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SMD Operations Procedures Manual

8.1.3.22 OPERATION OF THE MAGCOOL TEST AND MEASURE SYSTEM for BAY C

Text Pages 1 through 9

Hand Processed Changes

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8.1.3.22 Operation of the MAGCOOL Test and Measure System for Bay C

1.0 Purpose

This procedure provides instruction for STARTUP/SHUTDOWN and operation of Test and Measure System in Bay C. T-M Operation provides cooling to the magnet for quenching and field measurement. It establishes flow control for current leads and handling of cold helium after quench. (Note: MAGCOOL is originally designed for forced flow cooling for test Bays A through E. Since 2000, Bay A is modified as part of liquefaction operation for vertical test and Bay B is disabled. In 2002, Bay C was modified for testing LHC magnets D2, D3 and D4 using either forced flow cooling or liquid cooled.) The LHC D2, D3, and D4 magnet test program ended in 2005. This OPM is not applicable to other types of magnets. However, this OPM contains all necessary information so that new a OPM could be developed to suit future applications.

2.0 Responsibilities and Scope

Operator is responsible for STARTUP/SHUTDOWN and operation of the Test and Measure System.

3.0 Prerequisites

3.1 Operator shall be instructed by a supervisor or designee.

3.2 Instruction shall include the MYCOM compressor, CRT, Low Temp and the MAGCOOL Refrigerator (MODEL 4000).

4.0 Precautions

4.1 Hearing protection shall be worn in the Compressor Rooms

4.2 Clear unauthorized personnel in the vicinity of operational equipment before startup.

5.0 Procedure

5.1 The MYCOM compressor, MAGCOOL refrigerator and LOW TEMP must be operational.

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5.2 Since year 2000, all tests involved only one test Bay. There is no magnet in other Bays. Once Cooldown I completed, the operator can switch to Test and Measure which will cool the magnet from 100 to 4.5 K for test.

5.3 Testing a magnet in Bay C, use screen display page D125 to monitor process condition and control (as shown in Figure 1). In the upper half portion of Figure 1, flow diagram is associated with the Low Temp. cold box. In the low portion of Figure 1, flow diagram is associated with the Bay C Feed Can and the LHC magnet. Controllers for liquid level in the end volume of the cold mass are given in the lower left corner. Valves 801 – 807 are located on the Feed Can. Liquid level gauges are installed in the end volumes of the magnet. In Forced Flow cooling, DOV804 and DOV806 are open to allow cold helium flow through the magnet. In Liquid Cool mode, the magnet serves as a liquid helium bath. High pressure helium goes through DOV807. DOV 806 is closed and low pressure boil off returns from DOV801 to Low Temp cold box. Liquid level in the cold mass is maintained by JT valves AOV803 and /or AOV805.

