UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

# NRC INSPECTION MANUAL



CHAPTER 2535

## DESIGN VERIFICATION PROGRAMS

### 2535-01 PURPOSE

To describe the techniques to be used in the performance of the Independent Design Verification Program (IDVP), the Engineering Assurance Program (EAP), and the design review aspects of the Readiness Review Program (RRP) for nuclear power plants as well as the NRC oversight and assessment of these programs.

### 2535-02 OBJECTIVE

The objective of the IDVP, the EAP, and the design review aspects of the Readiness Review Program is to gain additional assurance that the design process used for the facility effectively implemented NRC regulations and other licensing design commitments made by the applicant. In the programs, the Applicant contracts with an independent design organization to perform the review or performs the review with in-house but "off project" personnel. The NRC staff overviews the review for adequacy. The objective of this Manual Chapter is to provide guidance on the NRC oversight and assessment of these programs. These are multidisciplinary technical reviews to verify the quality of design products and, inferentially, the entire facility design.

### 2535-03 DEFINITIONS

Applicant or Licensee. Entity that has filed an application for a construction permit or an operating license.

Readiness Review Program (RRP). Formal assessment submitted incrementally by the applicant and evaluated by the NRC staff that determines that regulatory design, construction, and operation requirements and licensee commitments are being implemented and that the nuclear power plant will be ready to operate safely.

Readiness Review Modules (RRM). Basic units of the work breakdown structure into which the total task of constructing a nuclear plant is divided and submitted by the licensee to NRC for review, comment and/or approval as early in the licensing process as possible. A Design Review Module is initiated to review the design process for constructing a nuclear power plant.

Independent Design Verification Program (IDVP). Multidisciplinary design reviews of nuclear power plants similar to that performed by the NRC staff in the IDI Program. The principal difference from the IDI program is that the applicant hires an independent contractor to perform the IDVP and the NRC staff evaluates the program rather than performing a direct NRC inspection.

Engineering Assurance Program (EAP). Continuing series of technical audits of the design product and design process conducted by persons independent of the project who are intended to assess the quality of the overall facility design. The reviewers may be from the original design organization so long as they are independent of the original design process. This, and the fact that the applicant is in day-to-day control of the audit process, are the primary differences between an EAP and an IDVP.

Design Reviewer. Individual(s) and organization(s) who perform the IDVP, EAP and RRP design reviews for the applicant.

NRC Action Item. A matter identified by the NRC review team relevant to the reviewer's program plan, implementation of that program, or the design reviewer's audit observation reports and/or associated corrective actions. Design reviewer response and NRC evaluation of response are required.

Audit Observation Report (AOR). A report which reports an apparent error, inconsistency, or procedural violation with regard to licensing commitments, specifications, procedures, codes, or regulations and which is identified by the design reviewer.

Potential Enforcement Finding (PEF). An applicant's apparent noncompliance with specific regulatory requirements or specific licensing commitments that is identified during the review.

2535-04 RESPONSIBILITIES AND AUTHORITIES

04.01 Design Review Aspects of the Readiness Review Program

a. Program Manager (designated by the EDO). Assigns module review activities and coordinates related efforts, reviews report of the results of NRC evaluation of design aspects of Readiness Review Modules and incorporates evaluation of design aspects into the module review report.

b. Director, Division of Reactor Inspection and Safeguards (DRIS), NRR. Administers the design review aspects of a readiness review program, including forwarding reports of NRC evaluations of design aspects of readiness review modules to the Program Manager.

c. Chief, Special Inspection Branch (RSIB), NRR. Implements the design review aspects of a readiness review program as Primary Reviewer and as such:

Performs primary review activities for design and design process verification sections of the module.

Designates NRC staff and contractors to review the design review sections of the module.

Coordinates the work of the review effort prescribed herein with past or ongoing design verification reviews at the same plant to avoid unwarranted duplication.

Prepares reports of NRC evaluations of design aspects of Readiness Review Modules.

04.02 Independent Design Verification Program and the Engineering Assurance Program

a. Director, Division of Reactor Inspection and Safety, NRR. Approves applicants' proposals to participate in IDVPs or EAPs for specific facilities on the basis of NRC staff evaluations of the proposals and information received from NRC offices at headquarters and in the regions. Administers NRC staff review of the IDVP and EAP and issues the results of inspections either directly or through the Director of the appropriate Division of Reactor Projects, Office of Nuclear Reactor Regulation and issues the design verification inputs to SERs.

b. Director of Appropriate Division of Reactor Projects, NRR. Issues to the applicant NRC inspection reports of IDVPs and EAPs. Incorporates IDVP and EAP inputs into the relevant SER.

c. Chief, RSIB, NRR. Implements NRC staff review of the IDVPs and EAPs, including preparation of inspection reports and preparation of design verification inputs to SERs.

d. Regional Offices. Assist the NRR staff as needed, in management of followup actions resulting from the IDVPs and EAPs, including enforcement action.

