PIP-II BTL Dipole

Functional Requirements Specification

Document number: ED000XXXX, Rev. -

**Document Approval**

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Revision History

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# Purpose

An FRS describes the programmatic or project needs and/or requested behavior of a system or component. The document typically outlines what is needed by the end user as well as the requirements and requested properties of inputs and outputs. The FRS specifies the functions that a system or component must perform and establishes consensus among stakeholders on what the system is expected to provide.

# Scope

 This FRS addresses the functional requirements of the BTL dipole magnet for the 800 MeV Linac to Booster transfer line. There will be a total of 37 such magnets installed in the transfer line. In addition there will be two shorter magnets used for injection into the Booster. Power supplies and controls will not be considered here.

# Acronyms

|  |  |
| --- | --- |
| FESHM | Fermilab ES&H Manual |
| FRCM | Fermilab Radiological Control Manual |
| FRS | Functional Requirements Specification |
| L2 | WBS Level 2 |
| L3 | WBS Level 3 |
| PIP-II | Proton Improvement Plan II Project  |
| SCD | System Configuration Document |
| TC | Teamcenter |
| WBS | Work Breakdown Structure |
| BTL | Beam Transfer Line |

# Reference

|  |  |  |
| --- | --- | --- |
| **#** | **Reference** | **Document #** |
| 1 | *EPDM for given system shall be included here* | ED000xxxx |
| 2 | *L2 System Configuration Document (SCD) shall be included here* | ED000xxxx |
| 3 | [Fermilab Engineering Manual](http://directorate-docdb.fnal.gov/cgi-bin/RetrieveFile?docid=34) | NA |
| 4 | [Fermilab Environmental Safety and Health Manual](http://eshq.fnal.gov/manuals/feshm/) | NA |
| 5 | Fermilab Radiological Control Manual | NA |

# Key Assumptions

This FRS will describe the specifications for a horizontal bending dipole magnet suitable for bending the 800 MeV beam from the PIP-II Linac. Also included are the two (2) vertical bend dipole magnets needed for Booster Injection. Other magnetic elements as well as power supplies, and interlocks are not included in this FRS.

# Functional Requirements

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| **Requirement #** | **Requirement Statement** |
|  F-121.3.05-001 |  The dipole magnet will provide the necessary field to bend the 800 MeV particles with a current of less than 500 amps |
|  F-121.3.05-002 |  The horizontal dipole magnet (37) will have a magnetic length of 2.45 m and shall not exceed a flange to flange length of 3.1  |
| F-121.3.05-003 | The vertical dipole magnet (2) will have a magnetic length of 1.8 m |
| F-121.3.05-004 | All the dipole magnets will have a minimum gap of 52 mm |
| F-121.3.05-005 | All the dipole magnet will have a good field region of 24 mm where dB/B<.02% |
| F-121.3.05-006 | All the dipole magnet coils should be directly water cooled with a minimum cooling path diameter of .229 inches |
| F-121.3.05-007 | Coils shall be continuous, that is no splices  |
| F-121.3.05-008 | All external water connections shall be appropriately sized female NPT fittings |
| F-121.3.05-009 | The maximum water pressure drop is 80 psid at the operating flow |
| F-121.3.05-010 | Water flow velocity in the magnet coils shall be between 5 and 8 feet per second |
| F-121.3.05-011 | Water temperature rise shall not exceed 10 degrees C |
| F-121.3.05-012 | Provisions shall be made to allow for rigging the magnet |
| F-121.3.05-013 | Feet for mounting the magnet on a stand shall be welded to the body of the magnet |
| F-121.3.05-014 | Provisions shall be made to allow for the installation of alignment fiducials |

# Safety Requirements

The system shall abide by all Fermilab ES&H (FESHM) and all Fermilab Radiological Control Manual (FRCM) requirements including but not limited to:

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| Pressure and Cryogenic Safety |
| * FESHM Chapter 5031 Pressure Vessels
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| * FESHM Chapter 5031.1 Piping Systems
 |
| * FESHM Chapter 5031.5 Low Pressure Vessels and Fluid Containment
 |
| * FESHM Chapter 5031.6 Dressed Niobium SRF Cavity Pressure Safety
 |
| * FESHM Chapter 5032 Cryogenic System Review
 |
| * FESHM Chapter 5033 Vacuum Vessel Safety
 |
| Electrical Safety |
| * FESHM Chapter 9110 Electrical Utilization Equipment Safety
 |
| * FESHM Chapter 9160 Low Voltage, High Current Power Distribution Systems
 |
| * FESHM Chapter 9190 Grounding Requirements for Electrical Distribution and Utilization Equipment
 |
| Radiation Safety ANSI ASC A14.3-2000 Safety Requirements for Fixed Ladders |
| * FRCM Chapter 8 ALARA Management of Accelerator Radiation Shielding
 |
| * FRCM Chapter 10 Radiation Safety Interlock Systems
 |
| * FRCM Chapter 11 Environmental Radiation Monitoring and Control
 |
| General Safety |
| * FESHM Chapter 2000 Planning for Safe Operations
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Any changes in the applicability or adherence to these standards and requirements require the approval and authorization of the PIP-II Technical Director or designee.

In addition, the following codes and standards in their latest edition shall be applied to the engineering, design, fabrication, assembly and tests of the given system:

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| ASME B31.3 Process Piping ANSI ASC A14.3-2000 Safety Requirements for Fixed Ladders |
| ASME Boiler and Pressure Vessel Code (BPVC) |
| CGA S-1.3 Pressure Relief Standards |
| NFPA 70 – National Electrical Code |
| IEC Standards for Electrical Components |

In cases where International Codes and Standards are used the system shall follow FESHM Chapter 2110 Ensuring Equivalent Safety Performance when Using International Codes and Standards and requires the approval and authorization of the PIP-II Technical Director or designee.

Additional Safety Requirements that are not listed in the general list above shall be included in the Requirements table in the Functional Requirements section.