

TEMPORARY CHANGE REQUEST

TCR NO. TCR-ENG-033,R5-002

(e.g., TCR-ENG-021,R0-001)

The Temporary Change Request (TCR) Form is to be used to process urgent or minor changes for PPPL Policies, Organization/Mission Statements and Procedures. The TCR should be used when changes are:
1) urgent, and can not wait the 2-4 week period for Department Head review/comment, or
2) minor, and do not warrant Department Head review.

Person Requesting Change: Larry Dudek

Phone Ext: 2185

Department Name: Engineering

Document Number: ENG-033 Revision No.: 5

Document Title: Design Verification

Reason for change:

To more closely tie the ENG-036 and ENG-010 to ENG-033 (In Response to CAP 32.1), add chit control measures.

Change description: (Summarize and attach changed pages, with changes clearly indicated)

Add note to ENG-033 to point to the use of TMODES after Paragraph 7 in Section SCOPE: For changes that are not intended to be permanent but are for use for short periods of time a TMODE (see ENG - 036) should be employed. These changes are meant to be temporary (typically <90 days), and are not meant to modify the intended configuration as documented in drawings. T-Mods are needed occasionally to facilitate testing, maintenance, and operations during contingency situations.

Add to ENG-033 "Design Verification" the following in section "C.Design Reviews" after first sentence in third paragraph: Any design drawings must be processed according to ENG-010. ENG-010 defines the process to follow to create, change, check, and use drawings at PPPL. Only approved, signed, stamped drawings shall be used for procurements and field work.

In Section B. Peer Reviews step 8 change to - Forwards results and Chits to Ops Center.

In Section C. Design Reviews 14 add - "the report and chits" and add "Ops Center" to distribution list.

Attachment 7 - DRC Responsibilities add a step 10 "Ensure that DR documentation, results, and chits are sent to the Ops Center."

1. Does this TCR significantly alter the intent or scope of the document? YES: NO: X

2. Does this TCR significantly impact ES&H? YES: NO: X

If 1 or 2 is YES, Explain why the changes should not be routed for Department Head review:

Larry Dudek

Department/Division Head Approval

6/28/2016

Date

John DeLooper

Head, Best Practices and Outreach/designee

6/28/2016

Date

Release/Effective date of this TCR: 6/29/16

Incorporate this TCR into next revision of this document? YES: X NO:

| | | |
|---|--|---|
| Subject: Design Verification | Effective Date: August 14, 2015 | Initiated by: Associate Laboratory Director for Engineering and Infrastructure |
| | Supersedes: Rev. 4 dated April 12, 2011 and TCRs 1-6 | Approved: Director |

TCR-ENG-033,R5-002

Management System (Primary): 03.00 ENGINEERING (ENG)
Management System Owner: Associate Laboratory Director for Engineering and Infrastructure
Management Process: 03.06 Technical Project Management
Process Owner: Associate Laboratory Director for Engineering and Infrastructure
Sub-Process: 03.06.07 Design and Peer Review/Verification
Sub-Process Owner: Associate Laboratory Director for Engineering and Infrastructure; Head, Project Management
Subject Matter Expert Head, Project Management

Applicability

This procedure applies to all design verification activities at PPPL or for off site collaborations and can be used to document work for off site collaborations performed under host design verification procedures.

Introduction

Design verification for a particular job shall be prescribed in a Work Plan (WP) approved by the Cognizant Individual (COG) and the Responsible Line Manager (RLM) per ENG-032. For complex jobs with novel requirements beyond experience, the Work Plan should include risk assessment, a requirements document, initial and interstitial Peer Reviews, R&D and prototypes, a CDR to present the concept of choice, a PDR to present the analysis confirming the concept, and an FDR to present a mature technical, cost, and schedule package. A graded approach may be applied for less complex or less challenging jobs as permitted by the RLM and delineated by the associated Work Plan.

Peer and Design Reviews cover approved work scope per the WP, are prepared and presented by the COG and contributors for the project, and are conducted by the designated Design Review Chairperson (DRC) per this procedure. The DRC conducts the review and provides design review results, disposition, and chits to the RLM and the Ops Center for further action using Attachment 5. Design review objectives and input documentation for design reviews are specified in Attachment 4. The DRC qualifications, responsibilities, and guidance for conducting reviews are contained in Attachment 7.

Design verification encompasses technical requirements, scope, cost, schedule, ES&H, human factors, and risk assessment. Human performance factors should be considered at every level of design (Attachment 6) and when preparing Technical Procedures per ENG-30. This procedure also includes design tools for calculations, prototypes, and comparisons to working systems.

