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Spallation Neutron Source

Condenser Water System Functional System Design (FSD)

March, 2003

SNS Project Engineer



A U . S . D e p a r t m e n t o f E n e r g y M u l t i l a b o r a t o r y P r o j e c t

SPALLATION NEUTRON SOURCE

Argonne National Laboratory • Brookhaven National Laboratory • Lawrence Berkeley National Laboratory • Los Alamos National Laboratory • Oak Ridge National Laboratory

CUB Chiller/Condenser Cooling Water (CND) Controls Description **TD80015 Rev 2, March 3, 2003**

Operating Philosophy

System Description: The CND system provides cooling water to the chillers and consists of cooling tower cells 1 and 2 and four condenser water VFD pumps. The chillers and condenser water VFD pumps are controlled by the chiller control system provided by Trane (not by CF Controls PLC's), thus condenser water flow is controlled by the chiller control system. The Variable Frequency Drive cooling tower fans and cooling tower valves are controlled by CF Controls, thus temperature control is controlled by the CF Controls PLC. To provide proper chiller operation, CF controls receives a CND temperature setpoint signal from the chiller control system and uses this to manipulate cooling tower fan speeds and control valve positions to control the CND water temperature.

Normally, cooling tower cell 2 is valved so that it serves the CND system. However, if the tower water system that serves technical systems needs additional capacity, the operator may manually through the EPICS user interface (there is no automatic action), valve this cell such that it serves the Tower Water (TW) system. Reversing this operation to allow cooling tower cell 2 to serve the CND system is also a manual operation.

Purpose:

The purpose of CUB CND cooling operation is to:

- a) Maintain the CND water at an appropriate temperature setpoint.
- b) Utilize different fans to maintain uniform runtime on each pump/fan.
[Note – we can't utilize different CND pumps because we don't control them]
- c) Communicate with the Chiller Control System to send/receive pertinent information for coordinated CND tower and pump operation.
- d) Respond to a manual command to valve the swing cell (cell 2) to the tower water system.
- e) Provide freeze protection for the cooling tower
- f) Forward chemical treatment system makeup flow to Chemical Treatment System and pass open/close command signal to chemical treatment system bleed valve.

Assumptions:

- a) Control of CND pumps to provide appropriate flow, etc. is performed by the Chiller Control System (by Trane Corporation).
- b) The data listed in the Operator Interface section below will be exchanged between the Chiller Control System and the CF Controls PLC at the Cooling Tower shed via ControlNet.
- c) The Conventional Facilities PLC has no connection to the CND pumps. The CND pumps are directly and solely controlled by the Chiller Control System. The CND pumps (four total) run independent of tower cell operation. The pumps draw CND from a common basin header and are piped in a parallel operation mode. The basin can be

bypassed with CND water recirculated from pumps to “chiller condenser loads” and back directly to the pumps.

- d) The swing cell (cell 2) is valved into the CND or TW systems only upon a manual command on the EPICS screen.

Operator Controls and Operating Modes

- 1) OFF: CND Fans are de-energized. The CND cell return valve and temperature control recirculation valve will be closed. The swing cell valve will be positioned in accordance with the Swing to Condenser/Tower Water switch.
- ON: CND Fans are on or off as required to maintain uniform runtime and temperature control at the setpoint selected by the operator. The swing cell valve will be positioned in accordance with the Swing to Condenser/Tower Water switch.

