



NAC Executive Insights

Design Review

Key Points

- Design review ensures the effective transformation of the owner's project requirements (OPR).
- Design review is a primary element of the design management control process.
- It also is the backbone of the project's quality system.
- Alternate delivery methods (design-build) and emerging technologies (3D models; Artificial Intelligence or AI) create new challenges and opportunities in design reviews.
- Design reviews are often underpinned by robust checklists.

Introduction

The engineer is responsible for the quality and completeness of the designs that the project team produces. The engineering and design process begins with the owner's project requirements (OPR) and those of applicable government regulatory agencies. These requirements are then expanded to encompass a more comprehensive basis of design or so-called expanded basis of design (BOD^x, see NAC Executive Insight, Business Basis of Design) that includes construction and operations & maintenance (O&M) requirements to be incorporated in and influence the developed design. The design process translates these design inputs and criteria into the final design through a staged design process with design reviews at key stage gates.

The quality of the design product, in the form of specifications, datasheets, drawings, procedures, and building information models (BIM models) is ensured through a combination of strong processes and procedures, positive management controls, and a comprehensive and detailed set of reviews and checks at various stages in the process. The identification of work instructions, checklists, and who is responsible for preparing, checking, and approving documents is typically contained in a Design Activity Plan (predominantly single discipline projects) or Discipline Activity Plans (multi-discipline projects).

Project specifications, as required, are typically prepared by the discipline lead, who is also responsible for reviewing existing client specifications to determine fit-for-purpose and suitability for the project. These specifications form the basis for project procurement and engineering.

Design margins¹ may be established for specific systems, structures, components, and equipment to achieve consistency and economy across the project team. A formal design margin table may be issued.

All engineering and design work is performed in accordance with project procedures, specifications, industry codes, and standards. Design outputs are to be clear and comprehensive, and their identification and revision status, authorization, and distribution are controlled in accordance with project procedures that are included in the project procedures manual.

It is against this backdrop that design review occurs.

Design Reviews

Design reviews and associated checking are performed by experienced engineers other than those who produce the design documents. Design reviews are often underpinned by robust checklists, which help to confirm that:

- The basis of design is comprehensively addressed. This is particularly important when an expanded basis of design has been developed.
- Assumptions have been carefully made, defined, and are appropriate for their intended use. Sensitivity to small changes in assumptions are noted and those to be more closely tracked as the design evolves are highlighted.
- Inputs and criteria are properly selected and used.
- All requirements, both those of the owner and regulator, are met.
- The various engineering disciplines have been fully integrated.
- Resulting design is complete and correct.
- Appropriate design margins have been achieved.

Engineering and design documents may be reviewed and checked individually or the review may be performed on a design package, e.g., for a system, plant area, or design task.

Design documents typically examined at each review point include:

- *System descriptions and design criteria documents*
 - Reviewed to confirm the expanded basis of design (encompassing technical, construction, and O&M requirements) has been fully considered and addressed/reviewed.

¹ Design margin is any adjustment to the design value above what is required by code or to meet performance requirements established in the contract. Cumulative design margins are design margins which compound as each discipline applies additional margin to those that have been previously established.

- Confirm that the use of applicable industry codes and standards is complete and correct (including interpretation).
 - Technology selection and decisions are well supported.
 - Conceptual design is technically correct.
 - Interfaces well defined and controlled; responsibility assigned.
- *Calculations*
 - Reviewed in detail to confirm proper use of inputs, assumptions, methods, and tools used.
 - Results are checked for accuracy, reasonableness, and relevance to the defined basis of design and chosen specifications.
 - Computer programs utilized must be validated and verified and fit for purpose.
 - Extrapolation of methods, computational tools, and programs beyond their intended ranges are checked.
- *Drawings, sketches, diagrams, and BIM model*
 - Reviewed to confirm expanded basis of design is fully considered and addressed.
 - Reviewed/checked to confirm design quality throughout the design development process (conceptual and preliminary to final design).
 - Interdisciplinary reviews when design interfaces exist, which assures confidence in design adequacy and integration.
 - As-built drawings produced to reflect final delivered facility and variance from final design documents.
- *Specifications*
 - Review O&M requirements throughout the various design stages to ensure achievement of the O&M aspects of an expanded basis of design.
 - Review technical and test requirements for procurement for completeness and consistency with the developed design.
 - Includes relevant version of an acceptance test specified by code or standard.
 - Review installation/erection requirements as part of the final design.
- *Supplier and vendor submittals and design documents*
 - Reviewed to confirm quality and conformance to procurement specifications.
 - Reviewed to ensure proper integration with the overall design.

Other specialized design reviews may include:

- Reliability/RAM (reliability, availability, maintainability) analyses
 - Ensure consideration of potential failures and their consequences.
- Failure Mode and Effects Analysis (FMEA)
 - Documents current knowledge about the risks of failures.
 - Aids in continuous process improvement.

- Prevents failures.
- Used for control before and during ongoing operation of the process.
- Operational design review
 - Ensures consideration of O&M requirements established in the business basis of design and developed through the design development process.
- PDS (Plant Design Systems) models (increasingly being replaced by 3D models²)
 - Identifies interference checks.
 - Ensures proper spatial relationships for construction and O&M.
 - Confirms compliance to project safety requirements.

Design reviews of final drawings and specifications:

- Confirm client and regulatory requirements are met.
- Confirm quality requirements to be met by suppliers and construction are clearly and completely specified.
- Confirm all acceptance criteria and required tests are detailed.
- Ensure requirements for material identification are given when needed to prevent misuse of materials.
- Ensure completeness of requirements for shipping, handling, installation, operation, storage, and maintenance procedures.
- Ensure well documented basis for quality assurance during procurement, construction, testing, and start-up, including any changes approved as a result of requests for information (RFIs).
- Confirm that enough detail is provided to ensure the quality of the final plant meets the owner's project requirements and the business basis of design.
- Ensure system, structure, equipment, and component identification is complete to facilitate construction and operation and to support the owner's enterprise asset management system.

Emerging challenges in design review include:

- Growing use/reuse of standardized design.
- Growing use of AI-supported "knowledge assemblies" in the design process.
- Changed design sequence required in design-build projects:
 - Horizontal vs vertical slices
 - Granularity of front-end design activities and micro-focus on sequence (myriad of utility relocations or right-of-way acquisition packages).
- Increased use of AI in design tools and programs.
 - Shifts outputs from deterministic to probabilistic.

² 3D Model review is not covered in this Executive Insight.

About the Author

Bob Prieto was elected to the National Academy of Construction in 2011. He is a senior executive who is effective in shaping and executing business strategy and a recognized leader within the infrastructure, engineering, and construction industries.

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