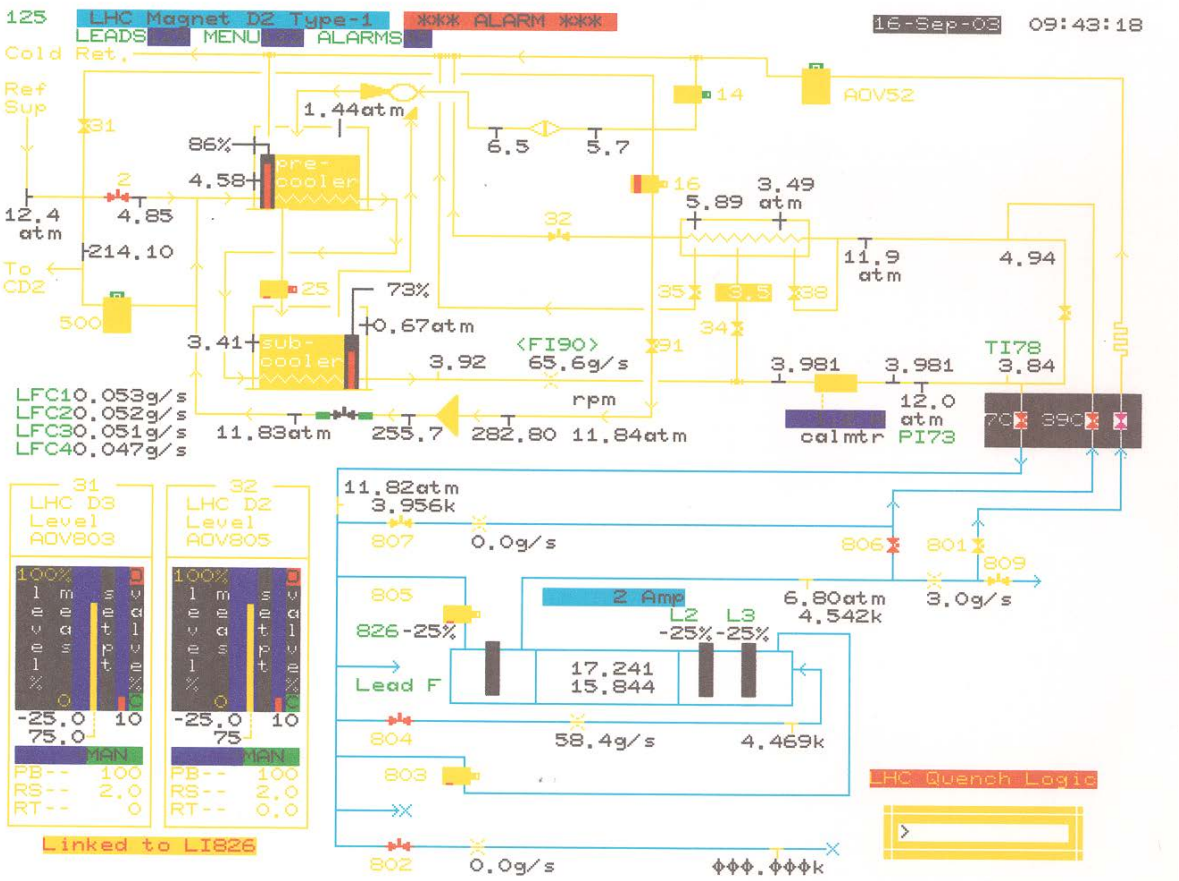

Figure 1. Display of control page D125 for Test and Measure in Bay C

5.4 Refer to OPM 8.1.3.13 Operation of MAGCOOL Refrigerator, make sure refrigerator by-pass is set to AUTO on control page D23. This allows cold helium return from the magnet to appropriate by-pass valve in HEUB.

5.5 Refer to OPM 8.1.3.13 Operation of MAGCOOL Refrigerator, bring cursor to **TEST and MEASURE. Press OPEN or ON** on page D9**.** Cold gas will now flow from the refrigerator through Low Temp Cold Box and magnet. The cooldown process can be monitored on display D125.

5.6 Magnet will stay in test and measure until operator is through testing.

5.7 The magnet can be run in 2 modes: Forced Flow cooling (Ejector mode) and Liquid cool.

5.8 In Forced Flow (Ejector) mode, helium flow through the magnet to the ejector. This mode is completely controlled by program in the Crisp computer.

5.9 In Liquid Cool mode, majority of cold helium goes through the ejector. A small amount is used as JT feed to maintain liquid level in the magnet.
NOTE: “C” bay is the only bay capable of providing Liquid Cool in MAGCOOL.

5.9.1 Use Forced Flow mode to cool magnet to 4.5 K.

5.9.2 Cool down transfer lines that are not used in Forced Flow mode

5.9.2.1 OPEN by pass valve 807, this cools the by-pass line and allows the Ejector to function in Liquid Mode.

5.9.2.2 OPEN AOV 52 low pressure refrigerator return, crack OPEN HE 5. This allows return of boil-off to Low Temp. cold box with minimum perturbation.

5.9.2.3 In the lower left corner of page D125, SET CONTROLLERS 31 and 32 for JT VALVES AOV803 AND AOV 805 TO 10%.

5.9.3 After the transfer lines are cold, install “C” bay magnet into liquid mode.

5.9.3.1 Isolate the magnet from Forced Flow cooling by closing inlet valve DOV 804 and return valve 806.

5.9.3.2 Proceed to reduce pressure in the magnet by opening DOV 809 for helium to warm return. Watch pressure PI812 in the magnet until it approaches 2.0 ATM.

A. When pressure PI812 is 1.8 ATM, OPEN Valve 801 Low pressure return to refrigerator.

B. CLOSE Valve 809 warm return.

C. Manually adjust JT VALVES AOV803 AND AOV 805 until liquid in the end volume of the magnet is between 75 and 85%.

5.9.4 When liquid level appears in the Subcooler and the liquid level in the Precooler is about 80% and TI1005 (at refrigerator) reads 20 K or colder, one expansion engine may be stopped and the other slowed to ~ 150 rpm. At this time, the last bypass valve D20 in the refrigerator has been opened. Proceed to set cold engine by-pass as below.

