NRC INSPECTION MANUAL IIPB

INSPECTION PROCEDURE 37802

FIRST-OF-A-KIND ENGINEERING INSPECTIONS

PROGRAM APPLICABILITY: 2502

37802-01 INSPECTION OBJECTIVE

01.01 Verify that the design bases and/or high-level certified design information are effectively translated into detailed construction documents.

01.02 Assure that applicable regulatory requirements, including those related to any specific design certification rule, are correctly implemented by the design control processes reviewed during first-of-a-kind (FOAK) engineering inspection activities.

37802-02 INSPECTION REQUIREMENTS

02.01 Inspection Preparation

a. System Selection. Select one or two safety-related systems used for mitigating an accident or maintaining fission product barrier integrity, with the option of selecting additional supporting systems, sub-systems, or risk-significant components to ensure the inspection objective is satisfied by the scope of the inspection. [Note: A risk-significant, nonsafety-related system or sub-system may also be considered for inspection, provided that all appropriate characteristics (see section 03.01 guidance) are considered in the system selection process.]

b. Obtain Information. Obtain the necessary information for determining the design bases for the selected systems(s), sub-system(s), and components.

c. Program Review. Review the design information in the Final Safety Analysis Report (FSAR) and in the Design Control Document (DCD) applicable to a related design certification rule, if available.

d. Team Selection. Assemble an inspection team composed of individuals with expertise in the various engineering disciplines related to the design and functions of the selected system(s), sub-system(s), and components.

02.02 Inspection Activities

a. Review Available System Information. Inspection activities to verify that the design bases and high-level certified design information are being correctly translated into detailed construction specifications, drawings, calculations, procedures, and other documents will be dependent upon the state and completeness of such derived products at the time of the inspection. Review applicant/engineering organization design procedures and relevant documentation in sufficient detail to establish the design flow logic and critical design areas for the selected systems. This review should encompass all of the following functional areas and disciplines, as applicable to the selected system sample:

(1) Civil/Structural
(2) Mechanical/Systems
(3) Electrical
(4) Instrumentation and Control
(5) Materials
(6) Component Engineering
(7) Quality Assurance

The Team Leader should ensure that the overall team plan makes provision for analyses of findings having similar root causes including all deficiencies, unresolved items and observations. The analyses should identify significant design and design process weaknesses which appear to exist across plant systems and functional areas.

b. Inspect Design Attributes. Review the applicant/engineering organization's programmatic design controls, the flow network of the design processes, and critical design areas to develop the inspection attributes for each of the disciplines applicable to the selected systems.

Perform the inspection activities associated with the attributes related to the following engineering topics:

(1) validity of design inputs and assumptions
(2) validity of and conformance to design specifications
(3) validity of analyses
(4) coordination of system interface requirements
(5) inadvertent effects of changes
(6) proper component classification
(7) revision control
(8) documentation control
(9) verification of the design
(10) design changes

c. Review Design Procedures and Design Calculations. Within each design discipline, review the project-specific specifications, instructions, procedures, and other documents that provide design criteria or guidance to design engineers. Also review a sample of design calculations relevant to the selected systems in each discipline to verify that: project-specific procedures have been met; design information and assumptions are current; methods of calculation are correct and properly controlled; and design verification principles are practiced. To achieve this result, a sample of the following engineering documents should be inspected, as applicable to each discipline related to the selected systems:

(1) system descriptions describing design bases, system functions and operation, component data, and associated instrumentation
(2) design and purchase specifications
(3) system flow diagrams showing flow paths, calculated flows, and temperatures and pressures for designed conditions of operation
(4) piping and instrumentation diagrams for the sample systems and interfacing systems, including the symbols and legend diagrams
(5) calculations and analyses
(6) significant design reports, including audits and assessments and engineering contractor correspondence and documentation

02.03 Identification and Resolution of Problems. Verify that the applicant and the quality assurance (QA) departments of all engineering organizations and contractors are identifying design issues at an appropriate threshold and entering them in the applicable corrective action programs. Select a sample of previously identified design issues for the selected system(s) or related safety/risk-significant systems and verify the effectiveness of implemented corrective actions.