OPERATOR INTERFACE DEFINITIONS

Local Hardware Displays/Operator Controls

- 1) Pressure differential across CND pump P-CU-01 (*PDG4001*)
- 2) Pressure differential across CND pump P-CU-02 (*PDG4002*)
- 3) Pressure differential across CND pump P-CU-03 (*PDG4003*)
- 4) Pressure differential across CND pump P-CU-04 (*PDG4004*)
- 5) FAULT indicator light on CND pump VFD's and fan VFD's
- 6) READY indicator light on CND pump VFD's and fan VFD's
- 7) RUN indicator light on CND pump VFD's and fan VFD's

Software HMI/EPICS Digital Operator Controls

- 1) CND Tower Mode
 - a. OFF
 - b. ON

Software HMI/EPICS Digital Displays

- 1) CND Tower Mode switch status [*Send to CMCS via ControlNet*]
 - a. OFF
 - b. ON
- 2) CND Swing Cell to TW Cooling switch status [*Send to CMCS via ControlNet*]
 - a. OFF
 - b. ON
- 3) CND Pump P-CU-01 running. (*PDS4001*) [*Receive from CMCS via ControlNet*]
- 4) CND Pump P-CU-02 running. (*PDS4002*) [*Receive from CMCS via ControlNet*]
- 5) CND Pump P-CU-03 running. (*PDS4003*) [*Receive from CMCS via ControlNet*]
- 6) CND Pump P-CU-04 running. (*PDS4004*) [*Receive from CMCS via ControlNet*]
- 7) CND cell return valve (for first cell) status. (*SOV4001/FCV4001*)
- 8) CND cell return valve (for second cell) status. (*SOV4002/FCV4002*)
- 9) Swing cell valve positions

Software HMI/EPICS Analog Operator Controls

- 1) CND supply temperature setpoint [*Receive from CMCS via ControlNet*]
- 2) CND Normal daily usage flow alarm setpoint (alarms at this plus 50%)

Software HMI/EPICS Analog Displays

- 1) CND pump inlet temperature (*TT4001*) [*Send to CMCS via ControlNet*]
- 2) CND supply temperature (*TT4002*) [*Receive from CMCS via ControlNet*]
- 3) CND return temperature (*TT4003*) [*Send to CMCS via ControlNet*]
- 4) CND basin temperature (*TT4004*) [*Send to CMCS via ControlNet*]
- 5) CND supply flow (*FT4001*) [*Receive from CMCS via ControlNet*]
- 6) CND bypass flow (*FT4002*) [*Send to CMCS via ControlNet*]
- 7) CND makeup flow (*FT4003*)
- 8) CND CT-CU-01 fan speed (*ST4001F*)
- 9) CND CT-CU-02 fan speed (*ST4002F*)
- 10) CND CT-CU-01 fan speed command (*SC4001F*)
- 11) CND CT-CU-02 fan speed command (*SC4002F*)
- 10) CND Pump P-CU-01 accumulated run hours
- 11) CND Pump P-CU-02 accumulated run hours
- 12) CND Pump P-CU-03 accumulated run hours
- 13) CND Pump P-CU-04 accumulated run hours
- 12) CND temperature control recirculation valve command (*IP4001*)
- 13) Fan run times
- 14) Chilled water (CHW) differential pressure at Target building (*PDT5001*) [*Send to CMCS via ControlNet*]
- 14) CND Pump P-CU-01 speed
- 15) CND Pump P-CU-02 speed
- 16) CND Pump P-CU-03 speed
- 17) CND Pump P-CU-04 speed

Software HMI/EPICS Alarms (via EPICS Alarm Handler)

- 1) CND pump fault alarms (*SA4001, SA4002, SA4003, SA4004*) [*Receive from CMCS via ControlNet*]
- 2) CND pump low flow (*PDIS4001, PDIS4002, PDIS4003, PDIS4004*) [*Receive from CMCS via ControlNet*]
- 3) CND fan fault alarms (*YA4001F, YA4002F*)
- 4) CND total flow high (totalizer resets at midnight)

Control Logic Description

If the CND Basin Temperature (*TT4001*) drops below 70 Degrees F, the CND fan(s) (*F4001 and/or F4002*) will be de-energized while the associated cell return valve(s) (*SOV4001 and/or SOV4002*) remains open. If the CND Basin Temperature (*TT4001*) drops below 65 Degrees F, the CND basin (cell bypass) valve (*SOV4007*) will be opened and all cell return valves (*SOV4001 and SOV4002*) will be closed.

