– addition of human performance in the objectives for each type of review.

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	The objectives for any peer review might include a subset of the following: ▪ 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. ▪ 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.	▪ 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.
Conceptual (CDR)	▪ Assure that the proper requirements are identified and can be satisfied within acceptable envelops. 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 and assure that appropriate design	▪ Updated Work Planning form, if applicable. ▪ Requirements. ▪ Design and development plan. ▪ Resource, schedule, and cost considerations. ▪ Resolution of chits from prior reviews, if any.

	and development plans and schedules have been developed.	
Preliminary (PDR)	▪ 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 manufacturability.	▪ 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.
Final (FDR)	▪ 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 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	▪ 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.

	final product have been established. ▪ Assure the appropriate incorporation of recommendations from previous design reviews. ▪ Review manufacturability.	

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 depth[1] 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 errors[2] 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]