SHMS Cryogenics and Q2(Q3Dipole) Cool Down

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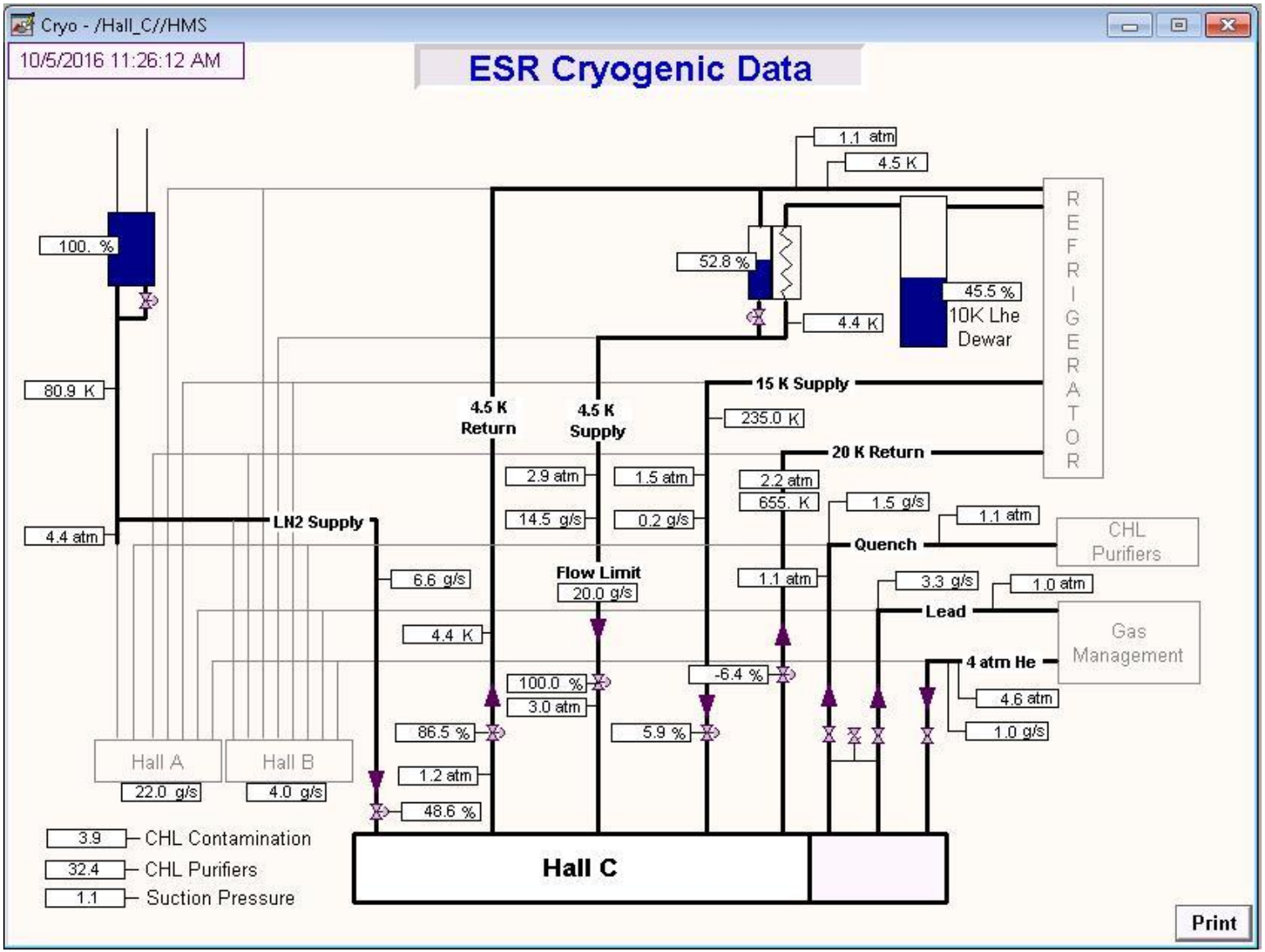
Cryogenics Top level

- Cryogenic System is common to JLAB Halls A, B and C
- All Halls are superconducting
- End Station Refrigerator(ESR) 1500 Watts
- Hall A- HRS right and HRS left(1994)
- Hall B – Clas12 Torus and Solenoid(2016)
- Hall C – HMS(1992)and SHMS(2016)

End Station Cryogenics



ESR Helium Refrigerator System

- ESR system
  - Completely automated system runs 24/7 unattended
  - 1500 watts capacity
  - 10,000 liter LHE local storage
  - 10,000 gallon LN2 local storage
  - 250,000 gallon gas Helium local storage
  - Purifiers- LN2 charcoal scrubbers
  - Cold and warm Connection to Central Helium Liquifier(CHL) for extra capacity and inventory
  - Transfer lines deliver LHE and LN2 to Hall A, B and C

Hall C Cryogenic System I

- Transfer Line from ESR
  - LHE supply and return
  - LN2 supply
  - 20 K He gas supply
  - 25 K Gas Helium return
- Gas supply and return line to ESR
  - 3.5 Atm gas Helium supply
  - Vapor cooled lead He gas return line
  - Warm He return line for cool downs
  - Exhaust N2 gas vent line to atmosphere

