

PPPL	PRINCETON PLASMA PHYSICS LABORATORY	PROCEDURE	No. ENG-033 Rev 8 page 1 of 15
Subject: Design Verification	Approval Date: 9/12/19	Initiated by: Head of Engineering	
	Effective Date: 9/12/19		
	Supersedes: Rev. 7-003 dated 12/14/18	Approved: Deputy Director, Operations	

Management System (Primary): 03.00 Engineering
Management System Owner: Head, Engineering
Management Process: 03.02 Engineering Design; 03.03 Configuration Management
Process Owner: Head, Engineering
Sub-Process: 03.02.01 Design Process; 03.02.02 Design Output; 03.02.03 Design Review; 03.03.02 Design Record Creation and Control
Sub-Process Owner: Head, Engineering
Subject Matter Expert: Head, Engineering; Head, Design Group; Head, Fabrication Group; Head, Power Systems Group

Applicability

This procedure defines the PPPL process for engineering design verification in accordance with the graded approach defined in the PPPL Quality Assurance Program Description and satisfies requirements in DOE Order 414.1 Order, Quality Assurance, 4.b(2)(b)4:

"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."

Scope

Design verification covers approved work scope per the Work Planning (WP) form found in PPPL Procedure ENG-032. Design verification encompasses technical requirements, scope, cost, schedule, ES&H, human factors, and risk assessment.

For off-site collaborations and reviews, the Cognizant Individual shall act as coordinator of the review process and ensure that the review complies with the minimum requirements of this procedure (Collaborators may impose additional requirements).

The Design Verification process shall evaluate hazard potential and avoid or mitigate hazards consistent with PPPL procedure ESH-025. Design considerations shall take into account any applicable Job Hazard Analyses, Safety Assessment Documents (SADs), Safety Certificates (for High Hazard Operations), and Accelerator Safety Envelopes (ASEs). A design process for an existing project that may affect an approved SAD, Safety Certificate, or ASE shall be communicated as necessary with the Chief Engineer, ES&H, Activity Certification Committee (ACC), and Accelerator Readiness Review (ARR) Team, where applicable. Proposed design changes to a High Hazard Operation or Accelerator with an approved SAD, Safety Certificate (High Hazard Operation) or ASE (Accelerator) must be evaluated by the Unreviewed Safety Issue Determination (USID) process found

in ESH-025 before being implemented. For Accelerators, DOE-PSO approval may be required to implement such changes.

Reference Documents

QAPD	Quality Assurance Program Description
EngPD	Engineering Program Description
P-010	Design Reviews
ENG-010	Control of Drawings
ENG-012	Identification and Control of Items
ENG-032	Work Planning Process
ENG-030	PPPL Technical Procedures for Experimental Facilities
ENG-050	Job Requirements Documentation & Control
ENG-063	Breakdown Structure and Graded Approach Categorization
ENG-064	Interface Control
ESHD 5008	ES&H Directives
ESH-025	Operations Hazard Classification Criteria and Safety Certification System.

Procedure

This procedure contains eight sections:

- A – Design Review Plan
- B – Calculations
- C – Peer Reviews
- D – Design Reviews
- E – Chits
- F – Review of Tooling, Prototypes and Test Samples
- G – Use of Prototypes
- H – Use of Comparisons to Working Systems

A. Design Review Plan

Each WP shall identify work scope requirements for Design Reviews, and hence a Design Review Plan. Items exempted from component classification via Attachment B of the QAPD will typically not require design verification. Maintenance items or equipment that are a ‘like for like’ replacement (same form, fit and function) do not require design verification. If the scope of the WP is subdivided into parts, individual Design Review Plans shall reflect the appropriate design review steps for each part of the WP scope.

The Cognizant Individual prepares the plan interacting with the relevant stakeholders. The plan is approved per the graded approach:

- A1: Responsible Engineer, Project Manager and Chief Engineer
- A2: Responsible Engineer and Project Manager
- A3: Responsible Engineer and Project Manager

The Design Review Plan is approved before beginning a review process. If revisions are necessary, to further detail the inputs produced for a review, the revision is approved again. Portions of the plan that have been accomplished become a record.

The plan shall identify which reviews will be performed and which of the deliverable inputs (delineated in sections C and D) are required at each review.

The Design Review Plan shall identify:

- calculations necessary to establish the design basis, including multiple load cases where applicable. Level of completion (draft, preliminary, final/checked/filed) of calculations shall be indicated for the various stages of review.
- the need for prototypes, stating at what stage of the plan the review of these items and/or results are required per sections F and G of this procedure.
- the need for specialized tooling, and include a review of these items as may be applicable per section F of this procedure.
- the need for comparisons with working systems, stating at what stage of the plan the results are required per sections H of this procedure.

Placeholder numbers for all planned documents and record shall be obtained from the Operation Center prior to the design review at which they are due.

Responsibility

Action

Cognizant Individual

1. Obtains number for the Design Review Plan (Attachment 1) from Operation Center.
2. Develops the plan and discusses it with the relevant stakeholders.
3. Collects approval per graded approach as detailed above.

Operation Center

4. Assigns document and record numbers prior to the design review at which they are due.
Note: Iterate steps when edits to the Design Review Plan are deemed necessary.

B. Calculations

Calculations support the design development and contribute to its verification. Calculations listed in the Design Review Plan shall be checked and filed as inputs at each stage of review at a level of completion defined in the Design Review Plan. All calculations shall be complete (final/checked/filed) prior to Final Design Review.

For calculations that rely on commercial software applications, the analyst shall provide input and output data with sufficient detail in a format such that a qualified reviewer can confirm its validity and/or use the input data to perform a confirmatory calculation.

