

# PIP-II Building Infrastructure (BldgI) Functional Requirements Specification

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## Document Approval

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## Revision History

Revision	Date of Release	Description of Change
R0	6/13/2019	Initial Release
R1	6/25/2019	Modified document after BCR0009 – Scope Split

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## 1. Purpose

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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

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This FRS addresses the functional requirements of building infrastructure systems for the Linac Complex and the PIP-II Mechanical Room, located at the Cryoplat Building (CPB). The Linac Complex consists of the High Bay Building, where the warm front-end equipment resides, the Linac Gallery and Tunnel, where the superconducting linac equipment resides, and the Beam Transfer Lines, which includes the transfer line to the main absorber. The Mechanical Room houses the PIP-II central water plant and compressed air and gas cooling systems from where cooling is distributed to the accelerator equipment within the Linac Complex footprint.

The building infrastructure work consists of the following:

### Design

The building infrastructure is responsible for the electrical and mechanical design of the utility systems for the accelerator components within the Linac Complex area. The electrical design includes the cable tray routing in both the gallery and tunnel, AC power distribution, and cable run thru penetrations. The mechanical system includes the design and layout of the cooling system, with the selection of plumbing components and instrumentation, and the distribution from the main manifolds to the point of usage. The mechanical design also extends to the Mechanical Room where the water plant and air-cooling equipment are located.

### Procurement

Building Infrastructure is responsible for procurement of the PIP-II commonly used cables and connectors, relay racks, hosing and flowmeters for the accelerator components, dedicated water skid for the warm front-end components, including a chiller for the RFQ circulator and all mechanical equipment required at the Mechanical Room.

### Installation of the Water-Cooling System at the Mechanical Room

Building Infrastructure is responsible for installation and commissioning of the water-cooling equipment and associated electrical equipment, such as relay racks and cables within the Mechanical Room area.

## 3. Acronyms

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AC	Alternating Current
BAL	Beam Absorber Line
BTL	Booster Transfer Line
CDS	Cryogenic Distribution System

EPDM	Engineering Process Document Management
FESHM	Fermilab ES&H Manual
FRCM	Fermilab Radiological Control Manual
FRS	Functional Requirements Specification
L2	WBS Level 2 Manager
L3	WBS Level 3 Manager
LCW	Low Conductivity Water
PIP-II	Proton Improvement Plan II Project
RFQ	Radio Frequency Quadrupole
UPS	Uninterruptible Power Source
WBS	Work Breakdown Structure
WFE	Warm Front End

#### 4. Reference

#	Reference	Document #
1	Building Infrastructure Engineering Process Document Management (EPDM)	ED0007969
2	<a href="#">Fermilab Engineering Manual (FEM)</a>	-
3	<a href="#">Fermilab Environmental Safety and Health Manual (FESHM)</a>	-
4	Fermilab Radiological Control Manual (FRCM)	-
5	PIP-II Standard Cables and Connectors	PIP-II docdb #2824

#### 5. Key Assumptions

The following key assumptions are relevant to these functional requirements:

- Other L3s will provide sub-system requirements for cooling, power, number of electronic racks, and cables in a timely manner to ensure systems are designed properly.
- Building Infrastructure shall provide bulk quantities of standard cables, connectors, and electronic racks. This will amount to roughly 90% of the total required cables and racks. Other L3s will be responsible for special cables, connectors, and racks in small quantities. Refer to the PIP-II docdb #2824 for a list of standard cables and connectors.

## 6. Functional Requirements

Requirement #	Requirement Statement
F-121.04.04-A001	Building Infrastructure shall design the LCW system for cooling, including piping, valves, and instrumentation of the WFE including the LEBT solenoids, beam absorber, chopper and scraper; RFQ couplers, power amplifiers, circulator, reflected power loads; MEBT bunching cavities, kicker systems (body and RF load), beam absorber, beam instrumentations such as scrapers and emittance scanner.
F-121.04.04-A002	Building Infrastructure shall design the LCW system, including piping, valves, and instrumentation within the SCL for cooling of the solid-state power amplifiers, circulators and loads for the HWR, SSR1, SSR2, LB650 and HB650 cryomodules.
F-121.04.04-A003	Building Infrastructure shall design the LCW system, including piping, valves, and instrumentation for the magnets of the 650 region, Beam Transfer Line to the Booster and the main beam absorber.
F-121.04.04-A004	Building Infrastructure shall design controls instrumentation for LCW flow.
F-121.04.04-A005	Building Infrastructure shall design controls instrumentation for LCW pressure.
F-121.04.04-A006	Building Infrastructure shall design controls instrumentation for LCW temperature.
F-121.04.04-A007	Building Infrastructure shall design the cooling water system, including supply and return piping, valves, and instrumentation for the Ion Source and the RFQ intermediate, vane, and wall skids.
F-121.04.04-A008	Building Infrastructure shall design the compressed air infrastructure including piping, valves, and instrumentation for WFE equipment to provide compressed air at 100 psig.
F-121.04.04-A009	Building Infrastructure shall design the compressed air infrastructure including piping, valves, and instrumentation for actuation of control valves on the CDS within the Linac to provide compressed air at 100 psig
F-121.04.04-A010	Building Infrastructure shall design compressed air infrastructure including piping, valves, and instrumentation for actuation of beam valves for vacuum system to provide compressed air at 100 psig.
F-121.04.04-A011	Building Infrastructure shall design the utility nitrogen inside the Linac Tunnel and the Beam Transfer Line enclosure at a pressure of 100 psig.
F-121.04.04-A012	Building Infrastructure shall design the AC power distribution system to serve accelerator components and support equipment for the Ion Source, LEBT, RFQ, MEBT, HWR, SSR1, SSR2, LB650, HB650, warm units, and transfer lines.
F-121.04.04-A013	Building Infrastructure shall design the electrical distribution from power panels fed by the building backup generator to the LLRF control relay racks.

