EFCOG Best Practice #65
Engineering Calculations

Facility: EPWOG/Y-12

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Brief Description of Best Practice: The purpose of this paper is to present guidance for developing engineering calculations to assure that such technical documents meet the quality requirements of 10 CFR 830 and DOE O 414.1C. More specifically, this paper presents guidance related to the following general topics: Development; Design Input/Assumptions; Documentation/Content; Format; Rigor; Review/Verification; Approval; Revisions.

Guidance for this paper was also taken from ASME NQA-1, *Quality Assurance Requirements for Nuclear Facility Applications* and its predecessor ANSI N45.2.11, *Quality Assurance Requirements for the Design of Nuclear Power Plants*. These standards clearly point to what can be described as a graded approach.

This guidance presented in this paper is intended to apply to safety related structures, systems and components (SSCs) whose reliable performance prevents or mitigates accidents that could cause undue risk to the health and safety of the public. Extension beyond this scope to non-safety related SSCs represents good engineering practice.

Why the best practice was used: This paper was developed in response to concern for this topic expressed in the DOE HS-64 Office of Environment, Safety and Health Evaluations site assessment reports.

What are the benefits of the best practice: Implementation of these practices helps ensure that calculations contributing to safety are complete, concise, and correct.

What problems/issues were associated with the best practice: The paper may appear to require a level of rigor greater than typical practice; however, these features are important to ensure the quality necessary to ensure the calculations are reliable.

How the success of the Best Practice was measured: Much of the guidance presented in this paper is already practiced at various DOE sites and as such is a compilation of the many of the best concepts from across the DOE complex as compiled by the author and with the concurrence of the members of the Engineering Practices Working Group (EPWOG).

Description of process experience using the Best Practice: DOE sites using the concepts in this paper have benefitted from improved quality of calculation result and better documentation for future review and understanding of previous work. Contributes to several ISM Core Functions and Guiding Principles: Define scope of work; Identify and analyze hazards; Develop and implement hazard controls; and Perform work within controls.

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Best Practices Related to Engineering Calculations

Engineering Practices Working Group by Ken Keith, Y-12

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- Development
- Design Input/Assumptions
- Documentation/Content
- Format
- Rigor
- Review/Verification
- Approval
- Revisions

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Development

Written quality standards for controlling design calculations are required (e.g., a design calculation procedure).

Engineering calculations can be design output for one phase of a project and yet design input for subsequent phases.

The level of detail of the design calculation should be that necessary to permit the design activity to be carried out correctly to provide a consistent basis for making design decisions, accomplishing design verification measures, and evaluating design changes. A general expectation is that a subject matter expert or knowledgeable individual can replicate the result without recourse to the original preparer.

Design Inputs & Assumptions

Design inputs must be reviewed and approved.

Design inputs should be given special consideration and obtained from controlled and approved documents where possible. Any uncontrolled or unapproved design input (e-mail, correspondence, verbal information, etc.) should be documented, referenced, and verified

Design output should be clearly traceable to design input. Design inputs should be clearly identifiable at the point of use with the body of the calculation. The intent is to identify attributes that can be independently verified and that need to be properly procured, tested, installed, configuration managed, protected, etc., for the SSCs to be consistent with the calculation basis.

Assumptions should be justified or a basis should be provided. Any assumptions that require later verification must be tracked for resolution.

Examples of design inputs are provided in ASME NQA-1, Non-mandatory Appendix 3A-1, *Guidance on Design Control*.

Documentation/Content

The results of design calculations must include not only the final output but also record of critical steps taken to reach the output, including sources of design inputs that support the final design.

Procedures that control development of design calculations should include requirements for ensuring that design input sources are derived from controlled, verified documents or standard reference sources. Documentation of the results of literature searches or other applicable background data should also be included in the design calculation. It can be inferred that documentation of the sources of "other applicable background data" applies to process specific data required for design input. Such data should be independently verified and should be representative of all expected operating conditions.

Procedures should include requirements for defining the objective and purpose of the design calculation, documenting the design inputs and assumptions that must be verified as the design proceeds, and identification of computer calculations.

Design bases, regulatory requirements and codes and standards related to the engineering calculations should be documented. Actual computations must be included in the design calculation. For computer calculations, design input and output shall be readily identifiable. Inputs to standard computer models shall be verified/validated and their use controlled and documented in accordance with an approved Computer Software QA Program and implementing procedures. Computer calculations shall also include the computer program or software used and its version, as well as references, which validate the program/software quality and suitability for its application. For single use software not independently verified, the coding, background logic, and/or formulas used in the calculation shall be included, in addition to the results, in order to provide a basis for review and verification.