Software on which calculations rely is handled in compliance with PPPL's software requirements.

Calculations generated/modified and signed off by an external Engineering Subcontractor may be accepted by PPPL for general use provided they: 1) meet the requirements developed in accordance with ENG-050, and 2) are reviewed and issued in accordance with the subcontractor's procedure(s).

Responsibility

Action

Preparer (Analyst or Responsible Engineer or Cognizant Individual)

1. Develops calculation using the Calculation Form (Attachment 2) as its cover. Cognizant Individual and Preparer signs form.

Relevant Technical
Authority
Checker

2. Appoints a qualified checker for the calculation.
3. Checks the calculation using the minimum requirements of Attachment 3. It is the responsibility of the Checker to use methods that will substantiate to their professional satisfaction that the calculation is correct.
4. Resolves concerns with developer of calculation.
5. Completes the Calculation Checking Form (Attachment 3), including concurrence of the relevant Technical Authority, then signs the Calculation Form (Attachment 2), and sends to the Cognizant Individual.

Cognizant Individual

6. Submits a copy of the Calculation Form, as well as the Calculation Checking Form, to the Operation Center (*). Calculation, cover and checking form are filed together. When a revision is filed, the existing calculations are retained for reference.

***Note:** In addition to submittal of forms to the Operation Center, supporting material (e.g. models) shall be archived by the analyst using a storage method that conforms to requirements of the project.*

() NSTX-U calculations (and those calculations for any other system already set up for DMS) to be submitted to the DMS only.*

C. Peer Reviews

Peer Reviews are used to examine detailed aspects of a design or procedure. They may be performed in preparation for a larger review (e.g. Final Design Review) under a WP or may cover standalone scope (e.g.; review of specific implementation of aspects of a design that has already passed a Final Design Review; review of a complex technical procedure). The scope of the review is determined by the Cognizant Individual and approved by the relevant Technical Authority, or the Chief Engineer if more than one Technical Authority is involved. Peer Reviews may also be used to supplement off-site reviews at the request of the Performing or Requesting Department Head, or the Chief Engineer.

When associated with a WP, Peer Reviews shall be listed in the Design Review Plan to ensure that their output (e.g. chits) is tracked.

Inputs to a Peer Review will typically include a subset of the following:

- Requirements
- Identified hazards and appropriate mitigation techniques
- SAD/ASE considerations including USI/USID
- Resource, schedule, and cost considerations

Objectives for a Peer Review may include a subset of the following:

- Ensure that the proper requirements are identified and satisfied by the design or procedure.

- Identify hazards associated with the work or its impact on operations and appropriate mitigation.
- Identify SAD/ASE considerations.
- Alert impacted organizations or systems changes.
- Specify issues that the Cognizant Individual or Project Manager have identified to be evaluated. These should be stated in a charge to the Peer Review team.

Responsibility

Action

- | | |
|------------------------------|--|
| Cognizant Individual | 1. Proposes the Design Review Chairperson (DRC). The DRC shall be independent of the design work being reviewed. |
| Chief Engineer | 2. Approves the DRC. |
| Cognizant Individual | 3. Proposes the attendees for the Peer Review. Consideration should be given to the need for representatives from ES&H, QA, Site Protection, or other support organizations. |
| DRC | 4. Approves the list of attendees. |
| | 5. Conducts the Peer Review in accordance with this procedure. |
| Cognizant Individual | 6. Fills in the top of the chit form (Attachment 4) and makes available enough copies, or makes the electronic form available. |
| Attendees | 7. Document on a chit (Attachment 4 or other means) questions, concerns, and recommendations raised during the review that require resolution. |
| Cognizant Individual,
DRC | 8. Disposition chits (concur/do not concur, in scope/out of scope, redundant, etc.) immediately after completion of the review. |
| DRC | 9. Fills the bottom of the chit form to record the disposition. |
| | 10. Documents the purpose and results of the Peer Review per Attachment 5, listing date, time, attendees, chits and their disposition (Attachment 11). |
| | 11. Signs and sends the Design Review Result and the Chit Dispositions to the Cognizant Individual. |
| Cognizant Individual | 12. Reviews and concurs with the Peer Review summary and the Chit Dispositions and signs the Peer Review Results. |
| | 13. Forwards the Peer Review summary, the Chit Disposition and all the material presented at the review to the Operation Center. |
| | 14. Tracks, and resolves chits electronically. |

D. Design Reviews

Design reviews are formal reviews of a design by qualified individuals to verify compliance with all applicable requirements.

Objectives of Design Reviews will typically include a subset of the following:

- | | |
|---------------------------------|---|
| Conceptual Design Review (CDR) | <ul style="list-style-type: none"> • Ensure that the proper requirements are identified and can be satisfied in practice. • Identify if more than one approach can satisfy the requirements and provide a comparative evaluation. • Review configurations or designs that are novel to PPPL. • Review plans and schedules. • Review cost and schedule estimates, including ranges. • Identify hazards associated with the work or its impact on operations, and appropriate mitigation. • Review SAD/ASE considerations. |
| Preliminary Design Review (PDR) | <ul style="list-style-type: none"> • Review updated design. • Verify that all requirements are being addressed. Identify requirements or design conflicts and potential "show-stoppers". • Verify that interfaces are identified and defined. • Ensure consideration of chits from previous reviews. • Review the results of analyses, calculations, and tests performed to justify the design. • Review the ability to implement the design taking into consideration capabilities, tolerances, costs, quality, reliability, human factors, ES&H and security. • Review manufacturability. • Review plans, costs and schedules. • Review procurement issues, e.g. make vs. buy. • Review test requirements and plans. • Review SAD/ASE considerations. |
| Final Design Review (FDR) | <ul style="list-style-type: none"> • Review and verify that the final design satisfies all requirements and is ready for implementation. • Verify resolution of chits from previous reviews. • Verify that detailed analyses, calculations, and tests are complete and documented including calculation checking. • Review and verify that the final product can be manufactured, inspected, assembled, stored, delivered, and installed reliably, safely, and cost effectively. • Review and verify that appropriate documentation is available for producing the final product (e.g. drawings). • Review and verify that procurement strategy issues have been identified and resolved. • Review and verify that appropriate test plans for the final product have been established. • Review and verify that identification and control of items has been addressed. |

