Cryogenic Summary - Testing D2L103 in MAGCOOL

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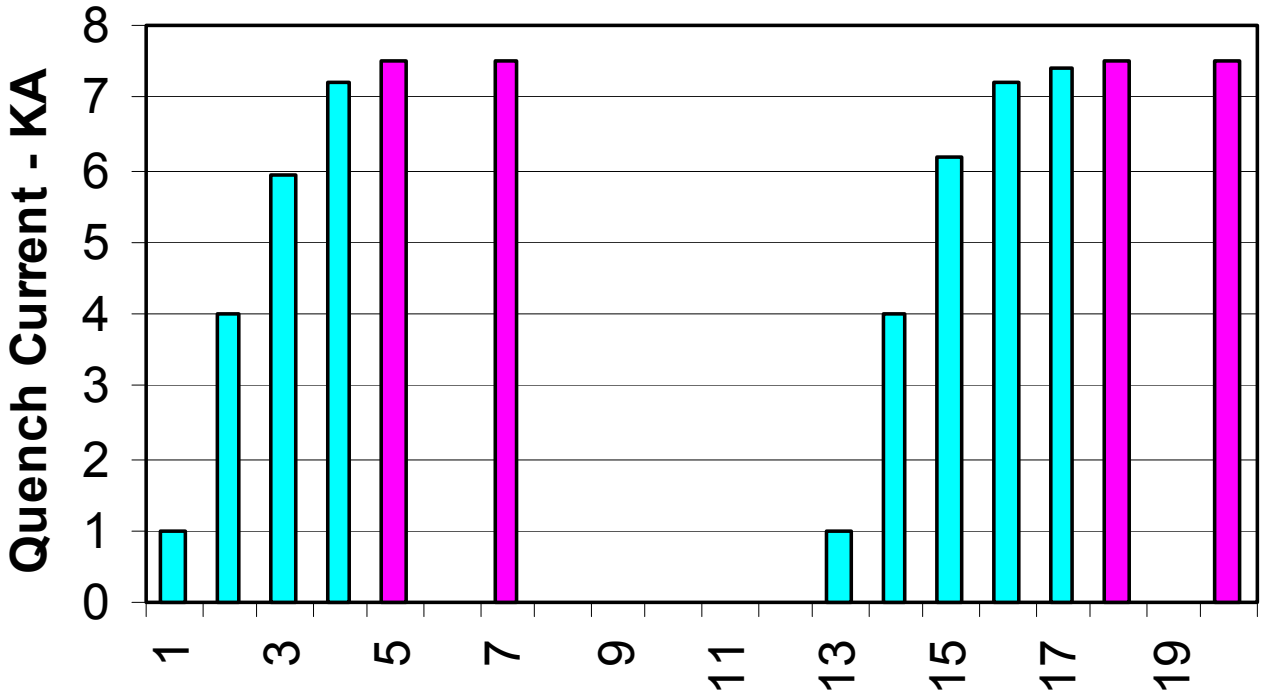
10/11/02 - rev

- D2L103
- Operating Summary
- Cooldown to 100 K, and to 6 K
- Test Condition – 12 atm, 4.5 K (forced flow)
- Test Condition – 1.48 atm, 4.67 K (liquid cool)
- Summary

D2L103

- After three training quenches, D2L103 can be ramped to 7500 A without quench using either forced flow cooling (at ~ 4.50 K) or liquid helium cool (at ~ 4.67 K). Performance of D2L103 is basically the same as D2L102
- Following improvements on the Feed Can are made for D2L103
  - Add cooldown line for low pressure return line
  - Insulate quench vent line
  - Separate flow control for the (+) and (–) lead
  - One CERNOX sensor in the middle and the other one in lead-end end plate

Quench Performance of D2L102 & D2L103
(1000 A is Shut Off, 4000 A is Strip Heater Quench)



Quench - No. 1- 5, D2L102 (Forced Flow)

