SHMS Cryogenics and Q2(Q3Dipole) Cool Down

Paul Brindza

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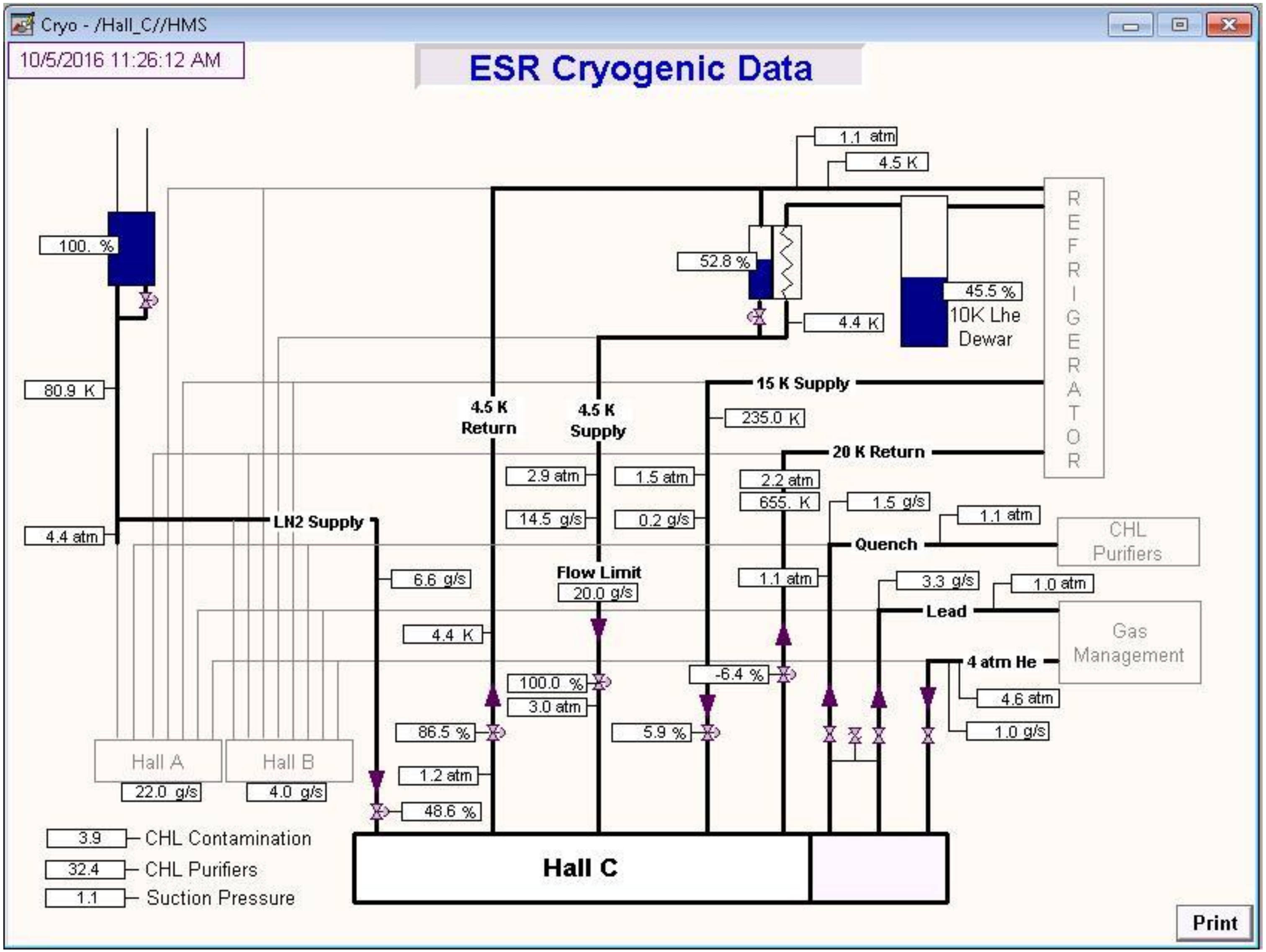
Cryogenics Top level

- 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
  - 1000 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

