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NEED LCLS INJECTOR WATER SYS. (IC)

LCLS Injector through BC1 Process Water Systems Operational Guide

Introduction

The LCLS Injector Process Water Systems includes two new systems and modifications to a number of existing systems. The new systems are the Injector Cooling System (ICS) and the Laser Room Cooling System (LCS). Four systems, including the Sector 20 and 21 Accelerator Cooling Systems (ACS) and Wave Guide Cooling Systems (WGCS), were modified to serve LCLS equipment as part of the installation project. The new systems and modifications to existing systems are described below.

Part 1 Injector Cooling System

1.1 System Summary

The LCLS Injector Cooling System (ICS) is a low conductivity water (LCW) system serving four general geographic areas associated with the LCLS Injector; the Sector 20 Injector Vault, the Sector 20 RF Hut, Sector 21 Linac housing and the Sector 20 Laser Facility.

The main components of the system are: one pump, a surge tank, a full flow 10 micron filter, a plate type heat exchanger, a pressure reducing valve and a temperature control mixing valve.

The system is monitored through the CEF DCS as well as EPICS. It is controlled by an Allen-Bradley Control Logix PLC located in rack LKG18 in Sector 20. There is a local HMI display on the LCS pump pad. ↓ 125 PSIG

The system is designed to provide up to 80 GPM of LCW to the various sub-systems. The system pressure is controlled by a Variable Frequency Drive (VFD) on the pump sensing discharge pressure. The system pressure is used by a string of magnets in the Sector 21 Linac Housing. The pressure setting should start at ~100 PSIG and be adjusted upward until the system or high pressure (pressure before the PRV) is at 100 PSIG. The balance of the ICS is operated at a reduced pressure controlled by a manually set Pressure Reducing Valve (PRV) located on the pump pad and is set to 55 PSIG.

The VFDs have built in protection from running the pump dry, deadheading or overloading it by "running out." The surge tank level control will cause a fault on the VFD and cause the PLC to stop filling the surge tank automatically. Should the VFD fault, the tank will have to be filled manually, any VFD faults will have to be cleared at the VFD panel, finally the pump faults will have to be cleared at the HMI panel on the LCS pad.

ICS temperature is controlled by a three way mixing valve set to 78.5 degrees F. the system stability should be better than +/- 0.5 deg. F. Heat from the ICS is rejected to CT1202 through a plate heat exchanger.

1.2 The RF Gun Cooling Loop

The RF Gun cooling loop consists of 3 temperature control valves, two heat exchangers and a process heater designed to control the temperature of the RF Gun inside the Injector Vault. The system is designed to provide:

A.	Nominal Flow	9.5 GPM
B.	Minimum Flow	6 GPM
C.	Temperature Setpoint	64.4 to 113 deg. F
D.	Temperature Stability	+/- .25 deg. F
E.	Maximum Pressure	100 PSIG
F.	Maximum Heater Temp	120 deg. F

The setpoints for the two control valves and the process heater is set through the Low Level RF Control system and is not directly adjustable by CEF operations personnel. The process heater regulates temperature through a controller located upstairs in the load lock room. The heater has software interlocks, two hardware temperature interlocks and a flow interlock. The flow switch is located on the North wall of the Injector vault and has 120 volts on it. Turn the power at the controller upstairs off to kill the power on the flow switch. There is a hardware reset button on the front panel of the controller, one at the heater (under the stairs in the injector vault) and a software reset button on the local interface panel at the pump pad. This heater should be secured before the pump is shut down and needs to be reset once the pump is started.

There is another flow switch on this system that will trip off Klystron 20-6. The MKSU will indicate an ACC 1 trip when this flow switch is tripped. The switch is located in the vault on the North wall. There are no other flow interlocks for station 20-6.

1.3 The RF Hut Cooling Loop

The RF Hut cooling loop includes a heat recovery heat exchanger, a process heater and a temperature control valve. The system is designed to provide:

A.	Nominal Flow	15 GPM
B.	Minimum Flow	9 GPM
C.	Temperature Setpoint	95 deg. F
D.	Temperature Stability	+/- .1 deg. F
E.	Maximum Pressure	100 PSIG
F.	Maximum Heater Temp	120 deg. F

The process heater regulates temperature through a controller mounted on the eastern wall of the RF Hut. The heater has software interlocks, two hardware temperature interlocks and a flow interlock. There is a hardware reset button on the front panel of the controller, one at the heater and a software reset button on

the local interface panel at the pump pad. This heater should be secured before the pump is shut down and needs to be reset once the pump is started.

