

PIP-II Review Plan

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Document Approval

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1. Introduction

Fermi National Accelerator Laboratory (FNAL) is building a new Superconducting Linear Accelerator and upgrading the existing synchrotron complex together designated The Proton Improvement Plan-II (PIP-II) Project. The Project is technically complex and organizationally ambitious. A first for the Office of High Energy Physics (HEP), PIP-II will incorporate into the Linac significant in-kind contributions from national and international partners that will range in scope from device design and development to fully integrated Superconducting Linac sub-systems. Upon completion, PIP-II will deliver proton beam power in excess of 1 MW to the Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment (LBNF/DUNE). The design intent of PIP-II is to provide a foundation for a high-intensity proton facility ultimately capable of multi-MW beam power after future upgrades.

PIP-II requires a significant design coordination and integration oversight. As part of the oversight strategy, a design review plan specific to PIP-II is detailed in this document which will facilitate the following: establish expectations of design and planning content and maturity at each review phase/class; provide guidance to managers to define scope and schedule of work for incorporation into the PIP-II Resource Loaded Schedule (RLS); and provide other stakeholders relevant information about the status of work for their interfacing activities.

The following sections define the scope, guiding principles, review classes, stakeholder roles and responsibilities, procedure to carry out the review types, and finally review deliverables expected at each level of maturity.

2. Scope

This document defines the review plan the PIP-II Project will use for systems, sub-systems, and components under development at Fermilab and International Partners.

3. Acronyms

BCR	Baseline Change Request
BOE	Basis of Estimate
CoDR	Conceptual Design Review
DDD	Design Deliverables Document
DRP	Design Review Plan
DUNE	Deep Underground Neutrino Experiment
EPDM	Engineering Process Document Management
FDR	Final Design Review
FEM	Fermilab Engineering Manual
FMEA	Failure Mode and Effect Analysis
FRS	Functional Requirements Specification

FNAL	Fermi National Accelerator Laboratory
HA	Hazards Analysis
HEP	High Energy Physics
ICD	Interface Control Document
IRR	Installation Readiness Review
ISD	Interface Specification Document
L2M	WBS Level 2 Manager
LBNF	Long Baseline Neutrino Facility
ORC	Operational Readiness Clearance
ORR	Operational Readiness Review
PDR	Preliminary Design Review
PIP-II	Proton Improvement Plan II Project
PRR	Production Readiness Review
RA	Risk Assessment
RDS	Room Data Sheet
RSR	Requirements Specification Review
SCD	System Configuration Document
SEP	Systems Engineering Process
SM	System Manager
TC	Siemens Teamcenter
TRR	Transportation Readiness Review
TRS	Technical Requirements Specification
WBS	Work Breakdown Structure

4. Reference Documents

1	Fermilab Engineering Manual
2	PIP-II Review Charge Template (TBD)
3	PIP-II Review Report Template (TBD)
4	Safety by Design Assessment (TBD)
5	PIP-II Risk Register DocDB # 599
5	Fermilab ES&H Manual

5. Guiding Principles of Reviews

Project design reviews provide an assessment of the ability of the Project to meet its technical, schedule, and budget commitments. The primary goal of the Project design reviews is to increase the likelihood of success by identifying potential or actual design problems as early as possible to minimize the cost, schedule, and performance impact. Design reviews are conducted within the framework established by the **Fermilab Engineering Manual (FEM)** [1].

For the PIP-II Project, periodic independent reviews appropriately phased to the DOE 413.3b Critical Decision stage and Director's readiness reviews will occur throughout the life cycle of the project. Reviews such as these are not included in the scope of this Review Plan but are correlated to this review process.

