Fermi National Accelerator Laboratory

Fermilab

PIP-II Linac Complex
Functional Requirements Specification

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Document Approval

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Revision History

Revision	Date of Release	Description of Change
	27 June 2019	Initial Release (*)

(*) This FRS is a combination of the following previous FRS documents:

- ED0006756 - High Bay Building
- ED0006790 - Linac Tunnel
- ED0007079 - Linac Gallery
- ED0006785 - Beam Transfer Line

Table of Contents

1. Purpose

An FRS describes the 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.

2. Scope

This FRS addresses the functional requirements of the Linac Complex (LC) which includes the conventional construction required to support assembly, installation and operation of the PIP-II accelerator components. The Linac Complex is divided into the following components:

2.1. High Bay Building

The High Bay Building (HBB) includes the construction package including the below grade and above grade structures, mechanical, electrical, conveying systems and related support systems to house the Warm Front End components and related infrastructure;

2.2. Linac Tunnel

The Linac Tunnel (LT) that includes the work required to install the below grade beamline enclosure to accommodate the beamline components and related support infrastructure;

2.3. Linac Gallery

The Linac Gallery (LG) includes the above grade service building and associated infrastructure to support the technical equipment for the beamline components;

2.4. Beam Transfer Line

The Beam Transfer Line (BTL) that includes the work required to install the below grade beamline enclosure to accommodate the beamline components, beam dump and related support infrastructure.

3. Acronyms

BTL	Beam Transfer Line
CDS	Cryogenic Distribution System
FESHM	Fermilab ES&H Manual
FRCM	Fermilab Radiological Control Manual
FRS	Functional Requirements Specification
HBB	High Bay Building
ICW	Industrial Cooling Water
L2	WBS Level 2

L3	WBS Level 3
LC	Linac Complex
LG	Linac Gallery
LT	Linac Tunnel
ODH	Oxygen Deficiency Hazard
PIP-II	Proton Improvement Plan II Project
PIP2IT	PIP-II Injector Test
SCD	System Configuration Document
TC	Teamcenter
WBS	Work Breakdown Structure

4. Reference

#	Reference	Document #
1	Conventional Facilities Engineering Process Document Management	ED0002857
2	Conventional Facilities System Configuration Document (SCD)	ED0008133
3	Fermilab Engineering Manual (FEM)	-
4	Fermilab Environmental Safety and Health Manual (FESHM)	-
5	Fermilab Radiological Control Manual (FRCM)	-
6	PIP-II Project Assumptions	PIP-II-doc-144
7	PIP-II – Fermilab Interface Document	PIP-II-doc-528

5. Key Assumptions

The assumptions for the Linac Complex include:

1. The Linac Tunnel portion is the only section of the Linac Complex that will be designated as a Oxygen Deficiency Hazard (ODH) system. The ODH system shall be designed in accordance with Fermilab policies and guideline. The Linac Complex (WBS 121.06.05) will install the mechanical equipment (louvers, fans, ductwork). The ODH analysis, design and installation of the control components, wiring, sensors and related work as well as commissioning is the responsibility of the Cryogenic Distribution System subproject.

