



NuMI Target Hall Radioactive Water and Target Air Cooling Controls

*P. Kasley
16 May 2005*

Hardware

The THSR RAW Control consists of an Automation Direct DL450 PLC mounted to a panel and wired to various field devices. A door-mounted graphics operator interface (OI) panel provides local access to pump status, instrumentation readings, and alarms in the Target Hall Support Room. Separate Moore Industries 535 PID-loop controllers regulate the temperature of the water supplied to the two focusing horns. The PLC uses a front-end at MI-62 to communicate to consoles via ACNET.

The PLC and all water skid I/O is located in rack THSR-101 behind the door containing the OI. Local Expansion Base #1 on the panel behind the PLC holds thermocouple I/O. Expansion Bases #2 and #3 are in the end-rack and service the target air cooling I/O.

All analog instrumentation sends a 4-20mA signal to the PLC for readback. The 535s retransmit the current loops from the horn skid RAW supply temperature to the PLC.

Loop powered field instruments are powered by 24V supplies on the PLC panel. Analog input and output channels are fused in groups of 4 with 1/8A 3AG fast-blow fuses.

The PLC IP is 131.225.124.228, THSR-LCW-PLC, station 5. The OI panel is THSR-LCW-OI, 131.225.124.246, station 8.

RAW Skids

The PLC is cabled to four RAW skids in the mechanical room: Horn 1, Horn 2, Target, and Upstream Decay Pipe (UDP). Each skid except UDP has two pumps that discharge into a common header. The motor controllers respond to momentary run and stop signals. Each motor control has a set of interlock contacts that must be made up for it to run, whether in local or remote mode. The interlocks are made-up by the PLC.

Horn 1 and Horn 2 skids have pneumatic proportioning valves that operate in response to a 4-20mA signal from the 535 PID controllers. There is no direct readback of the valve position.

Each horn skid has pneumatic-driven valves on the water supply and return lines. These valves ensure that the surge tank does not drain into the horn sump when the pumps are not operating. The valves are operated by time delay relays inside the termination box rather than the PLC. The spray line valve opens first to pump down the sump, followed by the check valve to establish circulation. The delay relays are Square-D 9050JCK13V14 .6-60 sec on-delay.



robot Docume

Horn Relays Schematic

The target skid has no temperature regulation or pneumatic valving.

The UDP skid is completely passive. It receives water from a downstream skid that has circulated through the decay pipe, directs it through a heat exchanger and then back out to the decay pipe.

Horn 1, Horn 2, and Target each have one to five flow meters that are wired in series with the PLC permit to the horn power supply. The flow meters provide a check on water flows that is independent of the PLC and its software.

Thermocouples

Thirty-three Type J thermocouples from various points in the target hall are terminated on the first local expansion base.

Target Air Cooling

Local expansion bases 2 and 3 receive air cooling IO from devices in the mechanical room and in the power supply room. The PLC monitors digital status of the fan, reheaters, filter differential pressure switches, and glycol and chiller pumps. The PLC reads, scales, and forwards to ACNET analog readings from all of these systems plus various air and glycol temperatures. The PLC actively manages six refrigeration coils in response to a calculated system heat load, though temperature regulation of the airflows is done with stand-alone Chromalox PIDs.

Miscellaneous I/O

The PLC is also a convenient termination for other I/O that has to get to ACNET. Items in this class are: compressed air pressure, target helium and vacuum valve controls, and target helium and vacuum readbacks.

Permits

LCW Permit – The THSR PLC reads the LCW permit and the heartbeat counter from the MI62 PLC via Ethernet. The permit is replicated on an output relay and sent up the shaft to the MI65 power supply room. The upstairs permit is dropped if the MI62 LCW permit drops or if the value of the MI62 heartbeat counter is over 5 minutes old. The LCW permit is not a factor in any of the other permits at THSR.

Beam Permit – The PLC generates separate permit contacts for Horn 1 RAW, Horn 2 RAW, Target RAW, and UDP RAW. The permits are routed to the “Pernicious Panel” in rack 103. **Note that the target RAW permit includes a term for target helium pressure (E:BTHP02).**

Horn Power Supply Permit – The PLC makes a permit for the horn power supply by ANDing the Horn 1 and Horn 2 beam permits. The output is daisy-chained with the horn flow meter contacts at the bottom of the rack and applied to the power supply.

Target Flow Meter – The contact pair from the target flow meter is wired separately to the Pernicious Panel.

Target Air Cooling – The PLC does not handle any permits from the target air cooling systems.

Watchdog Relay – A time delay relay helps to ensure that the PLC is operating properly. As long as the PLC resets it before its timer expires, the contacts remain closed. One contact pair goes to the horn power supply permit string and one pair goes directly to the Pernicious Panel.