2535-05 BACKGROUND

The above applicant-initiated design reviews addressed in this chapter and the Integrated Design Inspections (IDIs, see chapter 2530) conducted by the NRC staff were initiated following the mirror image design error at the Diablo Canyon project. It was determined that some licensee quality assurance programs and NRC inspections had not been effective in discovering design errors because the quality assurance (QA) audits looked only at the process and not at technical content. To ensure that near-term operating licensee (NTOL) plants did not have undiscovered problems in their designs, a series of short-term actions were initiated. Each NTOL was requested to provide additional assurance that their facility design complied with NRC regulatory requirements and FSAR commitments through the conduct of a technical review of the design. To add greater credibility to these reviews, NRC requested that they be performed by organizations totally independent of the applicant and its design contractors. These programs became known as IDVP's. NRC also began to perform a limited number of direct inspections of the technical adequacy of designs through its IDIs(Ref: Manual Chapter 2530). The IDVP's were a necessary addition to compensate for the lack of technical audits of design products in applicant QA programs. For plants not yet in the last stages of the licensing process, sufficient time remained to include technical audits of design products in applicant QA programs. These took the form of Engineering Assurance Programs or the design review module portion of

Readiness Review Programs. Applicants could choose to perform these reviews with in-house personnel, provided that the reviewers were not placed in the position of reviewing their own work. These reviews must be independent of the project cost and schedule considerations, which is the same requirement that has always been applied to regular applicants' QA organizations. Applicants are free to contract with independent organizations for their design reviews but are not required to do so. This Chapter, then, describes the techniques applicants may use to perform technical audits of their facility design as part of their overall program to assure quality.

## 2535-06 CONCEPT OF READINESS REVIEW, INDEPENDENT DESIGN VERIFICATION AND ENGINEERING ASSURANCE PROGRAMS

### 06.01 Design Review Aspects

The performance of these programs at nuclear facilities are comprehensive examinations of the development and implementation of the design for selected systems of the facility being inspected. Conclusions about the overall design process may then be drawn based on the results of the design review for the sample selected. The programs are multidisciplinary reviews including, as a minimum, areas such as mechanical systems, mechanical components, electric power, civil and structural design, and instrumentation and control.

The primary focus is on assessment of the implemented design control process for the organization and subcontractor. The process is evaluated by examining actual design details. If errors are found in the design details, the design process is evaluated to see if the error resulted from an isolated mistake or if it reflects a more fundamental weakness in the design process. Also the pervasiveness of a design error or weakness is evaluated including inspecting that aspect of design in other sectors of the plant design. An evaluation is performed to identify consistent design process weaknesses in the design process such as lack of FSAR control lack of verification of design calculations or lack of documentation of engineering judgment made in the design process.

a. A comprehensive review is performed for a specified sample system(s) that typically has some or all of the following characteristics:

   1. essential to plant safety

   2. designed mostly by the architect-engineer (AE)

   3. a clearly defined design basis

   4. generally representative of safety-related features in other systems

   5. design involving internal interfaces between the major technical discipline areas listed above and external interfaces with the nuclear steam supply system (NSSS) vendor, component vendors, and engineering service organizations

   6. for IDVP and EAP, major portions of the selected system(s) already installed in the facility.

b. Some evaluation will be conducted beyond the sample system(s), as needed, to test specific areas or functions.

c. An evaluation should be made of any program weaknesses identified by preceding audits of the same facility that could have root causes in the design or the design process.

d. The review covers topics such as:

1. validity of design inputs and assumptions
2. validity of and conformance to design specifications
3. validity of analyses
4. system interface requirements
5. inadvertent synergistic effects of changes
6. proper component classification
7. revision control
8. documentation control
9. verification of the design and design changes
10. verification of the as-built condition

2535-07 PROGRAM GUIDANCE

07.01 Program Scope and Schedule. The NRC staff review of a program should be a multidisciplinary evaluation of the total design process and should focus primarily on the potential areas of concern within each of the disciplines. The NRC staff responsibilities include:

a. Review and approval of the applicant's IDVP, EAP, RRM program plans.*

b. Inspection of the independent reviewer's procedures and preparations for the IDVP, EAP, or RRM.

c. Inspection of the design reviewer's implementation of the program plan approved by the NRC.

d. Inspection of audit results (observation reports) and the corrective actions taken or proposed.

e. Submittal of a SER input based on the NRC assessment of the IDVP and EAP results.

f. Submit report of NRC evaluations of design aspects of RRM to the RRP Program.

*IDVP, EAP, and/or RRM program plans will be called the design review (DR) module program plan.

A typical IDVP, EAP, or RRM schedule is as follows:

| NRC Staff Activity | Time Allocation |
|---|---|
| 1. Evaluate Design Review Proposed Program Plan and necessary revisions | 4 weeks |
| 2. NRC approves program plan | 2 weeks |
| 3. Inspect reviewer's procedures and preparation for the DR (2-4 weeks after program approval) in each major technical discipline | 2 days |
| 4. Inspect implementation of the design review when sufficient work has been completed to enable a meaningful preliminary assessment and prepare report | 2 weeks |
| 5. Inspect independent reviewer's audit results including justification for audit observation reports and prepare report | 2 weeks |
| 6 Inspect corrective actions taken or proposed to correct design process and/or design adequacy deficiencies | 2 weeks |
| 7. a. Prepare and submit SER input based on NRC staff assessment of the IDVP or EAP results | 4 weeks |
| b. Prepare and submit evaluation of design aspects of RRM submitted by applicant | |
| 8. Identify PEFs to region for followup | Concurrent with activity 7 above |