37802-03 INSPECTION GUIDANCE

General Guidance. In accordance with IMC-2502, Appendix B, "FOAK Engineering Inspections," the inspection will be conducted in two phases. Phase 1 of the inspection effort is initiated approximately one year before the earliest time the COL could be issued, if granted, and is intended primarily to assess the ongoing process for translating the certified reactor design into detailed engineering documents. Phase 2 of the inspection is implemented just before a decision on whether to issue a COL is made. Phase 2 is to follow up on identified problems, to verify corrective actions, and to evaluate items not previously ready for review.

The objectives of planning and preparation are:

1. to identify those elements that are applicable to the specific facility inspection
2. to formulate a detailed inspection plan appropriate for the particular facility (The inspection plan should be a guide for performing inspections and should be revised based on the results of ongoing inspection activities.)
3. to make specific functional assignments to each team member
4. to define inspection schedules
5. to familiarize the team members with the organization(s) performing design and

engineering services for the selected facility to familiarize the team members with the latest version of the documentation that defines the design (such as the DCD and FSAR, design procedures, design criteria, and high-level certified design information)

Before the initiation of the team planning phase for all FOAK engineering inspection activities, the Team Leader or his representative should contact and/or meet with applicant personnel, as necessary, to identify and obtain the background information needed for inspection preparation and the development of an adequate team inspection plan.

Specific Guidance.

03.01 Inspection Preparation

a. System Selection. System selection should focus on those system(s), sub-system(s), and components with the following characteristics:

(1) essential to plant safety or highly risk significant (DCD, Tier 2, Chapter 15 systems)
(2) a clearly defined design basis, as described in the certified design (if applicable), with the potential for site-specific impact upon the constructed facility
(3) generally representative of safety-related features in other plant systems or of a highly risk significant nature that merits the unique consideration of certain nonsafety-related systems/sub-systems
(4) design involving internal interfaces between the various functional areas and external interfaces with the design organization, component vendors, and other engineering service organizations
(5) construction involving the integration of multiple subsystems and/or components, some of which may have already been fabricated by the vendors

If more than one system is selected, the systems should complement each other, such as in mitigating the same type of accident. Other sub-systems and components chosen for review should have a supporting or supported relationship with the selected system(s).

b-d. Obtaining Information, the Program Review, and Team Selection. The primary focus of this inspection is on the translation of high-level certified design information into lower-tier construction/design documents. The inspection represents an assessment of the design control processes being implemented by the applicant, design organization(s), and applicable subcontractor(s). The design control program is evaluated by examining the design details that would be used in the actual construction/fabrication processes. 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 control program. A design error or weakness will be evaluated and will include an assessment of the extent to which the identified condition applies to other areas of the plant design.

The Team Leader will assign team members responsibility for preparing an inspection plan for a specific functional area. See Section 5.c of Appendix B of Manual Chapter 2502 for further inspection and planning guidance relating to inspection team composition.

Team members will use the following materials in planning the details of and preparing for the inspection, especially those portions pertaining to the sample system(s) to be inspected:

(1) Design Control Document
(2) Safety Analysis Report
(3) Probabilistic Risk Assessment Report information
(4) NRR Safety Evaluation Report
(5) Design Principles, as referenced in the commitments to established standards (e.g., ANSI/NQA-1)
(6) Current Organization Charts for the applicant and all involved engineering/design organizations. These charts should provide the inspectors with an overview of the management interfaces, communication channels, and the identification of key engineering-management personnel
(7) A list of all contractors and subcontractors doing engineering and design work for the applicant or one of its prime agents, including a scope of work for each contract and an explanation of the interface between the applicant and the design organizations
(8) Applicant/engineering organization(s) procedures:
    a) engineering/design control procedures and QA procedures related to design including those related to any existing engineering assurance program
    b) diagrams indicating the flow of design information
    c) design and engineering procedures specified by contract for contractors and subcontractors
    d) documents listing the scope and standards for engineering and design work expected to be done in the field
    e) documents indicating the scope of and procedure for the exchange of design information among the design organizations
    f) procedures describing how the applicant gets involved in the engineering process (e.g., oversight and audit of engineering activities)
    g) quality assurance manual indexes for all organizations performing design work in the project
(9) NRC-Applicant correspondence - questions and answers, principal meetings or special studies, and any licensee or certified design organization correspondence listing commitments and action items in response to NRC issues
(10) Applicant engineering organization documents (as available):
    a) principle design criteria
    b) system descriptions, design bases, system functions and operation, component data and instrumentation
    c) list of engineering, design, and purchase specifications
    d) system flow diagram showing flow paths, calculated flows, temperatures, and pressures for various conditions of operation
    e) piping and instrumentation diagrams for the sample system and

interfacing systems, including symbols and legend diagrams

f) list of calculations and analyses

g) significant reports, meeting minutes, letters, etc., related to progress, status, or control of the engineering and design process

(11) Construction Schedule status, plans and details.