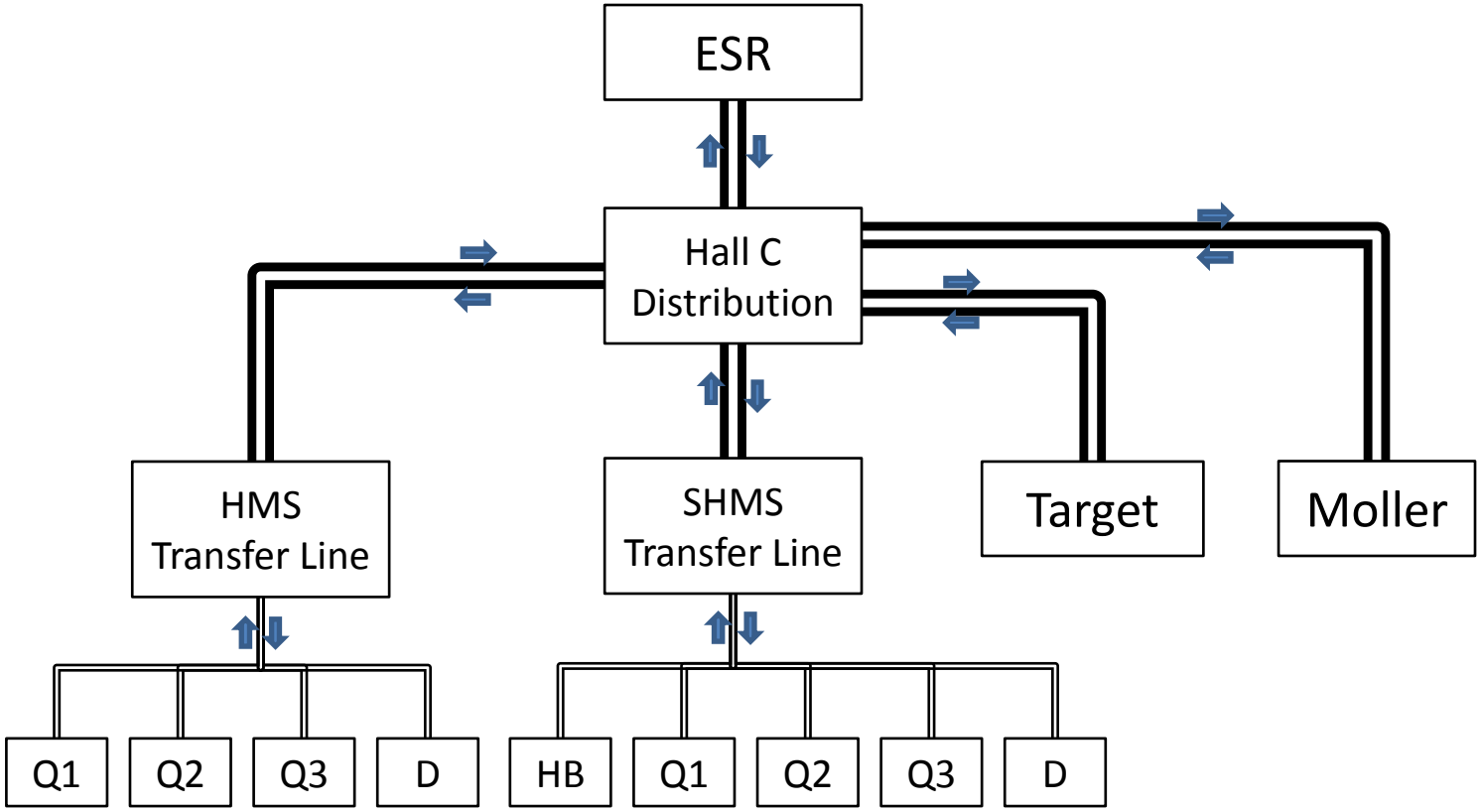
Hall C Cryogenic System II

- HMS system (1993)
  - Cools 4 SC magnets(Q1, Q2, Q3 & Dipole)
  - Flex line to permit rotations
  - HMS distribution XFER line- parallel supply/return
  - HMS gas return lines
- SHMS system(2014)
  - Cools 5 SC magnets (HB, Q1, Q2, Q3 & Dipole)
  - Flex line to permit rotations
  - SHMS distribution XFER line-parallel supply/return
  - SHMS gas return lines
- Hall C magnet reservoirs have min. 1 hour hold time

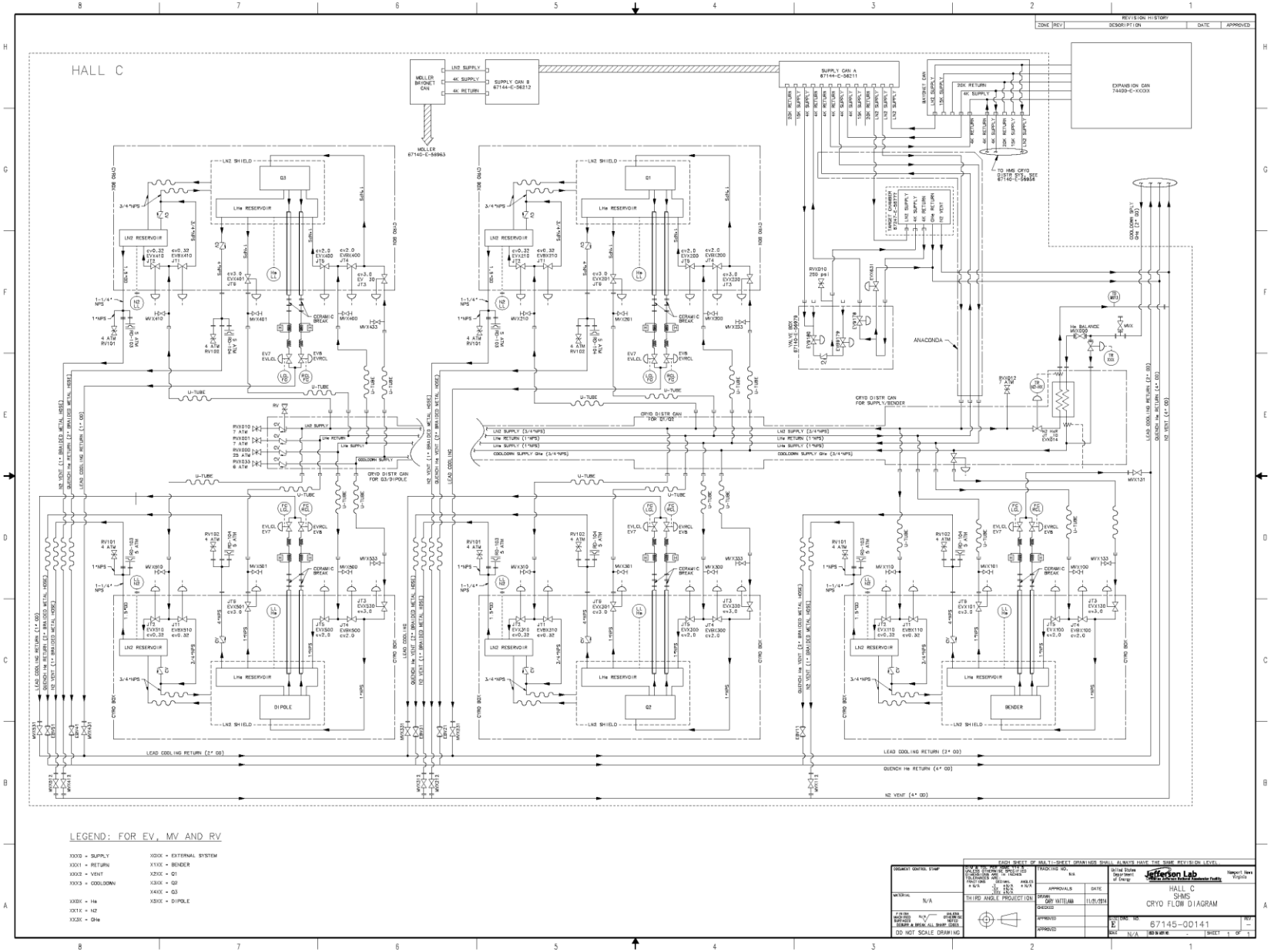
Hall C Cryogenics III

- Hall C Cryo-Target system
  - Cools local Hall C cryo-target-3 @ 800 watts
  - Local valve box to select LHE or 20 K HE cooling
  - LH2, LD2 targets at ~ 20 K
  - HE3 gas targets at 4.2 K
- Hall C Moller Polarimeter- beam polarization
  - 5 tesla SC solenoid to polarize iron foils
  - Transfer line for LHE and LN2
  - Gas return lines