07.02 Inspector Assignments. NRC staff and consultant assignments to a DR program inspection shall be based on the expertise needed to implement the scope of the inspection(s) planned. The NRC inspectors including consultants should have an appropriate degree of "on the board" nuclear power reactor design experience in the technical discipline for which they are responsible in the NRC review. All consultants and their employers on the NRC review team will be required to sign the "Agreement" and "Information Concerning Potential Conflict of Interest" forms enclosed as Appendix B to this chapter. Provision should be made, where possible, for continuity of inspector(s) in each technical discipline from inspection of initial program preparation through evaluation of audit observation reports and corrective actions.

07.03 NRC Program Oversight Planning, Preparation and Implementation

a. The objectives of the NRC review planning, preparation, and implementation are:

1. Readiness Review - Design Review Objectives

   (a) Verify that the applicant's design program verification activities are accurately described in the readiness review module.

   (b) Assure that the applicant's readiness review verification activities are sufficient to provide a competent verification of the program for all design aspects included in the module subject.

   (c) Determine the completeness, accuracy, and responsiveness of the findings and the open items reported in the module for design and design process verification.

2. IDVP and EAP Review Objectives

   (a) Ensure that the program plan submitted by the applicant has sufficient scope and depth to enable the reviewer to:

      (1) Verify that regulatory requirements and design bases as specified in the license application, are correctly implemented in specifications, drawings, calculations, and procedures.

      (2) Verify that the correct design information has been provided to the responsible design organizations.

      (3) Verify that design engineers have sufficient technical guidance and experience to perform assigned engineering functions.

      (4) Verify that design controls, as applied to the original design, have also been applied to design changes, including field changes.

   (b) Verify that the procedures and review plans developed by the design reviewer have sufficient scope and depth to enable the design reviewer to implement the program plan as approved by the NRC staff.

   (c) Verify, during the course of the program, that the program is being implemented in accordance with the program plan approved by NRC.

   (d) Ensure the results of the program, including all audit observations made by the design reviewer, open items established by either the reviewer or the NRC staff and resultant follow-up of the applicant's corrective actions.

3. To familiarize the NRC staff and consultant reviewers with the design review organization chosen by the applicant and their principal technical auditors in each of the major disciplines. The NRC inspectors should evaluate the qualifications of the applicant's design reviewers. The evaluation should include interviews as well as review of individual resumes and certifications.

4. To review the individual review plans of the design reviewers The level of detail required in these review plans should be in balance with the experience level of the design reviewers. In other words, the more experienced design reviewers should need less detailed review plans to perform their audits. The review plans should be technical discipline specific and should show the technical depth and scope of the independent design organization's audit of the following key design elements:

   (a) FSAR compliance
   (b) NSSS criteria compliance
   (c) calculations
   (d) drawings
   (e) diagrams and schematics
   (f) specifications
   (g) equipment qualification
   (h) vendor documents
   (i) design change control (including field changes)
   (j) hazards analyses (pipe whip, jet impingement and flooding)
   (k) use of problem reports (LERs, IE Bulletins)
   (l) interfacing between technical disciplines
   (m) interfacing between design organizations (applicant AE, AE consultants and subcontractors, vendors)

5. To make specific technical discipline assignments to inspection team members.

6. To define review and inspection schedules.

7. To familiarize the NRC inspection team members with the latest version of the documentation that defines the design (such as the FSAR, design procedures, specifications, design criteria, and drawings).

8. To indoctrinate the NRC inspection team members to IDVP, EAP and RRM concepts.

b. Before the start of each inspection, the team leader should address plans for the inspection, background and guidance material, significant items pertinent to licensing, and design-related items identified by the regional offices and the NRR. A design work inspection cutoff date should be established for the inspection and it should be the same date as the approval date of the sample system(s) to be audited. The inspection work product expected from each inspector needed for the inspection report should be delineated to enable the inspector to organize his individual inspection plan.

c. The NRC inspection team members should use the following materials in evaluating the formulation, implementation and results of the IDVP, EAP or RRM.

   1. Applicant's program plan

   2. Final Safety Analysis Report (FSAR)

   3. Probabilistic Risk Assessment (PRA) Report (where available)

4. NRC Safety Evaluation Report (SER)

5. Inspection history including:

   (a) Previous major NRC inspection in design or construction, obtaining information on any problems requiring further investigation during the program(s).

   (b) Special NRC audits and reviews in design and engineering.

   (c) Vendor Program Branch and regional audits of AE, NSSS, and vendors involved in design and engineering.

   (d) Systematic Assessment of Licensee Performance (SALP) reports.

   (e) Institute of Nuclear Power Operations (INPO) evaluations of design or engineering.

   (f) Inspection reports of site design activities including those of the resident inspector.

   (g) Major utility audits in design or construction.