5.9.4.1 At the refrigerator control panel, set TC-1 at 10^0K in **AUTO.**

5.9.4.2 Display page D21, bring cursor to valve D-24, press **OPEN or ON**

NOTE: ***This procedure allows some cold return helium to bypass the heat exchangers in the refrigerator if the discharge temperature of expander falls to 10 K.***

5.10 This test and measure system is only for stand C.

5.11 <u>Installing Test and Measure will activate your LEAD FLOW CONTROLLERS. in control page D129 as shown in Figure 2.</u>

5.11.1 The bay in Test and Measure, lead flows of the 7500 A leads are calculated as a function of currents. The lead flows are controlled by the HASTINGS flow controllers from the computer. NOTE: D129 permits individual flow control on the (-) and the (+) 7500 A leads. This feature is implemented to correct performance difference between the two leads. In Bay C, the (-) lead demands more lead flow than the (+) lead. If the (+)

lead has the same flow as the (-) lead, the warm end of the (+) lead will be too cold and fails. A display of temperature and voltage of the current leads is available in the magnet test computer. The cryo operator shall work closely with the magnet test operator.

5.11.2 Tare flow setting .050 g/s on cool down of magnet and over night operation.

5.11.3 Before testing set Tare flow to .070 g/s.

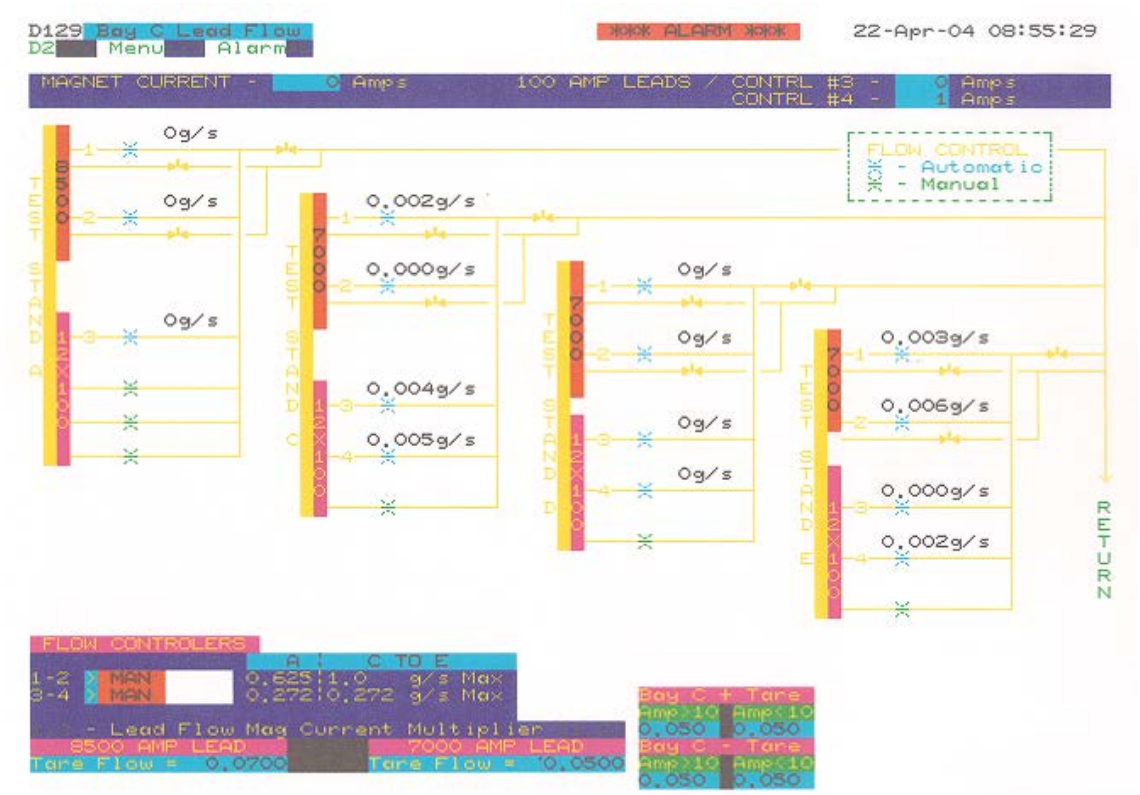

Figure 2. Display of control page D129 for Lead Flow Control of Bay C

5.11.4 <u>Bay C lead flow control on page D129 select.</u>

5.11.4.1 For quench test at 20 Amps a second ramp rate.

A. Tare flow at .20 g/s for (+) lead and .35 g/s for (-) lead.

B. Need to wait 3 minutes at 5000 A for the (-) lead to recover the voltage developed before ramping magnet above 5000 A.