Hall C Cryogenics “block” diagram



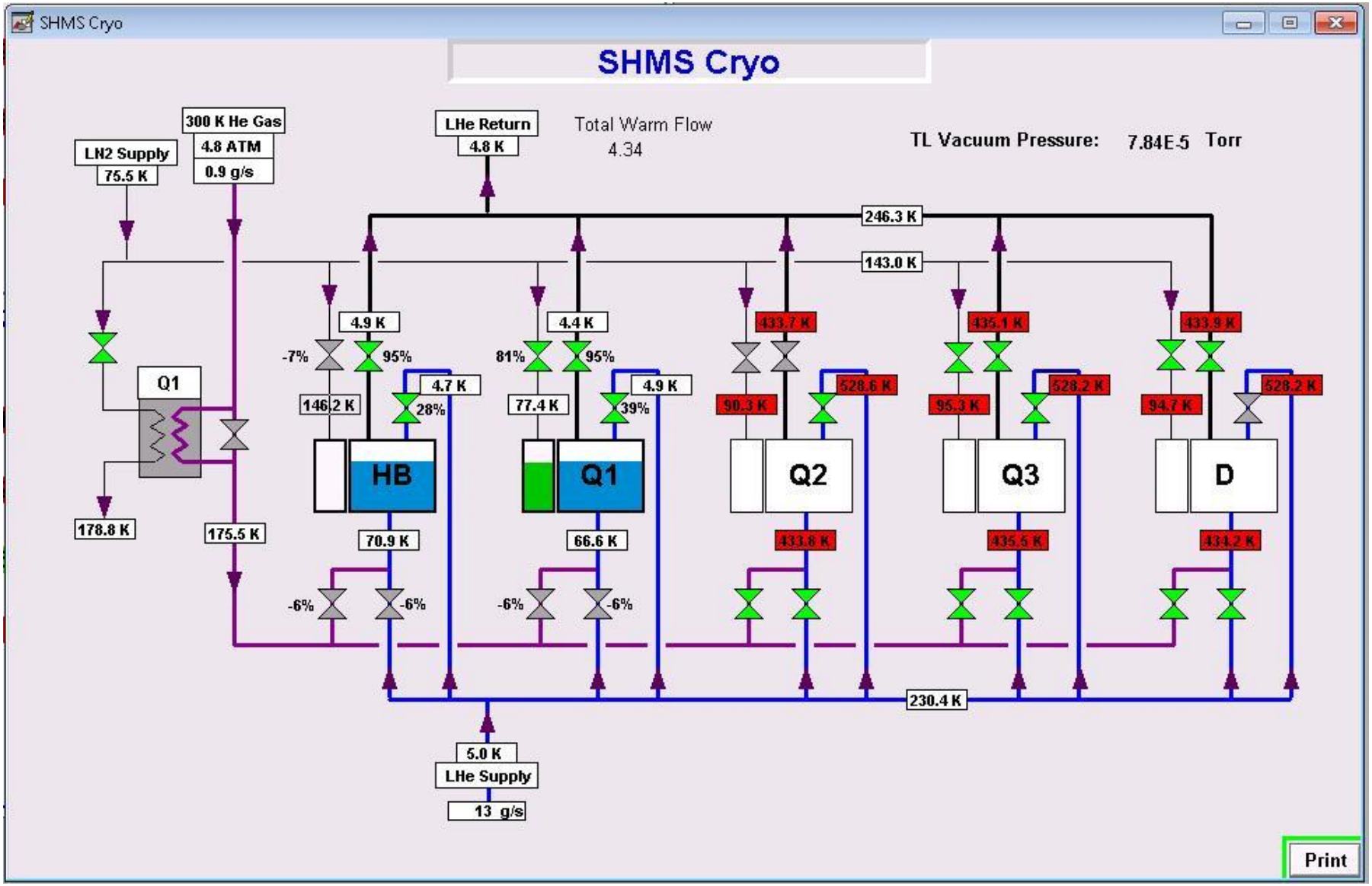
SHMS Cryogenic Schematics



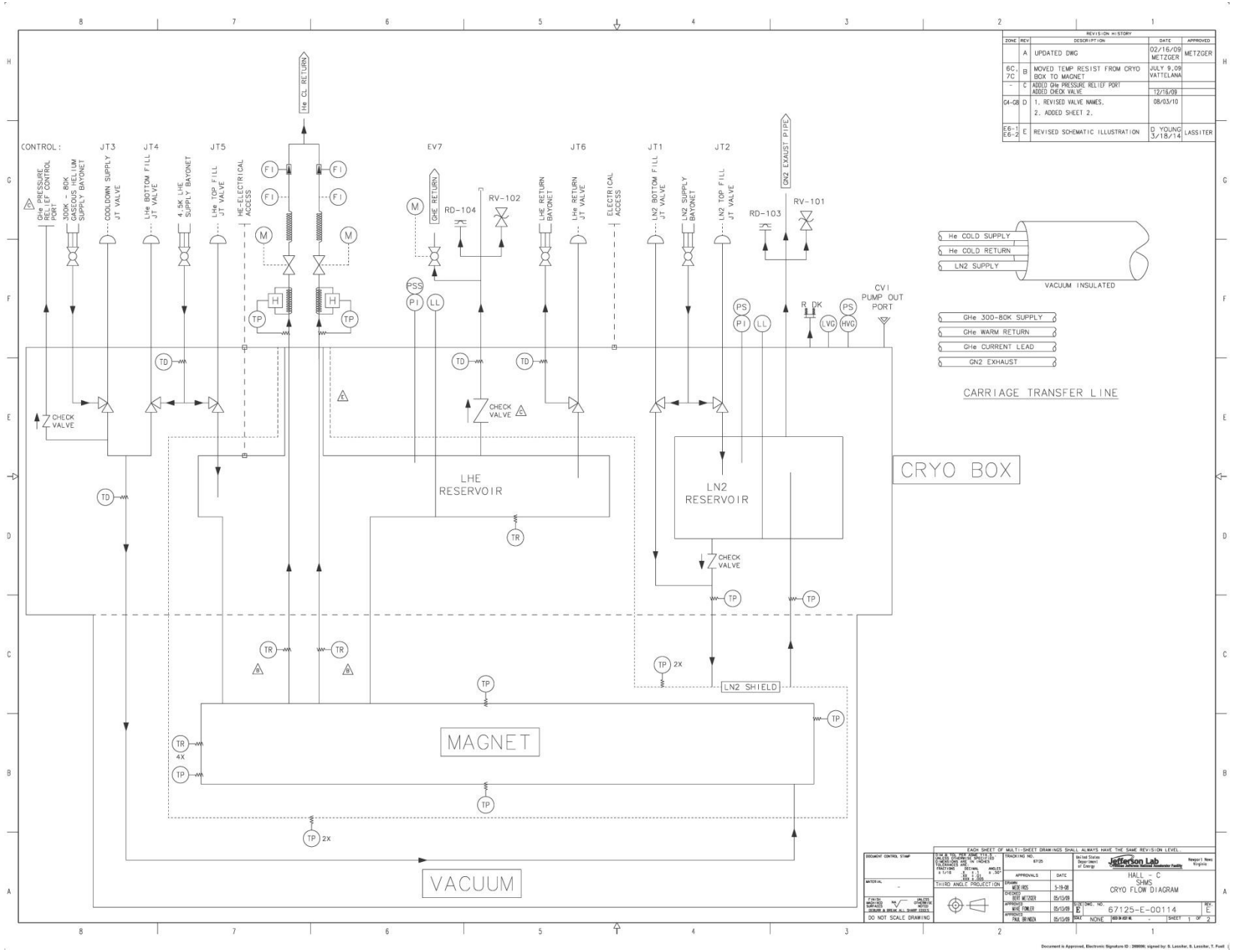
SHMS Magnet Cooling System

- Distribution transfer line on SHMS
- All magnets cooled in parallel independently
- Internal Cool Down/Warm Up Heat Exchanger
- He supply at 2.5 Bar 4.5 K
- He return at 1.2 Bar and 4.4 K
- LN2 supply 80 K , 3.5 Bar
- Cool down He gas 3.5 Bar (250 K to 80 K)

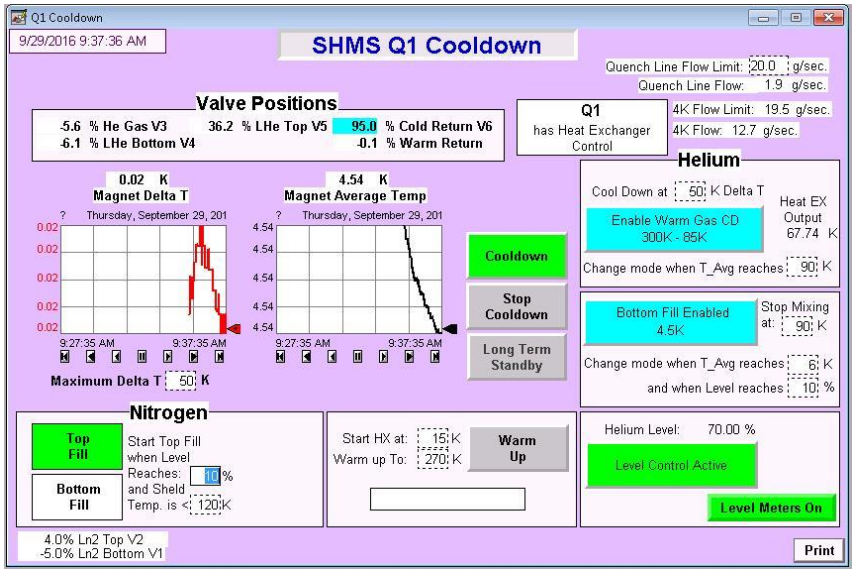
SHMS Distribution System

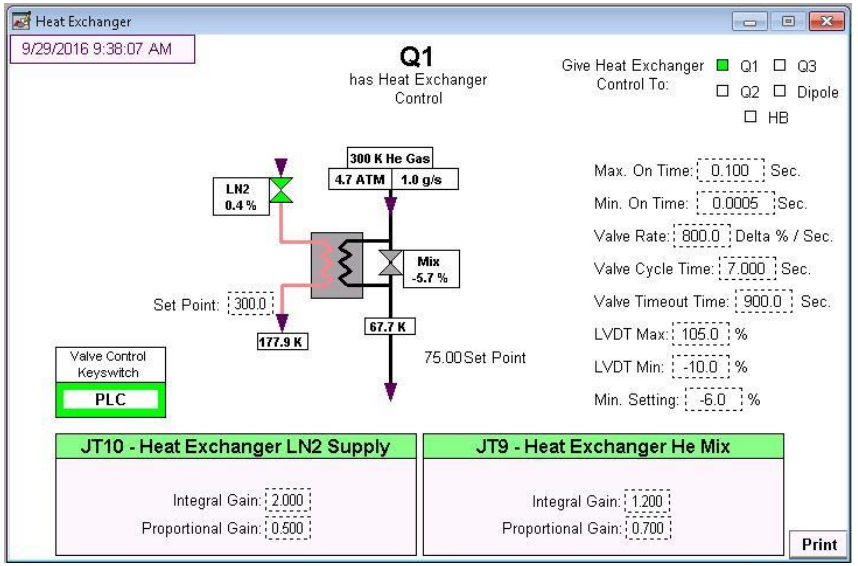


Q2 Magnet P&I


He CL RETURN
CONTROL :
JT3
JT4
JT5
EV7
JT6
JT1
JT2
GN2 EXAUST PIPE
GHe PRESSURE RELIEF CONTROL PORT
300K - 80K GASEOUS HELIUM SUPPLY BAYONET
COOLDOWN SUPPLY JT VALVE
LHe BOTTOM FILL JT VALVE
4.5K LHE SUPPLY BAYONET
LHe TOP FILL JT VALVE
HE ELECTRICAL ACCESS