6. 10 CFR 21 and 50.55(e) reports

7. NRC/applicant correspondence (questions and answers, principal meetings or special studies, and licensee or AE correspondence listing principal commitments and action items in response to NRC concerns

8. Construction status information (stage of completion will dictate the scope and types of inspections and evaluations appropriate for a particular discipline)

d. Additional guidelines to be considered in the NRC inspection team members implementation of their oversight responsibilities generally and for each technical discipline are provided in Appendix A to this chapter.

07.04 NRC Review and Oversight Documentation

All NRC inspection team members should remain with the team for the duration of the NRC review of an IDVP, EAP or a RRM. Team members will conduct the review with accompanying inspections in accordance with the program guidance provided herein. The NRC team members should evaluate the interface maintained between the independent design review organization and the applicant's architect/engineer's project design organization. The NRC team members should ensure that adequate independence is maintained by the review organization auditors in relationship with the applicant's/architect engineer's project design organization. The provisions of this independence should be stated in the applicant's program plan. The NRC team leader will conduct coordination meetings of all team members, as needed, to discuss status of activities and NRC actions items. As a result of such meetings, team members may be given additional assignments or their effort may be redirected.

Documents pertinent to the NRC review that are provided to team members, although not marked proprietary, may contain proprietary information. In similar manner, documents such as specifications that are reviewed in the licensee's and/or independent reviewer's offices may contain proprietary information. All such material handled during the NRC review will be treated as potentially proprietary. Team members will not make further copies or disclosure of documents received during the review/or inspections. All such documentation will be returned to the licensee when the review/or inspection is completed unless otherwise indicated by the licensee.

07.05 Entrance and Exit Interviews

An entrance interview between licensee and reviewer management and all NRC inspection team members shall be held before starting any onsite inspection. The regional office shall be invited to be represented at this meeting. IP 30703, "Management Meeting Entrance and Exit Interviews," should be used as guidance when conducting the entrance interview.

An exit interview shall be held between senior licensee and reviewer management and senior NRR management and inspection team. The regional office shall be invited to be represented at this meeting. The exit interview will be used to summarize the findings and to convey the significance thereof to senior licensee and reviewer management. All NRC action items will be orally communicated by the team leader to the appropriate licensee or reviewer contacts during the course of the inspection. The results of the inspection shall be discussed, but no written drafts of inspection findings shall be given to the licensee.

07.06 Inspection Documentation

The team will prepare an inspection report to be issued by the Director, DRIS, that documents all NRC action items identified during the inspection. The inspection report will conform to the requirements of NRC Manual Chapter 0610, "Inspection Reports." A typical format for a design verification inspection report is provided in Appendix C, Part A of this manual chapter. No disclosure of inspection notes (preliminary or draft inspection report materials developed by NRC team members) will be made, except to appropriate NRC staff (see below).

In accordance with NRR Office Letter No. 106 of December 7, 1987 and Rev. 1 of June 20, 1988, "Release of NRC Draft or Predecisional Documents and Information," from T. Murley and NRC Bulletin No. 3203-25 of February 9, 1988, "Policy on Release of Draft and Predecisional Documents and Information," under no circumstances should draft inspection reports, either in their entirety or in part, be released to licensees or their agents or to any source outside the NRC without the express permission of the Director, NRR. In the event any draft inspection report is inadvertently or otherwise released contrary to this policy, the Director, NRR shall be promptly advised in writing. The Director, NRR will take or recommend action, as appropriate, including prompt notification to the EDO.

07.07 Inspection of Design Review Audit Results and Associated Corrective Actions

At the conclusion of an EAP, or RRM audit, the NRC staff will inspect the reviewer's audit results and associated corrective actions proposed or taken

by the applicant and/or its contractors. The specific objectives of this inspection are to:

a. Assess the design reviewer's audit observation reports and ensure they are adequately justified.

b. Ensure the resolution of the audit observations are adequate.

c. Ensure proposed or initiated corrective actions are adequate.

d. Verify that NRC guidance provided to the reviewer on program scope and implementation was incorporated into the program or otherwise satisfactorily resolved. The report of this inspection should discuss the resolution of the items identified in the previous NRC inspections of the program.

e. Evaluate the program results in order to determine whether the program has provided adequate additional confidence that the design of the facility under review is in accordance with the FSAR, NRC regulations, and other applicant commitments.

07.08 Inputs to a Safety Evaluation Report. For NTOL facilities, a SER design verification input based on IDVP and EAP results is prepared by the NRC review team to be transmitted by the Director, DRIS to the Director of the appropriate Division of Reactor Projects as an input to part of a SER Section 17.0 QUALITY ASSURANCE and Section 17.5 INDEPENDENT DESIGN VERIFICATION. The major objective of this SER input is to provide a conclusion as to whether the IDVP, or EAP has provided adequate additional confidence that the design of the facility under review is in accordance with the FSAR, NRC regulations and other applicant commitments. The format of a typical Design Verification Program input to a SER is provided in the SER input based on the EAP of Milestone Unit 3, Ref. NRC letter dated November, 1986. The major sections of the SER are shown in Appendix C, Part B.

07.09 Input to Systematic Assessment of Licensee Performance (SALP). In accordance with the NRC SALP program (NRC Manual Chapter 0516), the Team Leader is responsible for submitting SALP input to regional management. This should be provided, as needed, or within 60 days of completion of the SER input to the appropriate region in the case of IDVP and EAP programs.