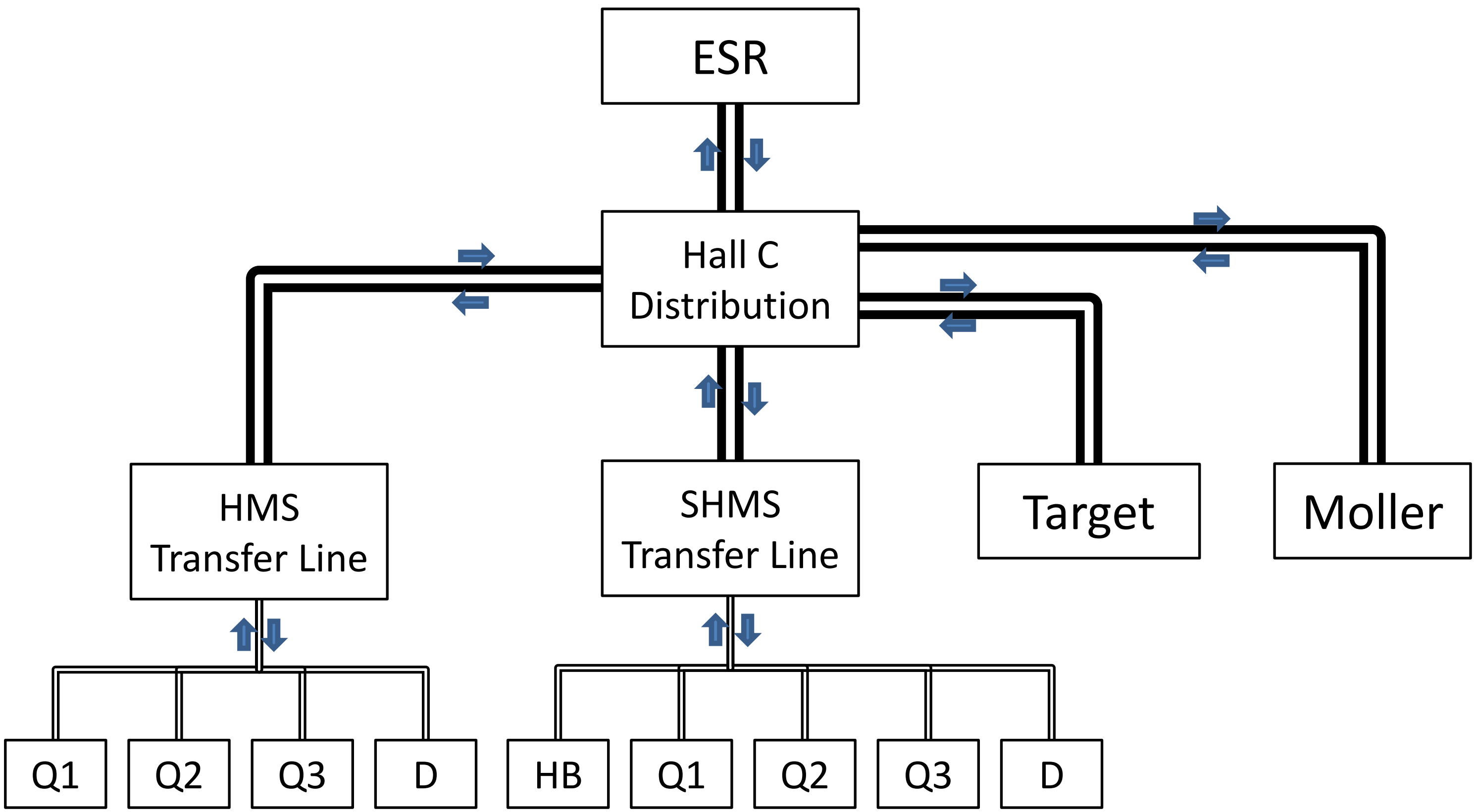
Hall C Cryogenic System II

- HMS system
  - 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
  - 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