03.02 Design Inspection. The purpose of a design inspection is to verify that the system(s) will function as required. For a FOAK engineering inspection, the certified design and higher-tiered engineering concepts have already been reviewed and approved by the NRC. The design details that will be used to actually construct the plant warrant further NRC engineering review. In the process of reviewing these lower-tier design details and documents, the inspectors should verify the appropriateness of the design assumptions, design input, boundary conditions, and models. Independent calculations by the inspectors may be needed to verify the acceptability of the applicant/design organizations' methods of analysis. The interface between safety-related and non-safety systems, as well as between supporting and supported systems, should also be reviewed.

In some instances, the design may not be complete and design documentation will not be available. In this case, ensure that there is a DAC which will verify the appropriate design item at a later date. If there is no DAC to inspect or verify this item, ensure that the engineering contractor, equipment vendor or the licensee has a commitment to inspect and verify this item, and report the results of that inspection to the NRC inspection team responsible for that item. The lack of this type of information would prevent a license from being issued. Close communication and coordination with NRR will be needed if this situation is identified.

a. Reviewing Available System Information. The Attachments included in this Inspection Procedure contain guidelines that are illustrative of the extent of the inspection to be conducted in each functional area. These guidelines are not intended to be used only as a checklist by team members, but also to provide a guidance framework that may be reviewed in the development of individual inspection plans. Inspection plans for each discipline will be developed for all FOAK engineering inspections at each plant inspected.

b. Inspecting Design Attributes. The attributes for a proper design emanate from the inputs into the system design, the component fabrication details, supporting and supported sub-system functions, and the interrelationship among these areas. Appendix A to this Inspection Procedure lists the design inputs to be considered in inspecting the selected systems, sub-systems, and components. In addition, Section 5.e of Appendix B of Manual Chapter 2502 lists other NRC Inspection Procedures which may also provide useful guidance, insight, and references for the successful conduct of the design/engineering inspection activities relevant to the FOAK engineering inspection process.

c. Reviewing Design Procedures and Calculations. The following guidance reflects the intent of the inspection objective of verfiying that the design bases are correctly translated into construction documents. Samples of these construction documents (which have been developed by the engineering organization's transfer of design details from the higher-tiered, certified design information) should be inspected, as necessary, within each functional area/discipline to confirm with reasonable assurance that the transfer of design principles, data, criteria, and other critical information is being properly controlled and effectively implemented.

(1) Design Procedures Review. Within each design discipline, review the project-specific specifications, instructions, and procedures that provide design criteria or guidance to design engineers. Determine the extent of the formal guidance given to the engineers for performing design activities. Focus the technical review on areas of limited or inadequate guidance to the engineers.

(2) Design Calculation Reviews. Review engineering calculations and design details, as follows:

a) Verify that design information is current and correct. This may require tracing back to the source of the input. Internal and external interfaces should 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. Do not repeat reviews that were conducted as part of the design certification.

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 result in all affected elements of the design being evaluated; e.g., re-analysis 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 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/assessing undocumented calculations/decisions, and confirming that as-built conditions are reflected in design analyses.

During the course of FOAK engineering inspection activities , documents pertinent to the inspection that are provided to team members may contain proprietary information. Treat design information as potentially proprietary. Do not make further copies or disclosure the documents received during the inspection without coordinating such needs through the NRC Team Leader. Normally, all such documentation will be returned to the licensee when the inspection is completed.

03.03 See Inspection Procedure 71152, “Identification and Resolution of Problems,” for additional guidance.

37802-04 RESOURCE ESTIMATE

This inspection procedure is estimated to use approximately 1600 inspection hours for Phase 1 activities and 400 hours for Phase 2 activities. See Sections 4.b & 5.b of Appendix B of Manual Chapter 2502 for a further discussion of the projected level of effort, program scope and timetable, and the team composition expected to be used in the conduct of this multi-disciplinary FOAK engineering inspection.