- Review and verify any SAD/ASE considerations have been resolved.
- Review and verify that human factors are appropriately addressed in the design.

Required content for each review of a specific WP will be defined in the Design Review Plan.

The design output is released for use once the relevant Design Approval Form (Attachment 6) is signed by the Main Approver (A-1: Chief Engineer; A2 and A-3: the FDR, or appropriate, DRC).

Typically, a design is approved after a successful FDR by approving a Design Approval Form. However, the procurement of long lead items may need to start before the design as a whole is ready for a FDR. In this case, a review is needed to confirm that the design basis for a long lead item is verified and cannot be affected by the remainder of the design activity. The review to justify long lead procurement may be part of the PDR (and explicitly identified as such) or may be covered by a dedicated Peer Review. The necessary technical specifications and drawings are released via a Design Approval Form by listing them as design outputs.

By listing design output documents in a Design Approval Form, they can be released for bid for a finalized portion of the design, while work continues on the rest of the design, as long as the released portion cannot be affected by the remainder of the design activity.

In the following table, the Design Review requirements and approvals are listed as a function of their category. The category of a design review is based upon the highest assessed risk among all of the items covered by the scope of the review. All items being reviewed require a category. The Responsible Engineers shall follow ENG-063 to obtain the missing categories, or accept A1.

TABLE 1. Graded Approach for Design Review Requirements and Approvals

Category	A1	A2	A3
CDR	Optional*	Optional*	Optional*
PDR	Optional*	Optional*	Optional*
FDR	Required	Required	Required
DAF	Chief Engineer	DRC	DRC
*Note: CDR and PDR may be waived when deemed unnecessary by the Responsible Engineer and Project Manager, using the form in Attachment 7. The waiver for A1 and A2 shall also be approved by the Chief Engineer.			

In Attachment 1 is a guide to determine whether a waiver is acceptable. Examples of circumstances when a Design Review Waiver can be used include but are not limited to:

1. If the scope is similar to previous projects,
2. If the scope definition is very mature,
3. If the nature of the work does not require multiple reviews

Waivers can be filed during initial development of the Design Review Plan, or at any point necessary before the FDR where the Design Review Plan will have to be revised. A single form may be used to

waive both CDR and PDR if appropriate. Approved Design Review Waivers are sent to the Operation Center by the Cognizant Individual.

The DRC is proposed by the Cognizant Individual and approved by the Chief Engineer.

The scope covered by a CDR could span a whole project when it serves to identify the overall project scope and to confirm its feasibility. The scope of PDR/FDR needs to be narrow enough to allow for sufficient technical detail to be covered. For large and complex projects, a Design Review Plan, including integration CDR, individual system (or sub-system or even component) PDRs and FDRs, prototype, working system comparisons, and in-depth Peer Reviews feeding into the PDRs and/or FDRs, is recommended.

If design changes become necessary after FDR, the Main Approver shall assess the changes, determine if they are minor, if the design/fabrication process can continue unabated, or whether an additional review is necessary (covering the specific changes or the full scope of the FDR).

The Cognizant Individual has full responsibility for the design process and shall ensure that the design as presented and vetted has been captured in drawings and other documents. The Cognizant Individual shall ensure that FDR chits have been incorporated into the design and the Main Approver shall review and approve the chit resolution documents. The Cognizant Individual shall forward the chit resolution documents to the Operation Center.

Responsibility

Action

Head, Engineering

1. Selects and maintains a roster of Design Review Chairpersons, available on the Engineering Department website home page.

Cognizant Individual

2. Proposes the DRC. The DRC shall be independent of the design work being reviewed.

CE

3. Approves the DRC.

Cognizant Individual

4. Briefs DRC regarding the work to be reviewed.

5. Recommends the membership of the Design Review Board, consisting of:

- Design Review Chairperson
- the Responsible Engineer of the reviewed system
- All relevant Technical Authorities
- Engineers or physicists qualified to assess the design
- Responsible Engineers for each of the systems listed in the Interface List of the system being reviewed.
- QA and ES&H
- others as applicable (e.g. IT, ESU, Procurement)

The Design Review Board can also include:

- Reviewers from other National Laboratories, other fusion facilities, or universities with relevant experience.

- Other external reviewers including industry specialists and consultants.