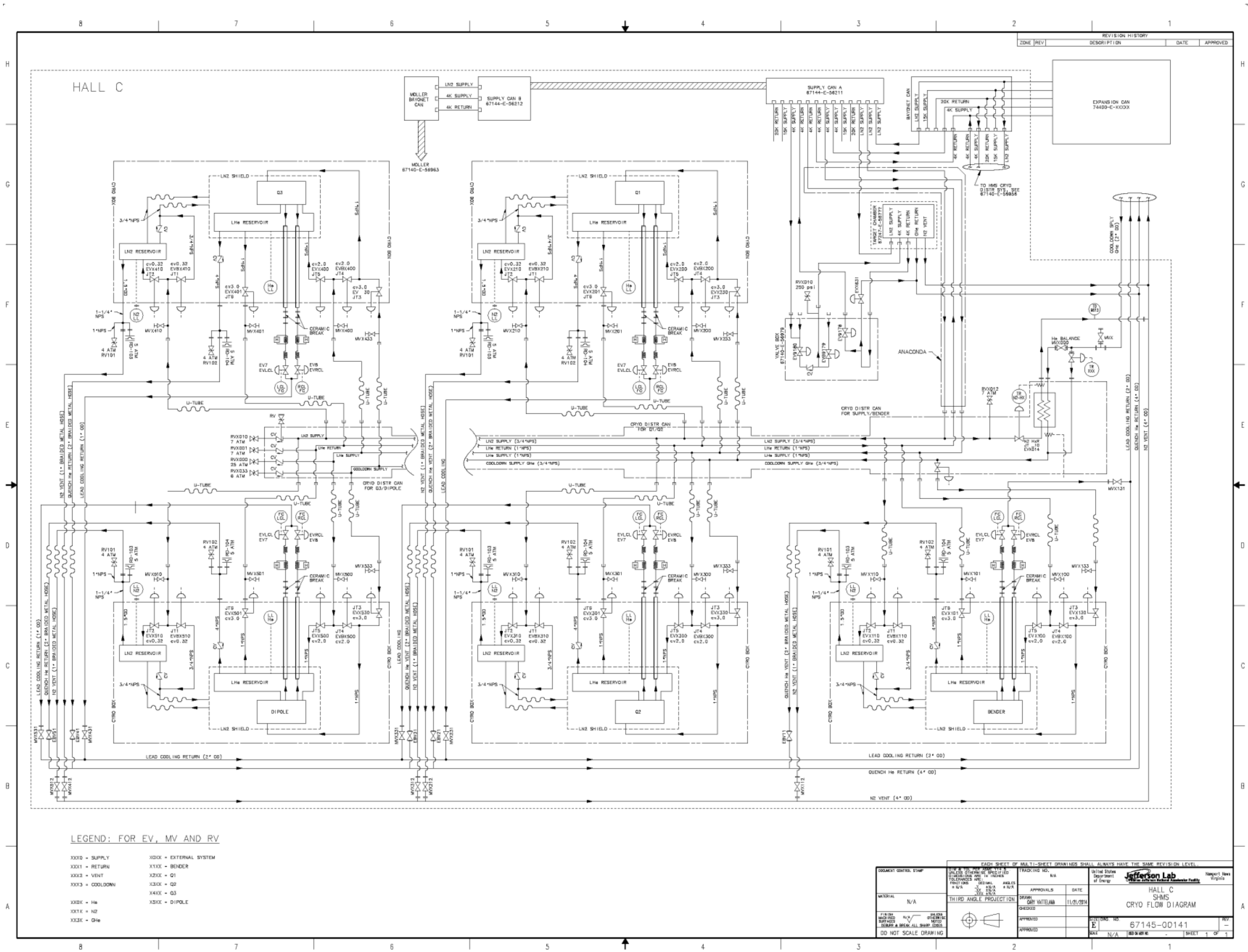
Hall C Cryogenics III

- 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



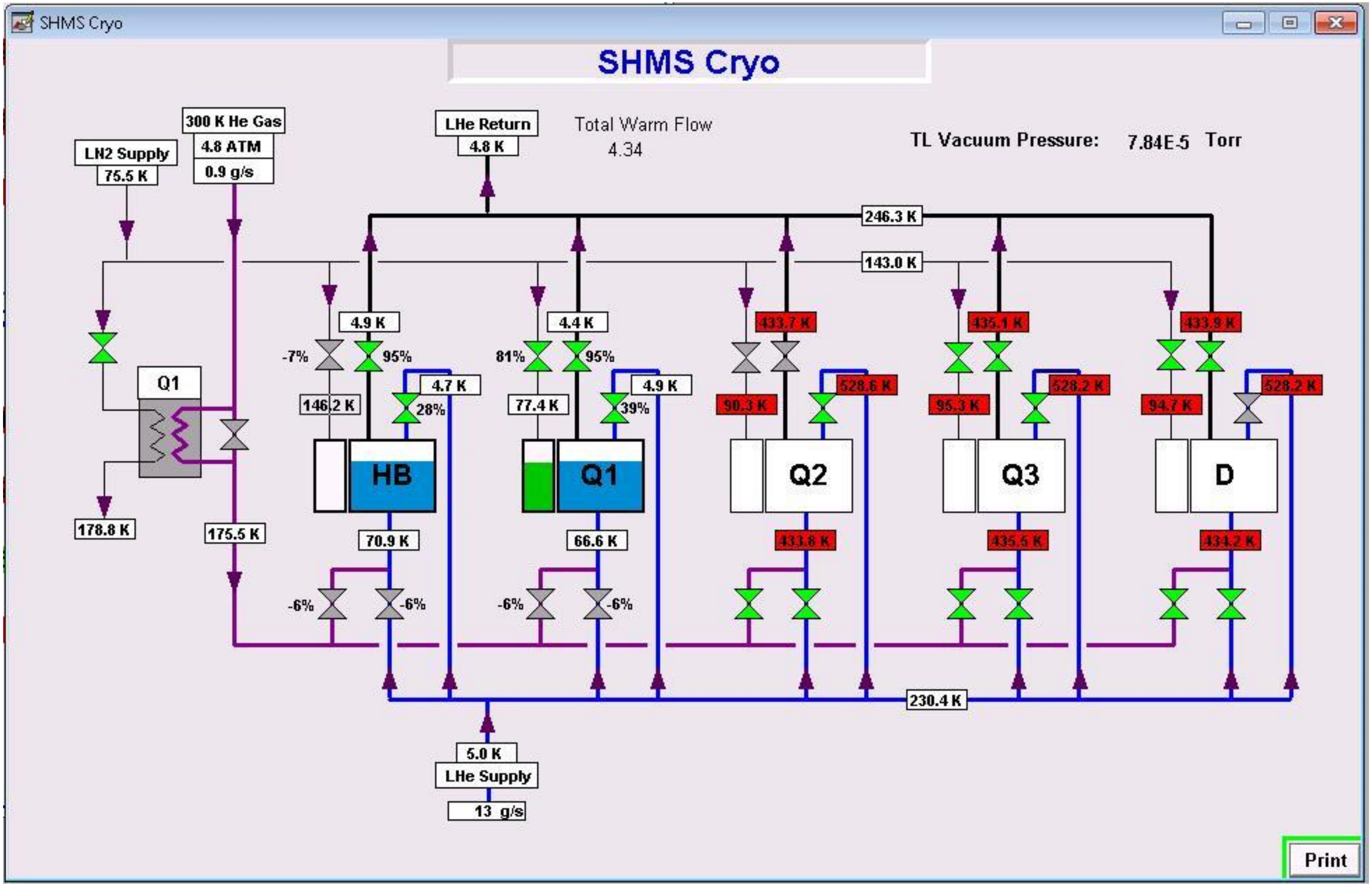
SHMS Cryogenic Schematics



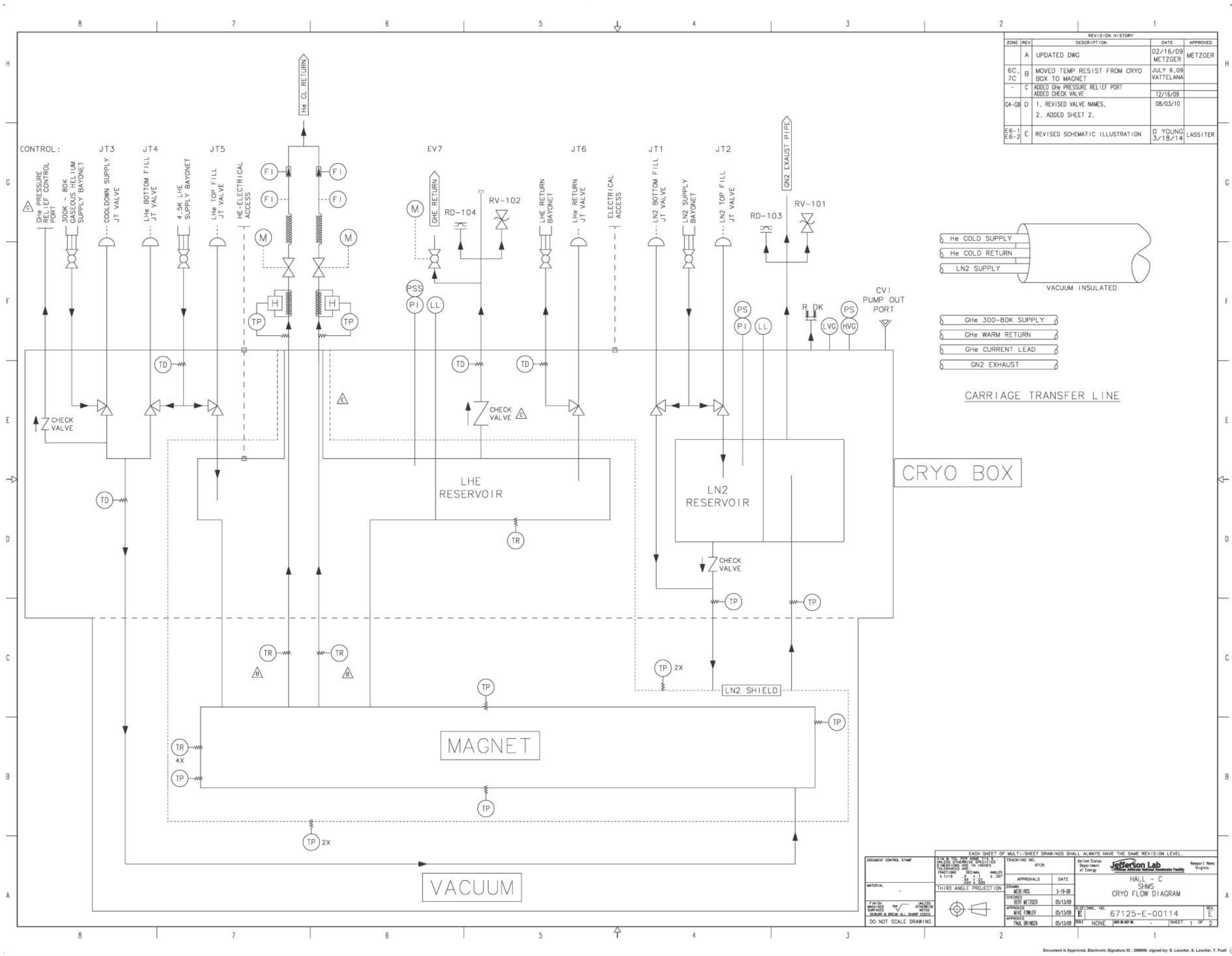
SHMS Magnet Cooling System

- Distribution transfer line on SHMS
- All magnets cooled in parallel independently
- Internal Cool Down 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

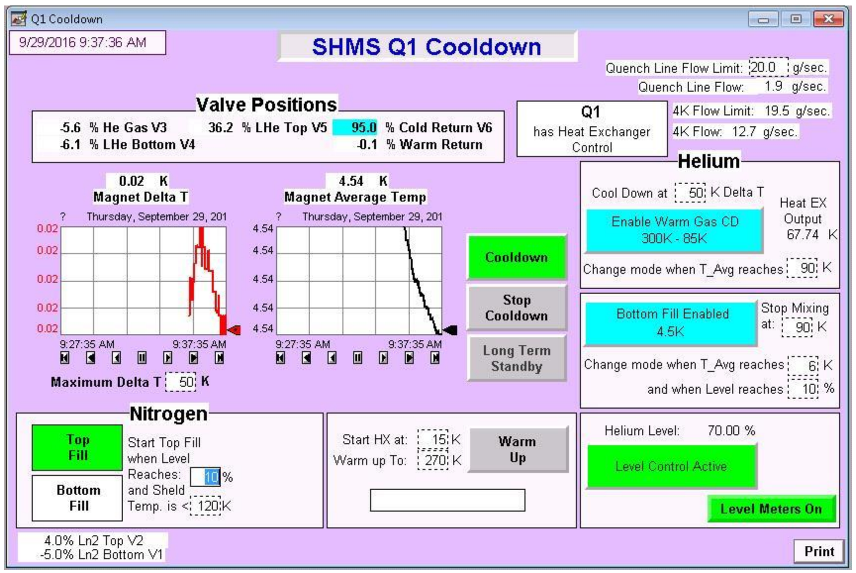