37802-05 COMPLETION STATUS

This inspection procedure is completed when the Phase 1 and Phase 2 FOAK engineering inspection activities, as discussed in Manual Chapter 2502, Appendix B, have been conducted. An inspection sample of one or two safety system reviews (including supporting system, sub-system, and component reviews) deemed necessary to meet the inspection objectives, is sufficient to constitute completion of this procedure.

37802-06 REFERENCES

Inspection Procedure 71152, “Identification and Resolution of Problems”

NRC Inspection Manual Chapter 2502, Appendix B, “First-of-a-Kind Engineering Inspections”

NRC Inspection Manual Chapter 2512, “Light-Water Reactor Inspection Program - Construction Phase”

NRC Inspection Manual Chapter 2515, “Light-Water Reactor Inspection Program - Operations Phase”

NRC Inspection Manual Chapter 2530, “Integrated Design Inspection Program”

ASME NQA-1 - 1994 Edition, “Quality Assurance Requirements for Nuclear Facility Applications”

END

Attachments: Functional Area Inspection Guidelines
Attachment A, Civil and Structural
Attachment B, Mechanical Systems
Attachment C, Electrical Power
Attachment D, Instrumentation and Control
Attachment E, Materials, Welding, and Nondestructive Examination
Attachment F, Mechanical Components
Attachment G, Quality Assurance

Appendix A, Design Input Considerations

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Attachment A: Functional Area Inspection Guidelines
for
Civil and Structural

The overall design basis of the mechanical fluid system(s) or other process systems selected for the inspection sample 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.

a. Identify the location of the process system selected. Include associated equipment, such as:

    (1) pumps and valves
    (2) tanks
    (3) power supplies
    (4) control systems
    (5) piping supports

    There is no attempt in this inspection procedure 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.

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

c. 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.

d. 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.

e. Review samples of the design calculations based on the internal forces resulting from the analyses. Ascertain that the design techniques identified in the FSAR or Design Control Document have been or are being met. Also review specific areas of the design calculations.

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

g. Review examples where the basic design documents are used to make products, 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.

h. 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.

i. Review and evaluate several types of design changes, such as those initiated by the following organizations or events:

(1) design office
(2) engineering contractors
(3) the applicant
(4) identified interference/coordination problems
(5) identified errors in engineering

j. Review and evaluate the acceptance process used in the civil-structural area for final acceptance of the structures or elements thereof. Inspection Procedure 37051 should be reviewed for guidance and criteria relevant to this effort.

k. 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.

Attachment B: Functional Area Inspection Guidelines
for
Mechanical Systems

To accomplish a review of the mechanical fluid system, it may be necessary to review how the applicant 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 is a good opportunity to evaluate the interface between the various design organizations. Review calculations that confirm that certified design requirements can be met.

b. Identify a function which is related to the selected 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 calculations for fluid systems and flow calculations for systems 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, sub-compartment pressurization, and plans for the 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, 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.

Attachment C: Functional Area Inspection Guidelines
for
Electric Power

The degree to which emergency power, and electric power in general, are relied upon as safety-related or risk-significant features of the design, or asset protection support systems, should be considered in the development of a electric power inspection plan for the facility. The reliance on emergency and safety-related electric power sources will depend upon the unique facility design and the specific types of power sources (AC or DC) that are used for the safety grade actuation or risk mitigation features of that design. Such unique design applications in the use of electric power should be reviewed and considered in the formulation of an inspection plan for the safety-related and risk significant components that comprise the electric power system for the facility. Therefore, depending upon the plant design, the following inspection guidance should be flexibly adapted to the focus on power sources (AC or DC) and component selection (e.g., diesel generators or batteries) that provide the most safety significant impact and risk return for the inspection resources expended.

a. Identify all components of the process and mechanical fluid system(s) selected that require electric power to perform their safety function(s) or otherwise use electric power to reduce risks or preserve plant assets. Determine whether the electric power system supplying power to each of these components will be capable of providing the required electric energy (AC or DC) as needed by each component.

