108050000-TD8014-R02

Spallation Neutron Source

Tower Water System
Functional System Design (FSD)

March, 2003

APPROVED
BY: David Meyer
DATE: 3/10/03

J. E. Chrouch 3/3/03
SNS Project Engineer

A U.S. Department of Energy Multilaboratory Project

SPALLATION NEUTRON SOURCE

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

SNS

CUB Process Cooling Water (TW) Controls Description
TD8014 Rev 2, March 3, 2003

Operating Philosophy

System Description:

The TW system provides cooling water to the technical systems and consists of cooling tower cells 3 and 4 and four tower water pumps. Tower water on/off pumps, VFD fans and valves are controlled by CF Controls PLC's, thus both flow control and temperature control are provided by the CF Controls PLC.

Normally, cooling tower cell 2 is valved so that it serves the CND system. However, if the tower water system 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 TW cooling operation is to:

a) Maintain the TW at an appropriate temperature setpoint.
b) Energize the appropriate number of TW pumps to supply the TW flow to the facility.
c) Utilize different TW pumps to maintain uniform runtime on each pump.
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 Treatement System and pass open/close command signal to chemical treatment system bleed valve.

Assumptions:

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

b) The TW pumps (three total) run independent of tower cell operation. The pumps draw TW from a common basin header and are piped in a parallel operation mode. The basin can be bypassed with TW water recirculated from pumps to "process loads" and back directly to the pumps.

Operator Controls and Operating Modes

1) OFF: TW pumps and fans are de-energized. The TW cell return valves and TW temperature control recirculation valve will be closed, and the TW basin (cell bypass)

valve will be open. The swing cell valve will be positioned in accordance with the Swing to Condenser/Tower Water switch.

2) ON: TW pumps and fans are on or off as required to maintain uniform runtime, temperature control at setpoint selected by the operator, and flow at appropriate levels. 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) TW Pump P-CU-05 differential pressure switch isolation valves *(HV4023, HV4024)*
2) TW Pump P-CU-06 differential pressure switch isolation valves *(HV4028, HV4029)*
3) TW Pump P-CU-07 differential pressure switch isolation valves *(HV4033, HV4034)*
4) Pressure differential across pump TW P-CU-05 *(PDIS4005)*
5) Pressure differential across pump TW P-CU-06 *(PDIS4006)*
6) Pressure differential across pump TW P-CU-07 *(PDIS4007)*
7) FAULT indicator light on local TW pump motor starters and TW fan VFD's
8) READY indicator light on local TW pump motor starters and TW fan VFD's
9) RUN indicator light on local TW pump motor starters and TW fan VFD's

Software HMI/EPICS Digital Operator Controls

1) TW Tower Mode
    a. OFF
    b. ON
2) CND Swing Cell to TW Cooling
    a. OFF
    b. ON

Software HMI/EPICS Digital Displays

1) TW Tower Mode switch status
    a. OFF
    b. ON
2) CND Swing Cell to TW Cooling switch status
    a. OFF
    b. ON
3) TW Pump P-CU-05 running. *(PDIS4005)*
4) TW Pump P-CU-06 running. *(PDIS4006)*
5) TW Pump P-CU-07 running. *(PDIS4007)*
6) TW cell return valve (for first cell) status. *(SOV4003/FCV4003)*
7) TW cell return valve (for second cell) status. *(SOV4004/FCV4004)*

Software HMI/EPICS Analog Operator Controls

1) TW water supply temperature
2) TW Normal daily usage flow alarm setpoint (alarms at this plus 50%)

Software HMI/EPICS Analog Displays

1) Outside air temperature *(TT4015)*
2) TW pump inlet temperature *(TT4016)*
3) TW supply temperature *(TT4017)*
4) TW return temperature *(TT4018)*
5) TW basin temperature *(TT4019)*
6) TW supply flow *(FT4017)*
7) TW bypass flow *(FT4018)*
8) TW makeup flow *(FT4019)*
9) TW CT-CU-03 fan speed *(ST4003F)*
10) TW CT-CU-04 fan speed *(ST4004F)*
11) TW CT-CU-03 fan speed command *(SC4003F)*
12) TW CT-CU-04 fan speed command *(SC4004F)*
13) TW Pump P-CU-05 accumulated run hours
14) TW Pump P-CU-06 accumulated run hours
15) TW Pump P-CU-07 accumulated run hours
16) TW temperature control recirculation valve control command *(IP4018)*
17) TW differential pressure at Klystron DI water system 3 *(PDT4300)*
18) TW differential pressure at Klystron DI water system 5 *(PDT4302)*
19) TW differential pressure at Target building *(PDT5003)*

Software HMI/EPICS Alarms (via EPICS Alarm Handler)

1) TW pump fault alarms *(YA4005, YA4006, YA4007)*
2) TW pump low flow *(PDIS4005, PDIS4006, PDIS4007)*
3) TW fan fault alarms *(YA4003F, YA4004F)*
4) TW total flow high (totalizer resets at midnight)
5) TW differential pressure at Klystron DI water system 3 low-low, low, high, and high-high
6) TW differential pressure at Klystron DI water system 5 low-low, low, high, and high-high
7) TW differential pressure at Target building low-low, low, high and high-high

Control Logic Description

Temperature *(TT4016)* drops below 70 Degrees F, the TW fan(s) *(F4003 and/or F4004)* will be de-energized while the associated cell return valve(s) *(SOV4003 and/or SOV4004)* remains open. If the TW Basin Temperature *(TT4016)* drops below 65 Degrees F, the TW basin (cell bypass) valve *(SOV4011)* will be opened and all cell return valves *(SOV4003 and SOV4004)* will be closed.