5.11.4.2 For AC cycle at 10 Amps a second ramp rate directly to 6400 A (no wait at 5000 A)

A. Tare flow is .15 g/s for (+) lead.

B. Tare flow is .38 g/s for (-) lead.

5.11.4.3 For DC loop at 10 Amps a second with 80 second stops at various currents.

A. Tare flow is .10 g/s for (+) lead for all currents.

B. Tare flow is .10 g/s for (-) lead below 2000 A and .35 g/s afterward.

C. Reduce (-) lead Tare flow to .10 g/s when below 2000 A.

D. Unused leads set at .07 g/s and .05 g/s.

5.12 <u>Installing Test and Measure will activate your Quench detection system.</u>

5.12.1 When a magnet quenches, the magnet stored energy is deposited to the cooling helium instantaneously. Large amount of cold helium gas is generated at rapid rate. The operator needs to handle the transient of large amount of cold gas return to the refrigerator. The quench handling in Forced Flow cooling is given in 5.12.2 and that in Liquid cool is given in 5.12.3.

5.12.2 Quench handling in Forced Flow mode

5.12.2.1 At quench you will have a quench flag in red for 2 minutes.

A. This will lock out Valve DOV 35 to stop helium in the surge tank from returning to refrigerator.

B. It will open Valve DOV 38 to the surge tank when pressure at Low Temp indicator PI74 reaches 13.7 ATM.

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Note: It will open and close to hold pressure in the magnet below 13.7 ATM.

5.12.2.2 After quench flag in red disappears, a quench mode flag will appear.

A. Valve DOV 38 will lock out.

B. Valve DOV 35 return to refrigerator will open and close until surge tank indicator PI75 pressure is below 3.5 ATM.

C. COLD GAS WILL BE GOING TO THE RETURN OF THE REFRIGERATOR. STOP ENGINES TILL, REFRIGERATOR STARTS TO WARM, WHEN REFRIGERATOR IS ABOUT OPERATING TEMPERATURES, START ENGINE.

D. When surge tank pressure indicator PI75 is below 3.5 ATM the quench mode flag will disappear.

5.12.3 Quench handling in Liquid Cool mode
NOTE: This procedure is handled manually by two operators working simultaneously.

5.12.3.1 As soon as magnet quenches,

A. OPEN VALVE 809 “C” BAY warm return to prevent excessive pressure in the magnet.

B. CLOSE VALVE 801 “C” BAY refrigerator return to avoid pressure build up in the low pressure side of the refrigerator.

C. SET CONTROLLERS 31 and 32 FOR JT VALVES AOV803 AND AOV 805 TO 10%.

5.12.3.2 When magnet pressure indicator PI812 is at 1.8 ATM, OPEN DOV 801 refrigerator return.

A. CLOSE VALVE 809 "C" BAY warm return. NOTE: If magnet pressure indicator PI812 goes to 2 ATM reopen VALVE 809. Repeat until PI812 is stable and under 2 ATM with VALVE 809 closed.

B. Reset JT valves AOV803 AND AOV 805 to operational settings.

C. COLD GAS WILL BE GOING TO THE RETURN OF THE REFRIGERATOR. STOP ENGINES UNTILL, REFRIGERATOR STARTS TO WARM, WHEN REFRIGERATOR IS ABOUT OPERATING TEMPERATURES, START ENGINE.

5.13 Switch from Liquid Cool Mode to Forced Flow.

5.13.1 CLOSE Valve 801 Low Pressure return to refrigerator.

5.13.2 When magnet pressure PI812 reaches 6 ATM OPEN DOV 806 force flow return and Valve 804 forced flow inlet.

5.13.3 CLOSE by pass valve 807

5.13.4 Set JT VALVES AOV803 AND AOV 805 to 10%.

5.13.5 CLOSE AOV 52 low pressure refrigerator return and crack OPEN HE 5.

6.0 Documentation

Documentation is kept in the CRYOGENIC Logbook located in Building 902.

7.0 References

7.1 Operations and Maintenance manual provided by CVI is kept in the CRYOGENIC Control Room located in Building 902.

7.2 An Operators Problem Guide and Operations Guide is give to all operators and a copy is kept in the CRYOGENIC Control Room located in Building 902.

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7.3 Operator's Manual Model 4000 Helium Refrigerator for Brookhaven National Laboratory, August 1975. A copy is kept in the CRYOGENIC Control Room located in Building 902.

8.0 Attachments

None