The RLM is responsible for the disposition of design documentation and its records management. Documentation may reside on COG, Analyst, RLM computers or files, project files, or the Ops Center. It is recommended that all documentation eventually be transferred to the Ops Center after closeout. This transmittal is especially important if a COG or RLM changes jobs or is no longer on PPPL staff. Documentation includes but is not limited to presentations, calculations, chits or chit logs, and other materials. Large models, mathematics, and analyses should be stored on hard drives and registered with the Head of Mechanical Engineering Division. The Head of Mechanical Engineering shall maintain a list of stored items and their owner, location, and date including determination of shelf life or life of project. All storage locations should have adequate backup arrangements to ensure preservation. Note: the Ops Center typically stores all documentation by Work Plan number on the Ops Center WP file server.

Project Design to Cost Principles

A fundamental principle for designing to cost is to ensure that the project contains enough scope contingency (i.e., scope that can be removed from the project) such that the overall project cost objective can readily be met. This includes time-phasing the contingency scope in a way that allows it to be removed from the project before unintended costs are incurred.

Cost estimates and projections must be evaluated continuously throughout the life of the project to ensure that the design-to-cost objectives are being met. Whenever the estimate or projection for an element of the project is anticipated to exceed the amount that was planned, one or more of the following steps must be taken:

1. The design of the element must be changed to fit the planned cost constraint.
2. The increased cost associated with the design must be traded off with one or more other elements within the total project.
3. The overall project design must be changed to accommodate the cost increase associated with the offending element and the overall project budget replanned.
4. Scope must be removed from the project (scope contingency) and the remaining budgets adjusted accordingly.

As with all projects, good project management practices are necessary to maintain cost and schedule.

Typically, a Design to Cost type project will have a WAF review as part of every design review and will employ EVMS with monthly status.

Scope

The design verification process is a vital part of the PPPL Work Planning process. Therefore, this process is included in the purview of the Work Planning Review Board. The WPRB Chair will monitor and evaluate the design verification process for compliance and consistency across active projects and provide feedback to RLMs and Design Review Chairpersons for continuous improvement of project management systems.

For off site collaborations where reviews may be held elsewhere, the RLM shall act as coordinator of the review process and insure that the review complies with this procedure. The RLM shall document the off site review and catalogue chits. If the review does not fully meet the criteria

herein the RLM can hold additional peer reviews to address issues not covered by the off site review. The RLM shall submit documentation to the Ops Center as with other reviews.

Stakeholders for the job can include the requesting and performing Department Heads, collaboration divisions, and collaborators. For collaborations, special care must be taken to include sponsor requirements for the collaboration in all phases of the job and to ensure effective communications.

Additional procedures are used to delineate steps in the project management process in conjunction with design verification. These procedures are shown in the Project Management Flow Chart on the in ENG-032 Work Planning and on the Project Management website.

Per ESHD-5008 Chapter 11, the Design Verification process shall evaluate hazard potential and avoid or mitigate hazards as appropriate. Design considerations shall be weighed against any applicable Job Hazard Analyses, Safety Assessment Documents (SAD), and Safety Certificates for any change to the safety envelope. Any design process for an existing project that affects the safety envelope shall communicate as necessary with the applicable RLM management and Activity Certification Committee (ACC) if any exists. Any design issue that may challenge the Safety Manual, SAD, or Safety Certificate shall be considered an Unreviewed Safety Item (USI) and must follow Procedure ESH-025 to reach an Unreviewed Safety Item Determination (USID). Any actions pertaining to a USID shall be reviewed by the applicable ACC for recommendation prior to any operation.

The Design Verification process for any components or rooms where more than 1 gram of lithium or any amount of finely divided lithium (such as powder) will be used or stored requires a Failure Modes and Effects Analysis (FMEA) to be developed for Lithium based hazards. The Lithium Experts Committee (LitEC) must be made aware of this work by checking the box "Review of Materials for Lithium Impact and Safety" on the Work Planning Form.

This procedure satisfies the requirement of The DOE Order 414.1 Order, Quality Assurance, 4.b(2)(b)4, that requires "*The adequacy of design products shall be verified or validated by individuals or groups other than those who performed the work. Verification and validation work shall be completed before approval and implementation of the design.*"

For changes that are not intended to be permanent but are for use for short periods of time a TMOD (see ENG - 036) should be employed. These changes are meant to be temporary (typically <90 days), and are not meant to modify the intended configuration as documented in drawings. T-Mods are needed occasionally to facilitate testing, maintenance, and operations during contingency situations. TCR-ENG-033,R5-002