1.4 The Magnet Cooling Loops

A. There are two magnet cooling loops. One is located in the Sector 21 Linac Housing and operates at 100 PSIG. There is one flow interlock on the string and it is located at penetration 21-3 upstairs. The supply valve is located at penetration 21-4. Both of these 1 inch copper lines were formerly used as ACS cooling lines for DLWG sections associated with Station 21-2. DLWG Sections 21-2 B & C have been removed leaving these pipes available for use as ICS supply and return lines.

B. The second magnet cooling loop is located in the Injector Vault and it too has a single flow switch for the whole loop. This flow switch is located on the south wall of the injector vault.

1.5 ICS System Start-up Procedure[1]

A. Open suction and discharge valves.

B. Fill surge tank manually until it is at least ¾ full – do not over fill.

C. Put VFD HOA switch in Auto.

D. Clear any VFD faults.

E. At PLC interface – clear any software faults associated with the pump.

F. Press touch screen "Start" button.

G. Check System Pressure

1. 100 PSIG before the PRV – assuming the pressure is good skip subsection "a" (if not 100 PSIG follow procedure "a" below)

   a. Pressure setting at discharge of pump should start at ~100 PSIG (this is the VFD set point) and be adjusted upward until the high pressure (pressure before the PRV) is at 100 PSIG.

2. 55 PSIG after the PRV assuming the pressure is good skip subsection "a" (if not 55 PSIG follow procedure "a" below)

   a. The PRV is set to provide adequate flow throughout the system; 55 PSIG is the initial setting.

   b. The pressure after the PRV should never operate above 85 PSIG. There is a software interlock that will shut the pump down if the pressure rises above 100 PSIG.

H. Turn heater control on and clear faults at RF Hut and RF Gun heater control panels.

I. Reset heater software faults at HMI display panel.

1.6 ICS System Shut-down Procedure[1]

A. Turn heater control off at RF Gun and RF Hut heater controller panels

B. Push "Stop" button at VFD panel.

Part 2 Laser Room Cooling System

2.1 System Summary

The LCLS Laser Room Cooling System (LCS) is a chilled water system serving the drive laser room and RF Gun in the Sector 20 Injector Vault.

The main components of the system are: two pumps, a thermal storage tank, an expansion tank, a ten ton water chiller and a temperature control mixing valve.

The system is monitored through the CEF DCS as well as EPICS. It is controlled by an Allen-Bradley Control Logix PLC located in rack LKG18 in Sector 20. There is a local HMI display on the LCS pump pad. The chiller is controlled through the DDC system.

The LCS is a primary/secondary closed loop chilled water system. The recirculation pump is dedicated to the water chiller and independent of the process side. The recirculation pump provides a minimum of 20 GPM to the water chiller and is set maintain 33 PSIG at the discharge of the recirculation pump. The recirculation pump discharge pressure is controlled by a Variable Frequency Drive (VFD) sensing the discharge pressure. The chiller is designed to leave at least one evaporator circuit open at all times. A second circuit may open, should a second compressor be needed. The chiller has a total of three independent evaporator water circuits, only two should ever be used at one time.

The LCS is designed to provide up to 25 GPM of chilled water to the RF Gun cooling system and 15 GPM to the Drive Laser sub-systems. The system (process) pressure is controlled by a Variable Frequency Drive (VFD) on the process pump sensing discharge pressure. The pressure setting of 45 PSIG is adequate to satisfy the initial process flow requirements totaling ~26 GPM.

The VFDs have built in protection from running the pump dry, deadheading or overloading it by "running out." Should the VFD trip off, any VFD faults will have to be cleared at the VFD panel, finally the pump faults will have to be cleared at the HMI panel on the LCS pad.

LCS temperature is controlled by a three way mixing valve set to 60 degrees F. the system stability should be better than +/- 0.5 deg. F. Heat from the LCS chiller is rejected to CT1202.