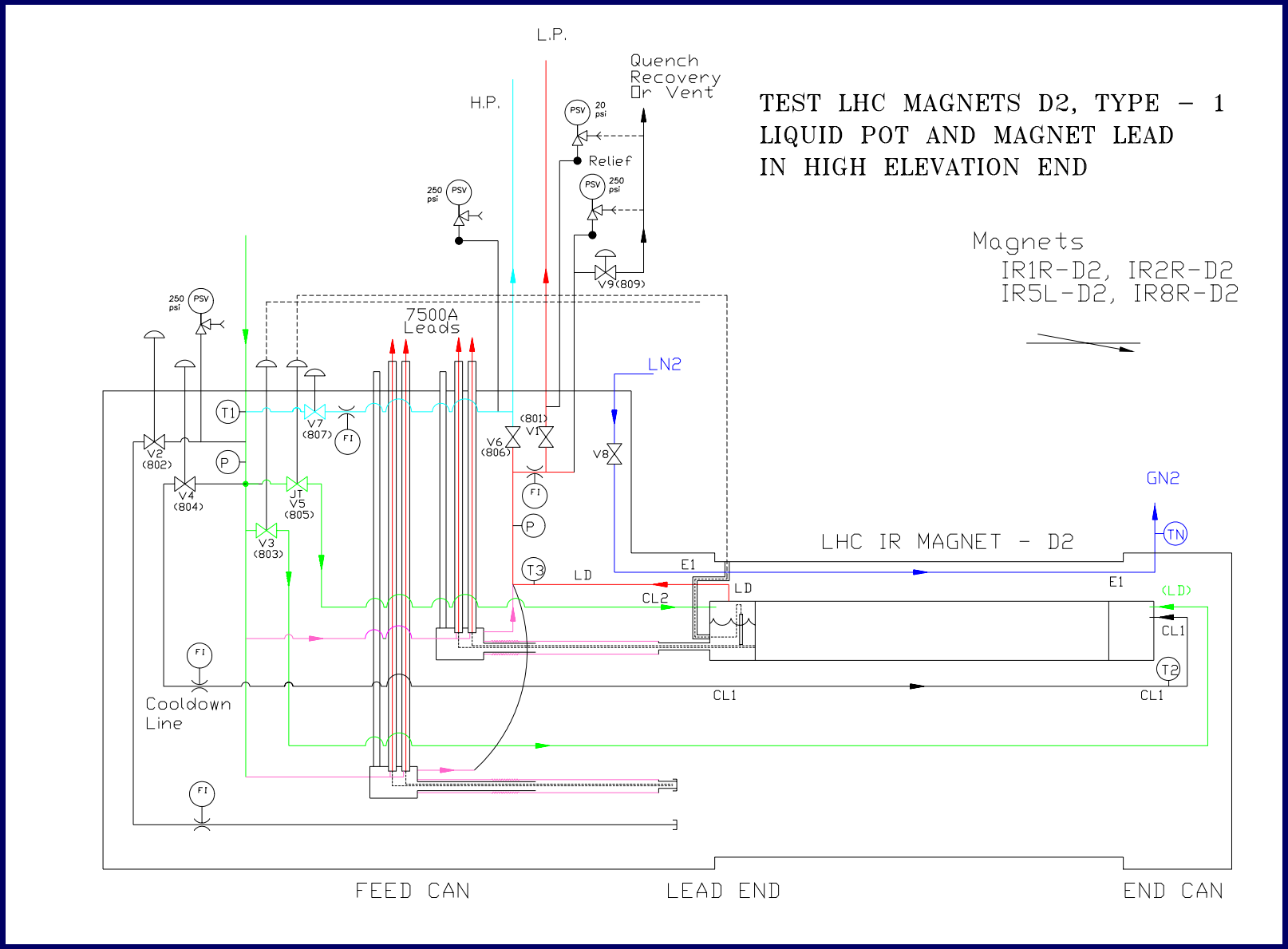
No. 5 - No Quench

No. 7, D2L102 (Liquid Cool) - No quench

No. 13 - 18, D2L103 (Forced Flow), No 18 - No quench

No. 20 (Liquid Cool) - No quench

Flow diagram for D2L103 – Capable of feeding LHe from either high or low elevation ends



Operating Summary

- 8/1-2 & 5-6 Cooldown - 300 to 100 K
- 8/6 Cooldown - 100 to 6 K
- 8/7 Reach 6 K, cold check, Shut off and strip heater quench
- 8/7-9 Test D2 via forced flow cooling
- 8/9 Switch to liquid cool
- 8/10 Test D2 in liquid helium
- 8/12-13 Warmup