   For AC circuits, 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. For example, a review of diesel-generator load sequencing of the selected mechanical fluid system components (if they require emergency electric power to perform their safety function) should be performed.

b. Identify all components of the process or mechanical fluid system(s) 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 process or mechanical fluid system(s) 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, AC and DC valve operators, batteries, battery chargers, inverters, 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 bases. Verify that acceptance criteria are consistent with applicant commitments and certified design information.

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

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

    (1) the test conditions specified were consistent with predicted accident conditions at the equipment location
    (2) required equipment performance was properly specified for the worst accident for which the equipment was required to operate
    (3) test results showed 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 operable 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 (AC or DC) 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 (AC or DC) 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.

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Attachment D: Functional Area Inspection Guidelines
for
Instrumentation and Control.

The I&C design acceptance criteria (DAC) will likely need to be verified in order to accomplish an adequate review of I&C under a FOAK engineering inspection.

> NOTE: If the I&C programmatic concepts and Tier 1 material cannot be validated as part of the FOAK engineering / pre-COL inspection activities using this procedure, supplemental I&C inspections may be needed during the construction phase. Any post-COL inspections, while related, are not considered part of the FOAK engineering reviews under IMC-2502, but will be addressed, as applicable, in other manual chapters.

If the I&C design is not complete when this FOAK engineering inspection is conducted, the governing design verification program (i.e., established by the licensee, engineering contractor, or vendor, as applicable) will be reviewed instead of detailed design material. In this situation, the inspector should check whether specific ITAAC or DAC are available to validate the acceptability of the design at a later time. If it cannot be established that ITAAC/DAC are directly applicable to the selected I&C inspection sample, the licensee commitments and/or programmatic controls, as a minimum, should be checked to ensure an adequate approach to the verification of complete and accurate I&C design functions and system installation details.

Refer any apparent ITAAC/DAC deficiencies to the NRR/EEIB for additional review and consideration. If the requisite design documentation is found to be incomplete during a FOAK engineering inspection, the applicable I&C program specifications and procedural controls should be evaluated to assure compliance with all regulatory requirements and commitments in the areas of design verification, design change and interface controls, and quality record generation and retention.

Because of the known limitations of the pre-COL I&C design, inspector judgement must be used when selecting the I&C inspection sample and when determining the scope and level of detail that can be verified using the specific inspection attributes, as discussed below.

a. Select two different process parameter measurements, such as flow, level, pressure, temperature, etc., providing inputs/outputs to a digital system which is the intelligence for the mechanical fluid system selected (reference: Attachment 02) and select two associated controlsystems.

   At least one of the parameters should be selected from those that perform a critical function such as reactor trip or actuation of one or more engineered safety features. If the mechanical fluid system selected for inspection is not emergency core cooling system (ECCS) related, additional consideration should be given to ECCSsignal inputs.

b. Review all system requirement input information used for the design related to the selected parameters and control systems; it will be necessary to interface with the electrical power system design and the mechanical system design. Verify that the I&C design inputs 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 ITAAC, DAC, or licensee commitments, as applicable. If the installation drawings are not available, review the engineering contractor's or vendor's hardware specification, system architecture, block diagram, and/or other programmatic information provided to determine whether the functional and installation requirements are accurate, complete, well documented and conform to ITAAC, DAC, or licensee commitments.

d. Select several design change requests (or, as applicable, any revisions to the I&C system specifications or drawing details) and verify that the engineering contractor's and/or vendor's configuration control program and design verification program are being effectively and accurately implemented. A review of the configuration control program and design verification program should include the following:

- 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, construction drawings, and drawing revisions that complete the design change cycle;
- the results of the functional tests available for fabricated components; and
- the documentation to assure that all design changes have been evaluated for general implications.

If the design is not complete, and no design change requests are available, review the engineering contractor's or vendor's design verification program to ensure conformance with committed industry and regulatory standards. Focus on the adequacy of the controls for handling design changes or revisions to other engineering documents. To the extent that licensing guidance would be helpful to the inspector in reviewing I&C system characteristics and attributes, Chapter 7 of the Standard Review Plan can be used as a reference.

e. Review qualification documentation for safety-related instruments to determine compliance with regulations, regulatory guides and national standards applicable to qualification. If qualification documents are not yet available, review the engineering contractor's or vendor's requirements for such documentation, as applicable, to assess the existence and adequacy of qualification controls.

f. For each of the process and mechanical fluid system(s) selected for inspection (as well as for any applicable supporting electrical systems), identify alarms or annunciators provided as part of the instrumentation and review the basis for providing these alarms or annunciators, their set-points, and their locations.

g. Review the I&C portion of the system descriptions for the mechanical fluid system(s) selected for inspection. Check for any unusual operating requirements and verify that the I&C design details that are available for review adequately address all operational conditions and any abnormal 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, verification that passive systems have actuated and performed as designed, or any special automatic/manual control features.

