Jefferson Lab

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HALL B PROCEDURE NO.:
B000000402 –P001 Rev - D

TITLE: **Hall B Superconducting Magnets Pre-Power-Up Power Supply Internal Interlock Checklist**

BY: R. Fair
DATE: 01 /12 /2017
Intended Checker and Approvers:
CHK: Sarin Philip
1. APP: O. Kumar
2. APP: P. Ghoshal

Solenoid

Completed
7/14/2020
P. Ghoshal

REV.	ECO#	DESCRIPTION	BY	CHK.	APP.	APP.	DATE
D		Sequence modified by S. Philip to check phase imbalance relay, ground faults, over-currents etc. using only "Control Power" with Mains (480 V) not on. Added E-stop in the counting house.	R. Fair	S. Philip	O. Kumar	P. Ghoshal	July 24, 2018
C		Document missing					
B		Modify Step 1 to check jumper XC5 on I-Loop Code Module and change approver	R. Fair	G. Biallas	S. Philip	P. Ghoshal	01.12.17
A		Update document to include Hall B Solenoid Power Supply	R. Fair	G. Biallas	K. Bruhwel	P. Ghoshal	12.20.16

SUMMARY OF CHANGES FROM PREVIOUS REVISION:

Approved: 7/31/2018; E-Sign ID : 370302; signed by: Ap. 1: O. Kumar; Ap. 2: P. Ghoshal; C.: S. Philip; D: A. Barron

Hall B Superconducting Magnets Pre-Power-Up Power Supply Internal Interlock Checklist

Introduction

The checklist below should be completed only in conjunction with the most current release of the B000000401-P020 Hall B Torus Power-Up and Power-Down Procedure and the B000000400-P001 Hall B Solenoid Power-Up and Power-Down Procedure.

This document refers to the Danfysik System 8500 Magnet Power Supply.

There are three key areas of protection as described below – Personnel Protection, Power Supply Protection and Load Protection.

General Safety

Steps 2, 4, 6, and 10 require door 1 of the power supply to be open during the work. Two qualified electrical workers, wearing the required PPE (high-voltage rubber gloves that are V-rated, leather protectors, safety glasses, ear plugs, hard hat with arc rated flash shield, flame resistant coveralls or jacket with long flame resistant pants, leather closed toe shoes), are required to accomplish these steps. The work area has to be cordoned off with safety barricades.

Personnel Protection

No live parts will be accessible without the use of tools. All doors covering live parts will be equipped with door switches. Opening a door will trip and interlock the MPS.

For complete isolation, a disconnect switch will be mounted in a separate box, leaving the main cabinet free from live parts when disconnected.

An emergency stop push-button will be placed on the front side of the main cabinet. One switch on the emergency stop will interlock the MPS via the control system, and another switch on the emergency stop will be wired in series with the coil of the main contactor (releasing main power directly).

An emergency stop push-button will be placed on the front side of the remote control crate. One switch on the emergency stop will interlock the MPS via the control system, and another switch on the emergency stop will be wired in series with the coil of the main contactor (releasing main power directly).

A ground fault (earth leakage) detector will be implemented, interlocking the MPS if more than 100 mA of current flows to ground. This circuit will tie the mid-point of the dump resistor to Ground through a sensing resistance of 100 Ω.

Power Supply Protection

A phase-control-relay will monitor the three-phase mains to ensure the presence of all three phases and correct voltage. This relay will interlock the MPS if a phase is missing or if incorrect voltage is connected.

The power supply will incorporate several levels of over-current protection:

On the primary side of the main transformers, a thermal overload relay will trip to protect the transformers and wiring in case of an overload of the primary.

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On the output side, the MPS will incorporate four levels of over-current protection:

1. By remote control, the digital output current set point ("DA 0") can be clamped to stay within an arbitrary window (refer to the "ESC<DASET" command paragraph in AD4 in the Power Supply System 8500 User's manual for further detail on the SW clamp).

2. An analog overcurrent interlock with adjustable trip level is implemented on the regulation module. This circuit senses on the current measured by the main DCCT (also used by the loop).

3. A 110% current safety interlock using a separate DCCT will be implemented. Foreseen current transducer: LEM HAZ6000.

4. Inherent 120% current interlock (implemented in the DCCT electronics, see paragraph "DCCT electronics module" above).

The transistor bank will be protected against excess power dissipation by a circuit monitoring voltage across and current through it.

All power devices (transformers, inductors, semiconductors, etc.) will be monitored by thermal switches – interlocking the MPS if the temperature rises above safe level for the individual devices.

Flow switches will monitor the cooling water flow of each parallel water path, and interlock the power supply if the flow drops below the critical rate for the individual path.

At thermal overload or insufficient flow of cooling water, the power supply will also release the dump- switches to ensure a fast ramp-down of the output current.

Load Protection

The load will be protected against over-current and -voltage by the circuits protecting the power supply against the same.