Test Conditions

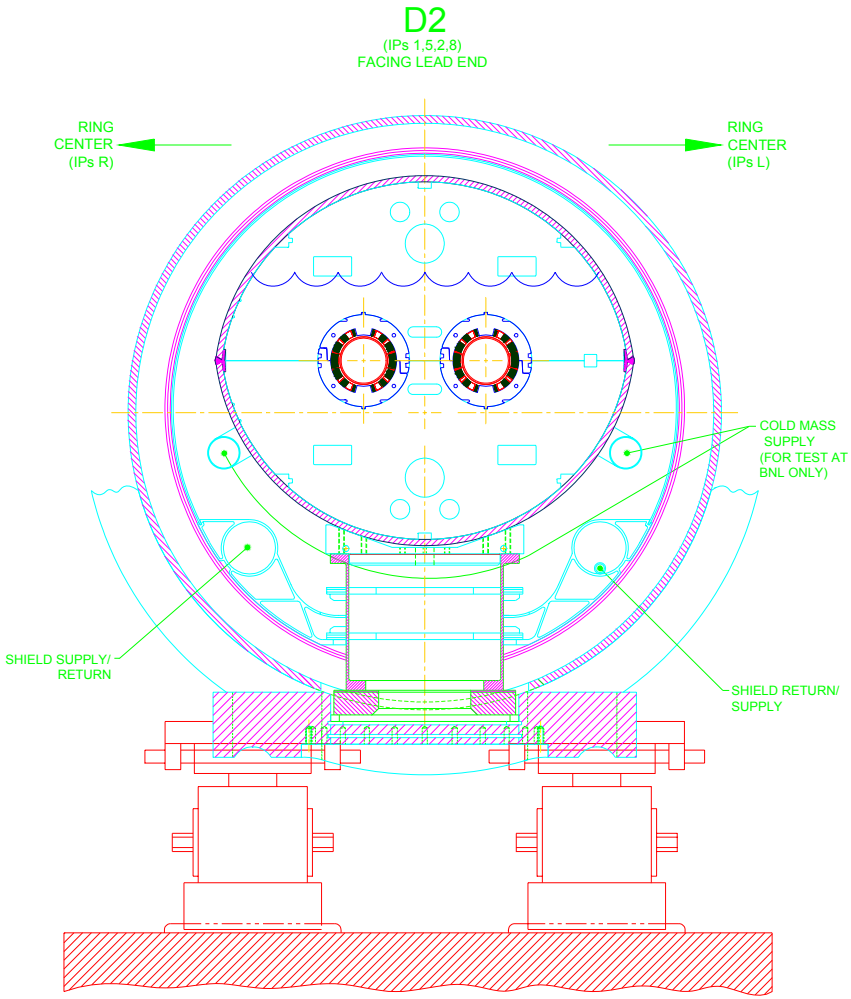
- Forced flow cooling

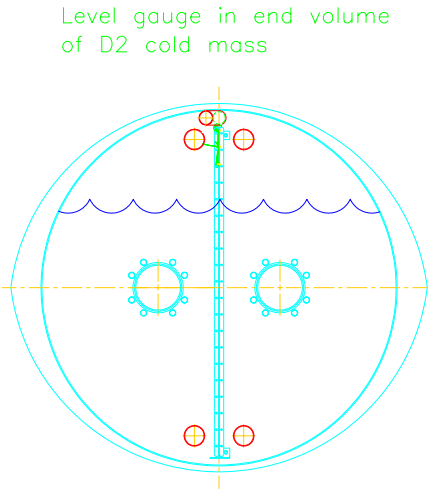
  12 atm, 4.5 K & 60 g/s, magnet temperature ~ 4.5 K prior to ramp, (~ 4.47 K at 7500A)

- Liquid helium cooling

  1.48 atm & ~ 4.66 K in D2,
  (low temperature portion of MAGCOOL is not fully cold, test is performed with JT inlet between 4.85 K and 4.32 K)
  Liquid level in end volume
  high elevation end: ~78% (7 cm above coil)
  low elevation end: ~98% (18 cm above coil)
  JT Valve
  Inlet condition: 11.9 atm & 4.85 K to 4.32 K
  Liquid after expansion: ~75 % to 80 %

Sectional View of D2 with Liquid Level in High Elevation End ~ 78% for D2L103 (Left Figure), Level Gauge in End Volume (Right Figure)



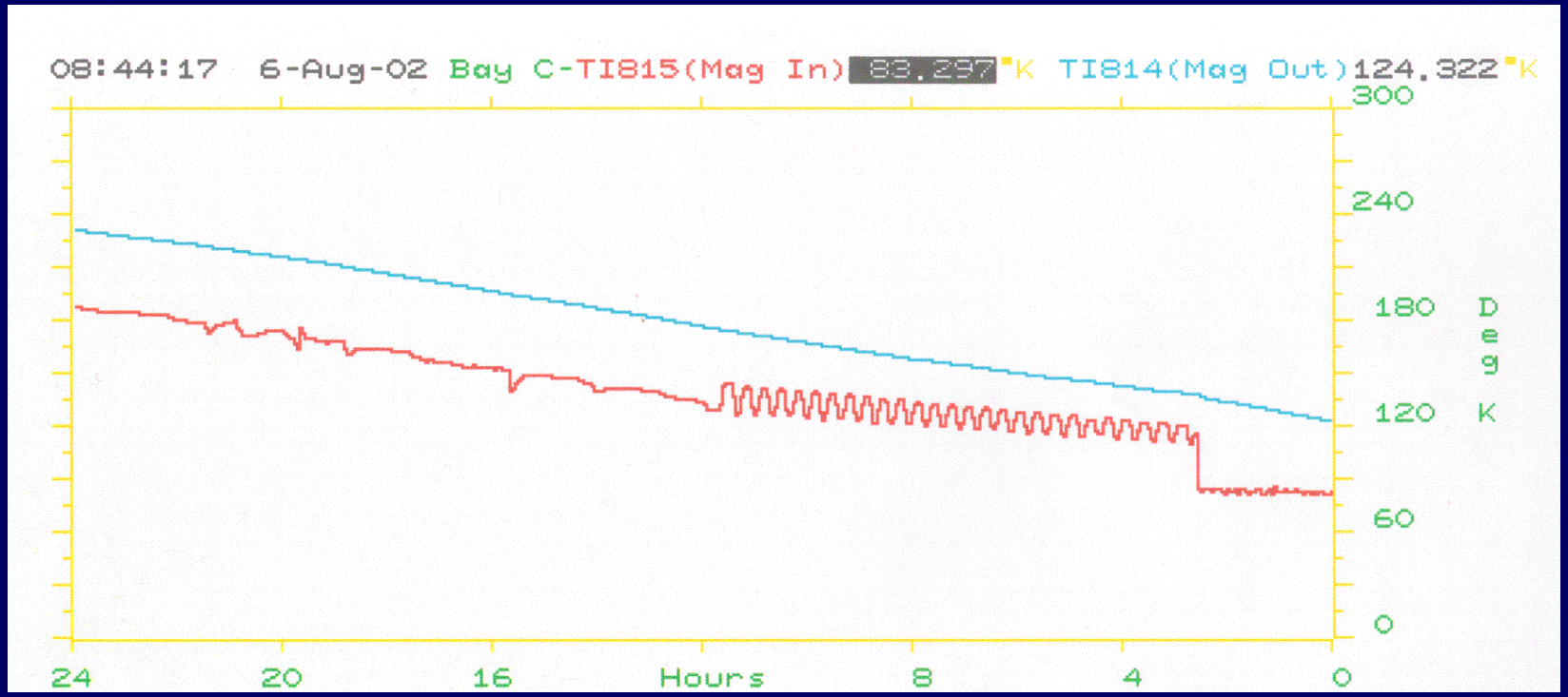


Shell of cold mass is used as liquid helium vessel with level gauge installed in the end volume for liquid control. Typically, liquid is kept at 75 % or ~6 cm above supderconducting coil

