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TEST PROCEDURE FOR PRODUCTION LHC D1 DIPOLES (SINGLE APERTURE) IN HORIZONTAL TEST BAY E

RUN PLAN

This note documents the procedures (e.g., cold checkout, quench testing) used during magnet testing in Horizontal Test Bay E. The test history (quench currents, number of cooldowns, etc.) is recorded in a separate note.

Note: In the following run plan, some parameters, such as data logger sampling rate, quench detector settings, and ramp rate, may have been varied according to testing conditions and needs.

Note: D1 magnets have, by design, a more restricted space between the magnet cold bore tube and the ID of the magnet coils than the RHIC arc dipoles. This will reduce the flow of the helium to cool the conductor, especially after a quench or the introduction of heat leaks from the outside such as that from the warm bore tube. It is expected that this may lower the quench performance of the magnet until either the warm bore tube is removed entirely or it is reconfigured to reduce heat leaks.

I. INITIAL WARM CHECKOUT AND MEASUREMENTS

Note: All warm and cold checks must be okayed at each step by appropriate personnel

I.1. Leak check of cryostat by vacuum group.

I.2. Standard electrical checkout by electrical group.
1. Hipot of main coils to ground; all other systems grounded
2. Hipot of each quench (strip) heater circuit to ground
3. DC resistance checks

I.3. Record the total coil resistance for use later while monitoring the Warmup.

I.4. Warm level shift test (1 A)
Make sure that the strip heater power supplies are properly set up before initiating the shift test. The strip heater power supplies should be on a dummy load and set to not more than 20V during this test. Verify that the magnet is not under vacuum or being pumped on when doing the shift test. There should be at least one atmosphere present. Set loggers at 0.5kHz.

I.5. Warm magnetic field measurements and survey (field angle)
There are 10 z positions.
1. Install the mole into warm bore tube.

2. Perform full z-scan. Take read of +/- 10A at each position.
3. Data from z-scan must be analyzed before beginning cooldown.

Note: If warm field measurements are not done before cooldown, it is important that they be done after warmup.

II. COLD CHECKOUT (PRELIMINARY MEASUREMENTS AT 4.5K, 10 atm)

NOTE: The cold checks in II.1 - II.5 (resistances, voltage tap checks, etc) can be done when the magnet temperature is 7K or less if this benefits the test schedule. Remember that all power supply shutoffs and strip heater quenches must be done only when the magnet has reached 4.35K.

II.1. Cooldown magnet to 7K or less. Prior to cooldown, the operators should verify that
a) cold mass leak check has been done by cryogenics group;
b) the warm bore tube is sealed and evacuated, and that the bore tube heaters are off.
c) there is water to the leads; and
d) the fans and heaters for the leads are operating.

II.2. Make sure that SCR voltage is set to 0 for all tests.

II.3. Hipot tests by electrical group. (Maximum of 200 uamps allowed)
It is OK to perform this test at 7K, but verify that there is at least 2 atm helium pressure
1. 500V hipot of main coils to ground; all other systems grounded
2. 500V hipot of each quench (strip) heater circuit to ground

II.4. With ohmmeter, measure the following resistances:
1. Coil to ground, to strip heaters.
2. Strip heaters to ground.
3. Across all strip heaters.
4. Check main taps for continuity by measuring the resistances of all taps (each tap has a 200 ohm resistor)
5. 1A ac measurements of coil inductances

II.5. 1 A level shift test (to be done only if there was an unusual result in the cold checks in Part II.1 or if no warm shift test was done). If this test is done, make sure that the LeCroy data logger is set to 0.5kHz sampling rate and that the strip heater power supplies are set to no more than 20V.

II.6. Connect magnet to main power supply at link box.

NOTE: The magnet must be at 4.5K for the remainder of the cold checks.

II.7. Balance Idot quench detection circuit for ramp rate of 20A/s.

II.8. Standard test conditions:

1. Quench Detection Circuit(QDC)	Threshold
1: top-bottom coil (delta)	1 V
2: Magnet - Idot	4 V
	10V (when turning on power supply)

2. Function Delay

Delta QDC	5	ms
Idot QDC	50	ms
Strip heaters	5	ms (minimum setting)

3. Threshold for gas-cooled lead voltages:
   Set flags on monitor page to 80mV.
   Critical threshold is 150mV.

NOTE: A fuse in the power supply circuitry protects the power supply from ground faults and ground fault currents are indicated by a warning light in the control room. Ground fault current is fully instrumented to both fast and slow data loggers.

II.9. Crash button tests at 25A (if necessary).

II.10. 1000A power supply shutoff:
Purpose: to check quench detection, power supply, and data acquisition systems before actually initiating a quench.
1. Set LeCroy logger time base to 1kHz.
2. Set strip heater delay to 80ms.
3. Set strip heater power supply voltages to 20V.
4. Ramp magnet to 1000A at 20A/s.
5. Manually trip the delta (voltage difference) quench detector.
6. Examine all quench signals for proper behavior

III. TEST OF STRIP HEATERS

III.1. Strip heater quench at 2000A:
Purpose: to check strip heater performance at 2000A.
Note: This test is optional after first magnet tested.
1. Set LeCroy logger time base to 1kHz.
2. Set both strip heater power supplies to 60V.
3 Set strip heater delay to 5ms.
4. Ramp magnet to 2000A at 20A/s.
5. Manually trip the delta (voltage difference) quench detector.
   Note: Steps 6-8 below are to be performed by physics personnel.
6. Examine all quench signals for proper behavior.
7. Verify that both outer coils quench <200 ms after heater firing. Check current and voltage waveforms.
8. Calculate the MIITs value for this quench and verify that it does not exceed the maximum safe value for this magnet's conductor.
9. If the criteria in Steps 7-8 were not satisfied, increase strip heater voltage by 20V and repeat Steps 5-7.