2.2 LCS System Start-up Procedure[1]

A. Open the recirculation pump suction and discharge valves.

B. Put VFD HOA switch in Auto.

C. Clear any VFD faults.

D. At PLC interface – clear any software faults associated with the recirculation pump.

E. Press touch screen "Start" button.

F. Check System Pressure

1. Recirculation pressure setpoint is 33 PSIG
2. Verify the recirculation flow is at least 20 GPM
   a. If the pump seems to be running dead-headed, (it will shut down in 4 seconds if dead-headed) check the chiller evaporator solenoids. At least one evaporator circuit must be open.

G. Open the process pump suction and discharge valves.

H. Put process pump VFD HOA switch in Auto.

I. Clear any VFD faults.

J. At PLC interface – clear any software faults associated with the process pump.

K. Press touch screen "Start" button.

L. Check System Pressure

1. Process pressure setpoint is 45 PSIG

M. Put all chiller HOA switch in "Auto"

2.3 LCS System Shut-down Procedure[1]

A. Put all chiller HOA switches in "Off"

B. Push "Stop" button at process pump VFD panel.

C. Push "Stop" button at recirculation pump VFD panel.

Part 3 Summary of Existing System Modifications

3.1 Sector 20 Accelerator Cooling System Modifications

A. Two DLWG structures L0A and L0B are cooled by LI20 ACS as is the TCAV. All three structures are fed by one two inch line. Three throttling valves are located in the Injector Vault, one for each structure. L0A has a flow switch that will trip Klystron Station 20-7. The MKSU will indicate an ACC 1 fault. L0B has a flow switch that will trip Klystron Station 20-8. There are no other flow interlocks for 20-7 or 20-8.

B. ACS water flows through the 20-5D rotometer upstairs in the gallery, through the 20-5D DLWG structure and finally through approximately 120 feet of rectangular WG, then to the return header near penetration 20-16 down stairs in the housing. This rotometer may have a flow lower than others in the sector due to larger pressure drop associated with the long wave guide run.

C. Piping was modified at Klystron Stations 20-6, 20-7 & 20-8 to remove the flow switches and strainers from above the Fiat Racks to avoid leaking water into the racks. The15 GPM ACS rotometers for stations 20-6, 20-7 and 20-8 were replaced with 5 GPM rotometer since these three Klystron tubes no longer drive the DLWG structures in the Linac housing. They are used to drive structures in the Injector Vault. There are no flow interlocks on these rotometers. The flow should initially be set to ~2 GPM.

3.2 Sector 20 Wave Guide Cooling System Modifications

D. Rectangular wave guide fed from Klystron Station 20-6 is cooled with LI20 WGCS with at supply valve near the klystron tube. The WG is labeled "line 3" ends at penetration 20-16 through a 5 GPM rotometer. Line 3 is also referred to as the "delay line."

E. Rectangular wave guide fed from Klystron Station 20-7 is cooled with LI20 WGCS with at supply valve near the klystron tube. The line is labeled "line 2' and feeds L0A and part of the WG for the RF Gun and ends at penetration 20-16 through a 5 GPM rotometer.

F. Rectangular wave guide fed from Klystron Station 20-8 is cooled with LI20 WGCS with at supply valve near the klystron tube. The line is labeled "line 1" and feeds L0B, PH01 and "Line 4" WG exiting the Injector Vault. The water circuit ends at the bottom of penetration 20-16 and joins the other WG returns through the vertical ¾ in WG return and finally through a 5 GPM rotometer.

G. There are no other flow interlocks for any of the wave guide on 20-6, 20-7 or 20-8.

3.3 Sector 21 Accelerator Cooling System Modifications

A. The following DLWG cooling circuits were removed from Sector 21: 21-1A, 21-2A, B, C & D, 21-3A. WG return circuits for 21-2 were removed from service and the pipes reused as described below.

B. Klystron Stations 21-1 and 21-3 have been modified to move some of the flow switches and strainers from above the Fiat racks to avoid leaks into the racks. Only circuits that were modified for LCLS have had this modification completed; other stations may have similar modifications in the future.

