WCNOC Procedure AP 05F-001, "Design Verification"

WOLF CREEK
NUCLEAR OPERATING CORPORATION

AP 05F-001

DESIGN VERIFICATION

Responsible Manager

Design Engineering

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1.0 PURPOSE

1.1 This procedure establishes the requirements for performing design verification to ensure the design of a system, structure and/or component is adequate and provide assurance that the design intent has been correctly translated into the design documents.

2.0 SCOPE

2.1 This procedure applies to verification of safety-related and special-scope documents as required by the governing procedure for generation of those documents or otherwise, where required by the supervisor.

3.0 REFERENCES AND COMMITMENTS

3.1 References

3.1.1 USAR 17.2.3.6, "Design Review and Verification"

3.1.2 USAR, Section 3.2, "Classification of Structures, Systems and Components"

3.1.3 AP 30F-001, ENGINEERING SUPPORT PERSONNEL TRAINING AND QUALIFICATION PROGRAM

3.1.4 AP 05D-001, CALCULATIONS

3.1.5 ASME Boiler and Pressure Vessel Code Section III

3.1.6 ANSI N45.2.11 - 1974, "Quality Assurance Requirements for the Design of Nuclear Power Plants"

3.1.7 ANSI N626.3, Qualifications and Duties of Specialized Professional Engineers (1979 and 1988 Editions)

3.1.8 10CFR50 Appendix B Criterion III, "Design Control"

3.1.9 WCNOC-162, WCNOC Handbook for Professional Engineering Oversight and Conduct

3.2 Commitments

3.2.1 PIR 97-1852, Generic Calculation Issues

3.2.2 PIR 98-0500, Design Document/Document Review Errors

4.0 DEFINITIONS

4.1 BENCH MARK SOLUTION - A standard by which calculations employing specialized computer programs are verified, e.g., hand calculations, calculations using comparable industry standard programs, or programs employing numerical methods independent of those used by the calculation being verified, empirical data and information from technical publications.

4.2 DESIGN VERIFICATION - The process of reviewing, confirming or substantiating a design by either testing, design review, alternate calculation or a combination of these methods to provide assurance that the design meets the specified input requirements including assurance that all required documents are complete prior to completion of the design verification.

5.0 RESPONSIBILITIES

NOTE

For those activities dealing with Practice of Engineering and requiring eventual certification, as described in WCNOC-162, a Designated Licensed Engineer will be assigned initial ownership of the activity. The Designated Licensed Engineer will fulfill the role of supervisor for the assigned activity except for those documents which the Designated Licensed Engineer originates and certifies him/herself.

5.1 The Supervisor Engineer/Designated Licensed Engineer is responsible for:

5.1.1 Assigning Engineers to perform design verification.

5.1.2 Ensuring design verification is complete and adequately documented prior to release of the design.

5.1.3 Ensuring that adequate interfaces and overlaps have occurred when multiple verifiers are used.

5.2 The Engineer is responsible for:

5.2.1 Performing and documenting design verification as described in this procedure.

5.2.2 Reviewing design verifications performed by outside engineering organizations.

5.2.3 Coordinating with other disciplines and/or groups to ensure verification of the complete scope.

6.0 PROCEDURE

6.1 General Notes

6.1.1 Design verification shall be performed by a competent individual or group other than those who performed the original design.

NOTE

Since independent verification is contrary to the requirements for oversight provided by the Licensed Engineer, the Licensed Engineer cannot both perform the Independent Verification as described in this procedure and subsequently Certify the document being verified. See WCNOC-162 for further discussion.

6.1.2 Design verification may be performed by the design originator's immediate 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 if the supervisor is the only individual in the organization competent to perform the verification. In this case, the need to have the supervisor perform the independent verification is approved and documented in advance by the supervisor's management.

6.1.3 Design analyses shall be sufficiently detailed as to purpose, method, assumptions, design input, references and units such that a person technically qualified in the subject can verify the adequacy of the results without recourse to the originator

6.2 Extent of Design Verification

6.2.1 The extent of verification required is a function of:

- the importance to safety of the item,
- the complexity of the design,
- the degree of standardization, and
- similarity with previously proven designs.

6.2.2 Cursory reviews do not satisfy the intent of this procedure.

6.2.3 Design verification may vary from spot checking to actual tests in the field.

6.2.4 Safety related and special scope design analyses and design output documents, both new and changes, require verification as required by the governing procedure for generation of those documents.

