Magnet Power Supply (MPS) Inspection and Test Plan

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Abstract

The EIC General Purpose Detector system includes a 2T solenoid (MARCO) at its heart with an operational central field of 1.7T. The magnet will operate at normal operating current of 4000 A. The inductance of the magnet is approximately 6H and stored energy is approximately 50 MJ. The power supply for the detector solenoid is a 5000A, ±20V power supply. The magnet power supply is part of the BNL EIC detector solenoid magnet and will be located in an existing experimental facility at BNL, NY.

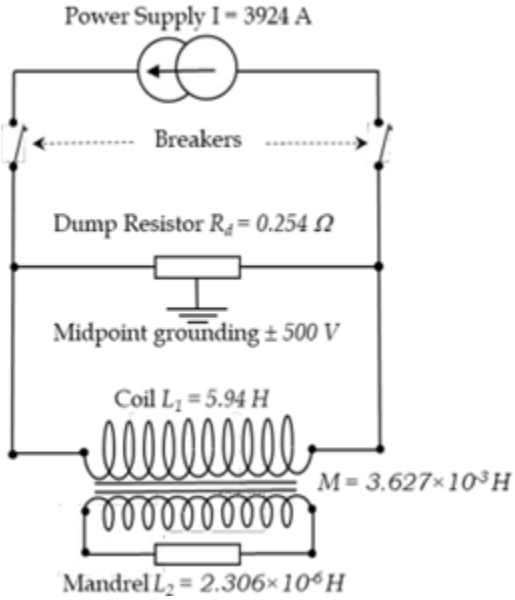

Figure 1. Electrical Circuit with dump resistor

Contents

1. MAGNET PROPERTIES

The main components of the magnet power supply are:

- Power supply with a reversal switch
- Dump Resistor
- Quench detectors

The magnet power supply output requirements and DC power system energy dump specifications are given in **Error! Reference source not found.** and table 2 respectively.

Table 1. Magnet power supply output requirements

DC Power Supply Description	**Specification**
Normal operating current/voltage MARCO magnet	4000 Amps / ± 20 VDC
Ramp Rate	± 3.0 A/sec nominal
Drift (30 min.)	< ± 5 PPM
Drift (8 Hr.)	< ± 10 PPM
NMR field stabilization	1 Micro tesla lock in
Current resolution	< 4 PPM
Absolute accuracy	< 100 PPM
Temperature stability	0.2 pp/degree C

Table 2. DC Power Energy Dump Specifications

DC Power Systems	**Magnet**	**Magnet Operating Current (Normal)**	**Inductance**	**Stored Energy**	**Maximum Dump Voltage**	**Discharge Resistance**
MARCO Solenoid	Solenoid Magnet System	± 4000 A	6.0 H	48.0 MJ	< 1000 V	0.250 Ohm

The following are the key parameters that will be evaluated by the tests and inspections.

- Overall Operation of the magnet power supply for electrical safety
- Dump resistor
- Quench Detectors

2. PROCESSES AND PROCEDURES

This section will describe the processes and procedures that are required to evaluate each of the properties described the preceding section. There should be a level 2 sub-section for each of the properties identified in section 1.

2.1. Overall Operation of the magnet power supply for electrical safety

Final Acceptance Testing will occur after the DC Power Systems have been delivered to BNL and the DC Power System has been successfully tested by BNL/Jefferson Lab with a superconducting magnet and found to be in compliance with the requirements of this specification.

2.1.1. In-Process Testing

Testing of the DC Power Systems at the subcontractor's factory is required to validate the performance and compliance to specifications of the power supply design.

2.1.2. Incoming Inspections or Acceptance Testing

BNL/Jefferson Lab and the contractor will repeat all acceptance tests at BNL with large inductance superconducting magnets after delivery, as site acceptance test (SAT).

2.1.3. Verification Testing

Jefferson Lab will witness the pre-shipment factory acceptance testing of DC Power System.

2.1.4. Failures and Non-Conformances

If any of the performance parameters are out of specification range, immediate corrective action will be taken by the vendor and approved by JLab technical representative.

2.2. Dump Resistor

The DC system shall have an energy dump full load switch and an energy dump resistor that is capable of removing the magnet's stored energy with a nominal magnet discharge voltage of no higher than 500 V. The energy dump resistor should be temperature monitored and interlocked to prevent over temperature conditions resulting from water coolant failure or repeated magnet discharges. The temperature in the dump resistor needs to be limited to a maximum of 350 deg C. The energy dump switch shall be remotely resettable.