OFF MODE

In the OFF mode, the CND fans (*F4001, F4002*) are de-energized. The CND basin (cell bypass) valve (*SOV4007*) will be opened and the CND cell return valves (*FCV4001, FCV4002*) and the CND temperature control recirculation valve (*TCV4001*) will be closed. The swing cell valve will be positioned in accordance with the Swing to Condenser/Tower Water switch.

ON MODE – “FLOW CONTROL”

None – This is provided by the chiller control system.

ON MODE – “TEMPERATURE CONTROL”

In the ON mode, the CND cell return valve (*SOV4001/FCV4001 or SOV4002/FCV4002*) associated with the CND fan with the least amount of runtime will be opened allowing returned CND to flow through the cell and the swing cell valve will be positioned in accordance with the Swing to Condenser/Tower Water switch.

If the swing cell is serving the CND system and the CND water temperature is above its setpoint, the control valve will be closed and after a 60 second delay (in case of freezing air temperatures), the associated CND fan (with the least amount of runtime) will be energized (*F4001 or F4002*) and set to the minimum RPM setting. The CND fan speed (*SC4001F or SC4002F*) will be modulated by a PID algorithm to maintain the CND Supply Temperature Setpoint at TT4002.

If the running CND fan alarms (*YA4001F, YA4002F*), the running CND cell (fan/valve) will be de-energized and the second CND cell (fan/valve) will be energized at the same rpm setting and fan speed modulated temperature control will resume. Again, a 60 second fan delay will be implemented.

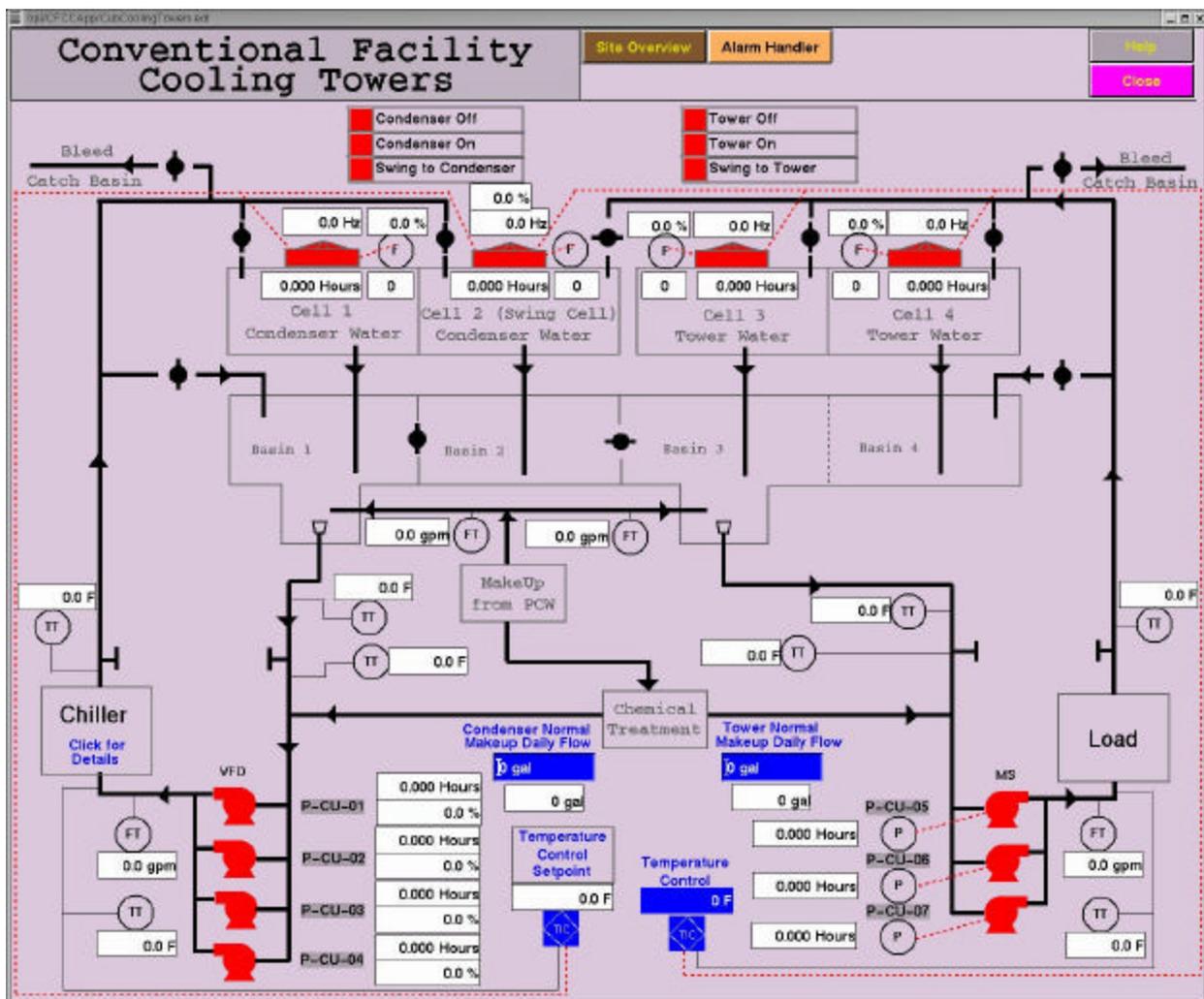
If the flow (FT4001) through a single energized cell exceeds 7000 GPM, the second CND cell (fan/valve) will be energized and both fan speeds will be modulated (in parallel) to the same speed to maintain the CND Supply Temperature Setpoint at TT4002. Again, a 60 second fan delay will be implemented. If the flow (FT4001) through the combined cells falls below 6500 GPM, the CND cell (fan/valve) with the most runtime will be de-energized.