   If the fluid system and I&C support descriptions are not yet available, review the mechanical fluid system requirements and any related I&C functional details or operational objectives for similar criteria and design conformance to licensing commitments.

h. Verify that the I&C system (as detailed in the available design documents or in the programmatic requirements and commitments) detects and maintains essential parameters during all anticipated plant conditions. Determine if the detection and control capability during a loss of offsite power, or other anticipated operational occurrences and accident conditions, meets design requirements.

i. Assure that all logic functions, (e.g., interlocks, automatic actuation and permissives) are properly specified in accordance with the design program and detailed, to the extent that the design is complete, with an accuracy that assures proper implementation.

j. Assure that bypassed and inoperable status is indicated as necessary or, as a minimum, that programmatic controls exist to adequately address the I&C design criteria for alerting operations personnel of such equipment or system unavailability.

k. Review the procedures and basis for developing set points and for ensuring that as-built deviations are considered or will be considered when the as-built information is available.

l. Determine if the engineering contractor's or vendor's design for the selected I&C inspection sample of digital systems meets the basic requirements established in the applicable IEEE /other industry standards and in other commitments.

   Determine if the following programmatic considerations have been adequately addressed in the digital system design :

   - a software qualification program,
   - a verification and validation (V&V) program,
   - a design approach that invokes the diversity or defense-in-depth requirements stipulated in ITAAC, DAC, or licensee commitments.

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Attachment E: Functional Area Inspection Guidelines
for
Materials, Welding, and Nondestructive Examination

To accomplish a review of the materials, fabrication, and nondestructive examination (NDE) activities, it may be necessary to review the applicant's commitments in the Final Safety Analysis Report (FSAR) and the Design Control Document (DCD) as it relates to the fluid systems, structural components and structures selected for inspection.

a. Review and evaluate the process by which materials, welding, and NDE requirements are translated into design documents, engineering drawings, and procedures to ensure that licensing commitments, ASME Code and/or other applicable codes and standard requirements are met.

b. Review examples of components and structures to ascertain that the process ensures that materials, welding and NDE requirements are incorporated in the design of the component and/or structure.

c. Verify that the applicant has established an acceptable procurement program which includes provisions for procurement of materials, welding, and/or NDE services.

d. Review examples of purchase orders involving procurement of materials, welding, and/or NDE services. The verification should include the following:

    (1) Verify that appropriate procedural controls have been established to ensure that procurement documents adequately describe the work the materials supplier will perform.

    (2) Verify that applicable regulatory, design, technical, administrative, and reporting requirements are included in the purchase specifications.

    (3) Verify that governing codes and standards are referenced in the purchase specifications.

    (4) Verify that applicable NDE, qualification, test and acceptance requirements stated in the governing codes and standards are referenced in the purchase specifications.

e. For components and structures selected for review in accordance with item (b) above, verify that selected materials are compatible with the intended service of the component and/or structure. In addition, verify that the specified welding processes and NDE are suitable to produce the quality required by the governing codes and standards.

f. For components and structures selected for review in accordance with item (b) above, ascertain that lessons-learned from operating experience has been included during the design phases of the component and/or structure.

g. For components and structures selected for review in accordance with item (b) above, ascertain that procedures exist to control design changes involving substitution of materials, welding processes and NDE. Verify that changes are approved in accordance with an approved procedure or process.

Attachment F: Functional Area Inspection Guidelines for 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.

c. Review the model used in the piping analysis. This includes review of the analyses performed (thermal, deadweight, seismic, 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 applicant 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 applicant commitments. Particular attention should be given to the operability evaluation for seismic events. Also, valve actuator qualification documentation should be reviewed for conformance with certified design information.

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 applicant commitments and construction procedures. The load combinations should be checked for the correct specification of primary and secondary loadings.

   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 were considered. Review the attachment to the structure and verify that the loads have been considered by the structural group.