Reference Documents

| | |
|----------|--|
| EQP-004 | PPPL Institutional Quality Assurance Plan (QAP) |
| P-010 | Design Reviews |
| ENG-010 | Control of Drawings, Software, and Firmware |
| ENG-032 | Work Planning Process |
| ENG-030 | PPPL Technical Procedures for Experimental Facilities |
| ESH 5008 | ES&H Directives |
| ESH-025 | Operations Hazard Classification Criteria and Safety Certification System. |

Procedure

This procedure contains five sections:

- A – Calculation and Design Analyses Checks
- B – Peer Reviews
- C – Design Reviews
- D – Prototypes
- E – Comparisons to Working Systems

Documentation produced by design verification shall ultimately be forwarded to the Operations Center. When a project creates and keeps its own centralized project files, the project then has responsibility for maintaining these files until such time as the files are transferred to the Operations Center. Each reference to the Operations Center in A through E below includes appropriately designated project central files, including project websites. The Operations Center uses the Work Planning number for storage in its server files. Documentation may also reside on COG, Analyst, or RLM computers and files. The RLM is responsible for dispositioning all documentation.

A. Calculation and Design Analyses Checks

Calculation and design analysis checks provide for an independent review by a technically qualified individual prior to using the results for other significant design or fabrication activities. Formal checks are required when calculation and analysis checking is specified in the Work Plan or as determined by the RLM. This checking process may be iterative as the design verification procedure progresses.

Responsibility

Action

Cognizant Individual
(COG/or designee)

1. Develops calculation in accordance with Attachment 1 or project equivalent. For software calculations using code or software applications, Cog/or designee shall so document the input and code used that a competent reviewer could determine validity of the calculation.

Responsible Line
Manager (RLM)

2. Appoints a qualified checker or reviewer for the calculation.

Checker

3. Reviews the calculation using the minimum requirements of Attachment 2. It is the responsibility of the checker to use methods that will substantiate to his/her professional satisfaction that the calculation is correct.
4. Resolves concerns with developer of calculation and signs calculation sheet or project equivalent.

COG

5. Stores calculation in a file location designated by the RLM or a project specific procedure. Project files shall be kept for the life of the project and forwarded to the Ops Center for proper records management.

Note: This procedure allows and recommends Calculation Logs to be held and maintained by the project during the design phase or longer at RLM discretion. The numbering system for Calculations should be project specific and relevant to the project through Work Planning or WBS or similar means.

B. Peer Reviews

Peer Reviews provide a mechanism to utilize the technical expertise of others and to communicate the status of a design process. A peer review may be required by a Work Planning Form or as good practice. Peer reviews may be the foundation to other larger reviews or may be sufficient as the sole review for a design change per RLM discretion. The scope of the review is determined by the COG and approved by RLM. Peer Reviews can also be used to supplement off site reviews at the discretion of the RLM.

For software code, Peer Reviews can be used to present code to a group of cognizant individuals with appropriate programming skills other than the software engineer(s) writing the code as a means of verifying that the code has been written properly, meets standards, makes appropriate use of the language, follows best practices, includes documentation, and will work reliability to meet requirements. However, a Code Peer Review would not be used to replace functional code validation normally provided through pre-operational testing.

Responsibility

Action

Cognizant Individual
(COG)

1. Proposes the Design Review Chairperson (DRC) and attendees for the peer review. Consideration should be given to the need for representatives from ES&H, QA, security or other support organizations.

Responsible Line
Manager (RLM)

2. Approves DRC and list of attendees or acts as DRC.

COG

3. Conducts peer review addressing the objectives of Attachment 4.

Attendees

4. Document on a chit (Attachment 3 or other means) questions, concerns, and recommendations raised during the review that were not adequately resolved.

COG, RLM, and DRC

5. Resolves chits or assigns action items immediately after completion of the review. Dispositions chits accordingly and provide to the COG. The COG/RLM may request QA to track and verify closeouts of chits.

COG

6. Catalogue, record, track, and resolve chits electronically. This information shall be filed in project files and the Ops Center as

appropriate and the paper forms can be discarded.

- COG, RLM, and DRC 7. Documents the purpose and results of the peer review in a Design Review results document listing date, time, attendees, and chits and their resolution. See Attachment 5.
- DRC (RLM) 8. Distributes Peer review results to attendees. Forwards results to the Operations Center.
- COG/RLM 9. Forwards presentation materials and chit resolution information to the Ops Center.

C. Design Reviews

Design reviews (conceptual, preliminary, and final) are formal reviews of a design by qualified individuals to verify compliance with functional and project requirements per the associated Work Plan. Design Reviews should be performed at major project milestones prior to making decisions that may prove costly, time consuming, or difficult to reverse. Objectives and input documentation for the various types of design reviews are contained in Attachment 4.