Tests Performed - D2L103

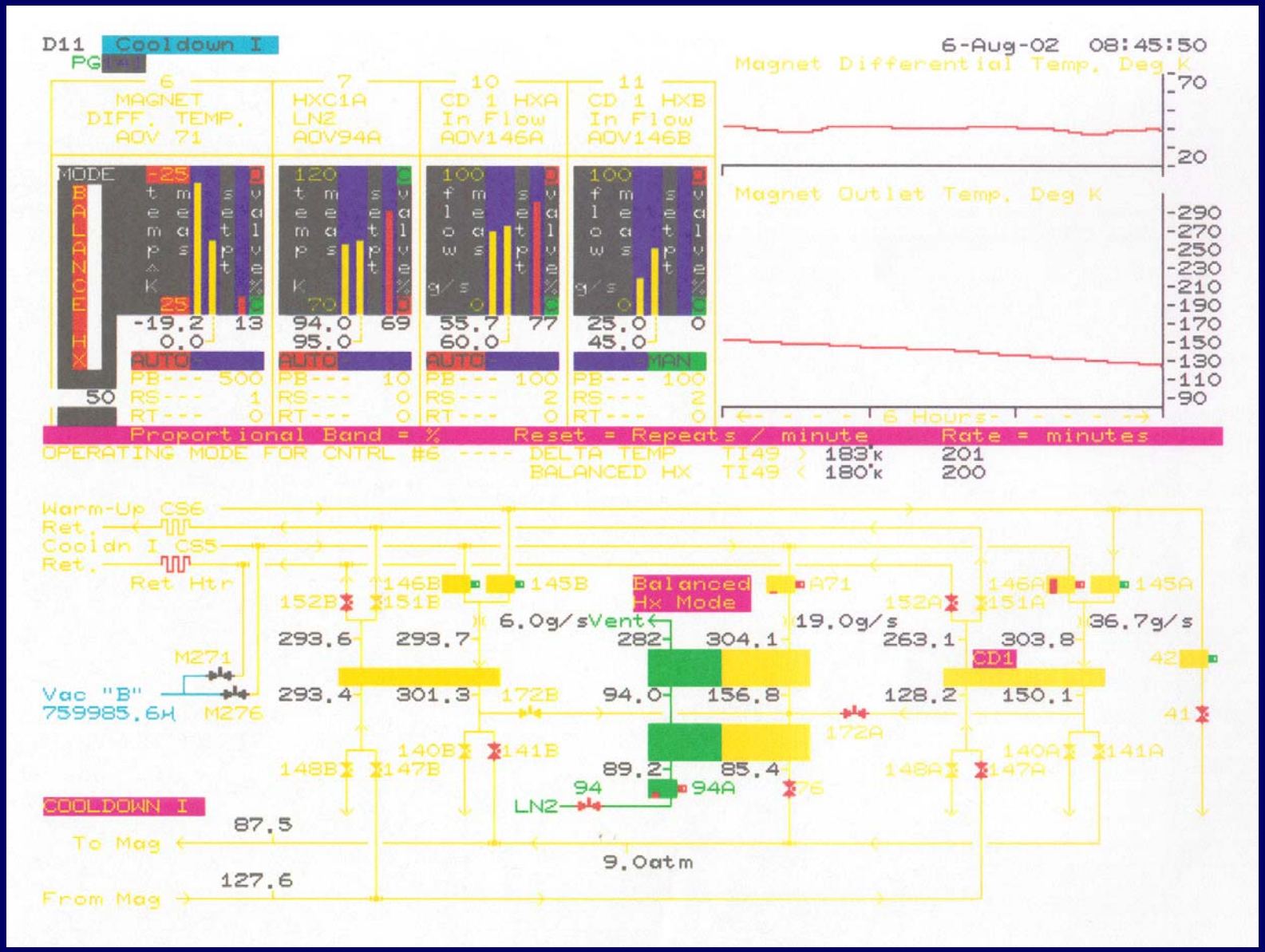
- 1st test group (forced flow cooling ~ 4.5 K),
  - Shut off - 1000 A (8/7)
  - Strip Heater - 4000 A (8/7)
  - 1st quench – 6167 A (8/8)
  - 2nd quench – 7227 A (8/8)
  - 3rd quench - 7423 A (8/8)
  - Ramp 5 cycles – 7500 A (8/8) (at 7500 A ~ 1 min.)
  - Park - 7500 A (8/9) (at 7500 A ~ 1 hour)
- 2nd test group (liquid cool ~ 4.65 K),
  - Ramp 4 cycles - 7500 A (8/10)
  - Park - 7500 A (8/10) (at 7500 A ~ 20 min.)
  - Test is shorten (from 5 to 4 cycles, and 1 hour to 20 min.) - run out of time