GHE RETURN
RD-104
RV-102
LHE RETURN BAYONET
LHe RETURN JT VALVE
ELECTRICAL ACCESS
LN2 BOTTOM FILL JT VALVE
LN2 SUPPLY BAYONET
LN2 TOP FILL JT VALVE
RD-103
RV-101
CVI PUMP OUT PORT
R DK
He COLD SUPPLY
He COLD RETURN
LN2 SUPPLY
VACUUM INSULATED
GHe 300-80K SUPPLY
GHe WARM RETURN
GHe CURRENT LEAD
GN2 EXHAUST
CARRIAGE TRANSFER LINE
CHECK VALVE
LHE RESERVOIR
LN2 RESERVOIR
CRYO BOX
LN2 SHIELD
MAGNET
VACUUM
REVISION HISTORY
ZONE REV DESCRIPTION DATE APPROVED
A UPDATED DWG 02/16/09 METZGER
6C, 7C B MOVED TEMP RESIST FROM CRYO BOX TO MAGNET JULY 9,09 VATTELANA
- C ADDED GHe PRESSURE RELIEF PORT ADDED CHECK VALVE 12/16/09
G4-G8 D 1. REVISED VALVE NAMES. 2. ADDED SHEET 2. 08/03/10
E6-1 E6-2 E REVISED SCHEMATIC ILLUSTRATION D YOUNG 3/18/14 LASSITER
Jefferson Lab
HALL - C
SHMS
CRYO FLOW DIAGRAM
67125-E-00114
DO NOT SCALE DRAWING