Subsequent development of the design as presented, especially after a Final Design Review, requires remedial review steps to reestablish that the design has been properly vetted. The RLM may determine that the changes are minor and may allow the design process to continue unabated. However, when the RLM determines that the changes require more review, the RLM may hold a Peer Review to discuss the changes or the RLM may require that the original review take place again with the new information.

The RLM has the full responsibility for the design process and shall ensure that the design as presented and vetted has been captured in drawings and other documents. Any design drawings must be processed according to ENG-010. ENG-010 defines the process to follow to create, change, check, and use drawings at PPPL. Only approved, signed, stamped drawings shall be used for procurements and field work. The RLM has the responsibility to ensure that FDR chits have been incorporated into the design and ensure that chit logs have been dispositioned properly and forwarded to the Ops Center. **TCR-ENG-033,R5-002**

| <u>Responsibility</u> | <u>Action</u> |
|--|---|
| Associate Director for Engineering and Infrastructure (ADEI) | 1. Selects and maintains a roster of Design Review Chairpersons (DRC) in accordance with Attachment 7 (list on the Engineering Department home page). |
| Responsible Line Manager (RLM) | 2. Determines, in consultation with the appropriate Engineering and Infrastructure Department Division Head, the individual to be Chairperson (DRC) The DRC shall be independent of the design work being reviewed. |
| COG | 3. Briefs Chairperson regarding the work to be reviewed. |
| COG/RLM/DRC | 4. Determines the composition of the Review Board, the input |

documentation for the review, and the criteria for success. Typically, the Design Review Board shall consist of:

- Design Review Chairperson
- Cognizant Individual
- Engineers or physicists with background and skills required to thoroughly assess the functional needs and design adequacy.
- Representatives from interfacing or impacted organizations.
- Others, such as QA, ES&H, or recognized experts from outside the Laboratory, as appropriate.
- Reviewers from other National Laboratories, other fusion facilities, or universities with relevant experience.
- Other external reviewers including industry specialists and consultants.

COG 5. Secures a room for the review meeting and issues an invitation to the Board and invitees. Invitees shall include, if not part of the Board, QA, ES&H, security and organizations impacted by or interfacing to the design.

COG 6. Supplies a documentation package to the Review Board members before the review meeting.

7. Presents and defends the design at the review.

Design Review Chairperson 8. Conducts Design Review to ensure that the presentation materials address objectives of Attachment 4. (See Attachment 7 for DRC Responsibilities and Guidance in conducting a DR.)

Attendees 9. Document on a chit (Attachment 3 or other means) questions, concerns, and recommendations raised during the review that were not adequately resolved.

DRC & Design Review Board 10. Resolves chits or assigns action items immediately after completion of the review. Dispositions chits accordingly. Catalogue, record, track, and resolve chits electronically. This information shall be filed in project files and the Ops Center as appropriate and the paper forms can be discarded.

COG 11. Catalogs, tracks, and resolves chits electronically. This information shall be filed in project files and the Ops Center as appropriate and the paper forms can be discarded. The COG/RLM may request QA to track and verify closeouts of chits.

DRC 12. Prepares a report within 5 working days using Attachment 5 which includes the list of attendees, chits with the Design Review Board's recommendation, and a summary conclusion which states whether the design review was successful as well as any significant

observations or recommendations.

- | | |
|-----|---|
| DRC | <p>13. Obtains concurrence of RLM on the results and chits such that the RLM acknowledges the outcome of the review and owns the work. Note: If concurrence is not obtained, the DRC and RLM shall meet with the ADEI and requesting and performing department heads to resolve differences.</p> <p>14. Distributes the report to the attendees, QA, security, ES&H, and the Associate Director for Engineering and Infrastructure.</p> |
| COG | <p>15. Responds to the recommendations of the Design Review Board by providing chit resolution at subsequent reviews or to the RLM.</p> |
| RLM | <p>16. Ensures that chit recommendations have been incorporated appropriately.</p> |
| COG | <p>17. Forwards Design Review presentation materials and chit resolution information to PPPL Operations Center within five working days.</p> |
| RLM | <p>18. Ensures that the Cog has captured the vetted design in final documentation.</p> <p>19. Ensures that the Design Review documentation is complete in the Ops Center.</p> |

D. Prototypes

Prototypes are used for various design verification steps, including the need to test a concept, clarify requirements, demonstrate the feasibility of a design approach, validate analysis, perform software simulations, or evaluate techniques for hardware fabrications. Prototypes shall be reviewed per this procedure as with all other work using a graded approach per the RLM.

| <u>Responsibility</u> | <u>Action</u> |
|-----------------------|---|
| COG | <p>1. Documents the requirements for the prototype listing the objective for the prototype, technical information about how the prototype was performed, the results of the prototype, and the impact of the results on the design.</p> |
| RLM | <p>2. Reviews the documentation and indicates concurrence with the results by signing the documentation.</p> |
| COG | <p>3. Forwards the documentation to project files or the Ops Center.</p> |