6. Classes of Reviews

The level of a design review will be commensurate with complexity, cost, or safety importance of the design. The following types of project driven reviews are identified as follows:

- Requirements and Specification Review (RSR)
- Conceptual Design Review (CoDR)
- Preliminary Design Review (PDR)
- Final Design Review (FDR)
- Production Readiness Review (PRR)
- Transportation Readiness Review (TRR)
- Installation Readiness Review (IRR)
- Operations Readiness Review (ORR)

7. Roles and Responsibilities

7.1. System Managers

The System Managers (SM) are the L2 System Design Authorities and have overall technical and budget approval for their respective systems and sub-systems. SM responsibilities related to technical reviews are:

- Develops Design Review Plan (DRP)
- Assures design reviews are conducted as required for sub-systems within their respective authorities
- Appoints the Review Coordinator
- Approves the Review Committee Chair
- Approves the Review Committee Members
- Ensures that any recommendations arising from the review are adequately addressed

7.2. Review Coordinator

The Review Coordinator is appointed by the SM. The Review Coordinator organizes and plans the review and has the following responsibilities and roles:

- Forms a review committee

- Provides the committee with a review charge (written purpose and goal of the review) utilizing the **PIP-II Review Charge Template** [2]
- Provides the committee Chair the **PIP-II Review Report Template** [3]
- Establishes an Indico site to host presentation materials
- Works with the technical team to create an appropriate agenda that meets the review charge
- Ensures that the technical team is organized and prepared for the review by making review packages and associated materials available to the committee a minimum of one week prior to the scheduled review
- Provides opening statement and slides explaining the review goal and instructions to the review participants
- Assists the review chair in leading the executive sessions throughout the reviews
- Obtains the final report from the committee

7.3. Review Committee Chair

The Review Committee Chair(s) is appointed by the Review Coordinator and approved by the SM. The Chair serves as the primary point of contact with the review committee and has the following responsibilities:

- Coordinates questions and requests ahead of or during the review that require additional material to be generated to address concerns
- Coordinates the presentation of findings, comments, and recommendations during the close-out session at the end of the review
- Transmits the final review report to the Review Coordinator and the SM

7.4. Review Committee

The Review Committee is selected by the Review Coordinator with the SM approval, and typically drawn from the Fermilab engineering staff, but augmented by technical experts as required. The Review Committee has the following responsibilities:

- Consists of at least one reviewer external to the project team
- Provides verbal and written feedback to the project on whether the subsystem has successfully demonstrated their technical and programmatic readiness based on the review scope and class
- Documents their assessment
- Provides findings, comments, and recommendations as required

8. Procedure

8.1. Design Review Plan

The SM shall develop a Design Review Plan (DRP) that incorporates the relevant design review milestones into the PIP-II Project RLS. The DRP shall reference Design Deliverables Documents (DDD) associated with each review type. The DRP shall be approved by the PIP-II Project Technical Director. The design reviews may be scheduled when the applicable component or system to be reviewed is ready, or, during the design stage, when significant changes have been made to the original design or concept. The design review plan shall list the components and systems requiring technical, safety, and any other planned reviews. The review plan shall be updated as needed to maintain consistency with current project planning. The System Manager should periodically brief the project management team on the status and execution of the DRP.

8.2. Presentation Materials and Support Documentation

Presentation materials and supporting documentation shall be distributed in advance of the review, typically a minimum of a week before the review. Presentation materials shall be posted to the project document database <https://pip2-docdb.fnal.gov/>. An Indico site (<https://indico.fnal.gov/>) shall be created for each review. The review presentation materials, committee's draft report, and attendance and agenda, shall be posted to the Indico site. Support materials shall be uploaded to Teamcenter (TC) and identified in the relevant sub-system engineering process document management (EPDM) files in TC.

8.3. Review Report

All review reports are prepared using the latest **PIP-II Review Report Template**. The Review Report shall include at a minimum:

- The title of the item or system under review
- A description of the item or system
- The type of review
- The date of the review
- The names and association of the reviewers
- The review agenda
- List of design deliverables reviewed
- The Requests for Actions, including **Findings**, **Comments**, and **Recommendations**, where:
 - **Findings** – general, factual observations about material presented, and require no response.
 - **Comments** – observations with value judgments, or “soft” recommendations that require action by the design/engineering team, but where a formal written response is not requirement.
 - **Recommendations** – items that require formal action and closure in writing prior to receiving approval to move into the next phase of the project, or items that require formal action and closure in writing prior the next review.

The SM shall ensure that all responses to Comments and Recommendations are technically appropriate and adequately addressed. The SM shall issue through TC an approval workflow to the review committee of the final Review Report and Review Response. The final review report shall be posted on the project document database <https://pip2-docdb.fnal.gov/> after approval through TC.