If both CND cells (fans/valves) are energized, indicating more than 7000 GPM required, and a CND fan alarm (*YA4001F, YA4002F*) is detected, an alarm will be generated on the EPICS screen. The CND fan will be de-energized but its associated cell return valve (*SOV4001 or SOV4002*) will remain open and the CND basin (cell bypass) valve (*SOV4007*) will remain closed to provide whatever cooling can be obtained without the fan running.

If the swing cell (cell 2) is serving the Tower Water system, (and thus is not available to provide increased capacity) and the running CND fan alarms, a signal will be sent to the CMCS to indicate the need to shutdown the chillers.

“CHEMICAL TREATMENT/MAKE-UP”

If the chemical treatment system sets the CND bleed input (*FC4008*), then the CND bleed valve (*SOV4008*) will open. The PLC software continuously forwards to the chemical treatment system the CND makeup flow (*FT4003*) measurement. The CND makeup flow (*FT4003*) will be totalized and checked for 50% greater than the Normal Daily Usage Flow Alarm Setpoint value (entered by the operator on the EPICS screen). If the totalized value exceeds the 50% check, a total flow high alarm will be generated on the EPICS screen. The totalized value will be reset at midnight.



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Central Utilities Building Chiller Parameters

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TEMPERATURES

Cond. Tower Pumps Inlet Water	0.0 F
Cond. Tower Water Supply	0.0 F
Cond. Tower Water Return	0.0 F
Cond. Tower Water Basin	0.0 F
Chilled Water Return 1	0.0 F
Chilled Water Return 2	0.0 F
Chilled Water Return 3	0.0 F
Chilled Water Return 4	0.0 F
Chilled Water Out	0.0 F
Chilled Water In	0.0 F

Chiller Permissive ● Chiller Setpoint

CHILLER	STATUS	ALARM	PUMP	STATUS	VFD ALARM
1	●	○	10	○	○
2	●	○	11	○	○
3	●	○	12	○	○
4	●	○	13	○	○