E. Comparison to Working Systems

Comparison to working systems may be used to validate a design to provide confidence that a selected design will work.

| <u>Responsibility</u> | <u>Action</u> |
|--------------------------|---|
| Cognizant Individual | 1. Documents the comparison identifying the objective for the comparison, technical information about how the comparison was performed, the results of the comparison, and the impact of the results on the design. |
| Responsible Line Manager | 2. Reviews the documentation and indicates concurrence with the results by signing the documentation. |
| Cognizant Individual | 3. Forwards the documentation to project files or the Ops Center. |

Training Section

- | | |
|-------------------------------------|--|
| Author | <p>1. Ensures the training listed below is provided and informs the Training office.</p> <p>A. Target Audience: <u>COGs and Department Heads who assign RLMs</u> Instructor: <u>Head, Project Management Office</u> Training Method: <input checked="" type="checkbox"/> Read only training to this procedure – once only <input checked="" type="checkbox"/> Email distribution for major revisions of this procedure <input checked="" type="checkbox"/> COG/RLM training before work commences and Online updates annually</p> <p>B. Target Audience: <u>Supervisors</u> <input checked="" type="checkbox"/> Best Practices sends out notice of new/changed Procedures to all Supervisors</p> |
| Management System Owner or Designee | <p>2. Notifies the Human Resources Training Office of the training so that they will be aware of the training requirements and be able to provide assistance and guidance in the course development, implementation, tracking, and maintenance</p> |

Records Requirements Specific To This Procedure

Records Custodians must assure records are maintained as follows:

| Record | Record Custodian | Location | Retention Time |
|-------------------------------|--------------------------------------|------------------------------------|---|
| PPPL Calculation Form | Operations Center | Operations Center | Until project completion or termination whichever is earlier. <i>Reference: Admin 17 Cartographic, Aerial Photography, Architectural & Engineering Records (30.A)</i> |
| Design Review Chit Form | Project Manager | Project files | Destroy after the information has been converted to an electronic medium and verified, when no longer needed for legal or audit purposes or to support the reconstruction of, or serve as a backup to, the electronic records, or (applicable to permanent records only) 60 days after NARA has been provided the notification required by 36 CFR 1225.24(a)(1), whichever is later. <i>Reference: Admin 20 Electronic Records (2.a.4)</i> |
| Design Review Chit (Software) | Project Manager or Operations Center | Project Files or Operations Center | Destroy after the expiration of related disposable records or when related system is removed from service. <i>Reference: Admin 20 Electronic Records (10.1.a)</i> |
| Design Review Chit (Other) | Project Manager or Operations Center | Project Files or Operations Center | Until project completion or termination whichever is earlier. <i>Reference: Admin 17 Cartographic, Aerial Photography, Architectural & Engineering Records (30.A)</i> |
| Design Review Results Form | Project Manager or Operations Center | Project Files or Operations Center | Various retention times; see Admin 17 Cartographic, Aerial Photography, Architectural & Engineering Records (30.c) for specific record type |

Attachments

1. PPPL Calculation Form.
2. Minimum Requirements for Checking of Calculations.
3. Design Review Chit Form
4. Design Review Objectives and Input Documentation
5. Design Review Results Form
6. Human Performance Improvement/Factors Considerations in Design Reviews
7. Design Review Chair Qualifications, Responsibilities, and Guidance

PPPL Calculation Form

Calculation # _____ Revision # _____ WP #, if any _____
(ENG-032)

Purpose of Calculation: (Define why the calculation is being performed.)

References (List any source of design information including computer program titles and revision levels.)

Assumptions (Identify all assumptions made as part of this calculation.)

Calculation (Calculation is either documented here or attached)

Conclusion (Specify whether or not the purpose of the calculation was accomplished.)

Cognizant Engineer (or designee) printed name, signature, and date

I have reviewed this calculation and, to my professional satisfaction, it is properly performed and correct.

Checker's printed name, signature, and date

1. Assure that inputs were correctly selected and incorporated into the design.
2. Calculation considers, as appropriate:
 - Performance Requirements (capacity, rating, system output)
 - Design Conditions (pressure, temperature, voltage, etc.)
 - Load Conditions (seismic, wind, thermal, dynamic)
 - Environmental Conditions (radiation zone, hazardous material, etc.)
 - Material Requirements
 - Structural Requirements (foundations, pipe supports, etc.)
 - Hydraulic Requirements (NPSH, pressure drops, etc.)
 - Chemistry Requirements
 - Electrical Requirements (power source, volts, raceway, and insulation)
 - Equipment Reliability (FMEA)
 - Failure Effects on Surrounding Equipment
 - Tolerance Buildup
3. Assumptions necessary to perform the design activity are adequately described and reasonable.
4. An appropriate calculation method was used.
5. The results are reasonable compared to the inputs.