8.4. Announcement and Attendance

Announcements shall be made in advance of the review - preferably one month prior to the date of the review. The announcement should communicate relevant details of the major reviews, such as the system being reviewed, the location of relevant documents, review meeting time and location, etc. Attendance records shall be posted in the Project document database (<https://pip2-docdb.fnal.gov/>), and should be appended to the final review report.

9. Review Deliverables

The following list is intended to define the minimal technical and programmatic content required to meet the design review deliverables. SMs shall determine the specific items subject to review for systems within their authority.

9.1. Requirements and Specifications Review

A Requirements and Specification Review (RSR) is held to ensure alignment between the scientific goals and drivers, and technical requirements. The review should address the following:

- Project level requirements
- System level requirements
- Requirement margins
- Operations requirements
- Reliability requirements
- Traceability to functional requirements
- Requirements validation processes

After closure of the review action items, the review outcome shall be used to assist SM in setting the baseline system level requirements, continuation of engineering specifications and component conceptual designs.

9.2. Conceptual Design Review [~5-15% Design Maturity]

The Conceptual Design Review (CoDR) is held to ensure that the objectives and requirements of the design is understood and that the proposed approach will meet these requirements. The emphasis shall be on the requirements, how they flow down, the proposed design concept and the definition of the major system interfaces. The review shall demonstrate a clear understanding of the interfaces and requirements needed for integration of the system with the rest of the Project. The review should present the major design alternatives considered, the relative risk for each, and the justification for the selection. The CoDR shall contain the following scope items and address these issues:

- Design Objective
- Functional Requirements Specifications (FRS)
- Preliminary Technical Requirements
- Preliminary Technical Interfaces
- Conceptual design that meets the requirements
- Preliminary engineering analyses to support conceptual design
- New technologies developed or R&D plan and rationale
- On-going or future trade-off studies
- Alternatives Analysis
- Preliminary Safety by Design Assessment [4]
- Risk Assessment (RA)
- Consideration for quality control and reliability
- Lessons learned from previous projects or experience
- Preliminary budget and schedule

A successful CoDR allows the design effort to proceed to the preliminary design phase.

9.3. Preliminary Design Review [~30-50% Design Maturity]

Preliminary Design Reviews (PDRs) are technical and programmatic reviews intended to assure the chosen design approach meets the technical requirements. Detailed designs are not expected at this time, but preliminary design and analyses are required to demonstrate compliance with requirements. A presentation of the design and interfaces by means of block diagrams, signal flow diagrams, schematics, logic diagrams, configuration and layout sketches, analyses, modeling and any early results is required. Supporting data and analyses for mechanical, power, thermal, and reliability assessments should be shown. PDRs shall contain the following scope items and address:

- Sub-system organizational structure and team
- Sub-system scope and deliverables
- Documented technical requirements
- Changes to baseline scientific or technical requirements
- Safety by Design and Code Compliance
- Risk Assessment
- Engineering design and analyses
 - Engineering analyses should show predicted performance and expected margin to relevant requirements.
 - Assumptions and limitations of current state of the analyses.
 - Draft list of critical items and single-failure point items and their analysis compared to specifications.
- Preliminary software requirements
- Preliminary reliability and maintainability requirements
- Plan for obtaining required safety approvals
- Preliminary QA/QC plan
- Lessons learned from previous projects or experience
- Closure of requests for action from previous review
- Preliminary safety hazard assessments
- Baseline cost and schedule

Typical PDR deliverables include documents (some in a preliminary stage of completion):

- Updated Preliminary Design Report Chapter related to areas being reviewed
- Functional Requirements Specifications (FRS)
- Preliminary Technical Requirements Specifications (TRS)
- Preliminary Interface Control Documents (ICD)
- Preliminary Interface Specifications Documents (ISD)
- Preliminary Engineering design and analyses documents
- Updated Safety by Design Assessment
- Code Compliance Assessment
- Completed Design requirements definitions
- Preliminary design verification methodology
- Preliminary layouts or drawings
- Design and performance specifications, including sub-system specifications
- Test reports from previous prototypes
- Room Data Sheet (RDS)

- System and sub-system CAD models
- Drawings of major components; final drawings of long duration items to be purchased
- Design level schematics of major electronics systems; final schematics and layout of long duration items
- Software functional architecture
- Failure Mode Effect Analysis (FMEA)
- Updated Alternatives Analysis
- Updated Risk Register [5]
- Updated Hazard Analysis (HA) related to area being reviewed
- Resolution of all previous review recommendations related to the sub-system
- Updated schedule
- Updated Basis of Estimates (BOE)
- Up-to-date Baseline Change Requests (BCR)

The completion of the PDR and the closure of any requests for action generated by the review establish the basis for proceeding with the detailed design. The SM may request endorsement by the design review committee for long lead items procurement or for additional advanced prototypes for final design verification prior to production start.

