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Quality Assurance for Investigations of Plant Safety and Reliability

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Abstract

Prudent engineering practice and current regulatory requirements dictate that formal quality assurance programs be established to control the analysis and design of nuclear facilities. Quality assurance procedures are well defined and well understood for the design of plant structures, systems and components. Regulatory agencies, however, offer less guidance for quality assurance for special analyses and investigations that are crucial to plant safety. This paper will present a specific quality assurance methodology applicable to "non-design" safety related studies. The purpose of this methodology is to improve the quality of each analysis performed and to establish in specific terms how to comply with typical regulatory requirements for quality assurance.

1. Introduction

Quality Assurance for the design, construction and operation of nuclear facilities is much discussed and much regulated. Numerous guidance documents and regulations have been promulgated to assist and control the nuclear power generation industry in its efforts to assure that plants are designed and built in a manner that provides for an appropriately high degree of confidence in plant safety and reliability.

Guidance documents for Quality Assurance of non-design activities such as intergated risk assessments are not generally available, even though these assessments provide information used in making important safety-related decisions effecting both plant design and operation.

2. Development of this Approach

This paper addresses Quality Assurance procedures applicable to specialized scientific and engineering assessments typically conducted by highly trained specialists. "Design Codes" that specify how this work must be performed are generally unavailable. Examples of this type of study are:

- Determination of seismic design bases,
- Consequence analyses of internal failures,
- Integrated risk assessment,
- General determination of site suitability.

This paper presents Quality Assurance procedures applicable for these studies. The authors are fortunate to have participated in these types of studies for over 40 existing and proposed nuclear facilities throughout the world; and have spent considerable effort in developing and implementing Quality Assurance procedures appropriate for this work. The following sections present a methodology developed gradually over the past ten years for performing studies consistant with the requirements of the international nuclear community. This development took place in the absence of specific regulatory guidelines for meeting those requirements, but the results obtained by applying this methodology have been accepted by our clients as fulfilling generally recognized Quality Assurance requirements such as those cited in Reference 1.

The most important aspect of this approach is that both the study and the specific quality controls utilized in its performance are planned and documented concurrently prior to the actual performance of analyses. The key steps are:

- Defining scope and requirements of the study.
- Preparation of the work plan.
- Performance and documentation.
- Verification and audits.

The balance of the paper describes each step.

3. Defining the Scope and Requirements of the Study

An initial planning session regarding the study should be conducted by both the parties who will perform the assessment and the parties who will be responsible for assuring that the appropriate quality controls are established and implemented. The scope and extent of analysis will depend upon the specific objective of the study.

For analyses where extent refers to either time domain or spatial verification, the extent of the analysis should be governed by knowledge of initial conditions or boundary conditions. An attempt should be made to define the extent of an analysis in a manner which minimizes the impact of unknown initial or boundary values. For analyses where extent refers to the number of items or concepts considered, the extent of the analysis should be sufficient to remove as many unknown influences as practical.

The data required for an engineering analysis depends on the specific nature of the analysis. However, data may be grouped into one of the following four classifications:

- Geometric configuration,
- Material properties and behavioral relationships,
- Environmental conditions, and
- Causal phenomenon.

Sources for input that will be required of the study should be identified during this early planning stage. At the conclusion of the study planning phase a work plan should be prepared to document the investigation that will be performed.

4. Preparation of a Work Plan

Control during the study is needed to assure that desired information is obtained. To provide control, the work plan indentifies specific activity tasks, personnel required to perform the tasks, required equipment or computer programs, approved standard methods for work performance and other applicable documents, and the verification prerequisites. A work schedule should be included as part of the work plan. Consideration of other ongoing studies, previous work available, and provisions for needed state-of-the-art testing and evaluation techniques which must be developed to meet the requirements of the study should be included in the development of the work plan.

Very often the performance of an activity must be adjusted during the course of work. To allow for this, the work plan should be sufficiently flexible to permit change while maintaining the desired control. The Work Plan should cite the Quality Control and Quality Assurance procedures for the study.

The Work Plan should be reviewed and approved by technical and quality assurance management. All changes to the Plan should be subject to the same level of control (preparation, review, and approval) as the original Plan.

5. Performance of the Study

Upon completion and approval of the Work Plan, the study is initiated in a logical, sequential manner. The following sections indicate a typical sequence and approach used by the authors. Each study performed may have unique modifications to the following descriptions.

Literature Review: Literature pertinent to the analyses should be reviewed to determine past problems with that type of analyses and other information useful to the objectives of the study. Results of literature reviews should be documented as part of the analyses and specific literature referenced in the final report, as appropriate.

Refinement of the Scope of the Analyses: The results of the literature review and program objectives should be used to refine the scope, level of detail, required accuracy, and analytical methods for the anlaysis.

Selection of Personnel: Personnel to perform the analyses should be selected based on qualifications to perform the work.

Selection of Analytical Methods: The results of the literature survey, program objectives, and experience of the personnel performing the analysis should be used to select the appropriate analytical method. Computer software requirements should be identified.

Software Selection: Software requirements should be reviewed relative to availability from the following sources:

- Existing software available within the organization responsible for the analysis.
- Existing software available in the public domain.
- Existing software available from service bureaus, and vendors.
- Development of specific software for the analysis.

Software Documentation and Verification: These tasks are of paramount importance should be performed in accordance with applicable regulatory guidelines and good engineering practice.

Section of Subcontractors (if appropriate): Engineering analyses may be subcontracted. Procurement documents should define the scope, objectives, and quality assurance requirements if subcontractors are used.