07.10 Followup and Enforcement. The focus of the IDVP, EAP and RRM is the evaluation of the design process and the adequacy of the plant design, rather than enforcement. However, the appropriate Regional Branch Chief will be notified by the Chief, RSIB of the potential enforcement findings (PEFs) found during the course of any of these programs for regional followup. The notification of PEFs to the region will include a preliminary determination of an appropriate enforcement classification for each PEF. The NRC team leader is responsible for ensuring that regional tracking numbers are assigned to each PEF and other items stemming from the program that require regional followup. During any program, situations may be encountered where the significance of a matter warrants consideration of prompt action (e.g., licensee stop work, NRR order, investigation of wrongdoing). If so, management in NRR and the appropriate regional office will be promptly

informed and the first priority will be pursuing the matter until the question of prompt action has been resolved. In addition, the NRC team leader will identify those audit observations which are appropriate for Vendor Program or regional programs followup.

END

Appendices:

A. Additional Guidance for NRC Oversight Planning and Implementation.

B. Proprietary Agreement and Conflict of Interest Forms.

C. Typical Formats for Design Verification Program Inspection Reports and SER Inputs.

# APPENDIX A

## ADDITIONAL GUIDANCE FOR NRC OVERSIGHT PLANNING AND IMPLEMENTATION

### A. PURPOSE

To provide additional guidance for the NRC staff oversight planning and implementation to ensure an adequate design review.

### B. GENERAL GUIDELINES

These guidelines relate to Manual Chapter 2535 Section 06.03 covering the design verification program plan and the design reviewer's individual review plans.

1. Project Design Procedures Review

   Within each design discipline, ensure that the audit will review the project-specific specifications, instructions, and procedures that provide design criteria or guidance to design engineers.

   The purpose of this review is to determine the extent of the formal guidance given to the engineers for performing design activities. The inspector should use the information from the review to highlight areas of limited or inadequate guidance to the engineers and for determining areas in which to focus the technical review.

2. Design Calculation Reviews

   Ensure that the independent review of engineering calculations and design details for each technical discipline:

   a. Verify that design information is current and correct. This verification may require tracing back to the source of the input. Internal and external interfaces should be verified to ensure that all disciplines and design organizations for a project use a consistent and up-to-date set of design inputs and assumptions, e.g., where the output of one analysis becomes the input of a second analysis.

   b. Verify that the guidance provided by the project-specific procedures has been met.

   c. Verify that assumptions used in the design calculations are based on sound engineering principles and practices.

   d. Verify that the output information has been transmitted to the appropriate design organizations.

e. Verify that the design information has been translated into project documents such as specifications, drawings, procedures, instructions, and contracts related to plant construction.

f. Verify that design changes (including field changes) result in all affected elements of the design being evaluated; e.g., reanalysis may need to be performed commensurate with the original design.

g. Confirm that design verification (design review, alternate independent calculations, or qualification testing) is being done. The extent of design verification is commensurate with the importance to safety, complexity, degree of standardization, state-of-the-art, and similarity with proven designs.

h. Confirm that calculational methods, using both hand calculations and computer programs, are being properly controlled. This confirmation includes computer program verification and qualification (assuring that the computer program functions correctly in all modes and options and is used correctly in representing a physical process) and the proper use and accuracy of inputs. Particular attention should be given to the basis and validity of assumptions, identifying and assessing undocumented calculations or decisions, and confirming that as-built conditions are reflected in design analyses.

## C. SPECIFIC TECHNICAL DISCIPLINE GUIDELINES

The NRC review should cover areas such as those described below. These guidelines will vary for each plant inspected and as such are not intended to be a checklist.

### 1. Mechanical Systems Design Review Guidelines

The overall design basis of the mechanical fluid system should be known by the inspection team. Particular attention should be given to the functional and performance requirements imposed on the system for the purpose of assuring reactor safety. To accomplish a review of the mechanical fluid system, it may be necessary to review how the licensee intends to meet the General Design Criteria as well as the system description for the selected fluid system.

a. If the selected fluid system is directly connected to or related in function and behavior to the reactor coolant system, it will be necessary to review the requirements imposed by the reactor coolant system. The associated parameters could include such items as temperature, pressure, flow rates, chemical characteristics as well as information related to redundancy, accident analyses, physical location and protection from or control of the surrounding environment. This portion of the review is a

good opportunity to evaluate the interface between the NSSS (reactor system designer) and the AE (fluid system designer). Review calculations that confirm that NSSS requirements are met.

b. Identify a function which is related to the elected mechanical fluid system. Determine whether the design ensures that this function will be met during all plant conditions. Various system parameters, such as temperature, pressure, flow rates, chemical composition, and action times, should be reviewed to verify proper design basis and to evaluate system interfaces. The system flow diagram and supporting calculations should be reviewed to evaluate whether the design ensures that system functions will be met under all anticipated conditions.

c. Review calculations which are important to the performance of the system to be inspected, e.g., net positive suction head (NPSH) calculations for fluid systems, and flow calculations for systems such as auxiliary feedwater where required flow rates are safety-related items.