9.4. Final Design Review [~90-100% Design Maturity]

Final Design Reviews (FDRs) are technical and programmatic reviews to provide assurance that the completed design of the selected configuration meets all functional and performance specifications as well as interface agreements. The technical areas addressed during the review include the design configuration and integrity of the selected design; verification planning, requirements, and compliance; operations planning; support equipment; and systems compatibility. Final Design Reviews contain the following scope items and address:

- Sub-system organizational structure and team
- Sub-system scope and deliverables
- A final design that meets the requirements supported by released engineering notes, drawings, schematics, software, etc.
- Safety by Design
- Detailed engineering analyses conducted to predict performance, including margins for relevant requirements
- A complete list of critical items, their analyses, and fabrication and test plans per applicable specifications
- Prototype test results that demonstrate functionality and/or technology readiness needed for start of production, including margins relative to requirements
- Draft fabrication, assembly, test, and transportation (if applicable) plans, along with lists of procedures, fixtures, and flow of work for component and sub-system fabrication, assembly, and test, and preliminary drafts of key procedures
- Draft operations and maintenance plans, including list of operating and maintenance procedures
- Quality assurance plans that include requirements for parts and material selection, inspection, and process control during manufacturing
- Code Compliance
- Updated technical, cost and schedule risk analysis, with focus on manufacturing risks
- Updated Hazard Analysis reflecting final design

- Cost and schedule
- List of identified outstanding problem areas/open issues
- Summary of resolution of request for action from previous reviews since PDR
- Summary of PDR Review Response and resolutions

Typical FDR deliverables include:

- Updated Preliminary Design Report Chapter related to area being reviewed
- Technical Requirements Specifications
- Interface Control Documents
- Interface Specification Documents
- Sub-system specifications, with all requirements completed, with traceability information and expected margin
- Updated Safety by Design Assessment
- Updated Code Compliance Statement
- Completed CAD models compatible with the overall Project model
- Final schematics and drawings of critical components.
 - Preliminary drawings of minor components should be available in draft form
- All released interface documents and drawings
- Finalized test reports from past prototypes
- Completed QA/QC plan
- Completed Verification Test Plan that defines all tests, test equipment, expected results, and description of tests, as well as a completed list of test procedures and draft procedures for key tests
- Software final functional architecture and infrastructure plan
- Updated Alternatives Analysis
- Updated Hazard Analysis assessment
- Updated Risk Register
- Resolution of the PDR recommendations
- Baseline Change Requests to date
- Up-to-date schedule and cost estimate
- Updated BOEs

After the closure of action items, the SM approves the final design; detail drawings and assemblies can be completed, items can be purchased, and part fabrication can begin.

9.5. Production Readiness Review

Production Readiness Reviews (PRRs) are held prior to the start of manufacturing and testing of major sub-system assemblies. PRRs are largely technical reviews, but include assessment of the planned cost, schedule, and personnel needs to complete the manufacturing processes that are covered. PRR shall contain the following scope items and address:

- Status of sub-assembly and detail drawings
- Status of bill of material and part list
- Final released drawings for assembly, test, and handling fixtures, and specifications or drawings for assembly and test equipment
- Production verification test plans, inspection and test travelers, and associated QA/QC documents such as travelers, component routing and handling procedures, etc.