SHMS Cool Down Control Screens

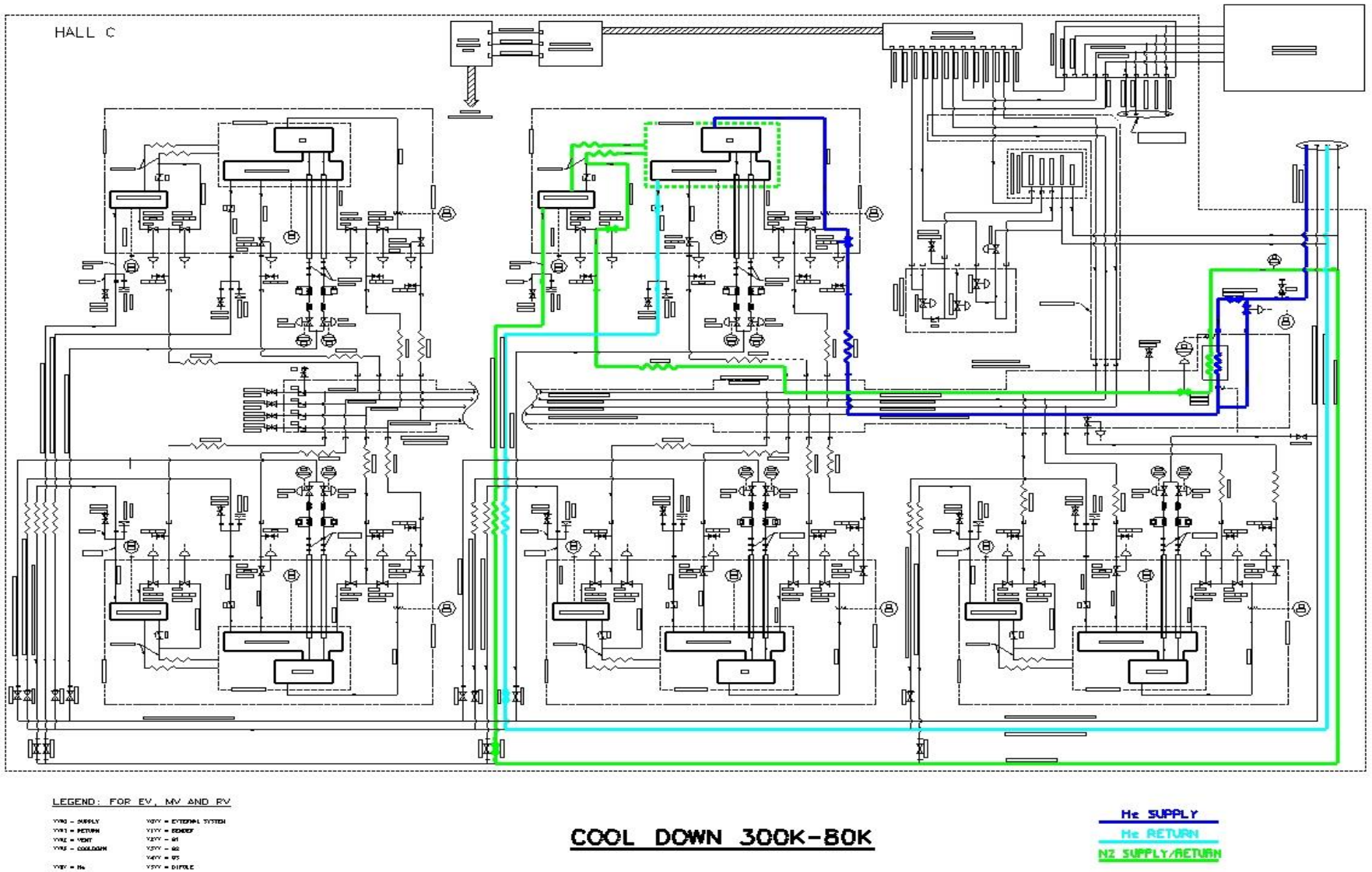




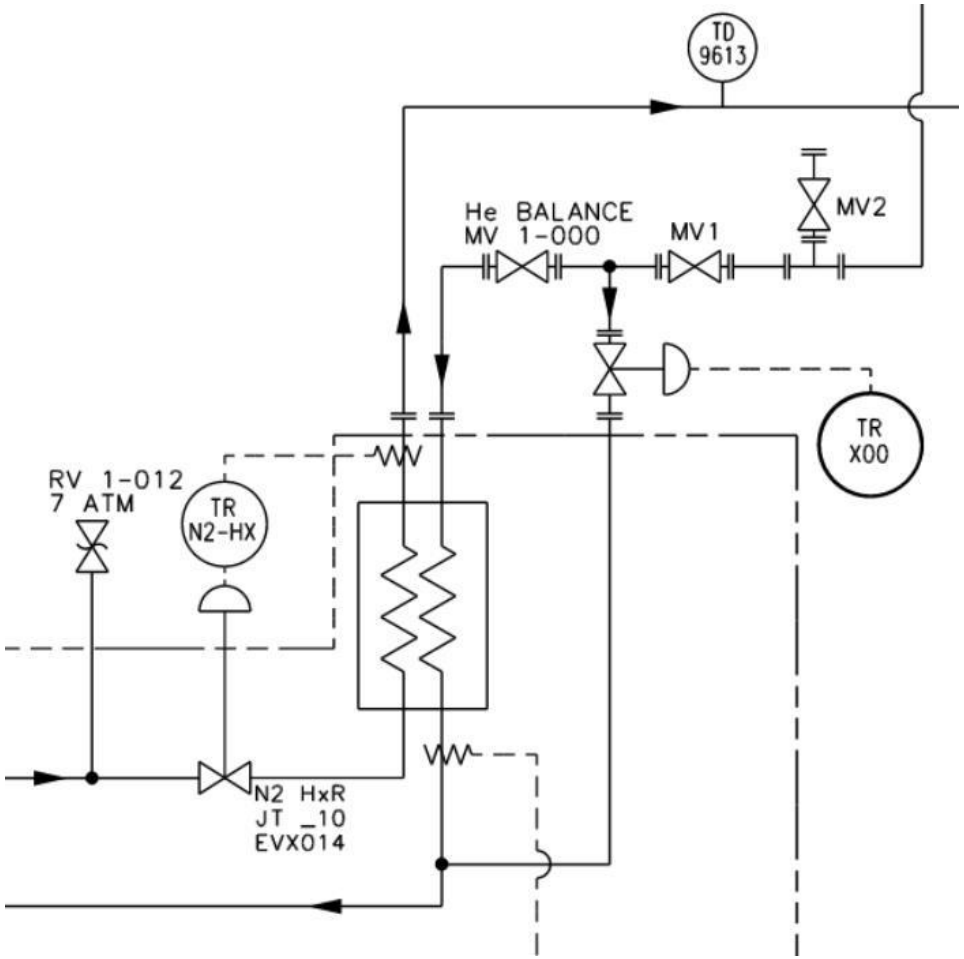
Hall C Magnet Cool Down I

- 300 K to 80 K cool down
  - Process uses a Hall C Heat Exchanger under local PLC control using sensors in subject magnet
  - Blends 80 K He and 300 K He to make any temperature cold He gas between 250 K and 80 K
  - Process makes 10 Grams/sec cold Helium
  - Consumes 30 Grams/sec LN2 when output Temp is 80 K
  - PLC manages LN2 supply, coolant Temp and interlocks
  - Coolant is 50 K < Magnet temp, Magnet gradients < 50 K
  - Coolant distributed to subject magnet (HB,Q1,Q2,Q3,Dipole)
  - Q2Q3 take 2 weeks(14 days) Dipole takes 3 weeks(21 days)