d. Review the design methods and assumptions used in evaluating the effects of pipe rupture on targets. Interfaces are involved in reviewing the designs of protective structures, pipe whip restraints, break exclusion runs, environmental effects of pipe rupture on essential electrical equipment and instrumentation, subcompartment pressurization, and inservice inspection of piping within protective structures or guard pipes.

e. Verify that the portions of the system penetrating the containment barrier are designed with isolation features that are acceptable for maintaining containment integrity for all operating and accident conditions. Check interfaces with the instrumentation and control functional area relative to isolation valve actuation and control.

f. Evaluate the classification of the structures related to the selected fluid system for conformance to the requirements for safety-related systems. Evaluate the spectrum of conditions that have been considered in the design of the structures. Evaluate the loading conditions that arise from events such as pipe rupture, loss of coolant accident (LOCA), earthquakes, operational transients, reactor trip, loss of component cooling, etc.

g. Verify the compatibility of the materials and components of the selected fluid system with the service conditions, including normal and accident conditions as well as the design life. Ensure that the fluid system's components have proper safety and code classifications.

2. Mechanical Components Design Review Guidelines

a. Select a sample of calculations to be reviewed. It should include the following items:

(1) piping analysis problems

(2) major components attached to the piping problem such as a pump or tank

(3) valves in the pipe run

(4) pipe supports: rigid, snubber, and spring

b. Review all input information used in the piping analysis. This will require coordination with other team members to determine that the correct inputs are used. Also, to the extent possible, verify that the correct as-built information has been obtained from the field (see Inspection Procedure 37051).

c. Review the model used in the piping analysis. This includes (thermal, deadweight, seismic, review of the analyses performed (etc.), review of the computer programs and the analytical model for conformance with licensee commitments and procedures. Particular attention should be given to the model used for seismic analysis for the appropriateness of the boundary conditions assumed at anchors and supports.

d. Review stress and support load summary sheets for correct load combinations as specified in the licensing commitments. Also verify that these documents have been transmitted to the appropriate group for support evaluations.

e. Review component design reports to verify that the basic premises are correct and that data are in conformance with licensee commitments. Review test qualification documents, if applicable, including correctness of the test parameters for conformance with the licensee commitments. This review should verify that the loads from the piping analysis are included in the component evaluation.

f. Review valve design reports for conformance with licensee commitments. Particular attention should be given to the operability evaluation for seismic events. Also, valve actuator qualification documentation should be reviewed for conformance with licensee commitments.

g. Review the loads used in the evaluation of pipe supports and verify that these are the correct loads from the piping analysis. Review the support analysis for conformance with licensee commitments and procedures. The load combinations should be checked for the correct specification of primary and secondary loadings.

h. Verify that integral attachments have been evaluated for their effects on the piping and that buckling of compression members has been considered. For spring hangers and snubbers, verify that thermal movements have been considered. Review the attachment to the structure and verify that the loads have been considered by the structural group.

3. Civil and Structural Design Review Guidelines

a. Identify the location of the fluid systems selected. Include associated equipment, such as:

(1) pumps
(2) tanks
(3) power supplies
(4) control systems
(5) piping supports
(6) heat exchangers

There is no attempt in this guidance to evaluate the global behavior of the individual buildings or the foundations. However, the load path of the structure or structural elements should be reviewed to ensure that the applied loads are properly carried through the structure or structural elements to the supporting points.

b. Verify that structural safety categories are consistent and correct. Consider the location and possible effect of non-safety-related items on the fluids system.

c. Review the safety categories defined in FSAR Section 3 and the classification of structures. Compare the safety categories of the mechanical fluid system selected against these criteria for compatibility.

d. Review the model and boundary conditions used in the structural analysis of the design configuration utilizing the output and information from other functional areas such as mechanical, electrical power, instrumentation and control, and systems design to verify the correctness. Also review the output provided from the civil structural area to the other disciplines. Assess the safety impact of these reviews.

e. Verify that all pertinent loads and load combinations are considered in the analysis of structural elements, in addition to the piping system. Examine the sensitivity of the structural analysis and design to changes in piping system loads, supports, and configurations as well as the influence on resulting structural deformations. Emphasis should be placed on the identification of the discipline boundaries and necessary interfaces in the design process. Ascertain that the correct loads and load combinations have been used and that techniques for combining loads or load elements are correct.

f. Review samples of the design calculations based on the internal forces resulting from the analyses. Ascertain that the design techniques committed to in the FSAR have been or are being met. Also review specific areas of the design calculations.

g. Review examples of the design documents produced as a result of the design calculations, such as detailed specifications, drawings, and procedures.

h. Review examples where the basic design documents are used to produce product, components, or elements that will be integrated into the final structure. This review would include such items as fabrication and shop drawings, produced by a subcontractor, or installation procedures, defined by a supplier.

i. Review and evaluate the process by which design documents are checked and verified and the process by which the final documents are issued for use and construction.

j. Review and evaluate several types of design changes, such as those initiated by:

(1) design office
(2) field engineering
(3) the licensee
(4) errors or interference in construction
(5) errors in engineering

k. Review and evaluate the acceptance process used in the civil/ structural area for final acceptance of the structures or elements thereof. As-built information per Inspection Procedure 37051, should be used in this portion of the effort.

l. Review the seismic analysis of one seismic Category I structure that is associated with the sample system being inspected.