Terminal Block Label	Position (L to R)	Description	Comment
H1-1	1	Horn 1 Outer Conductor Flow Meter	10/21/04 fixed always closed
H1-2	2	Horn 1 Inner Left Conductor Flow Meter	
H1-3	3	Horn 1 Inner Right Conductor Flow Meter	
H1-4	4	Horn 1 Clamp Conductor Flow Meter	10/21/04 fixed always closed
H2-1	5	Horn 2 Outer Conductor Flow Meter	
H2-2	6	Horn 2 Inner Left Conductor Flow Meter	
H2-3	7	Horn 2 Inner Right Conductor Flow Meter	
	8	(jumpered)	
SKD1	9	Horn 1 Skid Flow Meter	
SKD2	10	Horn 2 Skid Flow Meter	
RLY	11	PLC Watchdog Timer Relay	NO contact pr from timer module
PMT	12	PLC Horn Power Supply Permit Output	NO contact pr from PLC relay module
PS	13	Horn Power Supply Permit Line	Total Resistance about 30 ohms

Operator Interface Panel

A 10 inch TFT LCD panel with touchscreen, mounted in the door of rack 101, provides a local view into the RAW and air systems. The panel is wired to the lab Ethernet and not directly to the PLC. In principle, it can access data in any of the NuMI PLCs. Unlike the text panel which require extensive PLC program to push data to the display, the OI pulls data from the PLC with almost no assistance from PLC code. Digital and analog status of selected parameters is accessible through a series of nested menus. Local control is limited to resetting beam permit and motor trips, setting and clearing override bits, and the enabling and disabling of refrigeration coils. All control functions are available from the ACNET console in rack 105.

THSR Module Slot and Address Assignments

BASE	POSITION	MODULE	XADR	YADR
0	1	H4-ECOM		
0	2	F4-16AD-1	X0-X17	
0	3	F4-16AD-1	X20-X37	
0	4	F4-08TRS-2		Y0-Y7
0	5	F4-08TRS-2		Y10-Y17
0	6	F4-08TRS-2		Y20-Y27
0	7	F4-08TRS-2		Y30-Y37
0	8	D4-16NE3	X40-X57	
1	1	(empty)		
1	2	(empty)		
1	3	(empty)		
1	4	F4-08THM-J	X60-X77	
1	5	F4-08THM-J	X100-X117	
1	6	F4-08THM-J	X120-X137	
1	7	F4-08THM-J	X140-X157	
1	8	(empty)		
2	1	F4-16DA-1		Y40-Y77
2	2	F4-16DA-1		Y100-Y137
2	3	F4-08TRS-2		Y140-Y147
2	4	F4-08TRS-2		Y150-Y157
2	5	F4-08TRS-2		Y160-Y167
2	6	(empty)		
2	7	(empty)		
2	8	(empty)		
3	1	F4-16AD-1	X160-X177	
3	2	F08-RTD	X200-X237	
3	3	F08-RTD	X240-X277	
3	4	F4-16AD-1	X300-X317	
3	5	D4-16ND2F	X320-X337	
3	6	D4-16ND2F	X340-X357	
3	7	(empty)		
3	8	(empty)		

Watchdog Timer=Square-D Timer JCK22-14 modified for edge-triggering

PLC Program Overview

1. First scan

Initialization is done on the first scan after program reset and is listed at the top of the ladder. Scale factors and offsets, alarm limits, and time delays are set up. Unfortunately some constants are sprinkled through the code. Those constants that are in Vmem can be changed on the fly without changing the program. All alarms are cleared, all motor RUN command and status flags are cleared, and control relays through C257 are cleared. All analog outputs are set to 4mA.

2. All subsequent scans

- * Scan thermocouple modules. On each scan one channel on each of the four thermocouple modules is updated. The value is a direct binary representation of the temperature and is placed directly into the ACNET Vmem area.
- * Scan air cooling RTD module. RTD values are also placed directly into ACNET Vmem. RTD #1 is present but due to a mid-stream design change is not used.
- * Read and store air cooling analog inputs
- * Update air cooling analog outputs from Vmem
- * Convert and scale air cooling and helium/vacuum readings for presentation to ACNET
- * Fan and reheater control and monitoring
- * Air cooling digital status update
- * Read and store water system analog inputs
- * Convert and scale water system readings for presentation to ACNET
- * Water system digital status update
- * Evaluate Helium system permit
- * Evaluate and post water system alarms and permits
- * Evaluate logic for beam permits, horn power supply permit and motor control interlocks
- * Read MI62 via H4ECOM and evaluate upstairs power supply permit
- * Digital trip status update for ACNET
- * Trip reset update from ACNET
- * PLC internal error status update

- * Watchdog timer kick
- * Water skid motor control state machines
- * Chiller and glycol pump motor control state machines
- * Miscellaneous rungs to maintain local display items

Note: This document reflects the THSR system as of 7 June 2005. Additional logic to monitor and control the refrigeration coils and the temperature indicating controllers will be added during the October '05 shutdown or earlier if the opportunity becomes available to do the necessary rewiring and checkout without disrupting operations.

Revisions

7 June 2005 PLC updated to thsr051005 version