Besides that, four 4-channel quench detectors are included (pr. power supply). Each quench detector channel will have an adjustable threshold of 2mV-2V, and initiate the release of the dump-switches in case of a quench.

The 4-channel quench detector modules are 19" rack-mounted units, each taking up 2U of rack height (total of 8U pr. power supply). Note that the Torus magnet will use 4 quench detectors while the Solenoid magnet will use 3 quench detectors.

All quench detector inputs are bipolar/balanced, so polarity reversal will have no effect on the quench detection.

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Checklist

Hall B
Magnet Power Supply Internal Interlock Checklist

Date July 14th / 2020

Indicate relevant items requiring check below!

Relevant Item:	Checked By/Date	Verified By/Date	
N/A			1. Ensure jumper XC5 on I-Loop Code Module on regulator board is removed for inductive loads.
N/A			2. With Mains 480VAC turned OFF and locked out using LT&T (Lock, Tag and Try), connect 220VAC controls power to the box supply. Ensure doors are closed and the box supply output is enabled by suitable configuration of phase imbalance sensor relay (short between 11 and 14 on K5 of the Contactor Plate)
✓	PKG 13 July & 14 July 2020	PC 7/14/20	3. **Phase Detector Interlock** – switch open the short between 11 and 14 on K5 of Contactor Plate (Phase monitor relay) to simulate a phase fault. The phase detector interlock at P5.1 and P5.2 will trigger the AC main contactor to open. Audible confirmation of the contactor opening verifies function of interlock string (Removing the Phase detector wire)
✓	PKG 14th Jul 2020	PC 7/14/20	4. Re-configure short between 11 and 14 of K5 (Phase monitor relay), reset faults, keep doors closed and enable the power supply output
N/A			5. **Over-current Interlock** – Over-current Interlock - Unplug the X1 connector on Module12 to simulate an Over-Current Interlock and initiate the Main Contactor opening. Audible confirmation of the contactor opening verifies function of the interlock string.
N/A			6. Reconnect plug X1 on Module 12 to make up the interlock. Reset faults and enable power supply output.
✓	PC 07/14/20	PKG 7/14/2020	7. **Water Flow Switch** – Simulate a fault on the Water Flow Switch. The fault should initiate a fast dump and open the Main Contactor. Audible confirmation of the dump switch opening and the Main contactor opening verifies function of the interlock.
✓	PC 7/14/20	PKG 7/14/20	8. Restore water flow switch, reset faults, and enable power supply output.
N/A			9. **Thermal Breaker Faults** – Simulate a thermal switch fault on the dump switch resistors by opening wires TMP5 and TMP6 on the Contactor plate. The Main Contactor and Dump switch should open up. Audible confirmation of each opening verifies

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			function of the interlock. Restore TMP5 and TMP6, reset faults and repeat the test by removing TMP1 and TMP8 on the Contactor plate, and ensure same results to verify interlock function.
N/A			10. Restore wiring for thermal breaker faults on contactor plate, reset faults, enable power supply output.
✓	PKG 7/14/20	PC 7/14/20	11. **Ground Fault** – simulate a ground fault current and initiate a dump, the AC main contactor will open. Audible confirmation of the contactor opening verifies function of interlock string.
✓	PKG 7/14/20	PC 7/14/20	12. Remove ground current, reset faults and enable power supply output.
✓	PKG 7/14/20	PC 7/14/20	13. **Quench detector** – inject a voltage into one of the quench detector circuits to simulate a magnet quench and to initiate a dump interlock fault. Audible confirmation of the dump contactor opening verifies function of interlock string.
✓	PKG 7/14/20	PC 7/14/20	14. Reset power to the power supply. Ensure power is on, doors are closed, and the power supply output is enabled.
✓	PKG 7/14/20	PC 7/14/20	15. **E-stop1** – press the E-stop button on the front of the **power supply** to shut down the power. Audible confirmation of the Main contactor opening and Dump Switch opening verifies function of interlock string.
✓	PKG 7/14/20	PC 7/14/20	**16.** Restore E-stop1, reset faults and enable the power supply output.
N/A			**17. E-stop2** – press the E-stop button on the front of the power supply's **Remote Control Crate** to shut down the power. Audible confirmation of the main contactor opening verifies function of interlock string.
N/A			**18.** Restore E-stop2, reset faults, check Dump Switch has re-closed and enable the power supply output.
N/A			19. **E-stop3** – With communication established with a HallC Counting House personnel, press the E-stop button in the Counting house of HallC to shut down the power. Audible confirmation of the Main contactor and Dump Switch opening verifies function of interlock string.
N/A			**20.** Restore E-stop3 and verify Dump switch has re-closed and all fault clear upon Reset. Turn off all 220VAC control power, restore control power from 480VAC transformer. Ensure power is on, doors are closed, and the power supply output is enabled.
POWER SUPPLY INTERNAL INTERLOCK CHECKS COMPLETE			

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