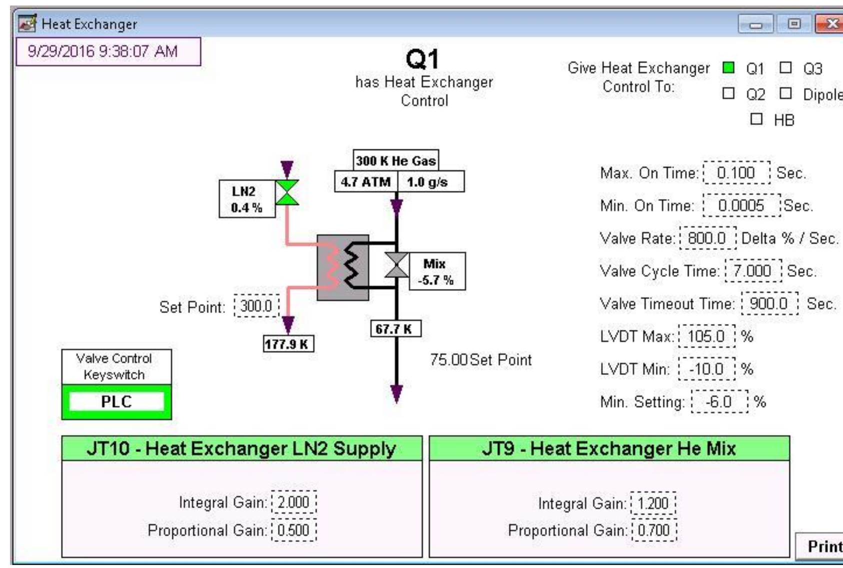
Q2 Magnet P&I



CONTROL:
JT3
JT4
JT5
EV7
JT6
JT1
JT2
He CL RETURN
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
CHECK VALVE
LHE RESERVOIR
LN2 RESERVOIR
CRYO BOX
LN2 SHIELD
MAGNET
VACUUM
CVI PUMP OUT PORT
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
REVISION HISTORY
A UPDATED DWG 02/16/09 METZGER 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
C4-C8 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
THIRD ANGLE PROJECTION