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| DRC | 6. Approves the Design Review Board. |
| Cognizant Individual | 7. Secures a room for the review meeting and issues an invitation and a charge letter to the Design Review Board and invitees. |
| | 8. Supplies the pre-review documentation package to the Design Review Board members at least one week before the review meeting. |
| DRC | 9. One week before the review, accepts the design and documentation as ready for the review by signing off the relevant portion of the Design Review Plan, or confers with Chief Engineer about delaying the review until the design and documentation is ready, or allow traceable deviation in the relevant portion of the Design Review Plan. |
| Design Review Board members | 10. Confirm availability to attend the design review for its full duration. If complete or partial absence is requested, a substitute shall be identified and/or absence allowed, subject to agreement of the DRC and the Cognizant Individual. |
| | 11. Study the material provided and prepare to participate in the review. |
| Cognizant Individual | 12. At the design review makes available enough copies of the chit forms with the top part fully filled to identify the review, or makes the electronic form available. |
| DRC | 13. Conducts Design Review in accordance with this procedure. Confirms continuous attendance of the Design Review Board during the review, except for absences previously confirmed per step 10 (and breaks of 5 minutes or less). Review shall be cancelled or declared unsuccessful if board members are missing without prior agreement. |
| Cognizant Individual (and team) | 14. Presents and explains the design at the review. |
| Attendees | 15. Document on a chit (Attachment 4 or other means) questions, concerns, and recommendations that require resolution. |
| Cognizant Individual, DRC, Design Review Board | 16. Disposition chits immediately after completion of the review. |
| DRC | 17. Fills the bottom of each chit form to record the disposition, or the electronic table. |

18. Documents the purpose and results of the Design Review per Attachment 5, listing date, time attendees, chits and their disposition (Attachment 11).
19. Signs and sends the Design Review Result and the Chit Dispositions to the Cognizant Individual.
- Cognizant Individual 20. Reviews the Design Review Result and Chit Dispositions and signs the Design Review Results.
21. Forwards the Design Review Result, the Chit Resolutions and all the material presented at the review to the Operation Center.
22. Tracks chit resolution electronically.
- Cognizant Individual 23. Coordinates actions to resolve the chits, summarizes the resolutions in a Chit Resolution Report (Attachment 10) that shall be approved by the Main Approver at a FDR or by the DRC of a CDR or PDR when a set of chits can or needs to be closed before FDR. All chits shall be closed (closure can be a trackable action, when the chit does not affect the design) by the FDR in the final version of the Chit Resolution Report. It is the responsibility of the Cognizant Individual to log and demonstrate closure of all chits.
- Main Approver 24. After a FDR, verifies that the chits submitted at the FDR have been implemented and identifies the differences in the design and design documentation before and after the chit resolution.
25. If minor or no changes were required to address the FDR chits, instructs the Cognizant Individual to circulate the Design Approval Form for signature, Attachment 6.
26. If design changes were necessary to address the FDR chits, determines whether an additional review is necessary (covering the specific changes or the full scope of the FDR).
- Cognizant Individual 27. Ensures that the Design Review documentation is complete in the Operation Center.

E. Chits

Chits generated at design reviews (peer, CDR, PDR, FDR, other) are critical inputs in the development of a design. At the end of each review, if chits are generated, the Design Review Board completes their disposition following the guidelines in Table 2.

TABLE 2 – Guidelines on chit acceptability

Acceptable Chit	Inadequate Chit
Comment affecting the design within the envelope defined by the GRD, SRD, PEP (if applicable) or other (e.g. Memorandum of Understanding) design requirement.	Comment involving or introducing new design requirements, attributes or performance requirements.
Suggestion to resolve or address known condition or operating experience at PPPL, phenomena observed elsewhere or credible risks within the design envelope.	Question or hypothesis outside of the design envelope, or unsupported by engineering / scientific principles or operating experience.
Clearly articulated comment, suggestion or question with a clear intent or purpose such that the work can be performed without interpretation.	Comments, suggestions or questions without a clear intent or not actionable.

The DRC completes the chit log (Attachment 11) with results of the chit disposition for each design review.

The Cognizant Individual collates chit logs belonging to all the reviews in a Design Review Plan, merging the chit dispositions from multiple reviews in a single Chit Log and identifying the design review during which each chit has been generated, as well as action, actionee, and due date.

Chits generated in previous design reviews can be closed at subsequent design reviews. When the action driven by a chit has been completed, the chit resolution form is filled and presented to the DRC of the coming design review as part of the design readiness package. If the DRC agrees that the chit has been closed, they sign the chit resolution form (Attachment 10) and the Cognizant Individual can log the chit as completed. If chits are completed after a FDR, the Main Approver reviews their closure and if the scope has been sufficiently affected by the chit the Main Approver can ask the Cognizant Individual to convene a further review.

F. Review of Tooling, Prototypes and Test Samples

Tooling issues can potentially impact the quality of deliverable items (even if they pass acceptance tests), and/or the delivery schedule. Therefore, it is appropriate to review tooling in advance of its use and provide proper controls. The following is specific guidance concerning requirements for the verification of tooling used in conjunction with A-1 and A2- items.

1. PPPL in-house fabrications

- a. Off-the-shelf tools do not require review, but any restrictions on their use shall be described in technical procedures or travelers.

Examples: Screwdrivers, hammers, drills, simple instruments (voltmeters)

- b. Custom tools are subject to a peer review chaired by the appropriate Technical Authority.

Examples: Peer Review of design and usage of complex coil winding and Vacuum Pressure Impregnation (VPI) tooling; Peer Review of usage (not design) of simple custom tools (clamps, bending tools, etc.)

- c. Custom tools for in-house production can be specified in sketches, instead of drawings,

following ENG-010, as judged appropriate by the Responsible Engineer, Cognizant Individual, and signed by the appropriate Technical Authority.

- d. Custom tools for drawings will be verified as required by their category and released for manufacture through a Design Approval Form after successful review.

2. For external vendor fabrications

- a. Tools developed by vendors are generally their responsibility in terms of design and usage.
- b. Certain complex tools may require PPPL review and approval in accordance with the procurement documents.