- Final plans for manufacturing workflow, including scheduling, personnel needs and how they support manufacturing workflow plans
- Safety by Design
- Review closeout recommendations from the FDR
- Updated Risk Register including manufacturing risks
- Cost and schedule updates based on manufacturing workflow plan details

Typical PRR deliverables include:

- Updated Safety by Design Assessment
- Final Drawings for all mechanical items
- Final design files for all electronics items
- Released parts and assembly drawings
- Bill of material and part list
- Quotes or purchase order description for procured items
- Procedures and travelers
- Verification test plan describing all tests for verifying subsystem code compliance, requirements and interfaces that include description of deliverables
- Plans and final drafts of procedures for acceptance and production verification tests
- Final plans for manufacturing, including scheduling, and personnel needs
- Hazard Analysis reports
- Summary of FDR Review Response and resolutions
- Up to date schedule and cost estimate
- Updated BOE

After the closure of PRR action items, the component and/or sub-assembly manufacturing and tests may commence.

9.6. Installation Readiness Review

Installation Readiness Reviews (IRR) serve as the final decision gate to install a component in the LINAC. IRRs are the means by which the responsibility of a particular device moves from the SM responsible for the supply of a particular component or sub-system to the LINAC Integration SM. IRRs shall contain the following scope items and address:

- Component or sub-system level devices have met all pre-installation acceptance criteria
- Confirm the necessary staffing, schedule, and procedures for installation
- Confirm installation technical preparedness
- Confirm that all technical design and pre-installation acceptance testing documentation is completed and released, if applicable
- Identify and confirm equipment and systems conform to safety requirements
- Assure prior review recommendations are completed
- Identify remaining risk elements
- Define operational transition date

Typical IRR deliverables include:

- Signed acceptance verification criteria or traveler from the originating SM
- Updated BOE and integrated RLS for integration of component under review
- Finalized installation plan
- Confirmation and closeout of all prior closed review recommendations
- Updated risk register
- Operations transition plan
- List of deliverables requiring installation
- List of technical design and pre-installation acceptance testing documentation with approval and release status

9.7. Operational Readiness Review

Operational Readiness Reviews (ORR) are ES&H reviews held as part of the Operational Readiness Clearance (ORC) process. ORRs are held in accordance with **FESHM, Chapter 2005** [6].

9.8. Transportation Readiness Review

Transportation Readiness Reviews (TRR) are held to ensure that equipment can be safely transported both onsite and from production facilities (partner laboratories, industrial partners) to Fermilab for testing and installation into PIP-II. TRRs should be held for complex or delicate devices where standard packaging/crating considerations are inadequate (e.g. Cryomodule transport). The review should be held after a final design has been completed but with sufficient time before the end of production (start of transportation) to allow design, review, and fabrication of appropriate transportation fixturing, shipping frames, etc. TRRs should contain the following scope items and address:

- Demonstrate that the plan adequately protects equipment from damage
- Determine if transportation risks are well understood
- Demonstrate that the transportation plans conform to relevant laws and safety regulations
- Determine if staffing level is adequate
- Determine if monitoring/verification plan is adequate to verify successful transport

Typical TRR Deliverables include:

- Organizational Chart
- Engineering analyses sufficient to identify critical/sensitive components
- Transportation Requirements Specification detailing criteria required to sufficiently protect all components during transport

- Transportation Plan
 - Analysis of the chosen transportation technique
 - Analysis of the chosen route
 - Detailed design/analysis of the transportation fixtures/packaging
 - Instrumentation and data collection Plan
 - Instrumentation specification
- Key Provisions of the future Shipping Contract
- Acceptance Plan and Verification Methodology

10. Review Closeout Procedure

Reviews must be closed to enable activity starts in the subsequent project phase. The following procedure establishes how reviews are closed.

- The SM (or designee) uploads the approved Review Report to TC in the same ED# as the review itself.
 - Approval of the Review Report is required by the Review Chair and Review committee members
 - Approval of the Review Report can be confirmed via email, signed cover sheet, or TC workflow.
- The SM (or designee) generates a Review Response with the following information:
 - List of comments and responses, if required
 - List of recommendations
 - Recommendation Responses
 - Action Items and schedule
 - Responsible party assigned to each action item
- The SM (or designee) uploads or links the Review Response to TC in the same ED# as the review itself.
- The SM (or designee) initiates an approval workflow process through TC to finalize the Review.
- The SM (or designee) uploads the approved Review Report and Review Response to the PIP-II DocDB.
- The SM (or designee) informs PIP-II Project Controls that the Review is complete, and the milestone achieved.