PIP-II Transfer Line and Beam Absorber

Functional Requirements Specification

Document number: ED0008140, Rev. -

**Document Approval**

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Revision History

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| --- | --- | --- |
| Revision | Date of Release | Description of Change |
| R0 |  | Initial Draft |
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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 documents functional requirements for systems designed by and work performed by Transfer Line and Beam Absorber (TLBA) WBS element.

This FRS addresses the functional requirements of the design and the specifications of the Beam Transport Line (BTL) from the PIP-II Linac to the Booster accelerator and Beam Absorber Line (BAL) to the dump.

This FRS addresses the functional requirements of the specifications and design of the collimators, a full power abort absorber, transfer line optics, and a movable low power absorber for Beam Transport Line (BTL) from the PIP-II Linac to the Booster accelerator and Beam Absorber Line (BAL) to the dump. It also addresses the functional requirements of a gamma-t jump system in Main Injector.

# Acronyms

|  |  |
| --- | --- |
| BAL | Beam Absorber Line |
| BLM | Beam Loss Monitor |
| BPM | Beam Position Monitor |
| BTL | Beam Transport Line |
| FEM | Fermilab Engineering Manual |
| 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  |
| RAW | Radioactive Water |
| TC | Teamcenter |
| TLBA | Transfer Line & Beam Absorber |
| WBS | Work Breakdown Structure |

# Reference

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| **#** | **Reference** | **Document #** |
| 1 | EPDM, PIP2 Transfer Line and Beam Absorber (TLBA) | ED0007705 |
| 2 | [Fermilab Engineering Manual](http://directorate-docdb.fnal.gov/cgi-bin/RetrieveFile?docid=34) (FEM) | - |
| 3 | [Fermilab Environmental Safety and Health Manual](http://eshq.fnal.gov/manuals/feshm/) (FESHM) | - |
| 4 | Fermilab Radiological Control Manual (FRCM) | - |

# Key Assumptions

* Building infrastructure shall supply the RAW system for the TLBA.
* Instrumentation shall provide all beam instrumentation for the TLBA.
* Vacuum shall provide enough aperture in the beam pipe and components to transfer the beam through the TLBA.

# Functional Requirements

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| **Requirement #** | **Requirement Statement**  |
|  F-121.5.02-A001 |  The TLBA shall provide H- beam transport from the end of the Linac to the Booster injection girder. |
|  F-121.5.02-A002 |  The TLBA shall have an appropriate beam size for the given aperture in the beam pipe and components to transport the beam. |
|  F-121.5.02-A003 |  The TLBA shall provide the specifications of the magnets and their power supplies. |
|  F-121.5.02-A004 |  The TLBA shall provide specifications and locations for BPM’s to the Instrumentation L3. |
|  F-121.5.02-A005 |  The TLBA shall provide specifications and locations for BLM’s to the Instrumentation L3. |
|  F-121.5.02-A006 |  The TLBA shall provide specifications and locations for the transverse beam profile monitors to the Instrumentation L3. |
|  F-121.5.02-A007 |  The TLBA shall provide specifications and location for the laser-based transverse beam emittance monitors to the Instrumentation L3. |
|  F-121.5.02-A008 |  The TLBA shall provide collimators that efficiently remove stray particles and provide protection against uncontrolled losses. |
|  F-121.5.02-A009 |  The TLBA shall provide a beam absorber that can handle the impact and dissipate the energy of the full beam power specified for injection into the Booster ring. |
|  F-121.5.02-A010 | The TLBA shall provide a low power beam absorber that is movable and can handle sufficient beam power for Linac commissioning. |
|  F-121.5.02-A011 | The TLBA shall interface to the Linac in a manner that maintains Linac low-particulate ultra-high vacuum. |
|  F-121.5.02-A012 | The TLBA shall connect to the Booster injection girder vacuum with conventional ultra-high vacuum design principles. |
|  F-121.5.02-A013 | The TLBA shall provide the quadrupole magnets required for the gamma-t jump system in Main Injector. The quadrupole magnets shall have enough strength to provide a loss free transition crossing in Main Injector. |
|  F-121.5.02-A014 |  The TLBA shall provide the power supplies require to drive the gamma-t quadrupole magnets in Main Injector |
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# 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.