

INDEPENDENT DESIGN VERIFICATION PROGRAM

93814 – 01 PURPOSE

To describe the features of the Independent Design Verification Program (IDVP) for nuclear power plants, as well as the NRC oversight and assessment of these programs.

93814-02 OBJECTIVE

The IDVP assesses whether the design process used for the facility effectively implemented NRC regulations and the applicant's licensing design commitments. The IDVP involves multidisciplinary technical reviews both by the applicant and NRC to verify the quality of a sample of design products and, inferentially, the entire facility design. The objective of this inspection procedure is to provide guidance for NRC inspection and oversight of the applicant's IDVP.

93814-03 BACKGROUND

In 1981, 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, such as calculations.

Since 1982, each newly completed nuclear power plant had either an inspection of the licensee's IDVP in accordance with Manual Chapter 2535 or an Integrated Design Inspection (IDI) performed by the NRC in accordance with Manual Chapter 2530. These were performed in order to provide additional assurance that the facility design complied with NRC regulatory requirements and FSAR commitments. Applicants could choose to perform IDVPs with their in-house personnel, provided that the reviewers were not placed in the position of reviewing their own work. Some IDVPs were performed by independent organizations, such as architect engineering firms.

93814-04 APPLICANT'S INDEPENDENT DESIGN VERIFICATION PROGRAM

IDVPs are multidisciplinary, including mechanical systems, mechanical components (piping/ pipe supports), electric power systems, civil/structural, and instrumentation/controls. A comprehensive review is performed for one or more sample system(s) having some or all of the following characteristics:

- a. Essential to plant safety
- b. Designed mostly by the architect-engineer
- c. A clearly defined design basis
- d. Generally representative of safety-related features in other systems
- e. Design involving internal interfaces between the major technical disciplines listed above and external interfaces with the nuclear steam supply system (NSSS) vendor, component vendors, and engineering service organizations.
- f. Major portions of the system(s) are already installed.

IDVPs review a “vertical slice” of the system(s) in which the design of a system is examined to ensure it can fulfill its intended safety function. In selecting areas to review, the IDVP should consider whether the plant is identical to another unit at the site, such as Units 1 and 2, and the extent to which these units share systems. Where Unit 1 has been operating and Unit 2 has requested an operating license, the Unit 2 IDVP should avoid inspecting areas that have been thoroughly reviewed at Unit 1, unless required to follow-up on corrective actions identified for Unit 1 that are applicable to Unit 2.

As appropriate, IDVPs should utilize Probabilistic Risk Assessments and component margin as a guide for selecting systems/components. When a problem is identified, such as with pump design, the applicant should review “horizontally” to determine whether the problem is isolated to that system or generic to pumps in other systems. Appendix A provides guidance in each discipline for these inspections.

93814-05 NRC OVERSIGHT OF IDVP

NRC should observe selected activities of the applicant performing the IDVP to confirm that it was completed in a quality manner. NRC staff and consultant expertise for IDVP oversight should parallel that of the applicant’s IDVP reviewers. Both the applicant and NRC teams should have an appropriate degree of hands-on nuclear power reactor design experience, such as attained by experience working for an architect engineer or a licensee design organization. In the case of an identified weakness in the level of expertise for an applicant review, the NRC inspection may focus in this area.

NRC initial IDVP oversight should confirm that the applicant's IDVP will be performed by personnel independent of the plant design. Such personnel may be an architect engineer not involved with the original design, or in-house but "off project" personnel. NRC IDVP oversight should assess the applicant's IDVP sample selection. This review should consider whether the sample is representative of overall plant design so that findings may be extrapolated to other systems. As reasonable, the IDVP should restrict its review to system/component documents issued prior to IDVP identification of the sample. If the applicant's IDVP reviewed documents that were issued after sample selection, NRC should consider this in its inspection scope determination.