NOTE: IT IS THE RESPONSIBILITY OF THE CHECKER TO USE METHODS THAT WILL SUBSTANTIATE TO HIS/HER PROFESSIONAL SATISFACTION THAT THE CALCULATION IS CORRECT.

BY SIGNING CALCULATION, CHECKER ACKNOWLEDGES THAT THE CALCULATION HAS BEEN APPROPRIATELY CHECKED AND THAT THE APPLICABLE ITEMS LISTED ABOVE HAVE BEEN INCLUDED AS PART OF THE CHECK.

PPPL DESIGN REVIEW CHIT

WP # _____ (ENG-032)

CHIT # _____

COMPONENT/SUBSYSTEM/SYSTEM _____

COGNIZANT DESIGN ENGINEER _____ DATE OF REVIEW _____

-
- PEER
-
-
- CDR
-
-
- PDR
-
-
- FDR

SUBJECT: (CHECK AS APPLICABLE)

-
- REQUIREMENTS
-
-
- ANALYSIS
-
-
- PERFORMANCE

-
- HARDWARE
-
-
- CONFIGURATION
-
-
- RELIABILITY/MAINTAINABILITY

-
- SAFETY
-
-
- SECURITY & SAFEGUARDS
-
-
- COST/SCHEDULE
-
-
- QUALITY

COMMENT/CONCERN/RECOMMENDATION

ORIGINATOR _____

NAME/ORGANIZATION

REVIEW BOARD COMMENT/RECOMMENDATION

(Address technical, cost, and schedule impacts as appropriate. If CHIT is not adopted, provide technical reason - do not simply state "out-of-scope or N/A" without explaining.)

0 CONCUR

0 DISAGREE

0 CHAIRPERSON _____ DATE: _____

Design Review Objectives and Input Documentation

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The table below lists the objectives and design review inputs for each type of design review. This list was developed based on PPPL experience in design reviews and using ANSI/ASQC D1160-1995, *Formal Design Review*, as guidance. It is recognized that the nature of systems under review may vary significantly and that, as a result, the inputs required may differ somewhat from what is listed. For each review, the specific inputs are subject to negotiation between the Cognizant Engineer, the Responsible Line Manager, and the design review Chairperson.

| Level of Review | Objectives | Inputs for Design Review |
|------------------|---|--|
| Peer Review | <p>The objectives for any peer review might include a subset of the following:</p> <ul style="list-style-type: none"> ▪ Communicate a proposed change to a requesting or performing group. ▪ Assure that the proper requirements are identified. Requirements should include functional, ES&H, regulatory, quality, reliability, interfaces, project specific, test, cost, human performance and ergonomics and schedule. ▪ Identify hazards associated with the work or its impact on operations and appropriate mitigation. ▪ Identify SAD/Safety Envelope considerations. ▪ Alert ACC if required. ▪ Alert others (e.g. ES&H, QA, ER/WM) security of a proposed change in order to clarify group responsibilities within the change. ▪ Alert impacted organizations or systems of the change. ▪ Discuss resources, schedule, and cost. | <ul style="list-style-type: none"> ▪ Updated Work Planning form, if applicable. ▪ Documented requirements, if required by WP. Otherwise, requirements presented as part of review presentation. ▪ Identified hazards and appropriate mitigation techniques. ▪ Resource, schedule, and cost considerations. ▪ Review SAD/Safety Envelope considerations including USI/USID |
| Conceptual (CDR) | <ul style="list-style-type: none"> ▪ Assure that the proper requirements are identified and can be satisfied within acceptable envelopes. Requirements should include functional, ES&H including human performance and ergonomics, regulatory, security, quality, reliability, interfaces, project specific and test. ▪ Review development and design plans and schedules. ▪ Review cost and schedule estimates, including contingencies. ▪ Review configurations or designs that are novel to PPPL. ▪ Obtain input when competing design approaches exist. ▪ Identify hazards associated with the work or its impact on operations and appropriate mitigation. ▪ Review SAD/Safety Envelope considerations. ▪ Alert ACC if required. ▪ Review and assure that appropriate design and development plans and schedules have been developed. | <ul style="list-style-type: none"> ▪ Updated Work Planning form, if applicable. ▪ Requirements. ▪ Design and development plan. ▪ Resource, schedule, and cost considerations. ▪ Resolution of chits from prior reviews, if any. ▪ Review SAD/Safety Envelope considerations including USI/USID |