Prototypes and test samples will be requested during the Design Review Plan. These auxiliary items need to be categorized individually, or have the same risk category as the item for which they are developed. When there is an opportunity to use prototypes as future spare or installed parts, their category shall be the same as the item for which they are developed. The design of prototypes and test samples will be verified as required by their category. In addition, when they have no safety implication and lack complexity (e.g. based on standards) or value (e.g. short turn over, cost significantly less than the review cost), they can be produced based on TA approved sketches, per ENG-010.

G. Use of 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, or evaluate techniques for hardware fabrications.

In the design verification process, the use of information gathered from producing and/or testing prototypes shall be reviewed per this procedure.

Responsibility

Action

- | | |
|------------------------------|---|
| Cognizant Individual | 1. Documents (using the Prototype Results form in Attachment 8, either in isolation or as a cover for cumulated evidence) the prototype activity including the objective, technical information about how the prototype was planned to be and then had been tested, the results, and the impact of the results on the design. |
| Relevant Technical Authority | 2. Reviews the documentation and indicates concurrence with the results by signing the Prototype Results form. |
| Cognizant Individual | 3. Forwards the Prototype Results form to the Operation Center. |

H. Use of Comparison to Working Systems

Comparison to working systems may be used to validate a design. Systems with a category equal or higher than that of the system being qualified can be used in the comparison.

Responsibility**Action**

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|------------------------------|--|
| Cognizant Individual | 1. Documents (using the Working Comparison Results form in Attachment 9, either in isolation or as a cover for cumulated evidence) the comparison identifying the objective of the comparison, the means to achieve the objective, and the results of the comparison, including the impact of the results on the design. |
| Relevant Technical Authority | 2. Reviews the documentation and indicates concurrence with the results by signing the documentation. |
| Cognizant Individual | 3. Forwards the Working Comparison Results form to the Operation Center. |

Training

Head, Engineering **Target Audience:** Cognizant Individuals, Project Managers, Project Directors, Responsible Engineers, Technical Authorities, Chief Engineer, QA, ES&H

Training Methods:

- Briefings (major re-issues, newly assigned personnel)
- E-mail (minor revisions)

Records Requirements Specific To This Procedure

All output from a review is filed before the following review.

All input to a review is filed before the review.

All documents and records, apart from the Design Approval Form, are filed before the Design Approval form is signed. The Design Approval form is filed within a week of being fully signed.

Record	Record Custodian	Location	Retention Time
Design Review Plan (attachment 1)	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>
Calculation Form (attachment 2)	Operations Center	Operations Center	MINIMUM Until project completion or termination whichever is earlier. <i>Reference: Admin 17 Cartographic, Aerial Photography, Architectural & Engineering Records (30.A)</i>

			RECOMMENDED Until the component analyzed is excessed.
Calculation Checking Form (attachment 3)	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 (attachment 4)	Cognizant Individual then Operation Center	Responsible Engineer	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)	Cognizant Individual, then Operation Center	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 Results Form (attachment 5)	Cognizant Individual, then Operation Center	Operations Center	Various retention times; see Admin 17 Cartographic, Aerial Photography, Architectural & Engineering Records (30.c) for specific record type
Design Approval Form (attachment 6)	Cognizant Individual, then Operation Center	Operations Center	Various retention times; see Admin 17 Cartographic, Aerial Photography, Architectural & Engineering Records (30.c) for specific record type
Design Review Waiver (attachment 7)	Cognizant Individual, then Operation Center	Operations Center	Until project completion or termination whichever is earlier. <i>Reference: Admin 17 Cartographic, Aerial Photography, Architectural & Engineering Records (30.A)</i>
Prototype Results Form (attachment 8)	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>
Working Comparison Results Form (attachment 9)	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>
Chit Resolution Report (attachment 10)	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>
Chit Log (attachment 11)	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>
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Attachments

1. Design Review Plan
2. Calculation Form
3. Calculation Checking Form and minimum requirements for checking of calculations
4. Design Review Chit Form
5. Design Review Results Form
6. Design Approval Form
7. Design Review Waiver
8. Prototype Results Form
9. Working Comparison Results Form
10. Chit Resolution Report
11. Chit log

Design Review Plan

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Design Review Plan No: _____ #

Revision No: _____ # Category: A-.

Scope being reviewed:

2-3 short paragraphs

List of relevant Technical Authorities:

...

List of Interfaces:

...

Cognizant Individual: _____ (sign and date)

Responsible Engineer: _____ (sign and date)

Project Manager: _____ (sign and date)

(A-1 only) Chief Engineer: _____ (sign and date)

Conceptual Design Review:

	Required?	Filing No:
Waiver		
OR		
Charge Letter and Review Panel confirmations		
Minutes of underlying peer reviews		
Chit closure report underlying peer reviews		
Requirements		
Interfaces		
Implementation options		N/A
Feasibility study (initial)		N/A
Resource, schedule, and cost considerations		N/A
FMEA considerations		N/A
SAD/ASE considerations		N/A
Design Review Results	After	
...		

T-1: acceptably complete **Yes/No**

If No but proceeding with review, describe deviation and rationale for proceeding

Design Review Chair: : _____ (sign and date)

Design Review Plan

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Preliminary Design Review:

	Required?	Filing No:
Waiver		
OR		
Charge Letter and Review Panel confirmations		
Minutes of underlying peer reviews		
Chit closure report underlying peer reviews and CDR		
Requirements (final)		
Interfaces (final)		
Design and development plan		N/A
Feasibility study (incl. manufacturability)		N/A
Resource, schedule, and cost plan (final)		N/A
Procurement plan		N/A
Testing plan (initial)		
Prototype result		
Comparison with Working Systems		
Checked Calculations: List items if any required...		
FMEA considerations		N/A
SAD/ASE considerations		N/A
Design Review Results	After	
...		