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a. Verify that the design activities were conducted in accordance with an approved QA program.

b. Select for review several risk-significant components described in the applicable construction procedure, a mix of safety related and non-safety related. Focus on components selected for the inspection and verify the following:
   (1) The reliability requirement for each component is equal to or greater than the reliability specified by the design-reliability assurance program.
   (2) Operations, maintenance, and monitoring activities were assessed during the process of estimating the reliability of these components.

c. Verify that design control measures provide for verifying or checking the adequacy of design, such as by the performance of design reviews, by the use of alternate or simplified calculational methods, or by the performance of a suitable testing program for the selected system or systems as follows:

   (1) The verifying or checking process is performed by individuals or groups other than those who performed the original design, but who may be from the same organization.
   (2) The results of design verification are clearly documented with the identification of the verifier clearly indicated.
   (3) Design verification is performed by any competent individual(s) or group(s) other than those who performed the original design but who may be from the same organization. This verification may be performed by the originator's supervisor, provided the supervisor did not specify a singular design approach or rule out certain design considerations and did not establish the design inputs used in the design or, provided the supervisor is the only individual in the organization competent to perform the verification. Cursory supervisory reviews are not acceptable.
   (4) Design verification is performed for changes, including evaluation of the effects of those changes on the overall design and on any design analyses upon which the design is based that are affected by the change to previously verified design.
   (5) Where design adequacy is to be verified by qualification tests, the tests are identified. The test configuration is clearly defined and documented. Testing demonstrates the adequacy of performance under conditions that simulate the most adverse design conditions. Operating modes and environmental conditions in which the item must perform satisfactorily are considered in determining the most adverse conditions. Where the test is intended to verify only specific design features, the other features of the design are verified by other means. Test results are documented and evaluated by the responsible design organization to assure that test requirements have been met. If qualification testing indicates that modifications to the item are necessary to obtain acceptable performance, the modification is documented and the item modified and retested or otherwise verified to assure satisfactory

performance. When tests are being performed on models or mockups, scaling laws are be established and verified. The results of model test work are subject to error analysis, where applicable, prior to use in final design work.

d. Verify the following for any significant condition adverse to safety that is associated with the system or systems selected:

(1) The corrective action was adequate.
(2) The corrective action was reviewed and approved by appropriate levels of management.

e. Verify that the applicant's audits of the design control process are adequate as follows:

(1) Planned and periodic audits are carried out to verify compliance with the significant elements of the design control process and to determine the effectiveness of the program.
(2) Audit results are documented and reviewed by management having responsibility in the area audited.
(3) Followup action, including re-audit of deficient areas, is taken where indicated.
(4) The individual or organizational (responsible for verifying QA program implementation activities) are periodically audited by designated offsite personnel.
(5) The auditing organization develops and documents an audit plan for each audit. This plan identifies the audit scope, requirements, audit personnel, activities to be audited, organizations to be notified, applicable documents, schedule, and written procedures or checklists.
(6) The auditing organization selects and assigns auditors who are independent of any direct responsibility for performance of the activities which they audit.
(7) Personnel having direct responsibility for performing the activities being audited are not involved in the selection of the audit team.
(8) Audit personnel have sufficient authority and organizational freedom to make the audit process meaningful and effective.
(9) Conditions requiring prompt corrective action are reported immediately to management of the audited organization.
(10) Follow-up action is taken to verify that corrective action is accomplished as scheduled.
(11) The QA program for any engineering contract associated with the design control process has been reviewed, approved and audited by the applicant.

APPENDIX A

Design Input Considerations
(Excerpt from ASME NQA-1 - 1994 Edition, Appendix 3A-1)

1. Basic functions of each structure, system, and component.

2. Performance requirements such as capacity, rating, and system output.

3. Codes and standards, regulatory requirements and commitments or responses to Federal, State, and Local Regulations. For example, these may include, but not be limited to:

   a. Safety Analysis Report
   b. NRC's Safety Evaluation Report and supplements thereto
   c. Environmental Report
   d. NRC's environmental statement and supplements thereto
   e. Technical Specifications
   f. Regulatory Guides
   g. Code of Federal Regulations
   h. NRC bulletins, circulars, notices, and generic letters
   i. Commitments in correspondence with NRC

4. Design conditions such as pressure, temperature, fluid chemistry, and voltage.

5. Loads such as seismic, wind, thermal and dynamic; the cumulative effect of design changes on the analytical design basis, e.g., the addition of a load to an existing wall or the addition of an instrument to a cabinet.