SHMS Cool Down Control Screens

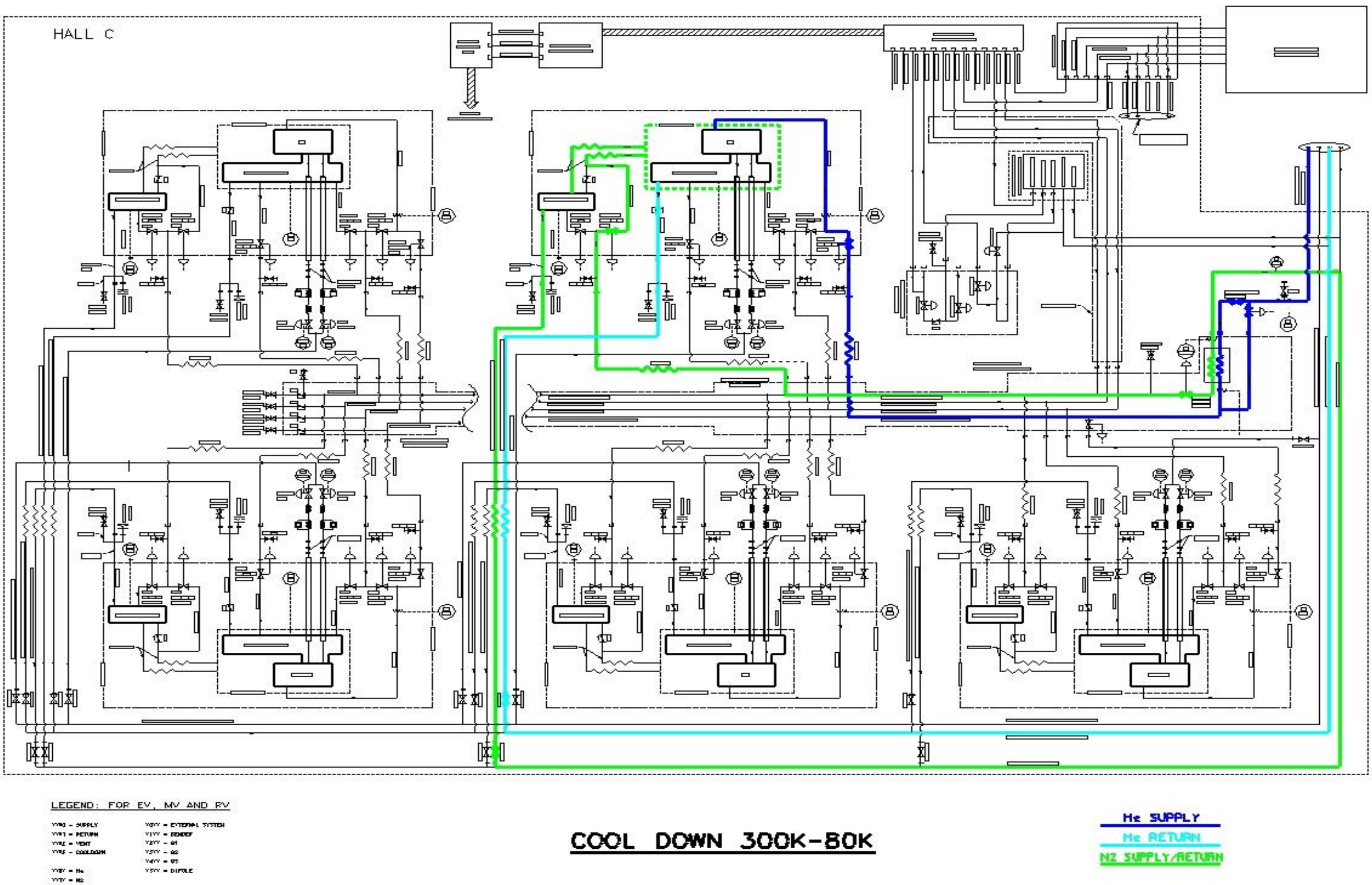




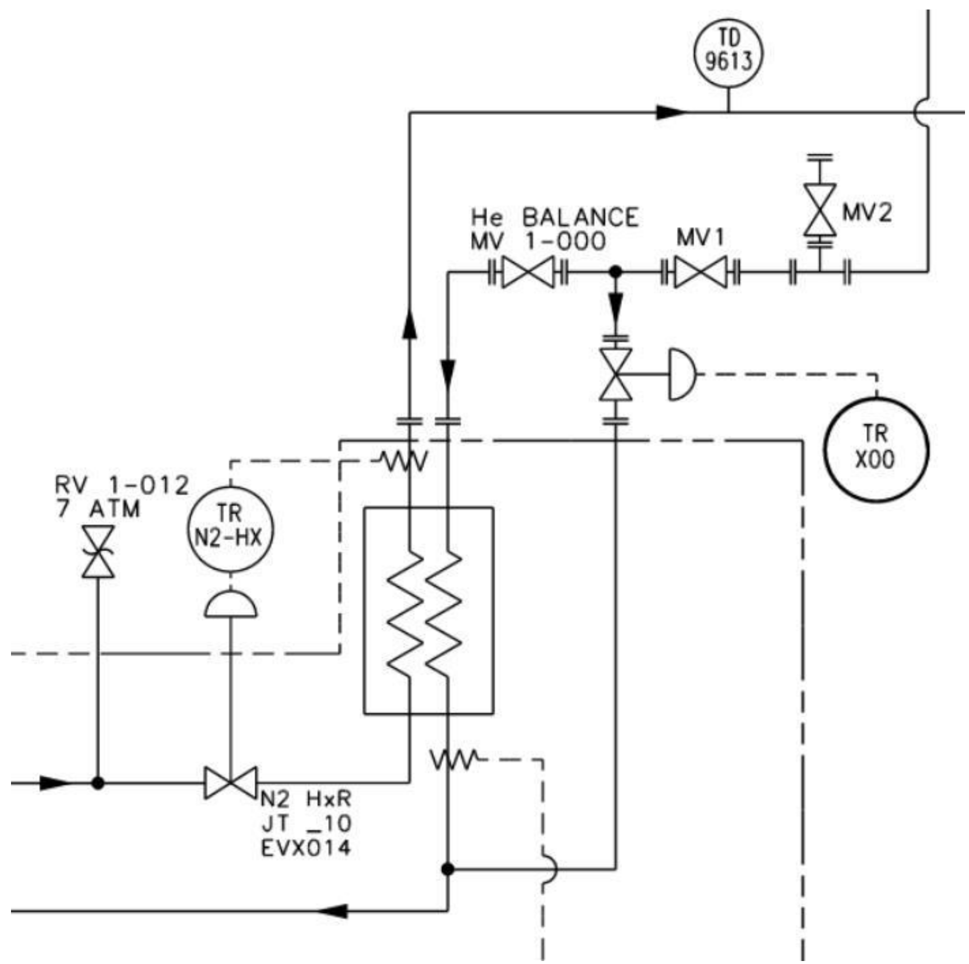
Hall C Magnet Cool Down I

- 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(1 of 5)
  - Q2Q3 take 2 weeks(14 days) Dipole takes 3 weeks(21 days)