Cooldown from 300 – 100 K for D2L103

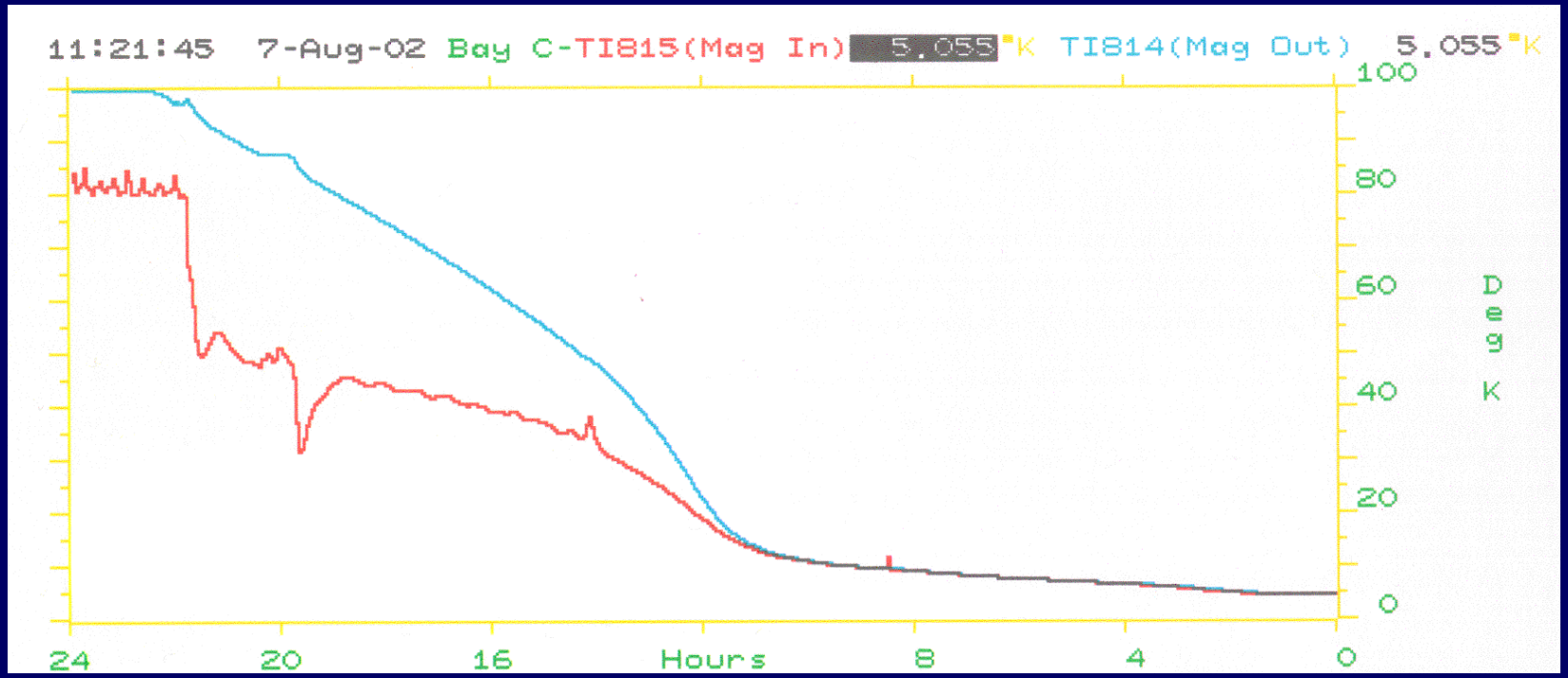


- 100 K Cooldown time ~ 50 hours
- Temperatures at the inlet (red) and the exit (blue) of D2L103 are shown
- Use 50 g/s (on 8/1-2) and 60 g/s (on 8/5-6) of helium flow for MAGCOOL cooldown I