Identification of Applicable Documents: Reference material appropriate to the analyses should be identified and made available to personnel who will perform the work. Typical documents include:

- Reports giving background information pertinent to the subject analysis.
- Reports providing data used in the analysis.
- Instruction and verification manuals for software used.
- Drawings, figures, and/or sufficient descriptions of the subject of the analyses to provide an understanding of all aspects of the analyses.
- Other information, as appropriate.

Performing Analytical Assessments and Computations: Specific or general procedures used in performing the analyses should be identified. These procedures should include the following typical activities:

- Preparation of input data,
- Identifying and documenting information, assumptions, etc., pertinent to an individual analysis if multiple analyses under various conditions are to be performed,
- Making computer runs or calculations,, and
- Summarizing results taken from computer output or calculations.

Presentation of Results: A report should be written which describes the methods, assumptions, models, and results of the analyses performed. Emphasis should be placed on ranges of applicability, limitations, and possible future implications of the results.

6. Quality Control Verification Techniques

The key aspect of these techniques is that they are accomplished by competent technical professionals who are independent of the performance of the activity to be verified. The techniques and their applicability are as follows:

Limited Evaluation: This includes a review of the analytical approach and the results obtained, and spot checking of numerical calculaitons. Limited evaluations are appropriate when the analyses are approximate and will lead to more detailed analyses. The results of the verification should be clearly documented with the reviewer and the date of review.

Detailed Evaluation: Analyses that will provide licensing or design input, or affect the results of a safety-related activity, should be completely verified. Detailed evaluations should be performed by either a complete independent check, alternate calculations, or model testing. The results of the evaluations should be documented and identify reviewing personnel and the date of review.

Independent Checking: An independent check should consist of a thorough technical review to verify assumptions, references, model, input parameters and theory, and a complete numerical verification including the checking of all computations, computer input and design related drawings which result from the analysis. The review should address the following:

- Has the analysis been identified as to project, site, subject, originator, and date performed?
- Have all design bases and technical requirements been correctly selected and incorporated into the analysis?
- Have assumptions been adequately described?
- Has an appropriate methodology been used?
- Has information from external sources been referenced?
- Are all calculations correct and have they been completely documented?
- Are the results reasonable considering the inputs?

Personnnel performing the review should be assigned by appropriate project management.

Verification of analyses may be accomplished by comparison with alternate methods of calculation, if an alternate means exists. Alternate calculations may employ a simplified approach, but must provide results consistent with the original analysis. Model testing is occasionally employed to verify analytical studies. A comparison of computed and observed behavior must be presented and documented.

Peer Review: The peer review process is a broad review of the overall study and is intended to complement the checking of numerical analyses and data processing. While checking provides review and confirmation of largely definitive work, peer review provides evaluation and assessment of interpretations, judgments, and decisions made.

The reviews should be performed by personnel not involved with the study, but who have a high degree of technical expertise. Peer review should begin during the planning phase of a study and extend through its technical activities to the final conclusions of the decision-making process. Major program changes should also be subject to the peer review process.

Reviews should address the following, as appropriate:

- Are the work plan and procedures, as developed, sufficient to control and permit duplication of the activities?
- Have procedures been correctly used?
- Do the procedures used result in obtaining data compatible with the scope of work, goals, and objectives of the activities and have the objectives been properly translated from applicable contractual requirements, industry standards, and federal/state/local regulations?
- Has sufficient site-related data on a specific subject been collected to reach a definitive conclusion?
- Are interpretations, judgments, or decisions supported by the data and are they defendable?
- Is documentation sufficient to verify the validity and reproducibility of study results?

Peer reviews should be coordinated with quality assurance personnel so that the recommendations of the reviewers and subsequent responses by study personnel can be verified. A mutually acceptable resolution should be obtained for each recommendation before results are reported or utilized further.

All peer reviews should be documented. It is recommended that the peer review report include the following:

- Date(s) of review;
- Participants: reviewers, study personnel, quality assurance personnel;
- Activities reviewed including interpretations, decisions, and judgments;
- Statement of agreement or disagreement with interpretations, decisions, and judgments; including the means for resolving disagreements;
- Recommendations for the extension of existing studies or the establishment of additional studies;
- If questions remain unresolved beyond the end of the review, the means for closing the questions.

Reports of peer reviews should be transmitted to project and quality assurance management and to personnel performing the study.

7. Quality Assurance Audits

Quality assurance audits of the study should be conducted to verify proper completion of the quality control activities described in the previous sections. These audits must be conducted by Quality Assurance Auditors independent of the group or organization that performed the study. Typical procedures utilized in performing quality assurance audits are described in references 2 and 3. The most beneficial type of audit starts with the study report and progresses "backwards" through all of the supporting calculations, computer runs, data, etc., to verify that the report indeed accurately presents the results of the study. The work is also reviewed to verify proper completion of the quality control procedures described in the previous sections. The audit is closed when it is determined that the study report fulfills the applicable Quality Control Requirements. A satisfactory closure of the audit is mandatory for release and use of the study.

The experience of the authors has been that these audits are most useful when conducted by personnel with technical expertise in the subject of the study. The auditors should ask technical questions and critically examine the adequacy of technical assumption employed. The authors have found that audits conducted in this manner are highly beneficial in improving the overall quality of the study as well as helping to assure compliance with regulatory agency requirements.

8. Summary

A sequential methodology for performing specialized technical studies in accordance with regulatory requirements has been presented. The methods described reflect the personal experiences and opinions of the authors. The authors gratefully express their appreciation to the clients, colleagues, and regulatory agency personnel who have added to our experience.

References

/1/ United States Nuclear Regulatory Commission, Appendix B to Title 10 Part 50, Code of Federal Regulations.

/2/ ANSI NQA-1, 1983

/3/ United States Nuclear Regulatory Commission, Regulatory Guide 1.144, Rev. 1, September 1980.