1. The 21-1A ACS water circuit provides cooling to SDMP as well as part of the SLED cavity for Klystron 21-1. The ACC 2 and WG 2 flow switches have been relocated to the North side of penetration 21-1 about 3 feet off the ground.

   a. There are two (redundant) BCS flow switches for SDMP located in the Linac housing.

   b. Setting the ACC 2 flow switch could trip the BCS circuit if flow to the "A" rotometer is decreased. Always call MCC and let them know that you are working on a cooling circuit

that could potentially trip the BCS device SDMP if you need to interrupt the flow to this circuit.

c. The following procedure should be used to set the ACC 2 flow switch.

i Do not adjust the "A" rotometer (always leave it wide open (~5 GPM).

ii Adjust the "B" rotometer to 10 GPM

iii Adjust the flow switch to the tripped position.

iv Increase the flow on the "B" rotometer make up the switch.

v Verify the switch trips between 9.8 and 10 GPM by adjusting the "B" rotometer.

vi Increase the flow on the "B" rotometer to 13 GPM.

2. The 21-3A ACS water circuit provides cooling to TD11 as well as part of the SLED cavity for Klystron 21-3. The ACC 2 and WG 2 flow switches have been relocated to the North side of penetration 21-5 about 3 feet off the ground.

a. There is one MPS flow switch for TD11 located in the Linac housing.

b. Setting the ACC 2 flow switch could trip the MPS circuit if flow to the "A" rotometer is decreased. Always call MCC and let them know that you are working on a cooling circuit that could potentially trip the MPS device TD11 if you need to interrupt the flow to this circuit.

c. The following procedure should be used to set the ACC 2 flow switch.

i Do not adjust the "A" rotometer (always leave it wide open (~5 GPM).

ii Adjust the "B" rotometer to 10 GPM

iii Adjust the flow switch to the tripped position.

iv Increase the flow on the "B" rotometer make up the switch.

v Verify the switch trips between 9.8 and 10 GPM by adjusting the "B" rotometer.

vi Increase the flow on the "B" rotometer to 13 GPM.

C. The right hand rotometer at penetration 21-3 is the water circuit serving Klystron Station 21-2 (X-Band) DLWG. This circuit has a nominal flow of between 0.3 and 1 GPM depending on structure temperature. There is no flow interlock on this circuit.

D. As mentioned above in section 1.4.A, the DLWG water circuits for 21-2B & C have been reused for the magnet string on the ICS system.

E. The ¾ in pipe in penetration 21-3 which is typically used for a WGCS return is now being used as a supply for the BC2 2 jaw collimator called CE11. This MPS device has a flow switch in the Linac housing.

F. The 21-2D DLWG water circuit has been reused to provide WGCS water to PH02. There is no flow switch on this device. Flow should be adjusted to provide at least 0.25 GPM at all times. The WGCS return line at penetration 21-4 is now used as the return for PH02.

Part 4 Injector Vault General

4.1 Compressed Air

A. The compressed air for the Injector Vault is supplied through a single ¾ inch copper line. The supply valve is located above the Fiat rack near penetration 20-11.

B. There is a pressure switch in the vault set to trip at 80 PSIG. This switch is tied into the DCS PLC. It is important for the vault to have an adequate air supply in order for the sump pump and vacuum valves to operate properly.

C. There is an air storage tank in the Injector Vault under the floor at the bottom of the stairs. There is a drain valve at the bottom of this tank which should be drained at least once a year.

4.2 Injector Vault Sump Pump

A. The Injector Vault sump pump is located near the shielding wall at the East end of the Injector vault under the floor.

B. The pump is a two speed air operated diaphragm pump.

C. Water pumped out of the sump is pushed through the shielding wall into the Linac housing.

4.3 Injector Vault Drain Lines

A. All hoses under the floor in the Injector Vault should have drain valves with ½ inch JIC fittings.

B. There are at least three drain hoses in place under the floor and pre-plumbed to the sump drain header connected to the Linac housing.

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[1] These procedures assume the operator has the proper training and authorization to perform the tasks described.