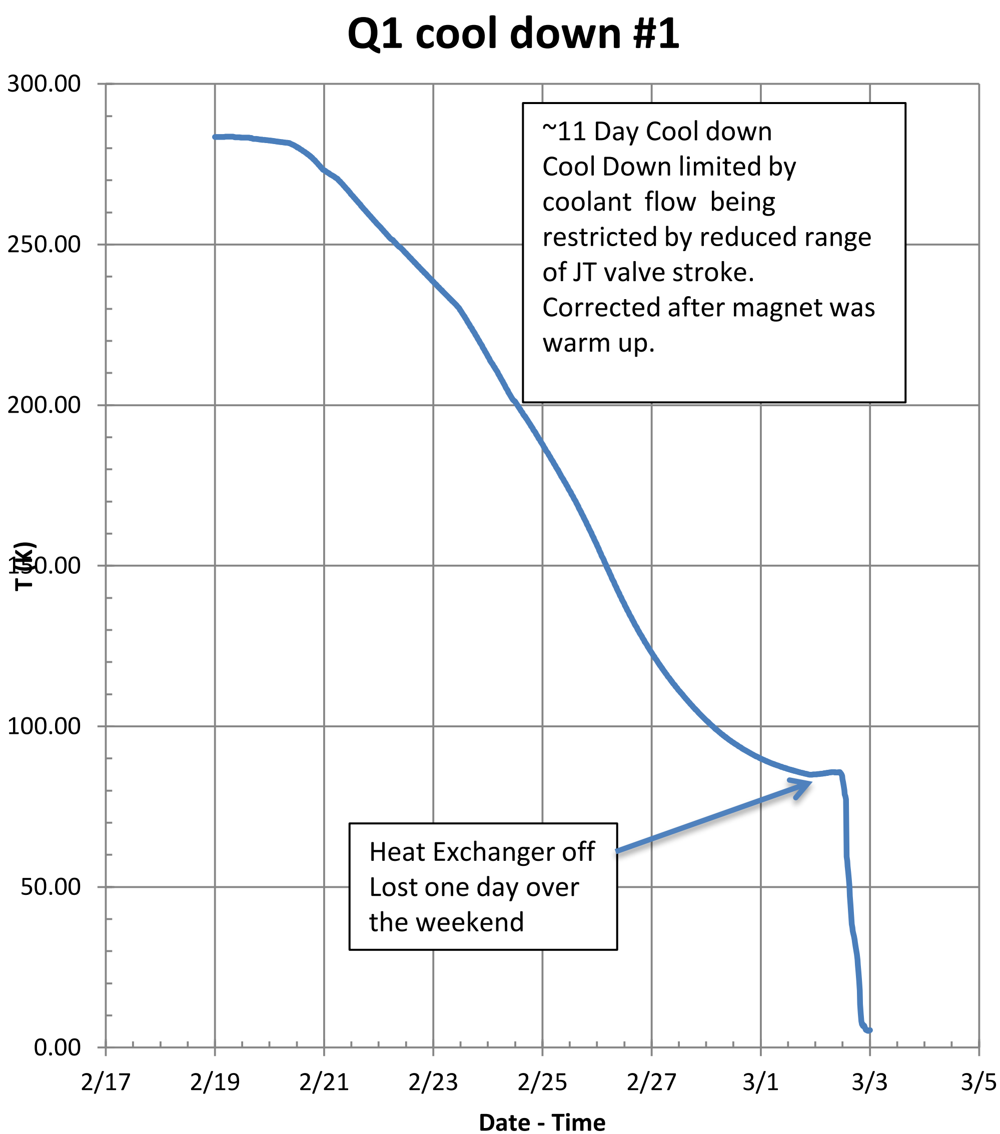
Cool Down 300K to 80K

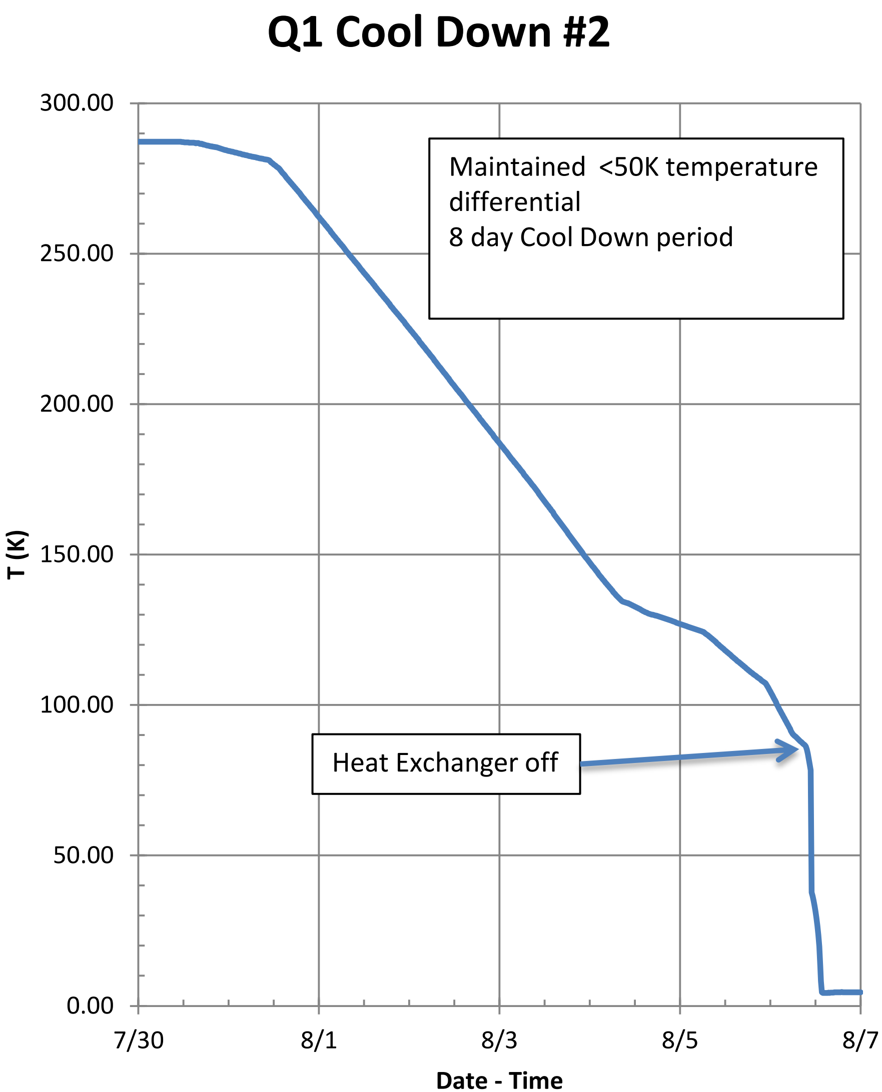


Hall C Cool Down Heat Exchanger



SHMS Q1 Cool Down

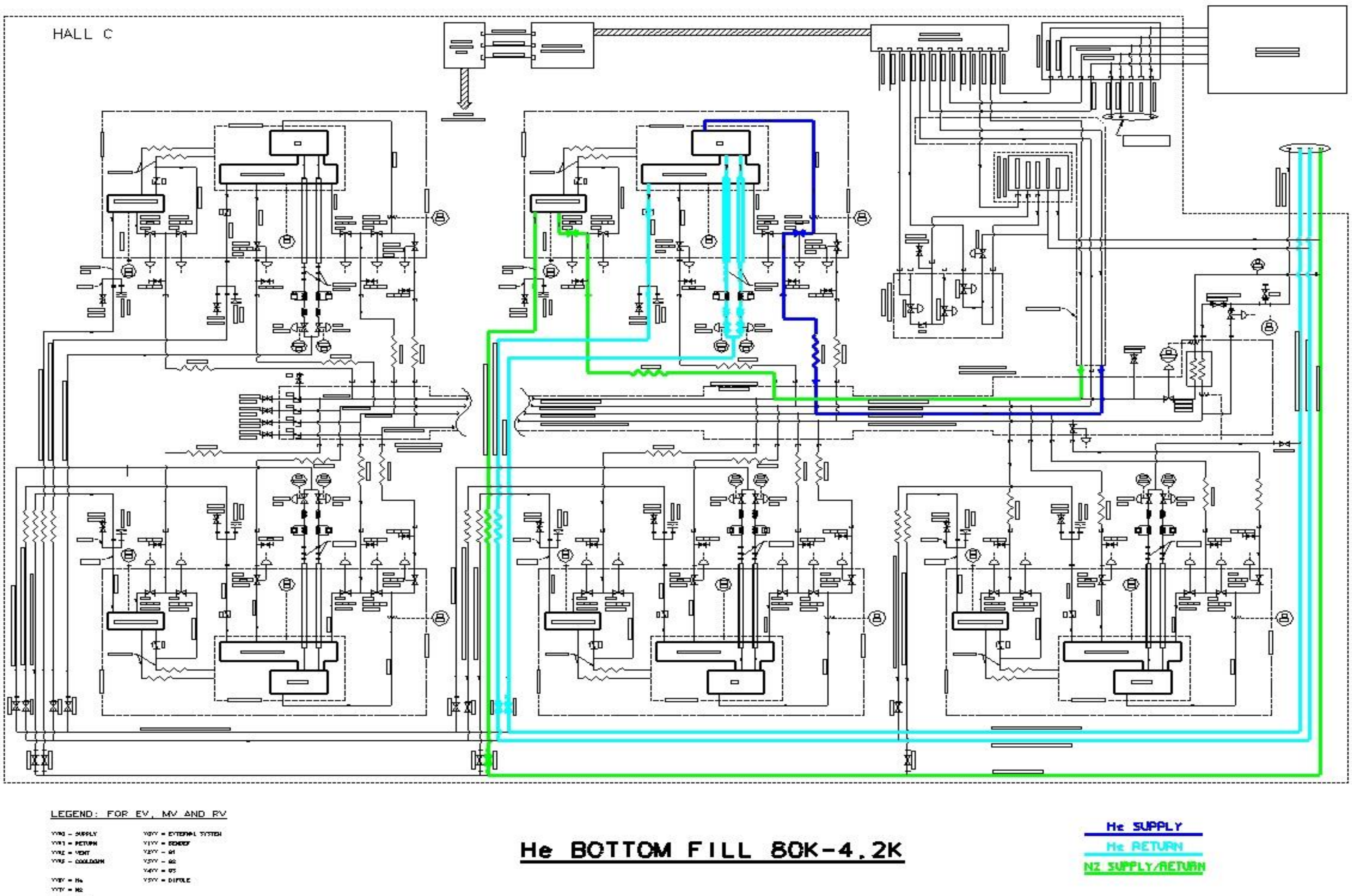




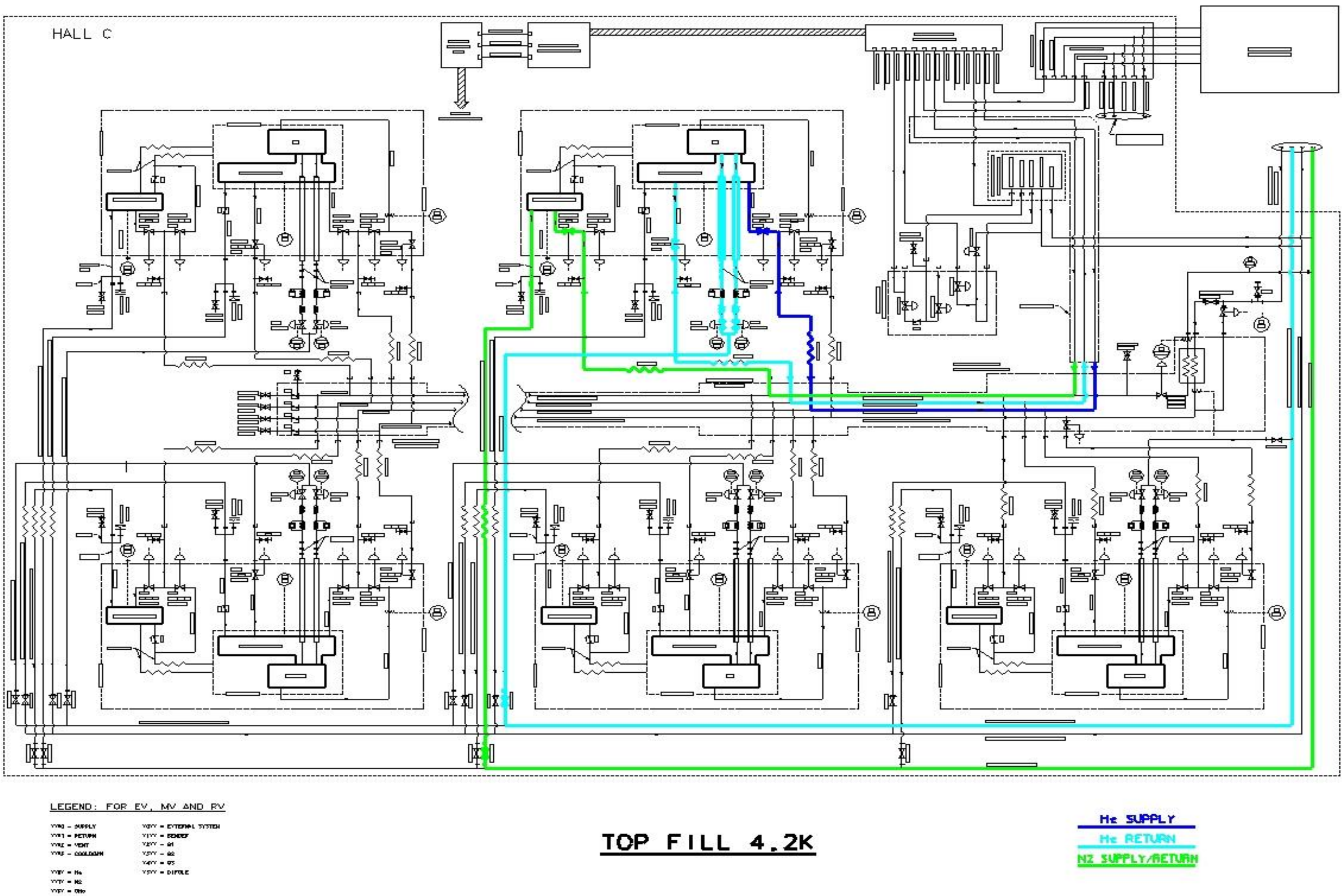