III.2 . Strip heater quench at 4000A:
Purpose: to check strip heater performance at 4000A.
1. Set LeCroy logger time base to 1kHz.
2. Set both strip heater power supplies to a voltage determined by the results of the 2000A strip heater quench above.
3. Set strip heater delay to 5ms.
4. Ramp magnet to 4000A at 20A/s.
5. Manually trip the delta (voltage difference) quench detector.
6. Repeat analysis in Part III.1, Steps 6-8.

IV. QUENCH TESTS AT 4.5K, 10 ATM

IV.1. Initial Quench Test
For the first quench, ramp up to 5500A at 20A/s, and remain at 5500A for 5 min. Carefully monitor lead voltages. Then continue to ramp at 20 A/s until the magnet quenches.
During the entire ramp, observe the lead voltages carefully and verify that they are at safe levels. Also watch for unusual increases in voltage. Take monitor page reads during the entire ramp and 5500A step. Fast data loggers at 1kHz sampling rate.

IV.2. Quench Tests.
Fast data loggers at 1kHz sampling rate.
Ramp current continuously at 20 A/s until quench occurs.
Repeat quenches until quench current reaches 7000A.

Wait at least one hour between quenches to insure that the coils are at Nominal temperature.

At every quench, check the vacuum of the 1.9K heat exchanger line to ascertain whether there is any leaking of helium or air into the line.

IV.3. If the magnet does not train properly, various procedures may be tried.
1) If quench currents are not erratic, vary the system temperature and perform quenches to determine if quenches are limited by the conductor.
2) Open the warm bore tube and allow the internal temperature to come up to room temperature. Install the 5-array RHIC dipole quench antenna into the warm bore tube, seal the ends, and evacuate the warm bore tube again. Repeat quench tests to determine locations of quench origin.
3) Warm up the magnet. Completely remove the warm bore tube and seal the flanges at the feed and end cans. This will eliminate heat loading from the outside due to the warm bore. Cool down the magnet again. Repeat cold electrical checkout Step II.4. Perform quenches and training procedure as in Step IV.2. If the magnet now trains to 7000A, go to next step IV.4 if time allows.

IV.4. 5 power cycles to 7000A. (Optional, do if time allows)
Fast data loggers at 1kHz sampling rate.
Perform five current cycles at 20 A/s ramp rate.
For each cycle wait at 7000A flattop for 5 min.
Take monitor reads during cycles and flattops.

V. INTEGRAL DIPOLE FIELD MEASUREMENTS AT 4.5K, 10 ATM

V.1. Warm up warm bore tube with heater and warm nitrogen flow.

V.2. Check for welding near test area.

V.3. Measurements with RHIC integral coil.
Install the integral field measuring coil into the warm bore.
Follow procedure written by Rich Thomas for performing integral field measurements. Do an AC cycle to 6500A. Then measurement cycle to 6500A. The Imax current may actually vary depending on the magnet quench performance with the warm bore tube open and warm.

V.4. Remove RHIC integral coil.

VI. MAGNETIC FIELD MEASUREMENTS WITH MOLE RA2 (Coil #69) or MOLE RA3 (Coil #72)

VI.1. Set up the transporter and install the mole into the warm bore tube.

VI.2. Perform the following DC loop at position #5 and a DC loop up ramp at each of the other 9 axial z positions. These should be the same positions used for the warm z-scan.

DC loop to 6500A.
Note: Reads at or near the injection current 340A (nom), the storage Current 5800A (nom), and the ultimate current 6400A (nom) should be included in the loop. Specific current levels should include the following: 50A, 100A, 200A, 300A, 350A, (400A, 600A, 800A, 1000A,...., to 6400A in 200A steps), 6500A.

The same set of currents should be used for the down ramp at one axial position (#5), and for the up ramp at all the 10 positions.

1) AC cycle to 6500A at 10 A/s.
2) DC loop to 6500A at 10 A/s

Note: The Imax current may vary depending on the magnet quench performance with the warm bore tube open and warm.

VII. DYNAMIC MAGNETIC FIELD MEASUREMENTS WITH FAST COIL #71

VII.1. Quench magnet at 20A/s, 1kHz logger speed
VII.2. Take fast measurements during various ramps, which will be specified at the time of testing. A specific run plan for dynamic measurements will be provided at time of testing.

Note: The Imax current may vary depending on the magnet quench performance with the warm bore tube open and warm.

VIII. WARMUP

VIII.1. Monitor the total magnet coil resistance as warmup proceeds.

VIII.2. When the total magnet coil resistance reaches the value measured in Part I.1, stop the warmup.

VIII.3. Warm magnetic field measurements and survey (field angle)
There are 10 z positions.
1. Install the mole into warm bore tube.
2. Perform full z-scan. Take read of +/- 10A at each position.