Cool Down 300K to 80K

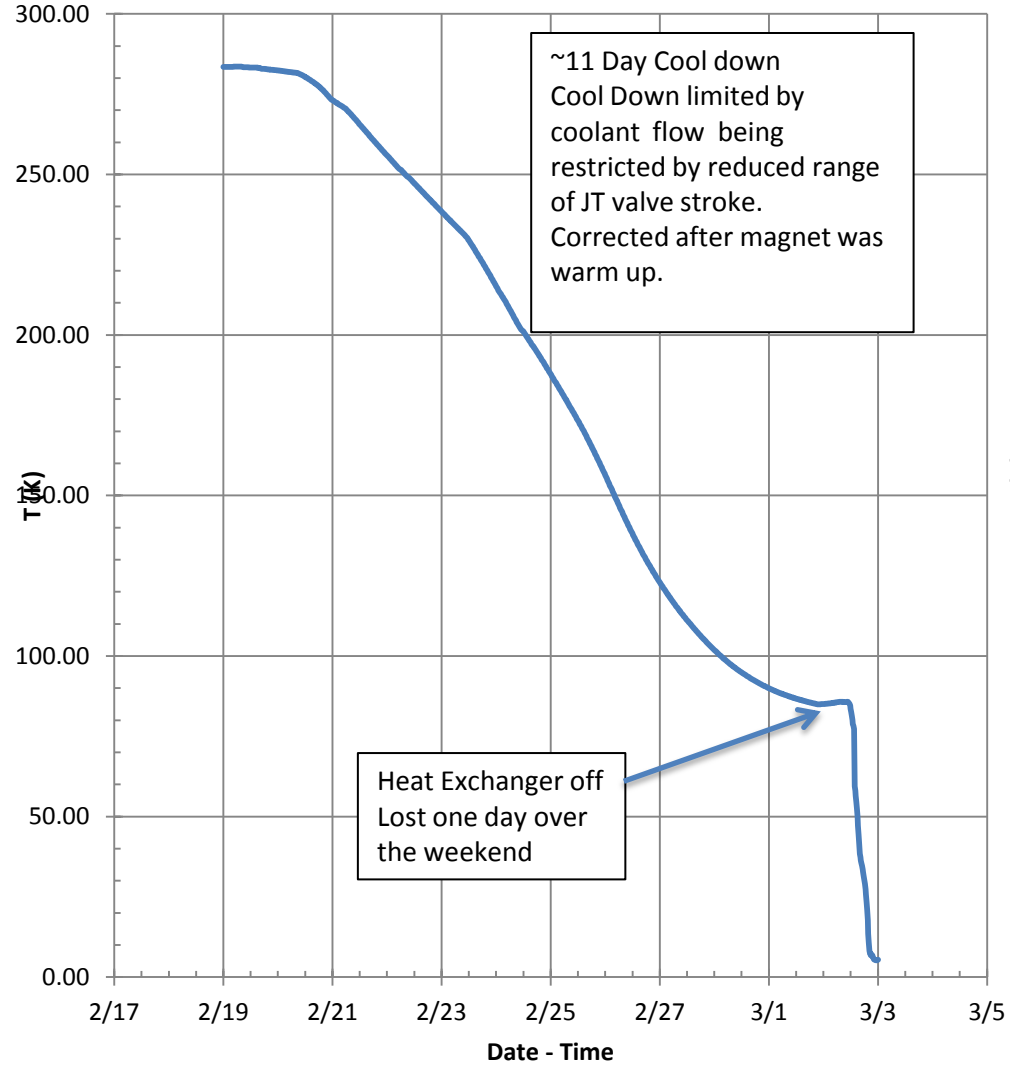


Hall C Cool Down Heat Exchanger

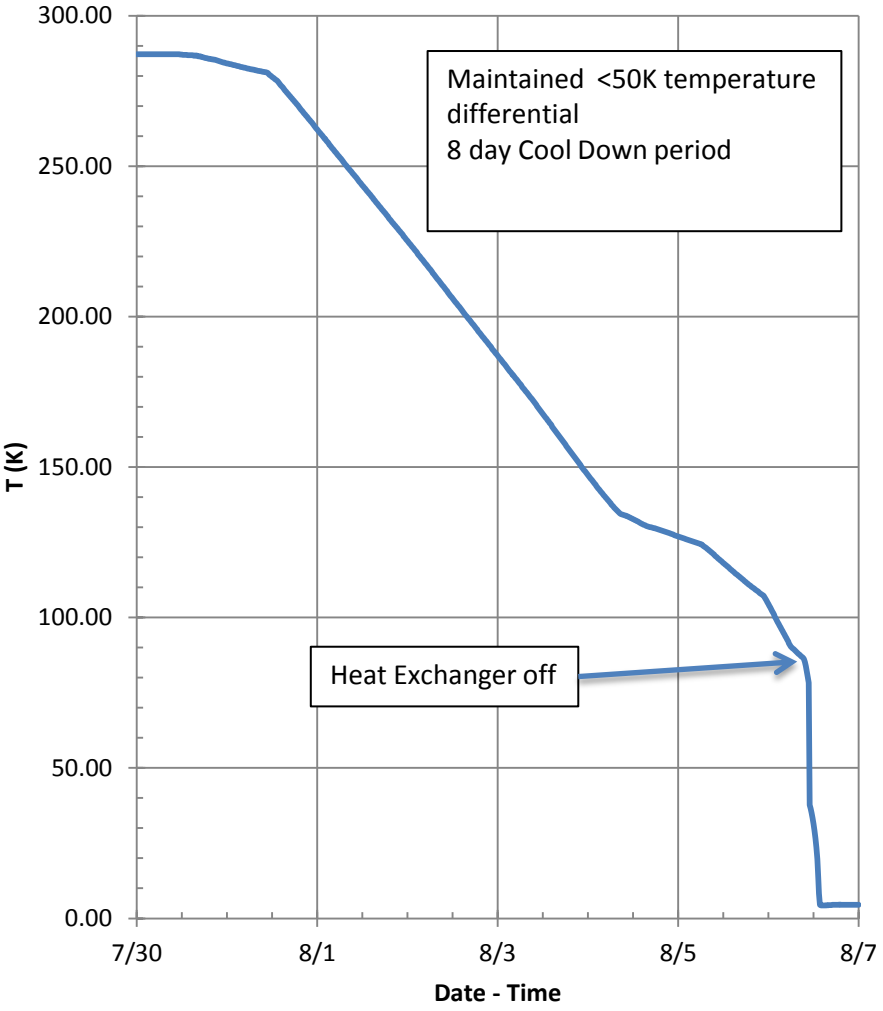


SHMS Q1 Cool Down

Q1 cool down #1



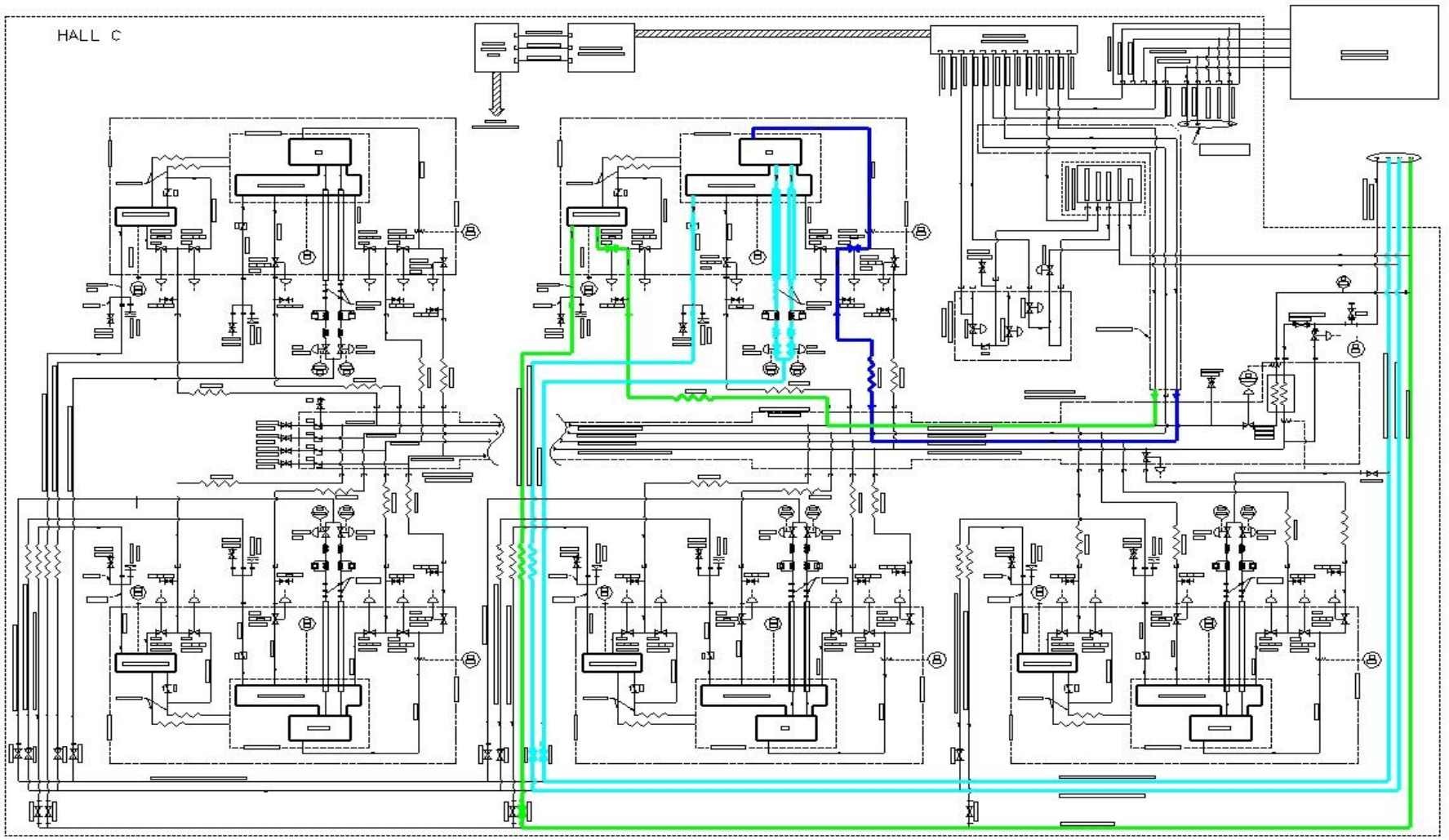
Q1 Cool Down #2



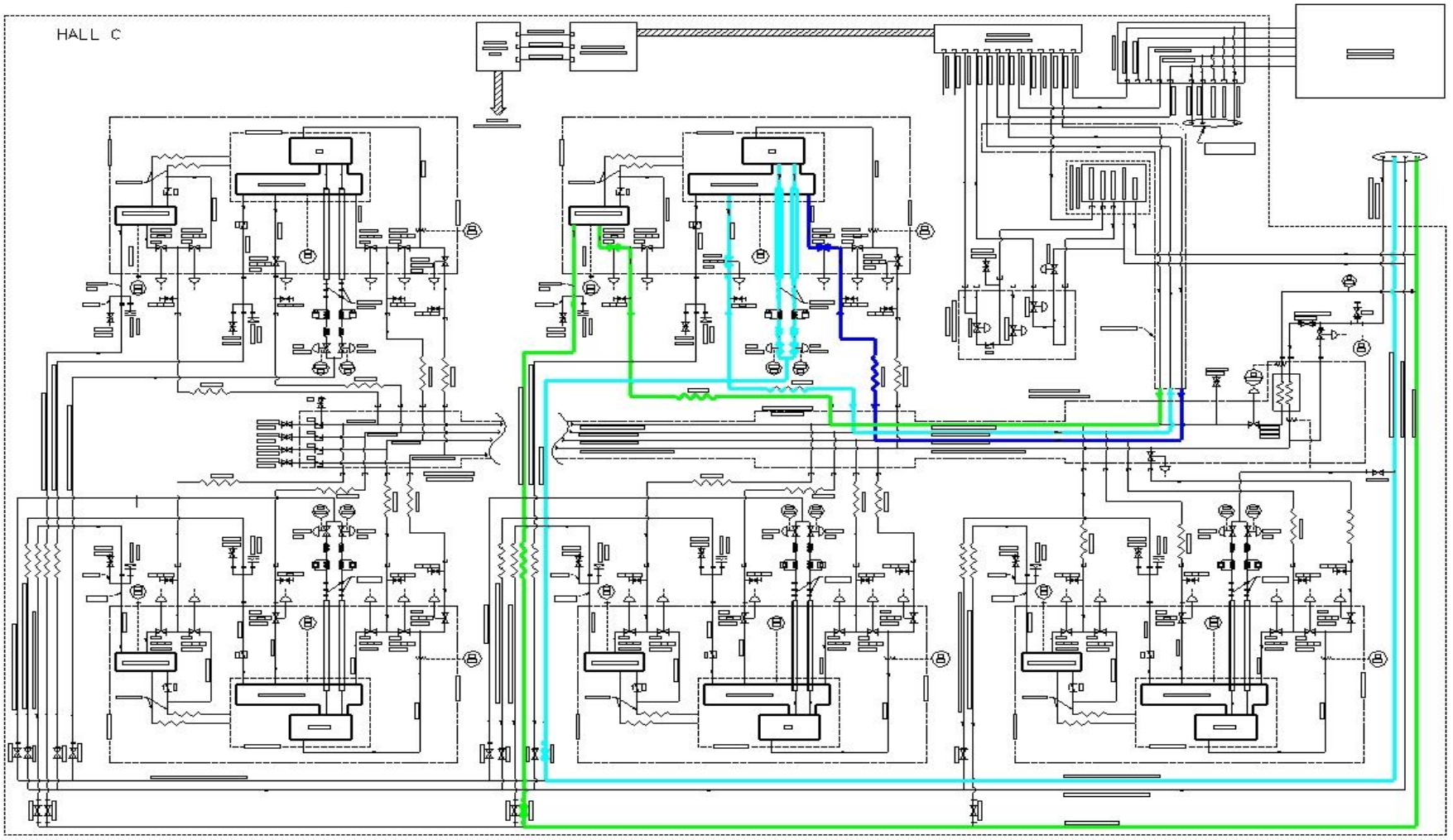
Hall C Magnet Cool Down II

- Entire process is managed by PLC
  - Magnet Temp below 100 K
  - Introduce LHE at 4.4 K thru “bottom fill” valve in each magnet
  - Internal manifold distributes LHe to far end of each magnet
  - Magnet cools to 4.4 K and starts accumulating LHE