Design Review Objectives and Input Documentation

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| | | |
|--------------------------|---|--|
| <p>Preliminary (PDR)</p> | <ul style="list-style-type: none"> ▪ Verify that all requirements are being addressed. Identify requirements or design conflicts and potential "show-stoppers" ▪ Review the results of analyses, calculations, and tests conducted to obtain additional information for the design. ▪ Review the ability to implement the proposed design taking into consideration capabilities, tolerances, costs, quality, reliability, human performance and ergonomics, security, and ES&H security. ▪ Review procurement issues, e.g. build vs. buy. ▪ Review test requirements and plans. ▪ Review updated design and development plans and schedules. ▪ Assure the appropriate incorporation of recommendations from previous design reviews. ▪ Review SAD/Safety Envelope considerations. ▪ Alert ACC if required. ▪ Review manufacturability. | <ul style="list-style-type: none"> ▪ Updated Work Planning form, if applicable. ▪ Resolution of CDR Chits, if any ▪ Requirement changes since CDR, if held. Otherwise, requirements. ▪ Documentation defining proposed design approach. ▪ Design and development information. ▪ Results of calculations upon which design is based. ▪ Design plans. ▪ Updated cost & schedule estimates. ▪ Drawings, as appropriate. ▪ List of identified procurements and build vs. buy decision. ▪ Review SAD/Safety Envelope considerations including USI/USID |
| <p>Final (FDR)</p> | <ul style="list-style-type: none"> ▪ Verify that the final design satisfies the requirements and is ready for implementation. ▪ Assure that detailed analyses, calculations, and tests to validate the design are complete and documented. ▪ Verify, as appropriate, that the final product can be manufactured, inspected, assembled, stored, delivered, and installed reliably, safely, and cost effectively. ▪ Verify any SAD/Safety Envelope considerations have been resolved. ▪ Alert ACC if required. ▪ Verify that human performance and human factors considerations are appropriately addressed in the design. Further information about human factors in designs may be found in Attachment 6. ▪ Verify that procurement issues have been identified and resolved. ▪ Verify that appropriate documentation is available for producing the final product (e.g. drawings, installation procedures). ▪ Verify that appropriate test plans for the final product have been established. ▪ Assure the appropriate incorporation of recommendations from previous design reviews. ▪ Review manufacturability. | <ul style="list-style-type: none"> ▪ Updated Work Planning form, if applicable. ▪ Resolution of PDR Chits, if any. ▪ Requirement changes since PDR, if held. Otherwise, requirements. ▪ Documentation defining final design approach. ▪ Documented and checked calculations upon which design is based. ▪ Formal drawings, to level required to proceed with procurement/ fabrication/ assembly as applicable. Examples are P&IDs and schematics. Drawings should be checked but need not be signed pending outcome of review and chit resolution. ▪ Revised cost and schedule estimates. ▪ Documentation of tests to be performed. ▪ Drawings, as appropriate. ▪ Review SAD/Safety Envelope considerations including USI/USID |

DESIGN REVIEW DOCUMENTATION – RESULTS

Title: _____

WP#: _____ (ENG-032)

Type of Review: Peer CDR PDR FDR

Cog Individual: _____ Date of Review: _____

Review Board Members:

Invited attendees :

Other Attendees:

Chairperson _____

QA _____

Regulatory Compliance _____

Items Reviewed:

Sat. Unsat.

Comments or n/a if not applicable

Appropriate requirements identified _____

Development plans and schedules _____

Regulatory compliance including USI/USID and NEPA _____

Disposition of CHITS from previous reviews _____

Cost objectives _____

Other review objectives addressed _____

(Attachment 4 of ENG-033)

SUMMARY OF RESULTS:

Disposition: [check one]

_____ **Acceptable**

_____ **Acceptable pending resolution of concerns-** CHITS identified above must be resolved prior to installation.

_____ **Incomplete** - Additional design work is required prior to another design review.

_____ **Unsuccessful** – Corrective actions must be taken and another review process must be initiated.

RLM Concurrence: _____ **Date:** _____

DR Chairperson Signature: _____ **Date:** _____

Distribution: Review Board Members, Operations Center, Cognizant Design Engineer, System Engineer(s), Head, Office of Project Management, Attendees, QA, ES&H, Security, Requesting & Performing Dept. Heads, and Associate Director for Engineering and Infrastructure

Human Performance Factors

Potentially relevant design review questions are listed below. However, the reader should not limit the human performance aspects of a review to these questions.