Operating Condition for 100 K Cooldown of D2L103



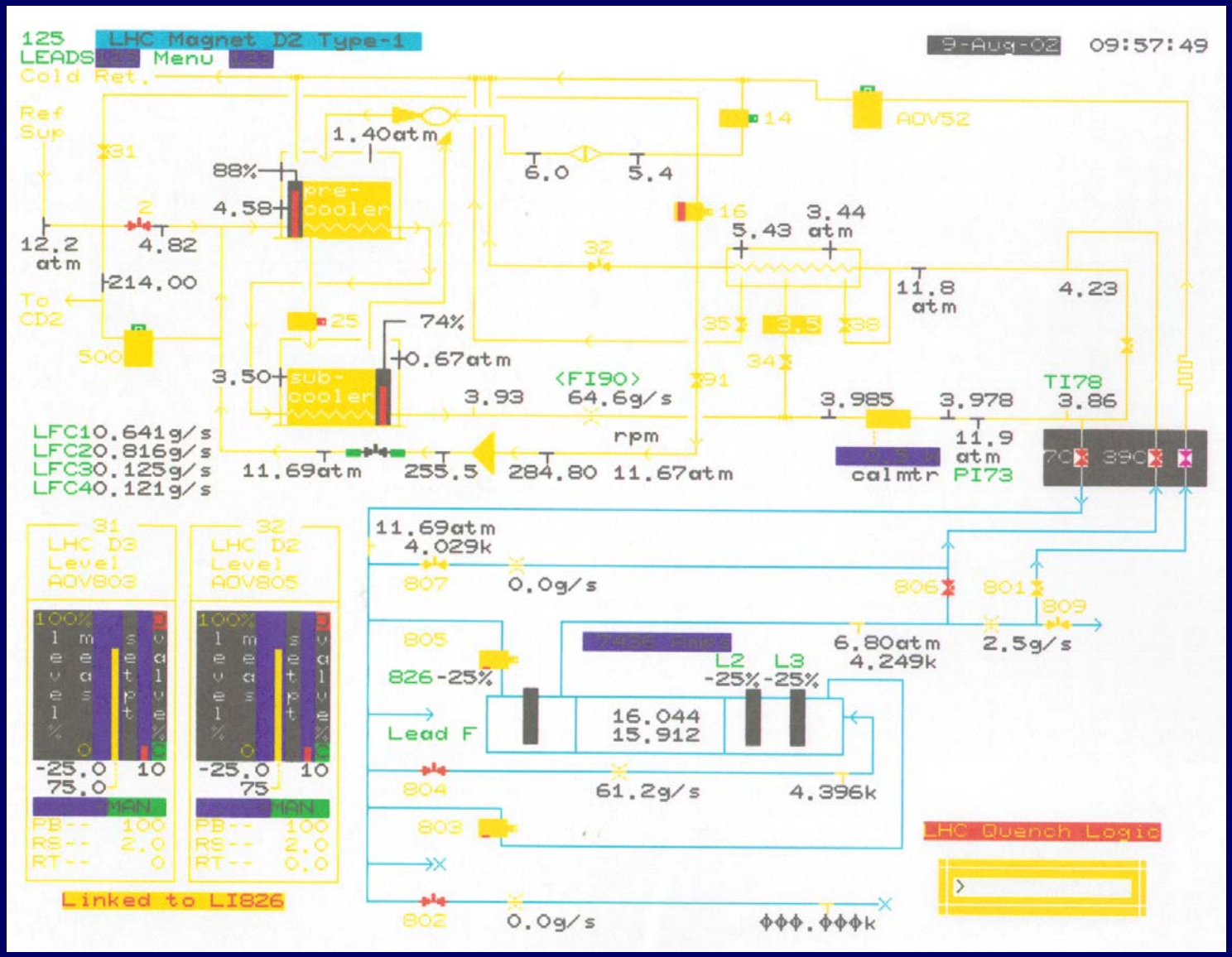
Cooldown from 100 – 6 K for D2L103



- Cooldown time (100 to 6 K) is ~ 17 hours
- Temperatures at the inlet (red) and the exit (blue) of D2L103 are shown
- Use two expanders E19 & E20

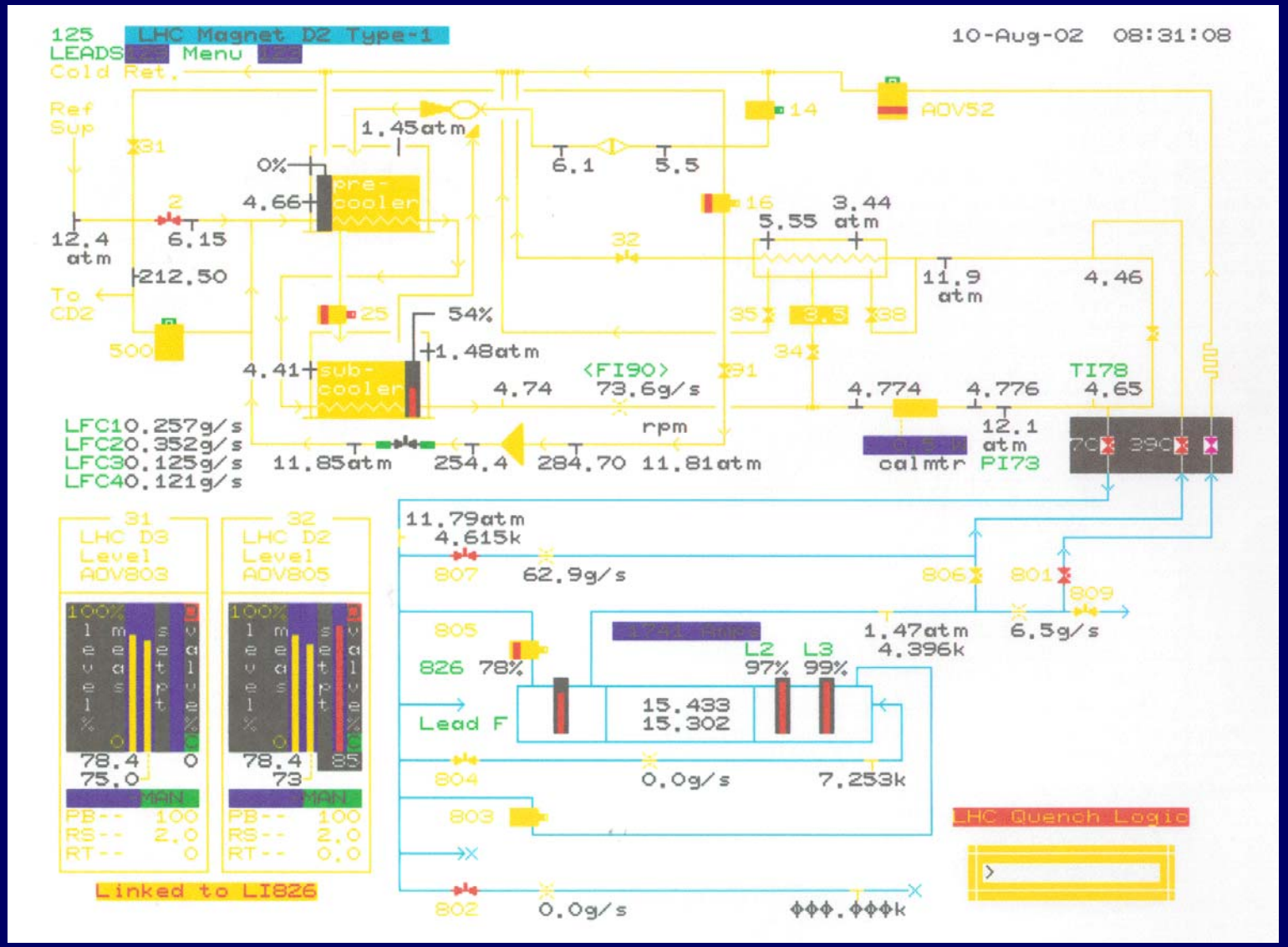
Forced Flow Cooling Condition for D2L103 at 7500 A