6. Environmental conditions anticipated during storage, construction, and operation, and accident conditions, such as pressure, temperature, humidity, corrosiveness, site elevation, wind direction, exposure to weather, flooding, nuclear radiation, electromagnetic radiation and duration of exposure; qualification test requirements; shelf or service life limitations.

7. Interface requirements including definition of the functional and physical interfaces involving structures, systems, and components:

   a. the effect on existing plant equipment capability, such as DC battery loads, AC bus capacity, available stored water inventory, service instrument air capacity, water systems capability (intake, service and component cooling water), and HVAC capability;
   b. the effect of cumulative tolerances in the design;
   c. the effect on design and safety analyses to ensure the analytical bases remain valid;
   d. the compatibility with unimplemented design changes to specify any required sequence for implementation;
   e. compatibility with Technical Specification requirements.

8. Material requirements including such items as compatibility, electrical insulation properties, protective coatings, and corrosion resistance.

9. Mechanical requirements such as vibration, stress, shock, and reaction forces.

10. Structural requirements covering such items as equipment foundations and pipe supports.

11. Hydraulic requirements such as pump net positive suction heads (NPSH), allowable pressure drops and allowable fluid velocities.

12. Chemistry requirements including provisions for system flushing, batch sampling and in-line sampling. Power plant water chemistry treatment for primary systems, steam generator, and plant limitations on water chemistry.

13. Electrical requirements such as power, load profile voltage, electrical insulation, motor requirements, physical and electrical separation of circuits and equipment; the effect of cable routing or rerouting on the cable tray system (loading, seismic capability, and capacity limitations).

14. Layout and arrangement requirements.

15. Operational requirements under various conditions such as startup, normal operation, shutdown, maintenance, abnormal, or emergency operation, special or infrequent operation including installation of design changes, and the effect of system interaction.

16. Instrumentation and control requirements including indicating instruments, controls, and alarms required for operation, testing, and maintenance. Other requirements such as type of instrument, installed spares, range of measurement and location of indication are included.

17. Security requirements to include access and administrative control requirements and system design requirements including redundancy, power supplies, support system requirements, emergency operational modes, and personnel accountability.

18. Redundancy, diversity and separation requirement of structures, systems and components.

19. Failure effects requirements of structures, systems and components including a definition of those events and accidents which they must be designed to withstand.

20. Test requirements including pre-operational and subsequent periodic tests and conditions under which they will be performed.

21. Accessibility, maintenance, repair, and pre-service and inservice inspection requirements for the facility including the conditions under which these will be performed.

22. Personnel requirements and limitations including the qualification and number of personnel available for operation, maintenance, testing and inspection, and radiation exposures to the public and facility personnel.

23. Transportability requirements such as size and shipping weight, limitation, and regulations for interstate commerce.

24. Fire protection or resistance requirements:

    a. safe shutdown analyses, the introduction of safe shutdown equipment into fire areas;
    b. routing of piping and electrical cables and the necessity for cable fireproofing and/or fire stops;
    c. fire detection and fire suppression capability;
    d. fire barrier capability including fire door installation;
    e. fire dampers;
    f. access to fire fighting and emergency equipment;
    g. use of non-combustible materials;
    h. introducing combustible materials into safe shutdown areas by design or during installation or operation;
    i. Smoke and toxic gas generation.

25. Handling, storage, cleaning and shipping requirements.

26. Other requirements to prevent undue risk to the health and safety of the public.

27. Materials, processes, parts, and equipment suitable for application.

28. Safety requirements for preventing personnel injury including such items as radiation safety, minimizing radiation exposure to personnel, criticality safety, restricting the use of dangerous materials, escape provisions from enclosures and grounding of electrical systems.

29. Quality and quality assurance requirements.

30. Reliability requirements of structures, systems, and components including their interactions, which may impair functions important to safety.

31. Interface requirements between equipment and operation and maintenance personnel.

32. Requirements for criticality control and accountability of nuclear materials.

33. Load path requirements for installation, removal, and repair of equipment and replacement of major components.