Hall C Magnet Cool Down II

- 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

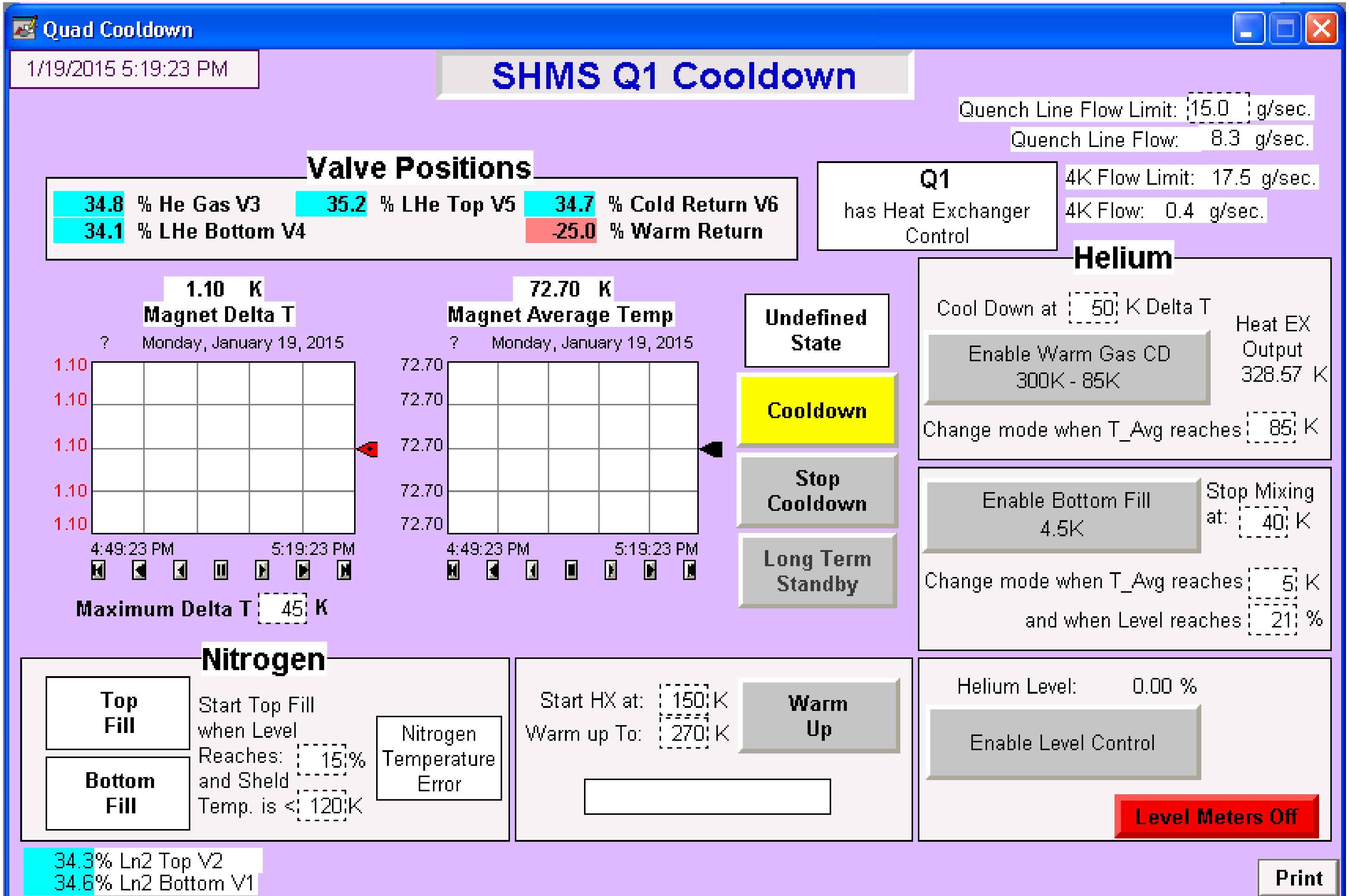
Cooldown to 4K



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

Summary

- Cool Down System has been in continuous use since 1992
- System has been copied by Halls A, B and D
- Hall C cryogenics in continuous service since 1992 for HMS
- SHMS cryo in continuous service since 2014
- PLC controls are very mature and have been in continuous service for 15 years