2.2.1. In-Process Testing

Testing of the dump resistor at the subcontractor's factory is required to validate the performance and compliance to specifications.

2.2.2. Incoming Inspections or Acceptance Testing

BNL/Jefferson Lab and the contractor will test the dump resistor at BNL site.

2.2.3. Verification Testing

Jefferson Lab will witness the pre-shipment factory acceptance testing.

2.2.4. Failures and Non-Conformances

If any of the performance parameters are out of specification range, immediate corrective action will be taken by the vendor and approved by JLab technical representative.

2.3. Quench Detector

An integral superconducting (SC) magnet quench detection unit is required that is capable of detecting over voltage conditions in the SC magnet coils and in the vapor cooled current leads. The detection threshold shall be adjustable over a range of 2milli-volts to 2 volts. The quench detection unit shall trigger a DC system fast magnet current ramp down energy dump circuit via a direct analogue interlock. This interlock shall be remotely resettable. The quench detection unit shall have a minimum of 16 dual channels. With a provision to add more channels as required.

2.3.1. In-Process Testing

Testing of the quench detector at the subcontractor's factory is required to validate the performance and compliance to specifications.

2.3.2. Incoming Inspections or Acceptance Testing

BNL/Jefferson Lab and the contractor will test the quench detector at BNL site.

2.3.3. Verification Testing

Jefferson Lab will witness the pre-shipment factory acceptance testing.

2.3.4. Failures and Non-Conformances

If any of the performance parameters are out of specification range, immediate corrective action will be taken by the vendor and approved by JLab technical representative.

3. EXPERIMENTAL/TEST SETUPS

This section will have an individual sub-section for each of the experiments/tests that will be performed. If the same experimental process will be used for multiple properties, it does not need to be repeated. Each experimental section should provide a detailed description of the method, resource requirements, conditions, and equipment.

3.1. Overall Operation of the magnet power supply for electrical safety

Overall operation of the magnet power supply for electrical safety will be tested at vendor site and then at BNL.

3.1.1. Resource Requirements

One trained technician and one qualified electrical engineer.

3.1.2. Test Conditions

These tests to be done at controlled room temperature ~27 deg C.

3.1.3. Equipment

List all specialized equipment that will be required to conduct this test. For instance,

- Magnet

3.2. Dump Resistor

Overall operation of the dump resistor for the magnet power supply will be tested at vendor site and then at BNL.

3.2.1. Resource Requirements

A trained test technician and a test engineer are required to perform these tests.

3.2.2. Test Conditions

The complete test will be done at room temperature and at 4.2 K at the time of magnet installation.

3.2.3. Equipment

Power supply and magnet.

3.3. Quench Detector

Overall operation of the quench detector for the magnet power supply will be tested at vendor site and then at BNL.

3.3.1. Resource Requirements

A trained test technician and a test engineer are required to perform these tests.

3.3.2. Test Conditions

The complete test will be done at room temperature and at 4.2 K at the time of magnet installation.

3.3.3. Equipment

Magnet and power supply

4. ENVIRONMENT, SAFETY & HEALTH CONSIDERATIONS

The procedures will be implemented in a way consistent with the environment, safety, and health policies of the relevant work areas. Within Jefferson Lab the process is described in the ES&H manual Chapter 3200, Work Planning and Control Program and at BNL within the SBMS: "Work Planning & Control for Experiments and Operations".

5. RECORDS AND DOCUMENTATION

All the design reports, calibration data etc. provided by the vendor will be part of the documentation for magnet installation. These will be saved/stored in JLab controlled folders for future reference.

5.1. Manufacturer/Producer Records

Power supply vendor will do all the tests and provide all the test results to JLab.

Power supply vendor will also provide all the as-manufactured data and procedures.

5.2. Deliverable Documentation and Records

The following deliverable documentation will be provided:

- All the calibration data
- Operating manual

6. REFERENCES

EIC Systems Engineering Group. (2022). *Interface Management Plan.* Brookhaven, NY: Brookhaven National Laboratory.

EIC Systems Engineering Group. (2022). *Requirements Management Plan.* Brookhaven, NY: Brookhaven National Laboratory.

EIC Systems Engineering Group. (2022). *Systems Engineering Plan.* Brookhaven, NY: Brookhaven National Laboratory.