(1) Review seismic inputs, such as the developing of ground response spectra, artificial time-history generation.

(2) Review procedure of seismic modeling, including stiffness, masses, damping values. Verify that the seismic model is representative of and consistent with the actual structural configuration.

(3) Review the techniques dealing with modal combinations, peak broadening, closely spaced modes, etc.

(4) Review the adequacy of computer programs used for seismic analysis.

(5) Review the procedure for soil-structure interaction (SSI), if applicable, to ensure that the adequacy of the procedure and the methodology prescribed is consistent with FSAR commitments.

4. Electric Power Design Review Guidelines

a. Identify all components of the mechanical fluid system selected that require electric power to perform their safety function(s). Determine whether the electric power system supplying power to each of these components will be capable of providing the required electric energy as needed by each component. Examine required voltage, current, and frequency maximums, minimums, and nominal (including transient values) and compare with power source voltage, current and frequency for several sample sets of conditions representative of maximum and minimum loads and expected perturbations on the power source. Determine if required power quality can be provided for the needed time of interest. A review of diesel-generator load sequencing of the selected mechanical fluid system components (requiring power to perform their safety function) should be performed.

b. Identify all components of the mechanical fluid system that require disconnection from their electric power source in order to perform their safety function. Review the control circuit for at least two such components to determine if it meets its design requirements. Focus on time allowed for disconnection from power source in the electric power system design and the corresponding time assumed in safety analysis.

c. Examine the control relaying for at least two components of the mechanical fluid system that require power to perform their safety function and two that require power disconnection to perform their safety function. Evaluate the documentation and actual installation of these circuits and assess the ability of the circuits to perform as required.

d. For several samples of each kind of electric component (i.e., motors, valve operators, relays, connections, cables), determine if the design meets acceptance criteria for performing the required safety function in the presence of the most severe environment specified in the component's design basis. Verify that acceptance criteria are consistent with licensee commitments.

e. Examine the physical arrangement of redundant electric power source components, including separation, barriers, and environmental controls, to ensure that single failures affecting such components will not cause the mechanical fluid system to fail to be able to perform its safety function(s).

f. Examine the qualification documentation of at least two motors, valve operators, relays, connections/connectors, and cables to determine if:

(1) The test conditions specified are consistent with predicted accident conditions at the equipment location.

(2) Required equipment performance is properly specified for the worst accident for which the equipment is required to operate.

(3) Test results show the equipment able to meet specified performance under the design-basis conditions specified.

g. Compare procurement specifications for equipment examined in item (f) above to determine if they are consistent with qualification specification for performance and environment.

h. Examine methods and procedures for providing electric power to operate electric equipment when the normal offsite source and the normal onsite emergency source are unavailable. Determine if these methods or procedures could compromise redundant power source independence or prevent supply of electric power to one or more redundant loads.

i. Confirm the power distribution system to safety-related electric loads has been adequately designed with regard to breaker, motor starter, and cable sizing, as well as breaker coordination. Review several sample calculations in this area.

j. For at least 2 electric loads, determine the basis for interruption of electric power in the case of an electric power demand in excess of the normal rating for the loads. Determine what basis was used to decide whether the system was designed to ensure the performance of the safety function or to protect the equipment in cases of overloads. Review design of electric motor-operated valves provided with torque switches used to cause motor shutdown when excess torque is detected. Determine the validity of basis for torque switch settings. Review procedures for testing such switches.

k. Examine specifications for several items of electric equipment and compare to the expected environment in their designated location to determine if special environmental controls should have been provided or if a different location should have been selected.

l. Determine how the need for special environmental controls (e.g., battery room ventilation) on electric equipment was determined. Review design documentation (descriptions, drawings, etc.) to determine how the environment is to be maintained and how operating personnel are made aware of the needs for these special environmental controls.

5. Instrumentation and Control Design Review Guidelines

a. Select two different process measurements, such as flow, level, pressure, temperature, etc., associated with the mechanical fluid system selected and select two associated control (or non-safety measurement) systems. The selected measurements (at least one) should be selected from those that perform a safety function, such as reactor trip or actuation of one or more engineered safety features (ESFs).

b. Review all input information used for the design; it will be necessary to interface with the electrical power system design and the mechanical system design. Verify that the design input parameters meet the design requirements for the fluid system design. This should include the ranges of system process parameters required for normal and accident conditions.

c. Review the appropriate functional, wiring, and installation drawings to assure conformance to licensee commitments.

d. Select several field design change requests and verify that the vendor's design verification program is being effectively and accurately implemented. The inspector should review: the verification method; the procedure for implementation; the authority for the design change, the associated equipment documentation, such as equipment specification purchase orders, IEEE Standards, Regulatory Guides, "Approved for Construction" drawings, and the as-built installation drawings that complete the design change cycle; the results of the functional tests after the components and systems have been installed; the documentation to assure that the field change had been evaluated for general implications.

