PIP-II BTL Quadrupole

Functional Requirements Specification

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**Document Approval**

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Revision History

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Table of Contents

[1. Purpose 4](#_Toc516145432)

[2. Scope 4](#_Toc516145433)

[3. Acronyms 4](#_Toc516145434)

[4. Reference 4](#_Toc516145435)

[5. Key Assumptions 4](#_Toc516145436)

[6. Functional Requirements 5](#_Toc516145437)

[7. Safety Requirements 5](#_Toc516145438)

# 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 Quadrupole magnets for the 800 MeV Linac to Booster transfer line. There are three different kinds of quad magnets; there are 49 regular transport line quads, 2 large aperture quads for the beam absorber line and 6 Booster Injection quads for a total of 57 magnets. .

# 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

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| **#** | **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 the quadrupole magnets in the the 800 MeV transport line from the PIP-II Linac. These magnets may be water cooled and the required current should not exceed 100 amps. 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 49 regular transport quads will be capable of a maximum integrated field of 2 Tesla at a current not to exceed 100 amps |
| F-121.3.05-002 | The 49 regular transport quads will have a magnetic length of .2 m, a aperture of 52 mm and a good field region of 24 mm where dB/B < .1% |
| F-121.3.05-003 | The 6 Booster Injection quads will be capable of a maximum integrated field of 3 Tesla at a current not to exceed 150 amps |
| F-121.3.05-004 | The 6 Booster Injection quads will have a magnetic length of .2 m, a aperture of 52 mm and a good field region of 24 mm where dB/B < .1% |
| F-121.3.05-005 | The 2 large aperture quads will be capable of a maximum integrated field of 2 Tesla at a current not to exceed xxx amps |
| F-121.3.05-006 | The 2 large aperture quads will have a magnetic length of .4 m, a aperture of 160 mm and a good field region of 150 mm(H) x 10 mm(V) where dB/B < .1% |
| F-121.3.05-007 | Coils with water flow shall be continuous, that is no splices |
| F-121.3.05-008 | The maximum water pressure drop is 80 psid at the operating flow |
| F-121.3.05-009 | Water flow velocity in the magnet coils shall be between 5 and 8 feet per second |
| F-121.3.05-010 | Water temperature rise shall not exceed 10 degrees C |
| F-121.3.05-011 | Provisions shall be made to allow for rigging the magnet |
| F-121.3.05-012 | Feet for mounting the magnet on a stand shall be welded to the body of the magnet |
| F-121.3.05-013 | Provisions shall be made to allow for the installation of alignment fiducials. Fiducials shall accept standard 1.5”dia. SMR balls or SMR nests and shall be visible from the beam right side. |

# 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 |
| * 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 |

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.