(Prior to ramping, return temperature is ~ 4.6 K in MAGCOOL)

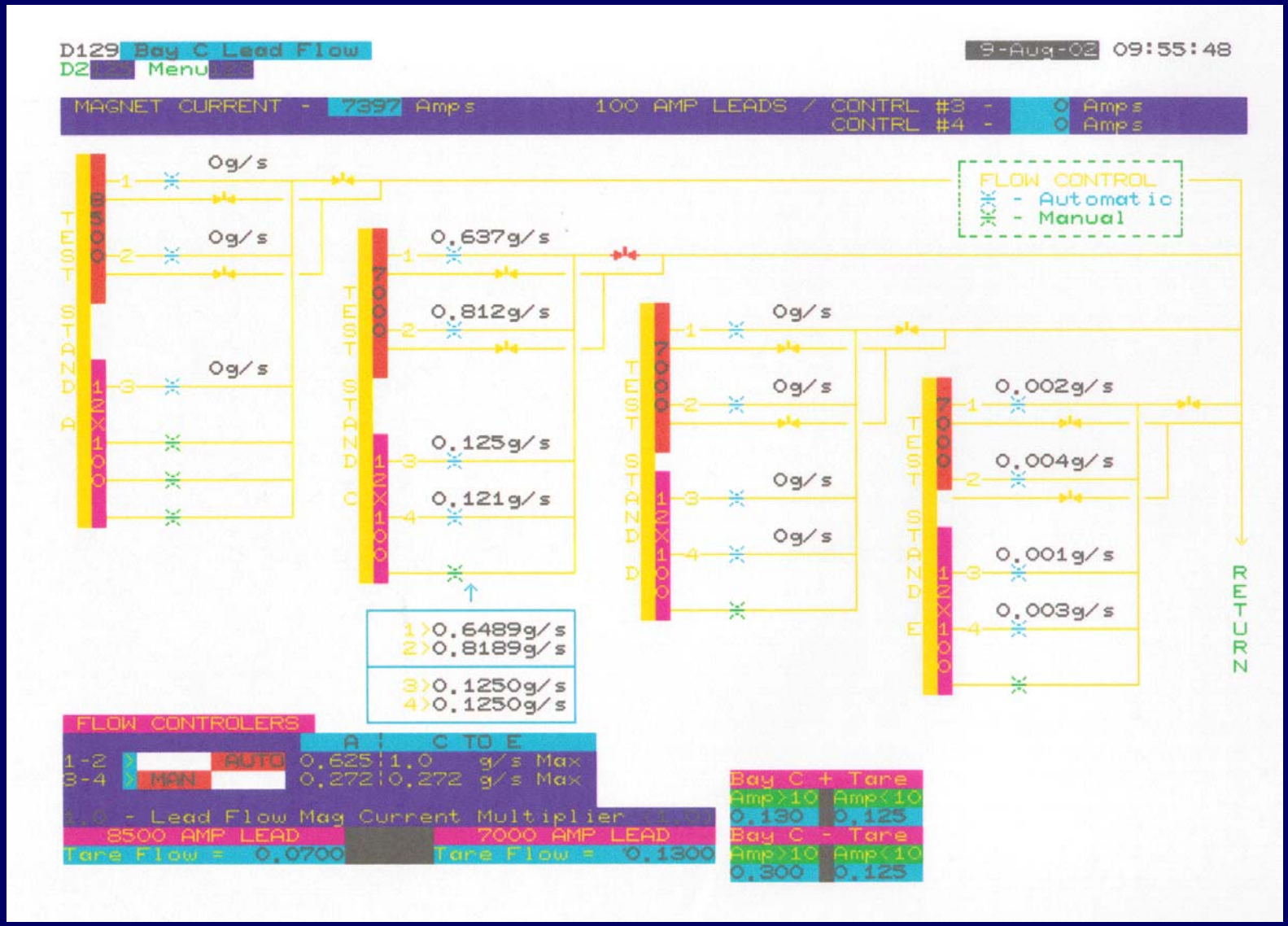


Condition for Ramping D2L103 to 7500 A – Liquid Cool

(Low Temp Portion of MAGCOOL Was Not Fully Cold)