System:				LCLS Linac Upgrade		
Drawing Number				Title		
Prefix	Series	Base	Suffix	Area / System (Second Line)	Description (Third Line)	Description (Fourth Line)
ID	383	104	31	Sector 21 Linac Housing	LCW Piping	Isometric Diagram
ID	383	104	32	Sector 20 Injector Vault	Process Water Systems	Isometric Diagram
ID	383	104	38	Sector 20 and Sector 21	Injector Process Water Systems	Title, Index & Legend
ID	383	104	39	Sector 21	Injector Process Water Systems	Structural Plan
ID	383	104	40	Sector 21	Injector Process Water Systems	Structural Details
ID	383	104	42	Sector 20 and Sector 21	Injector Process Water Systems	Piping Plan
ID	383	104	43	Sector 20 and Sector 21	Injector Process Water Systems	Piping Sections & Details
ID	383	104	44	Sector 20 and Sector 21	Injector Process Water Systems	Piping Support Details
ID	383	104	45	Sector 21	Injector Cooling System	Pump Pad Plan and Sections
ID	383	104	46	Sector 21	Laser Cooling System	Pump Pad Plan and Sections
ID	383	104	47	Sector 21	Injector Process Water Systems	Pump Pad Details
ID	383	104	48	Sector 21	Injector Cooling System	Piping & Instrumentation Diagram
ID	383	104	49	Sector 21	Laser Cooling System	Piping & Instrumentation Diagram
ID	383	104	50	Sector 20 and Sector 21	Injector Process Water Systems	Equipment Schedules
ID	383	104	51	Sector 21	Injector Process Water Systems	Electrical Single Line Diagram
ID	383	104	52	Sector 21	Injector Process Water Systems	Electrical Plan
ID	383	104	53	Sector 20 and Sector 21	Injector Process Water Systems	Electrical Details
ID	383	104	59	Sector 20 & 21 Injector Process Water	System Architecture Drawing	
ID	383	104	60	Sector 20 & 21 Injector Process Water	Processor Rack Panel Layout	
ID	383	104	61	Sector 20 & 21 Injector Process Water	Remote I/O Rack 2 Panel Layout	
ID	383	104	62	Sector 20 & 21 Injector Process Water	Injection Tunnel Termination Panel	
ID	383	104	63	Sector 20 & 21 Injector Process Water	RF Hut Termination Panel	
ID	383	104	64	Sector 20 & 21 Injector Process Water	Schematic Wiring Diagram	PLC Wiring Legend Sheet
ID	383	104	65	Sector 20 & 21 Injector Process Water	AC & DC Power Distribution	PLC - Processor Rack
ID	383	104	66	Sector 20 & 21 Injector Process Water	AC & DC Power Distribution	PLC - Remote I/O Rack
ID	383	104	67	Sector 20 & 21 Injector Process Water	Loop Diagram - Processor Rack 0	
ID	383	104	68	Sector 20 & 21 Injector Process Water	Loop Diagram - Processor Rack	Rack 1 - Slot 5
ID	383	104	69	Sector 20 & 21 Injector Process Water	Loop Diagram - Remote I/O Rack	Rack 2 - Slot 1
ID	383	104	69	Sector 20 & 21 Injector Process Water	Loop Diagram - Remote I/O Rack	Rack 2 - Slot 2
ID	383	104	69	Sector 20 & 21 Injector Process Water	Loop Diagram - Remote I/O Rack	Rack 2 - Slot 4
ID	383	104	69	Sector 20 & 21 Injector Process Water	Loop Diagram - Remote I/O Rack	Rack 2 - Slot 7
ID	383	104	69	Sector 20 & 21 Injector Process Water	Loop Diagram - Remote I/O Rack	Rack 2 - Slot 8
ID	383	104	69	Sector 20 & 21 Injector Process Water	Loop Diagram - Remote I/O Rack	Rack 2 - Slot 9
ID	383	104	69	Sector 20 & 21 Injector Process Water	PLC ControlNet Communications	Interconnection Diagram
ID	383	104	70	Sector 20 & 21 Injector Process Water	Instrumentation Installation Details	
ID	383	104	71	Sector 20 & 21 Injector Process Water	Instrumentation Location Drawings	
ID	383	104	72	Sector 20 & 21 Injector Process Water		