm response procedures. *For additional information, see the following associated alarm program response screens:*



Individual Alarm Summary (continued)





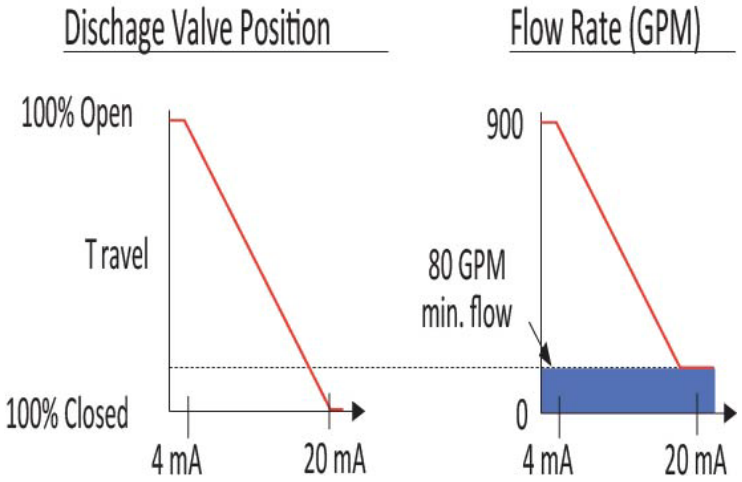
MAINTENANCE

Maintenance of the generator cooling equipment is generally limited to unscheduled troubleshooting and calibration of the control equipment during scheduled unit outages. The most common mechanical problem involves air entrapment in the coolers, and this condition typically occurs only after the coolers have been unwatered.

Each fall and spring valves are adjusted to direct the discharge water to either the heat supply header or the draft tube. This procedure is addressed in a separate OMI," Heating and Air Conditioning Systems".

Pneumatic Discharge Control Valve Calibration

The key to governor cooling is maintaining the proper relationship between action of the electro pneumatic discharge valve positioner, operation of the discharge valve and the PLC control logic. A 4 to 20 mA control signal from the unit PLC gives the valve positioner extend/retract commands and a second 4 to 20 mA feedback signal from the discharge valve tells the unit PLC how far the valve has opened.



Wiremen use the Yokogawa BT200 "brain terminal" to record the relationship between control signals, flow meter reads and discharge valve position and interpret this data to calibrate the equipment. Note that although 100% valve closure is set to 20 mA, PLC logic limits valve closure to maintain a base water flow rate at all times. This minimizes the opportunity for air to enter the coolers. Mechanical flow restricters limit the maximum water flow rate.

REFERENCE

Computer Programs

PLC Alarms Program

This internet program lists alarm source and response data for all PLC and SER alarms. Access it by clicking on the Alarm button on the right margin of any OMI screen.

Unit SOPs Program

This collection of text files provides standard operating procedures for routine tasks whose instructions must be updated frequently. Access it by clicking on the SOPs button on the right margin of any OMI screen.

Manuals

C1-C7

Barton/ITT Electronic Position Controller - Installation and Operation

C8-C11

Samson Electro pneumatic Positioner Type 3767 - Mounting and Operating Instructions

Samson Series 240 Pneumatic Control Valves Type 241-1 and 241-7, Globe Valve Type 241 with Micro-trim Element – Mounting and Operating Instructions

Admag Models AE100M/200M Integral Type Magnetic Flowmeter

To obtain a manual, check at the following locations:

- System Planning and Design Library
- Central Maintenance: General Foreman
- Rocky Reach Plant Engineer's Office
- Rocky Reach Print Room

Drawings

Identification No.	Subject
3S183189	RIVA Unit Control Logic Diagram C-1 thru C-7
3S189842	RIVA Unit Control Logic Diagram C-8 thru C-11
V5869.1025	ABB series
0220-00SK-0603	