e. Review qualification documentation associated with safety-related instruments to determine compliance with regulations, regulatory guides, and national standards applicable to qualification.

f. Identify alarms or annunciators provided from the instrumentation for the selected mechanical fluid system and review the bases for providing these alarms or annunciators, their set points, and their locations.

g. Review the system description for any unusual operating requirements. Examples of these requirements could be: special operation required of the systems during and after an accident, capability of the systems to shut down the reactor from a remote location, or any special automatic or manual control features.

h. Verify that the instrumentation and control system detects and maintains essential parameters during all anticipated plant conditions. Check if the capability to provide the required detection and control during loss of offsite power, or other anticipated operational occurrences and accident conditions meets design requirements.

i. Assure that all logic functions, i.e., interlocks, automatic actuation and permissives, are properly implemented.

j. Assure that bypassed and inoperable status is indicated as necessary.

k. Review procedures and basis for developing set points and for ensuring that as-built deviations are considered.

END

APPENDIX B

PROPRIETARY AGREEMENT AND CONFLICT OF INTEREST FORMS

PROPRIETARY AGREEMENT

_____ _____
Proposed Consultant Consultant's Employer

For proprietary and potentially proprietary information that is disclosed to me in connection with my work on the NRC's Program Name of the Plant name, I agree:

1. Not to make further disclosures.

2. Not to make further copies.

3. To return my copies to the NRC team leader upon completion of the Program unless copies were previously returned to the applicant or applicable design organizations.

4. Not to make further disclosures or copies of inspection and/or review notes that contain potentially proprietary information.

_____ _____
SIGNATURE DATE

INFORMATION CONCERNING POTENTIAL CONFLICT OF INTEREST

_____(Program Name)

_____ _____
Proposed Consultant Consultant's Employer

My participation in the (Program Name) of (Plant Name) does ( ) does not ( ) involve situations or relationships of the type set forth in 41 CFR 20-1.5403(b)(1). In particular, I have ( ) do not have ( ) direct previous involvement with activities at the plant that I will be reviewing and have ( ) do not have ( ) conflicting roles which might bias my judgment in relation to my work for the NRC. In addition:

1. ( ) I have not been previously employed by the Applicant or the Design Verification Reviewer to do similar design work.

   ( ) I have been previously employed by the Applicant or the Design Verification Reviewer. (State the nature of the employment.)

2. ( ) I do not own or control significant amounts of Applicant or the Design Verification Reviewer stock. (State amount and nature of ownership)

   ( ) I own or control significant amounts of Applicant or the Design Verification Reviewer stock. (State the nature of the ownership.)

3. ( ) Members of my. present household are not employed by the Applicant or the Design Verification Reviewer.

   ( ) Members of my present household are employed by the Applicant or the Design Verification Reviewer. (State the nature of the employment.)

4. ( ) My relatives are not employed by the Applicant or the Design Verification Reviewer in a management capacity.

   ( ) My relatives are employed by the Applicant or the Design Verification Reviewer in a management capacity. (State the nature of the employment.)

In the above statement, the "Applicant" is construed to mean the applicant (_____), the architect-engineer (_____), or the NSSS vendor (_____) for (Plant Name)

_____ _____
Signature Date

APPENDIX C

TYPICAL FORMATS FOR DESIGN VERIFICATION PROGRAM
INSPECTION REPORTS AND SER INPUTS

A. TYPICAL FORMAT FOR A DESIGN VERIFICATION PROGRAM INSPECTION REPORT

1. Transmittal Letter. The transmittal letter should discuss all major items requiring applicant management attention and followup actions.

2. Cover Page. The cover page should provide basic identifying information about the licensee inspected, facility inspected, place and time of inspection, and identification of inspection team members and responsibilities (see Exhibit 1 of IE MC 0610).

3. Inspection Report. The inspection report should have the following major sections.

   (a) Background. The background should provide an overview of the program status and a statement of the major milestones to be performed by the NRC staff during its review and evaluation of the program.

   (b) Purpose. This section should state the purpose of the inspection.

   (c) Personnel Contacted. This section should list the key licensee, design verification reviewer, and AE project personnel contacted during the inspection.

   (d) General Conclusions. This section should provide a summary of the major conclusions of the inspection. A statement should be made as to whether the areas of the program inspected are adequate to meet the program objectives, assuming satisfactory resolution of open items resulting from the inspection.

   (e) Specific Comments. Specific comments on a technical discipline basis should be included as an attachment. The attachment should typically consist of the following sub-sections; mechanical systems, mechanical components, electric power, instrumentation and control, and civil/structural.

B. TYPICAL FORMAT FOR A DESIGN VERIFICATION PROGRAM SER INPUT SER SECTION 17 QUALITY ASSURANCE

17.5 Design Verification

17.5.1 Background. This section should be a discussion of the applicant's independent reviewer's program plan and NRC monitoring of the conduct of the audit.

17.5.2 Program Technical Audit. This section is a description of the implementation of the program by the design verification reviewer.

17.5.3 Conclusions of the Independent Reviewer.

17.5.4 Assessment by the NRC staff.

17.5.5 NRC staff conclusions.

END