- a. NRC should review the applicant's written plan for performing the IDVP to ensure that it has sufficient scope and depth to verify that:
 1. regulatory requirements and design bases, as specified in the license application, are correctly implemented in specifications, drawings, calculations, and procedures.
 2. correct design information has been provided to the responsible design organizations.
 3. design engineers have sufficient technical guidance and experience to perform assigned engineering functions.
 4. design controls, as applied to the original design, have also been applied to design changes including field changes.
 5. results of the IDVP are documented and any identified deficiencies are promptly included in the applicant's corrective action program and that appropriate corrective action is taken.

During the performance of the IDVP NRC inspectors should observe a segment of the applicant's work to confirm that the IDVP is following the plan. Inspectors should review documents, observe activities, and conduct interviews to assess the quality of the effort.

The NRC team will review the IDVP report and supporting information to evaluate the completeness and adequacy of the IDVP results and corrective actions. The NRC team should review areas within the selected system(s) not reviewed under the IDVP to ensure that the IDVP sample was representative of plant design. In addition, the NRC may consider portions of other systems to perform some level of independent assessment of design adequacy. NRC oversight will pay particular attention to the adequacy of corrective actions in response to IDVP findings.

b. Some materials to be used by the team are:

1. Final Safety Analysis Report (FSAR)
2. Probabilistic Risk Assessment
3. NRC Safety Evaluation Report (SER)
4. Inspection history including previous NRC and applicant reviews of design or construction,
5. 10 CFR 21 and 50.55(e) reports
6. NRC/applicant correspondence listing principal commitments and action items in response to NRC concerns.
7. Construction status, which influences the inspection scope

93814-06 INSPECTION REPORT

The NRC team will issue an inspection report that will summarize the applicant's IDVP results and NRC's inspection of the IDVP. The report will be in accordance with IMC 2517, "Watts Bar Unit 2 Construction Inspection Program." This input provides a conclusion as to whether there is assurance that the facility design is in accordance with the FSAR, NRC regulations and other applicant commitments.

93814-07 RESOURCES

The NRC IDVP oversight team includes an NRC team leader, 2 NRC inspectors, and 4 contractor design engineering specialists covering the following disciplines: mechanical systems; electrical systems; instrumentation and controls; mechanical components (piping/pipe supports); and civil/structural. Each team member expends 3 weeks of direct inspection.

93814.08 REFERENCES

IMC 2535, "Design Verification Programs"
IMC 2530, "Integrated Design Inspection Program"

END

Appendices:

A. Technical Discipline Guidelines

Attachments:

1 Revision History for IP 93814

APPENDIX A

TECHNICAL DISCIPLINE GUIDELINES

The IDVP should cover areas such as those described below.

1. Mechanical Systems

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 exclusions 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

- 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, and seismic inputs. Review analyses performed, 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 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/Structural
- 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. Utilize information from other functional areas such as mechanical systems, mechanical components, electrical power, instrumentation and control, and systems. Review output provided from the civil/structural area to other disciplines.
- 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 met.
- g. Review 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 includes fabrication and shop drawings and 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 process 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 and artificial time-history generation.
 - (2) Review procedure of seismic modeling, including stiffness, masses, and 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, and closely spaced modes.
 - (4) Review the adequacy of computer programs used for seismic analysis.
 - (5) Review the procedure for soil-structure interaction (SSI) to ensure 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. Review diesel-generated load sequencing of the selected mechanical fluid system components requiring power to perform their safety function.
- 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 associated with the mechanical fluid system selected, such as flow, level, pressure, and temperature. 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. 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 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.

Attachment 1

Revision History for IP 93814

Commitment Tracking Number	Issue Date	Description of Change	Training Needed	Training Completion Date	Comment Resolution Accession Number
NA	11/15/10 CN 10-023	Researched commitments for 4 years and found none. Converts IMC 2535, "Design Verification Programs", to an inspection procedure for validating licensee self-assessment of design.	NA	NA	NA