T-1: acceptably complete **Yes/No**

If No, but proceeding with review, describe deviation and rationale for proceeding

Design Review Chair: : _____ (sign and date)

Final Design Review:

	Required?	Filing No:
Charge Letter and Review Panel confirmations		
Minutes of underlying peer reviews		
Chit closure report underlying peer reviews, CDR and PDR		
Drawings		N/A
Technical Specification		
Procurement plan		N/A
Test Plans		
Prototype Results		
Comparison with Working Systems		
Checked Calculations: List items required...		
FMEA		N/A
SAD/ASE review		N/A
USI determinations		N/A
Design Review Results	After	
...		

T-1: acceptably complete **Yes/No** If No, but proceeding with review, describe deviation and rationale for proceeding

Design Review Chair: : _____ (sign and date)

Guide to compiling and updating the Design Review Form

As soon as sufficient information is available, the COG prepares the Design Review Plan, discussing calculations requirements with Responsible Engineer and Technical Authorities. Prototype and manufacturing features are discussed with the Technical Authorities; USI with Safety experts.

If waivers are applicable, the COG develops justification (see guide in this attachment) and notes them on the plan.

The initial Design Review Plan contains as much details as available at the time.

If additional items are identified to be needed to support the design during its development, they are added in revisions of the plan.

Ahead of a review, at the T-1 (i.e. at least one week before the review), the COG previews with the Design Review Chairperson the material required to support the upcoming review. If the material is ready for the review, the DRC signs of the relevant portion of the plan. The DRC can note any deviation if it is acceptable to proceed with incomplete material. This portion of the plan is filed as a record, by adding the design stage to the TYPE, e.g. DRP-CDR.

Guide for calculation planning

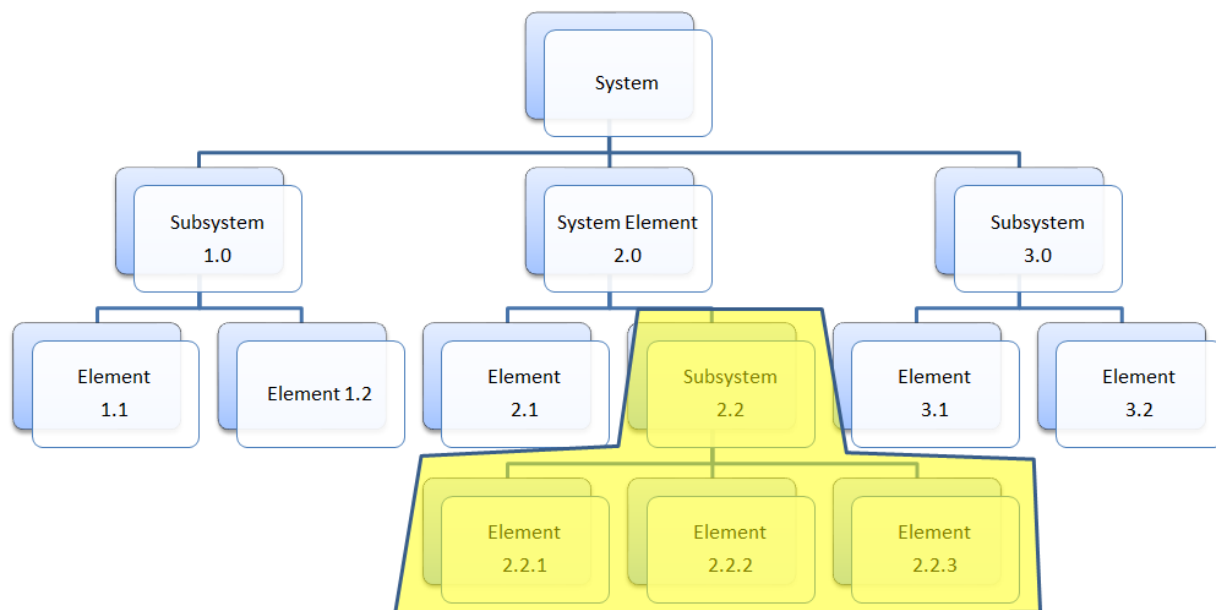
- Start from the Breakdown Structure, increase the level of granularity where required
- List all the loads that apply
- Indicate which load applies to each of the elements or parts
- State how each loading case will be analyzed:
 - First principles followed by finite element calculation if needed
 - Finite element calculation
 - Comparison with more challenged part or load
 - By inspection
- Give each cell not passed by inspection the reference to the calculation document covering it

If a new calculation is altering a previously filed calculation, either the old calculation needs to be revised to address the new content, or superseded.

If superseding an earlier calculation, the earlier calculation shall be re-filed with an annotation that it has been superseded by a certain calculation number, and the new calculation must address the reasons for superseding the calculation in the “purpose” and meet the same requirements for preparation and checking.

If a calculation is revised, the old calculation (including cover and checker’s form) must be retained to help tracking the revision changes, as well as having a revision table in the calculation.

Before the FDR the body of calculations needs to be reviewed as a whole to confirm full coverage and confirm all cross talk between calculations has been addressed, as described above.