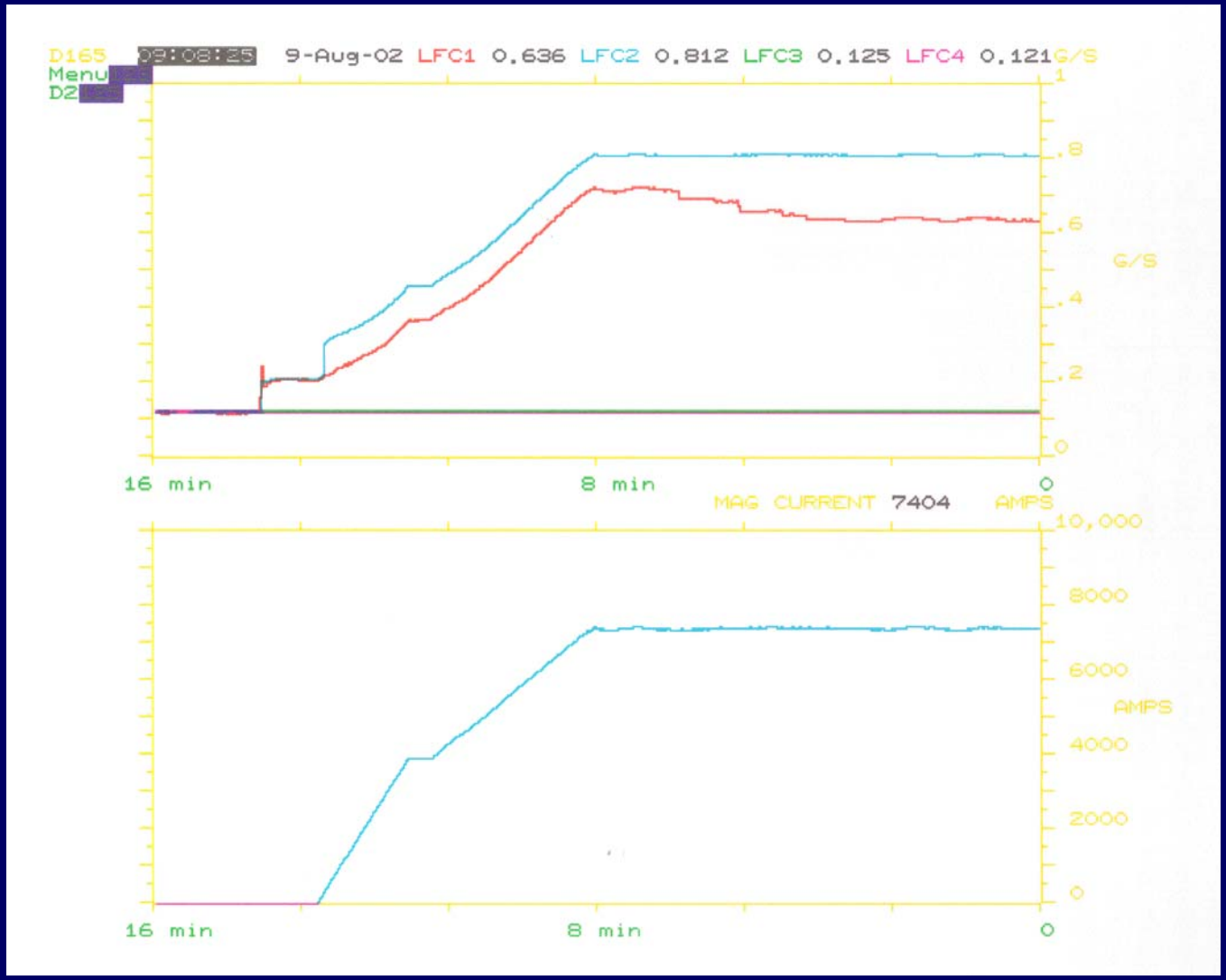
Separate Flow Control for (+) and (-) Leads in Bay C



Lead Flow and Current During Ramping of D2L103

Upper Figure: Lead Flow – Blue for (-) Lead and Red for (+) Lead

Lower Figure: Current as a Function of Time



Current leads

- Separate flow controllers for the 7500 A leads
- The (-) lead demands ~ 0.15 g/s more flow than the (+) lead at 7500 A
- Lead flow is adjusted by monitoring voltage and temperature in the warm end of the lead
- Lead flow is gradually reduced after the peak current is reached

Lead flow control – for both forced flow and liquid cool

- Main leads
  - Separate flow control for the (+) and (-) leads
  - Tare flow is set at 0.30 g/s for the (-) lead and 0.21 g/s for the (+) lead during ramp up
  - The voltage across the (-) lead is ~ 0.055 V at 7500A
- Unused leads
  - 0.100 to 0.125 g/s of lead flow during the test

Problems Encountered

- 8/7 - 0.5 atm pressure drop across the magnet and return line was found, the pressure drop disappeared after the 4000 A strip heater quench – suggesting possible breakage of contamination or obstacle. (After warm up, we found falling plug in the cryogenic valve DOV806 is the obstacle. The valve seal assembly remain stuck in the elbow of downstream piping. Luckily, it has little impact on the operation.)
- Heat load in the lead pot is slightly higher than D2L102 and needs ~ 0.2 g/s more lead flow .
- During switching from forced flow to liquid cool, helium leaked into D2 through DOV806. The cryogenic system was upset and required venting. After leakage is corrected, the system stabilized but it takes ~ 8 hours of extra cooldown time.

Summary

- Performance of D2L103 is essentially the same as D2L102
- After three training quenches, D2L103 is powered to 7500 A without quench using either forced flow cooling at ~ 4.50 K, or liquid helium at ~ 4.67 K
- It appears no need for long "soaking time" before ramping. In forced flow cooling, we powered D2L103 to 7500 A approximately 50 minutes after temperature at exit of D2L103 recovered from a 7423 A quench.
- In liquid cool, D2L103 reached 7500 A at 4.67 K in 1.48 atm saturation liquid while the Low Temperature portion of MAGCOOL was still cooling down.