Format

There is no required format for design calculations. However, it is suggested that a standardized format will help to ensure a logical presentation of engineering calculations as well as provide consistency between such calculations. A calculation should clearly identify inputs as well as what was done, why it was done, how it was done, and the results. A coversheet providing preparation, review, and approval signatures along with a unique identifier, revision number, keywords, and an abstract summarizing the responses to what, why, how and results questions has been shown to be an effective presentation format.

Appendix A provides a suggested outline that includes all the basic requirements of a design calculation.

Rigor

Design calculations should be developed in a form that is sufficiently detailed such that a person technically qualified in the subject can review and understand the analyses and verify the adequacy of the results without recourse to the originator.

Both external and internal interfaces between organizations performing work affecting the quality of the design calculation should be identified in writing. Such identification should include those organizations providing design calculation criteria specifications and technical direction. Design calculation criteria may be interpreted to mean process specific data or unique field conditions relevant to the calculation.

The level of rigor applied to design calculations should be based on factors such as the nature and scope of work and the importance of the SSCs to safe plant operation.

Review/Verification

Procedures must include requirements for review and approval. Measures should also be applied to verify the adequacy of the design calculation. Verification is the process of reviewing, confirming or substantiating the design calculation by one or more methods to provide assurance that the calculation meets the specified design inputs. The verification may be performed by any competent individual or group that is technically qualified and knowledgeable in the subject discipline(s) and condition(s) being addressed. The verifier(s) may be from the same work group. The verifier may be the originator's supervisor provided the supervisor did not specify a singular approach or rule out considerations and did not establish the design inputs. In any case, the verifier(s) must have had no involvement in determining the methodology used or in the development of the calculation. Cursory supervisor review does not satisfy the verification activities described here. Results of the verification should be clearly documented with identification of the verifier.

The extent of the design verification shall be a function of the importance to safety, the complexity of the design, the degree of standardization, the state of the art, and the similarity with previously proved designs. When design calculations duplicate previously performed and fully verified calculations (e.g., where design inputs have been previously verified in another calculation) the full verification process need not be duplicated for identical designs. However, known problems with the original design calculations should be considered. The previous design verification documentation shall be referenced in records of the subsequent design verifications.

The responsible design organization shall identify and document the particular design verification method to be used. Acceptable verification methods include, but not limited to:

- Design reviews
- Alternative calculations
- Qualification testing

The verification activities should address several basic questions, such as 1) were the inputs correctly selected and incorporated into the calculation, 2) are the assumptions adequate, 3) is the calculation method appropriate, and 4) has applicable operating experience been considered.

The role of design verifier is just as important as the preparer. The verifier is assuring that work is complete, results are valid, and technically sound.

Approval

Procedures should include requirements for review and approval of design calculations.

Revisions

Revisions to calculations should include review by original reviewers or assigned competent alternates. Procedures should address revisions to calculations. Appropriate markings indicating the changes by revision version should be apparent. Review requirements are the same as for a new calculation; however, for minor revisions (i.e., no change in assumptions, general approach, calculation method, etc.) a comprehensive review may not be necessary.

Example Calculation Outline

Title Page/Revision Block

Table of Contents

Section 1: Objective/Purpose Statement

Section 2: References

These are the sources of the design input information. Examples of references include drawings, reports, manuals, publications, codes, and standards. Each reference will contain the document name and if applicable, a document number. The revision number or publication date will be provided, if available. A reference section is not necessary for calculations performed for submittal to outside regulatory authorities (e.g., permit calculations).

Section 3: Design Input and Assumptions

List all data and assumptions in this section with reference to the source and/or justification (i.e., tie to references listed in Section 2, References). Design Input and Assumptions should also be clearly identifiable **at the point of use within the calculation**. The intent is to identify attributes that can be independently verified and that need to be properly procured, tested, installed, configuration managed, protected, etc. for the facility in operation to be consistent with the calculation basis.

Section 4: Analytical Methods and Computations

A clear, step-by-step description of the method of solution, numerical computations (including identification of units used), and identification of the source or derivation of all equations that are not common usage (including computer codes used). For spreadsheet or computer code computations (singe-use software), describe, in the body of the calculation, the equations used or reference a printout of the equations used and attach the printout to the calculation in an appendix. The spread sheet or single-use software calculation must be shown to be accurate through a manual calculation that confirms the spreadsheet/computer code results. The explanation of the calculation method and computations themselves should be succinct yet detailed enough to permit a qualified Verifier/Checker to perform the technical review with minimal interpretation of the facts presented.

Section 5: Results

A description of the results obtained

Section 6: Conclusion

A description of the degree to which the purpose and objectives have been met, along with the information on the appropriateness and completeness of the results for the intended purpose.

Attachments and Appendices

Include additional information, as needed, such as copies of references, memos, or pages of manuals, computer code output sheets, computations spreadsheets, worksheets showing/explaining equations used, input transmittals, etc.