OFF MODE

In the OFF mode, the TW pumps *(P4005, P4006, P4007)* are de-energized and the TW fans *(F4003, F4004)* are de-energized. The TW basin (cell bypass) valve *(SOV4011)* will be opened and the TW cell return valves *(SOV4003, SOV4004)* and TW temperature control recirculation valve *(TCV4018)* will be closed. The swing cell valve will be positioned in accordance with the Swing to Condenser/Tower Water switch.

ON MODE – "FLOW CONTROL"

In the ON mode, the TW pump with the least amount of runtime will be energized. After a delay period of 60 seconds, the differential pressure for the pump will be checked for low flow (low DP) every PLC scan. If the low flow condition exists, the pump will be de-energized, an alarm returned to the operator, and the next pump with the least amount of runtime will be initiated. If the flow (*FT4017)* from the one operational pump exceeds 95% of the pump capacity, then the next pump with the least amount of runtime will be energized (both operating in parallel). After a delay period of 60 seconds, the same low flow check will be performed on the second pump. If the combined flow (*FT4017)* from the two pumps exceeds 95% of their combined pump capacities, then the third pump will be energized (all three operating in parallel). Again, after a delay period the low flow check will be performed on the third pump. When multiple pumps are energized and the combined flow (*FT4017)* drops below 40% of the combined capacity of the pumps that are energized, the pump with the most runtime will be de-energized.

ON MODE – "TEMPERATURE CONTROL"

In the ON mode, the TW cell return valve *(SOV4003/FCV4003 or SOV4004/FCV4004)* associated with the TW fan with the least amount of runtime will be opened allowing returned TW to flow through the cell.

If the swing cell (cell 2) is valved to serve the tower water system, and the water temperature is above its setpoint, the temperature control valve will be closed and after a 60 second delay (in case of freezing air temperatures), the associated TW fan (with the least amount of runtime) will be energized *(F4003 or F4004)* and set to the minimum RPM setting. The TW fan speed *(SC4003F or SC4004F)* will be modulated by a PID algorithm to maintain the TW Supply Temperature Setpoint at TT4017.

If the running TW fan alarms *(YA4003F or YA4004F)*, the running TW cell (fan/valve) will be de-energized and the second TW 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 (FT4017) through a single energized cell exceeds 7000 GPM, the second TW cell (fan/valve) will be energized and both fan speeds will be modulated (in parallel) to the same speed to maintain the TW Supply Temperature Setpoint at TT4017. Again, a 60 second fan

delay will be implemented. If the flow (FT4017) through the combined cells falls below 6500 GPM, the TW cell (fan/valve) with the most runtime will be de-energized. If a running TW fan alarms, the affected fan will be de-energized, but the cell isolation valve will remain open and the cell bypass valve will remain closed to provide whatever cooling can be obtained without the fan running.

ON MODE – "SWING CELL OPERATION"

If both TW cells (fans/valves) are energized, indicating more than 7000 GPM required, and a TW fan alarm *(YA4003F, YA4004F)* is detected, an alarm will be generated on the EPICS screen. The TW fan will be de-energized and its associated cell return valve *(SOV4003 or SOV4004)* will be closed and the TW basin (cell bypass) valve *(SOV4011)* shall be opened to maintain TW flow.

The operator will then be required to determine whether or not to utilize the CND Swing Cell for the TW cooling by selecting the Swing Cell Swing to Tower button on the TW cooling screen. Once selected:

- the "Swing Basin to TW" isolation valve *(SOV4013)* will be opened
- the "Swing Cell to TW" cell return valve *(SOV4012)* will be opened
- the "Swing Basin to CND" isolation valve *(SOV4014)* will be closed
- the CND cell return valve *(SOV4002)* will be closed
- the TW basin (cell bypass) valve *(SOV4011)* will be closed
- the Swing Cell fan speed will be modulated to the same speed as the functioning TW fan (in parallel); after 60 second delay from the opening of the swing cell return valve *(SOV4012)*

If the flow (FT4017 minus FT4018) through the combined cells falls below 6500 GPM, [should we drop the swing cell first so that it is available to be valved back to the condenser system?] the TW or Swing cell (fan/valve) with the most runtime will be de-energized.

The Swing cell will not be returned to CND use, even if not needed for TW, until manual intervention by the operator.Once the fan alarm condition is cleared, the operator will then determine to utilize the CND Swing Cell for the CND cooling by selecting the Swing Cell Swing to Condenser button on the TW cooling screen. Once selected:

- the "Swing Basin to CND" isolation valve *(SOV4014)* will be opened
- the CND cell return valve *(SOV4002)* will be opened
- the "Swing Basin to TW" isolation valve *(SOV4013)* will be closed
- the "Swing Cell to TW" isolation valve *(SOV4012)* will be closed
- the TW basin (cell bypass) valve *(SOV4011)* will be closed
- the TW cell return valve for the fan that was in alarm will be opened *(SOV4003 or SOV4004)* and the fan started (60 second delay), assuming the flow exceeds 7000 GPM, otherwise the second TW cell will remain inactive [Would this be more clear if it said "Depending on flow, TW cells 1 and /or 2 will be placed on line (valves *(SOV4003 or SOV4004)* opened and the fan(s) started with a 60 second delay) or remain inactive. –

Now we don't have to worry about which on is in alarm or not – just do what the flow needs.

- modulated fan speed based temperature control for both cells (fans) in parallel will resume, assuming the flow exceeds 7000 GPM, otherwise the second TW cell will remain inactive

"CHEMICAL TREATMENT/MAKE-UP"

If the chemical treatment system sets the TW bleed input *(FC4018)*, then the TW bleed valve *(SOV4019)* will open. The PLC software continuously forwards to the chemical treatment system the TW makeup flow *(FT4019)* measurement. The TW makeup flow *(FT4019)* 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.