Design Review Plan

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	Normal Operation			Operational Transients		Fault Transients	Commissioning		Seismic
	vacuum cycling	thermal cycling	current waveforms	disruptions	ramp-up/down	EM	bake	no plasma shots	accel.
Subsystem 2.1	ref 2121vac	by inspection	cmp 21dis	21dis	cmp 21dis	cmp 21dis	by insp (children)	cmp 21dis	by insp (children)
System Element 2.1.1 (mirror)	by inspection	211+212cycle	ref 21dis	ref 21dis	ref 21dis	ref 21dis	211+212bake	ref 21dis	by inspection
System Element 2.1.2 (mirror holder)	by inspection	211+212cycle	ref 21dis	ref 21dis	ref 21dis	ref 21dis	211+212bake	ref 21dis	by inspection
Part 2.1.2.1 (window)	2121vac	cmp 2121bake	2121cw	2121dis	cmp 2121dis	cmp 2121dis	2121bake	cmp 2121cw	cmp 2121dis
Part 2.1.2.2 (conduit)	by inspection	cmp 2122bake	2122cw	2122dis	by inspection	cmp 2122dis	2122bake	cmp 2122cw	cmp 2122dis
Part 2.1.2.3 (support)	by inspection	by inspection	cmp 2123dis	2123dis	by inspection	cmp 2123dis	by inspection	cmp 2123dis	2123seism
Part 2.1.2.4 (support)	by inspection	by inspection	by inspection	by inspection	by inspection	by inspection	by inspection	by inspection	2124seism
System Element 2.1.3 (shutter)	by inspection	213cycle	cmp 213dis	213dis	cmp 213dis	cmp 213dis	213bake	cmp 213dis	cmp 213dis

Guideline to determine the applicability of a waiver

Section D provides lists of objectives of CDRs, PDRs, and FDRs.

If a CDR is to be omitted then, for each objective, there should be a reason why that objective is not applicable to the review scope, or whether the objective is appropriately covered at PDR.

For example, one of the objectives of a CDR is to identify multiple implementation options and identify tradeoffs. If multiple options are not appropriate for the scope of the review then that objective of the CDR is not applicable. Another CDR objective is to review cost and schedule estimates. If cost and schedule estimates will also be reviewed at PDR then that objective does not drive the need for a CDR.

Similarly, if a PDR is to be omitted then, for each objective, there should be a reason why that objective is not applicable to the review scope, or that objective can be appropriately covered at FDR. For example, requirements have already been reviewed or are externally imposed.

The table below presents the CDR, PDR and FDR objectives with a grouping by common category. Category items that are targeted for completion at CDR step are shown in blue, at PDR step in yellow, and at FDR step in green.

Objective Category	CDR	PDR	FDR
Requirements	Assure that the proper requirements are identified and can be satisfied within acceptable envelopes.	Verify that all requirements are being addressed. Identify requirements or design conflicts and potential "show-stoppers".	
Implementation Options	As appropriate identify if more than one approach can satisfy the requirements and provide a tradeoff study of the benefits and costs.		
	Obtain input when competing design approaches exist.		
Design		Review updated design	Review and verify that the final design satisfies the requirements and is ready for implementation.
Feasibility	Review configurations or designs that are novel to PPPL.	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 and verify that the final product can be manufactured, inspected, assembled, stored, delivered, and installed reliably, safely, and cost effectively.
		Review manufacturability.	

Design Review Plan
Page 7 of 7

Objective Category	CDR	PDR	FDR
			Review and verify that human performance and human factors considerations are appropriately addressed in the design.
Calculations		Review the results of analyses, calculations, and tests conducted to obtain additional information for the design.	Assure that detailed analyses, calculations, and tests to validate the design are complete and documented.
Cost/Schedule/ Resources	Review development and design plans and schedules.	Review development plans and schedules.	
	Review cost and schedule estimates, including contingencies.		
Documentation			Review and verify that appropriate documentation is available for producing the final product (e.g. drawings, installation procedures).
			Review and verify that identification and control of items has been addressed.
Procurement		Review procurement issues, e.g. make vs. buy.	Review and verify that procurement issues have been identified and resolved.
Testing		Review test requirements and plans.	Review and verify that appropriate test plans for the final product have been established.
FMEA	Review FMEA considerations.	Review FMEA considerations.	Final FMAE.
Safety	Identify hazards associated with the work or its impact on operations, and appropriate mitigation.		
	Review SAD/ASE considerations.	Review SAD/ASE considerations.	Review and verify any SAD/ASE considerations have been resolved.
Chits		Assure the appropriate incorporation of recommendations from previous reviews.	Assure the appropriate incorporation of recommendations from previous reviews.

So, for example, if it is proposed to omit CDR, then either the items highlighted in blue should not be applicable to the review scope, or could be appropriately covered at PDR.

If it is proposed to omit PDR, then either the items highlighted in yellow are not applicable to the review scope, or are already finalized.

If it is proposed to omit both CDR and PDR, and go directly to FDR, then either the items highlighted in yellow and blue are not applicable to the review scope, or are already finalized.

Calculation No: _____ #**Revision No:** _____ #

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

Codes and versions: (List all codes, if any, used)

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 Individual (or designee)

(sign and date)

Preparer

(sign and date)

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

Checker

(sign and date)

**Calculation Checking form and minimum requirements for
checking of calculations****Page 1 of 2****Checks for Calculation No: _____#****Revision No: ____#**

Component was checked against latest design

All required load cases are included and current

Discuss method used in the calculation

Discuss how the calculation was checked (*)

List issue identified and how they were resolved

Checker's name:

Technical Authority

(sign and date)

(*) independent calculations can be appended

PPPL	PRINCETON PLASMA PHYSICS LABORATORY	PROCEDURE	No. ENG-033 Rev 8 Attachment 3
Calculation Checking form and minimum requirements for checking of calculations			Page 2 of 2

Minimum Requirements for Checking Calculations

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 (Electromagnetic (Lorentz Force), 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.
6. Error bars (range) for inputs used, results / conclusions, assumptions, have been considered and are acceptable.