2. The process equipment will be installed by other PIP-II subprojects.

6. Functional Requirements

Requirement #	Requirement Statement
F-121.06.05-A001	The LC shall provide a safe environment for employees and the public.
F-121.06.05-A002	The LC-HBB shall provide space and infrastructure for the Warm Front-End components in a controlled environment.
F-121.06.05-A003	The LC-HBB shall provide space and infrastructure for unloading/loading activities.
F-121.06.05-A004	The LC-HBB shall include an overhead bridge crane for transporting equipment to the lower portion of the LC-HBB.
F-121.06.05-A005	The LC-HBB shall provide space for operating the Linac including commissioning space, meeting/planning space and support space.
F-121.06.05-A006	The LC-LT shall provide space for the installation, operation and maintenance of cryogenic beamline components.
F-121.06.05-A007	The LC-LT shall provide radiation shielding.
F-121.06.05-A008	The LC-BTL shall provide radiation shielding.
F-121.06.05-A009	The LC-LG shall house beamline support equipment.
F-121.06.05-A010	The LC-LG shall be located adjacent to the LC-LT to allow unrestricted access during beam operating conditions.
F-121.06.05-A011	The LC-LT shall be connected to the LC-HBB.
F-121.06.05-A012	The LC-LG shall house the beamline power supplies for the LC-BTL.
F-121.06.05-A013	The LC-LT shall connect to the CDS supply at the upstream end of the Linac upstream of the HWR.
F-121.06.05-A014	The LC shall provide penetrations to accommodate radio frequency waveguides between the LT and LG.
F-121.06.05-A015	The LC shall provide penetrations to accommodate instrumentation cabling between the LT and LG.
F-121.06.05-A016	The LC shall provide penetrations to accommodate power and instrumentation cabling between the BTL and LG.
F-121.06.05-A017	All penetrations between the LT and LG (cables, conduits, piping) shall be sealed to reduce to the extent possible air movement between the spaces.
F-121.06.05-A018	The LC-BTL shall house conventional beamline components.
F-121.06.05-A019	The LC shall connect to existing Fermilab electrical infrastructure.
F-121.06.05-A020	The LC shall connect to the existing Fermilab domestic water infrastructure.
F-121.06.05-A022	The LC shall connect to the existing Fermilab industrial cooling water infrastructure.
F-121.06.05-A022	The LC shall connect to the existing Fermilab sanitary sewer infrastructure.
F-121.06.05-A023	The LC shall connect to the existing Fermilab chilled water infrastructure.
F-121.06.05-A024	The LC shall connect to the existing Fermilab data/communication infrastructure.
F-121.06.05-A025	The flatness and levelness of the new floor slabs shall be designed for normal construction tolerances.
F-121.06.05-A026	The below grade portion of the Linac Complex shall include embedded Unistrut anchors along the walls at regular intervals.

F-121.06.05-A027	The HVAC systems shall conform to ASHRAE 90.1 and ASHRAE 62.
F-121.06.05-A028	Ventilation outside air shall be supplied to the spaces in accordance with the requirements of ASHRAE 62.1.
F-121.06.05-A029	All plumbing work shall be designed in accordance with Illinois Plumbing Code and Standard Specifications for Water & Sewer Main Construction in Illinois.
F-121.06.05-A030	The below grade portion of the LC shall include provisions for ODH ventilation which includes mechanical equipment and ductwork.
F-121.06.05-A031	The building power transformers shall be located away from the building on a concrete pad.
F-121.06.05-A032	A standby diesel generator shall be installed on a concrete pad adjacent to the transformers.
F-121.06.05-A033	Exit passages and corridors shall incorporate shielding labyrinths to reduce radiation exposure to as low as reasonably achievable (ALARA) levels per FESHM Section 1100.
F-121.06.05-A034	The BTL shall have a dedicated sump at the Beam Absorber Area to all for future monitoring prior to discharge.
F-121.06.05-A035	All sump discharges from the LT and BTL shall be directed to cooling ponds or ICW return ditches.
F-121.06.05-A036	Exhaust fans in the Beam Absorber Area of the BTL shall discharge directly to the exterior without passage through the tunnel sections.
F-121.06.05-A037	The LC shall comply with the overall character of the PIP-II campus and applicable portions of the Fermilab Campus Plan.
F-121.06.05-A038	The LT shall provide space for a future upgrade of the Linac.

7. 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:

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
• 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
Construction Safety
• FESHM Chapter 7010 ES&H Program for Construction
• FESHM Chapter 7030 Excavation
• FESHM Chapter 7060 Fall Protection
• FESHM Chapter 7070 Ladder & Scaffold Safety
Environmental Protection
• FESHM Chapter 8011 Groundwater Protection – Excavations and Wells
• FESHM Chapter 8012 Sedimentation and Erosion Control Planning
• FESHM Chapter 8025 Wastewater Discharge to Sanitary Sewers
• FESHM Chapter 8026 Surface Water Protection
• FESHM Chapter 8050 Domestic Water Protection
• FESHM Chapter 8080 Air Emissions Control Program
• FESHM Chapter 8081 Refrigeration Management
Material Handling and Transportation
• FESHM Chapter 10100 Overhead Cranes and Hoists
• FESHM Chapter 10110 Below-the-hook Lifting Devices

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:

ASME B31.3 Process Piping

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.