1. Have potential human or mechanical failures been identified? If so, is there adequate defense in depth¹ to either assure that these failures do not occur or, if they do, the consequences of these failures are minimized?
2. Does this design result in latent errors² that should be corrected?
3. Does the design take into consideration the human factors associated with fabrication, installation, testing, and operation? Considerations include:
 - a. Are the human interfaces and displays consistent with the work to be done, consistent with other interfaces and displays that the same individuals must use, easy to understand, properly labeled, considerate of human limitations such as color blindness, etc.?
 - b. Can the final fabrication or construction be safely performed? Are unique tools required that may not be available? Are there excessive lifting or carrying requirements? Does the design require people to work in an awkward position.

¹ An approach to facility safety that builds in layers of defense against release of or exposure to hazardous materials so that no one layer by itself, no matter how good, is completely relied upon. To compensate for potential human and mechanical failures, defense in depth is based on several layers of protection with successive barriers to prevent the release of or exposure to hazardous materials. This approach includes protection of the barriers to avert damage to the plant and to the barriers themselves. It includes further measures to protect the public, workers, and the environment from harm in case these barriers are not fully effective. Defense in depth controls include engineering controls, administrative processes, and personnel staffing and capabilities.[DOE M 450.1]

² An error, act, or decision that results in organization-related weaknesses or equipment flaws that lie dormant until revealed either by human error, testing, or self-assessment. [DOE M 450.1]

DRC Qualifications:

A candidate for DRC shall have met the following criteria to be approved for the DRC list:

1. Engineering or Physics staff member
2. Completion of COG training for WP system
3. Significant technical experience of at least five years as a COG or 3 completed DRs
4. Significant ES&H experience pertaining to their subject area
5. Significant project management experience completing jobs at PPPL or elsewhere
6. Participation in DR process as a COG, RLM, or Project Manager
7. One complete DR process as an adjunct to the DRC
8. Read only training and instructional discussion for this procedure with Office of Project Management
9. Formal approval by Associate Director for Engineering and Infrastructure and addition to the DRC list

DRC Responsibilities:

The Design Review Chair shall:

1. Judge the design work presented and conduct the Design Review (DR) in a formal and professional manner.
2. Determine that design work, presentation materials, analysis, drawings, photographs, calculations, and other items are well prepared and easily followed by like professionals.
3. Declare the DR incomplete if the presented material does not meet the criteria for the intended classification of review and reconvene when appropriate work has been completed.
4. Determine that the selected Design Review Board has an appropriate and sufficient panel of reviewers present to adequately vet the DR scope and materials.
5. Determine to their own professional satisfaction or by consensus of the Design Review Board that the technical presentation meets the requirements of the project for that stage of review.
6. Ensure that chits are written if technical questions or concerns arise.
7. Evaluate if the ES&H and regulatory compliance aspects of the design are acceptable as presented or ensure chits are generated to track action items.
8. Review the project management content to determine if the requirements, scope, cost, schedule, and risk appear properly developed for that stage of the work or ensure chits are generated to track action items.

9. Otherwise, if the work is off track, the DRC shall declare the DR Unsuccessful.

DRC Guidance

1. The DRC should be well matched to the scope of the job but independent of the actual work. The DRC can require a change to a different DRC if the technical requirements would dictate a different choice. Note: the RLM may chair a Peer Review or chair an off site collaboration review as a PPPL review for documentation purposes.
2. The DR should be presented in a logical manner with clear and professional materials. The DRC can halt or veto the DR if the work is not acceptable.
3. The DR design approach should be built on best engineering principles, solid evidence and calculations. General, unsupported, or vague statements should be challenged if necessary to be sure to adequately vet the design, ES&H, or cost and schedule.
4. The DR should address requirements, allowables, specifications, and ratings as required depending on the type of DR and engineering disciplines involved. If not addressed, the DRC can deem the DR incomplete until such parameters have been gathered and included in the material.
5. The DR should contain an appropriate level of analysis to support conclusions. A Peer Review or CDR should have scoping studies. A PDR should have thorough analysis. An FDR should have confirmatory or detailed analysis to support PDR analysis or to address chits.
6. If the DR generates an overly large number of chits or major chits that undermine the integrity of the design as presented, then the DR should be deemed incomplete until further work is done. If necessary, the DR can be reclassified as a Peer Review to document the chits, and a new DR of the same class can be convened when further design work has been completed.
7. The DR should have a level of scrutiny and formality based on the level of review, the complexity and maturity of the design, and the level of risk associated with use when placed into operations.
8. The DR should adequately cover ISM principles, ES&H, and PM, including hazards and controls.
9. The DR should delineate any special processes or procurements that could affect cost or delivery schedule.
10. If necessary, the DRC should discuss the results and any concerns with the RLM, the Office of Project Management, the involved Department Heads, or the Associate Director for Engineering and Infrastructure.