F-121.04.04-A014	Building Infrastructure shall design the grounding infrastructure to the accelerator components and support equipment inside the service buildings and accelerator tunnels.
F-121.04.04-A015	Building Infrastructure shall develop and maintain a cable database for the entire PIP-II machine components and sub-systems.
F-121.04.04-A016	Building Infrastructure shall supply standard cables and connectors in bulk for the machine sub-systems, such as cryogenic distribution system, controls, HPRF, beam instrumentation, LLRF, magnets and power supplies, safety system and vacuum systems.
F-121.04.04-A017	Building Infrastructure shall supply standard racks for the sub-systems WFE, HWR, SSR1, SSR2, LB650, HB650, BTL/BAL equipment; controls, safety system, LLRF, beam instrumentation, magnet PS and vacuum systems.
F-121.04.04-A018	Building Infrastructure shall design cable trays for the WFE, HWR, SSR1, SSR2, LB650, HB650 and BTL/BAL equipment; controls, safety system, LLRF, beam instrumentation, magnet PS and vacuum systems.
F-121.04.04-A019	Building Infrastructure shall supply hoses, valves, fittings, and controls instrumentation for measuring LCW flow, pressure, and temperature, for installation by others in the High Bay Building, Linac gallery, Linac tunnel, and Beam Transfer Line.
F-121.04.04-A020	Building Infrastructure shall supply grounding protection materials between the cable trays and the relay racks for installation by others.
F-121.04.04-A021	Building Infrastructure shall supply compressed air hoses, fittings, and flow meters for installation by others in the Linac tunnel.
F-121.04.04-A022	Building Infrastructure shall install and commission the LCW system within the Mechanical Room.

## 7. Safety Requirements

The systems 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
<ul style="list-style-type: none"> <li>• FESHM Chapter 5031 Pressure Vessels</li> </ul>
<ul style="list-style-type: none"> <li>• FESHM Chapter 5031.1 Piping Systems</li> </ul>
<ul style="list-style-type: none"> <li>• FESHM Chapter 5031.5 Low Pressure Vessels and Fluid Containment</li> </ul>
<ul style="list-style-type: none"> <li>• FESHM Chapter 5031.6 Dressed Niobium SRF Cavity Pressure Safety</li> </ul>
<ul style="list-style-type: none"> <li>• FESHM Chapter 5032 Cryogenic System Review</li> </ul>
<ul style="list-style-type: none"> <li>• FESHM Chapter 5033 Vacuum Vessel Safety</li> </ul>

Electrical Safety
<ul style="list-style-type: none"> <li>FESHM Chapter 9110 Electrical Utilization Equipment Safety</li> </ul>
<ul style="list-style-type: none"> <li>FESHM Chapter 9160 Low Voltage, High Current Power Distribution Systems</li> </ul>
<ul style="list-style-type: none"> <li>FESHM Chapter 9190 Grounding Requirements for Electrical Distribution and Utilization Equipment</li> </ul>
Radiation Safety
<ul style="list-style-type: none"> <li>FRCM Chapter 8 ALARA Management of Accelerator Radiation Shielding</li> </ul>
<ul style="list-style-type: none"> <li>FRCM Chapter 10 Radiation Safety Interlock Systems</li> </ul>
<ul style="list-style-type: none"> <li>FRCM Chapter 11 Environmental Radiation Monitoring and Control</li> </ul>
General Safety
<ul style="list-style-type: none"> <li>FESHM Chapter 2000 Planning for Safe Operations</li> </ul>

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.