  - LHE rises into reservoir and registers on LL probe
  - Cooling switches to top fill
  - LHE switches to cold return
- Operator tunes up PID liquid level regulation

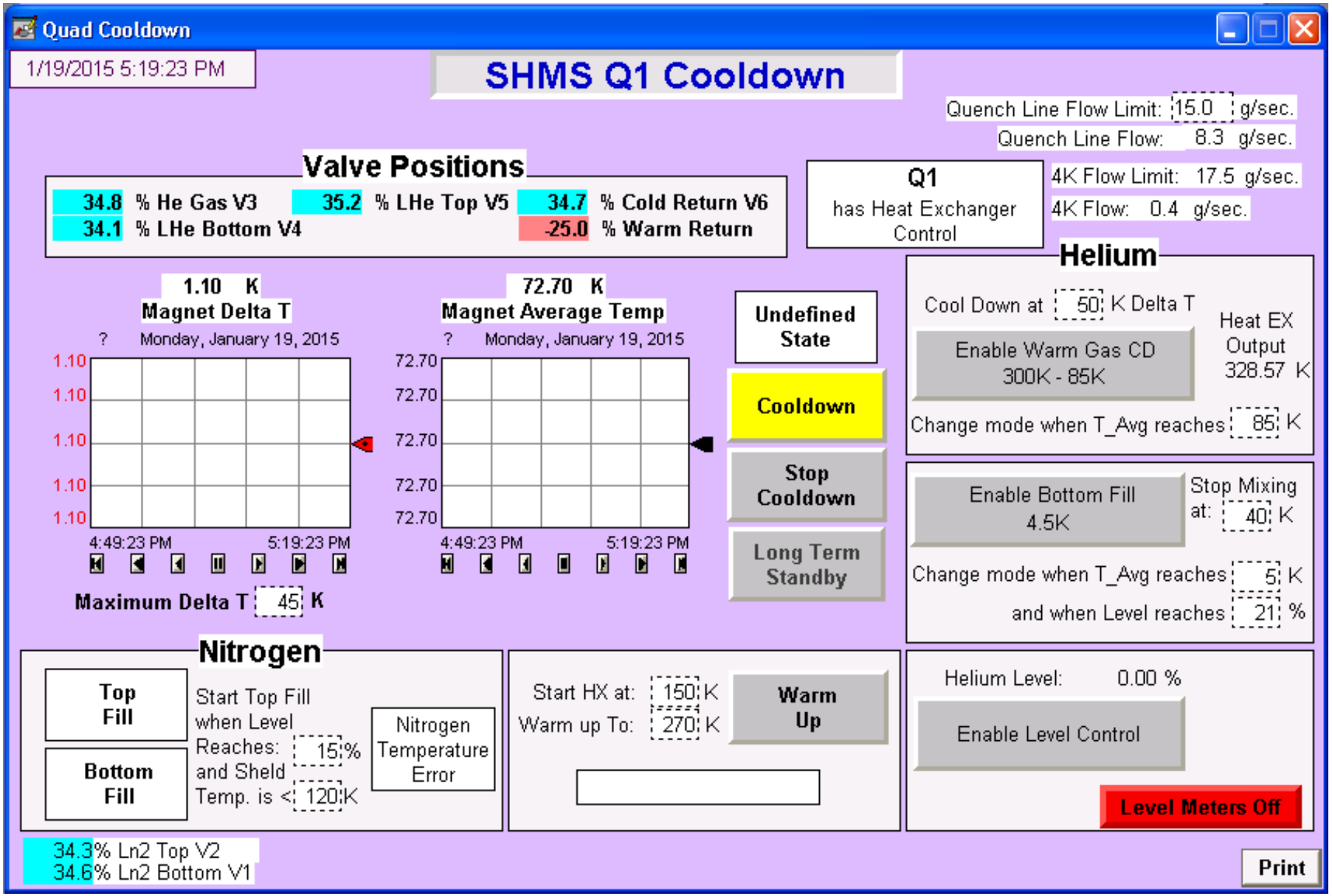
Cooldown to 4K



Top Fill / Cold Return



Cool Down Logic



Cool Down Interlocks / Controls

Event	Action
Magnet Temperature Delta > 50K	Close Supply valve
Temperature gradient between HX output and magnet input > 50K	Adjust HX output temperature set point, Close Supply valve to magnet.
Helium Pressure to High	Close Supply Valve, open warm Valve.
Helium Pressure below 1 atm	Interlock
Insulating Vacuum Bad	Interlock
Support Links out of range	Close Supply Valve. Adjust tension on links.
Flow to Hall C exceeds ESR set point by 0.5 g/s	Close supply Valve
Helium Cold Return temperature > 6K	Close cold return valve, open warm return valve

Cryogenics and Cool Down Summary

- Hall C cryogenics in continuous service since 1993 for HMS
- SHMS cryo in continuous service since 2014
- Cool Down(CD) System has been in continuous use since 1993
- CD System has been copied by Halls A, B and D
- PLC controls are very mature and have been in continuous service for 15 years