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 Form

Page 1 of 1

PPPL DESIGN REVIEW CHIT

WP # _____ (ENG-032)

CHIT # _____

CAT: ☐A1 ☐A2 ☐A3

COMPONENT/SUBSYSTEM/SYSTEM _____

☐ PEER

COGNIZANT INDIVIDUAL _____ DATE OF REVIEW _____

☐ CDR

☐ PDR

☐ FDR

COMMENT/CONCERN/RECOMMENDATION

ORIGINATOR ____

NAME/ORGANIZATION

REVIEW BOARD COMMENT/RECOMMENDATION

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

☐ CONCUR

☐ CONSIDER

☐ REJECTED (EXPLAIN)

☐ REDUNDANT (EXPLAIN)

☐ OUT OF SCOPE (EXPLAIN)

CHAIRPERSON _____ DATE: _____

Design Review Results Form

Page 1 of 1

DESIGN REVIEW DOCUMENTATION – RESULTS – No: _____ #

Title: _____

CAT: ☐ A1 ☐ A2 ☐ A3Type of Review: ☐ Peer ☐ CDR ☐ PDR ☐ FDR

Cognizant Individual: _____ Date of Review: _____

Review Board Members:**Invited Attendees:****Other Attendees:**

Chairperson _____

RE _____

TA (Subject) Name _____

TA () _____

QA _____

ESH _____

Regulatory Compliance _____

Items Reviewed:**Sat.****Unsat.****Comments or n/a if not applicable**Appropriate requirements identified ☐ ☐Development plans and schedules ☐ ☐Reg. compliance incl. USI/USID and NEPA ☐ ☐Disposition of CHITS from previous reviews ☐ ☐Calculations (all listed are signed and filed) ☐ ☐Cost objectives ☐ ☐Other review objectives addressed ☐ ☐**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.

Design Review Chair Person _____ Date: _____

Cognizant Individual Acceptance _____ Date: _____

Distribution: Review Board Members, Operations Center, Responsible Engineer (RE), Cognizant Individuals, Project Manager, Project Director, relevant Technical Authorities (TAs), Chief Engineer (CE), Fire Protection Engineer, Attendees, QA, ES&H, Security, Requesting & Performing Dept. Head

DESIGN APPROVAL FORM – No: # **Title:** **CAT:** ☐A1 ☐A2 ☐A3**Cognizant Individual:** **Date of Review:** **Design Output:***Drawings (List by number and revision level, append list if space is limited):**Technical Specifications (List by number and revision level, append list if space is limited):**Statements of Work (List by number and revision level, append list if space is limited):**Other documents (List by number and revision level, append list if space is limited):*

Confirm that the design output is as reviewed at the FDR or that any difference from what was presented at the FDR has been assessed and if necessary reviewed separately and that all chits that can affect this design output have been closed (and the report signed and filed).

Responsible Engineer **Date:** **Main Approver** **Date:**

Distribution: Operations Center, Cognizant Individual, Responsible Engineer, Design Review Chairperson (DRC)

DESIGN REVIEW WAIVER – No: #

Title: _____

CAT: ☐ A1 ☐ A2 ☐ A3Type of Review: ☐ CDR ☐ PDR

Cognizant Individual: _____ Date of Review: _____

Waiver Rationale:

Responsible Engineer _____ **Date:** _____**Project Manager** _____ **Date:** _____**Chief Engineer** _____ **Date:** _____
(Required for A1 and A2)

Distribution: Operations Center, Cognizant Individual, Responsible Engineer, Chief Engineer

PPPL	PRINCETON PLASMA PHYSICS LABORATORY	PROCEDURE	No. ENG-033 Rev 8 Attachment 8
Prototype Results			Page 1 of 1

Prototype Results: _____#

Describe Objective of Assessment:

Describes means to achieve the Objective:

Summarize Results, including how this support (or not) the design solution

Cognizant Individual:_____ (sign and date)

Technical Authority:_____ (sign and date)

PPPL	PRINCETON PLASMA PHYSICS LABORATORY	PROCEDURE	No. ENG-033 Rev 8 Attachment 9
Working Comparison Results			Page 1 of 1

Working Comparison Results: _____ #

Describe Objective of Assessment:

Describes means to achieve the Objective:

Summarize Results, including how this support (or not) the design solution

Cognizant Individual:_____ (sign and date)

Technical Authority:_____ (sign and date)

PPPL	PRINCETON PLASMA PHYSICS LABORATORY	PROCEDURE	No. ENG-033 Rev 8 Attachment 10
Chit Resolution Report			Page 1 of 1

Chit Resolution Report: _____#

List of chits closed in this report on the cover, details inside the report

Attach total log of chits, including all those previously closed and those not yet closed.

Cognizant Individual: _____ (sign and date)

Approver (*): _____ (sign and date)

(*) For CDR and PDR the DRC, for FDR and after FDR the Main Approver (A-1: Chief Engineer, A-2 and A-3: DRC)
DRC =Design Review Chairperson

Design Review Plan:							
CHIT LOG							
Chit No.	Parent element	Chit entry	Board disposition	Action	Actionee	Due	Status
CDR_001							
CDR_002							
CDR_003							
Peer#1_001							
Peer#1_002							
Peer#1_003							
PDR_001							
PDR_002							
PDR_003							
Peer#X_001							
Peer#X_002							
Peer#X_003							
FDR_001							
FDR_002							
FDR_003							