6.2.5 The applicability of standardized or previously verified designs, with respect to meeting pertinent design input requirements including environmental conditions and WCNOC licensing commitments, shall be verified for each application.

6.2.6 Where the design of a particular structure, system, component or subcomponent has been subjected to an ANSI N45.2.11-1974 verification process, verification need not be duplicated for identical designs. Known problems affecting the standardized design and their effects on other features shall be considered. The original design and associated verification measures shall be documented and referenced for subsequent applications of the design.

6.2.7 Where changes to previously verified designs have been made, design verification shall be required for the changes, including evaluation of the effects of those changes on the overall design.

6.2.8 Design verification for drawings, Stress Reports, Design Reports and Load Capacity Data Sheets (LCDS) associated with modifications to ASME Section III Class I components and supports shall ensure that the requirements of NCA-3550/NA-3350 have been satisfied.

6.2.9 Modification of ASME Section III Class I components or supports, for which a Stress Report or Design Report was supplied by the original supplier, shall include a review of the Stress Report, or Design Report, and Amendments. This review shall be completed in accordance with AP 05D-001, CALCULATIONS.

6.3 Methods of Verification

6.3.1 Design Verification is the process of reviewing, confirming, or substantiating the design by one or more methods to provide assurance that the design meets the specified design inputs.

6.3.2 Design verification methods include, but are not limited to:

- Design reviews.
- Alternate calculations.
- Qualification testing.

6.3.3 Design Review

1. Design reviews are critical and methodical reviews intended to provide assurance that design documents such as drawings, calculations, analyses or specifications are correct and satisfactory.

   a. Design reviews can range from multi-organization reviews to single person reviews.

   b. The depth of review can range from a detailed check of the complete design to a limited check of such things as the design approach and the results obtained.

   c. The results of the review shall be documented and measures taken to ensure that the findings are implemented.

   d. Form APF 05F-001-01, Design Verification Report, and Attachment A, Design verification Guidelines, contain a number of basic questions to be considered when performing design reviews.

2. A typical way to perform critical and methodical design reviews is to approach the review in phases. [Commitment steps 3.2.2 and 3.2.3]

   a. The first phase is an overall or 'big picture' review, where the following are determined and/or judged for appropriateness and consistency:

      - The purpose and nature of the item(s) being verified.
      - The overall approach used for design development.
      - The appropriate scope and extent of verification.

b. The second phase is a critical review where the crucial areas are determined and evaluated. These crucial areas are typically such things as:

- Design inputs and/or assumptions.
- Logic used.
- Supporting Data.
- Results and conclusions.

c. The third phase consists of methodically reviewing the crucial areas for reliability, accuracy, and consistency. Independent sources of information are used to validate and/or verify essential or questionable items.

NOTE

Sometimes during the first, second, or third phase it is recognized that some aspects of the design may require an alternate calculation or testing.

6.3.4 Alternate Calculations

1. Verification of some types of calculations or analyses may be achieved by comparison with alternate methods of calculations or analyses.

   a. Alternate calculations shall be performed by a person, or persons, other than those who performed the original calculation.

   b. When alternate calculations are performed to verify the conclusions of the original calculation, a design review shall also be performed to address the appropriateness of assumptions, input data, code and calculation methods used for the original calculation.

   c. The alternate calculation used for comparison may be a more simplified method or less rigorous, such as when a hand calculation is used to check the computer code output. The alternate calculation must provide results consistent with the original calculation or analyses.

d. The alternate calculation shall be developed in accordance with AP 05D-001 with the following exceptions:

- The same calculation number as the calculation being verified shall be used followed by "VR" or the alternate calculation number shall be specifically referenced on the verification report.

- Alternate calculations do not require verification. When an alternate calculation is not verified, it shall be attached to Form APF 05F-001-01 which in turn shall be attached to the calculation being verified. A non-verified alternate calculation shall not be submitted as a stand alone calculation.

e. If the calculation being verified has used a specialized computer program, the verifier shall demonstrate the program's capability to produce results closely matching benchmark solutions for a series of problems encompassing the usage defined in the calculation. The alternate calculation shall include, as applicable:

- Detailed descriptions of test problems, including mathematical models, boundary conditions, initial values and other key parameters.

- A list of test problem input and output data.

- Results obtained from benchmark solutions, citing references used.

6.3.5 Qualification Testing

1. Design Verification for some designs or specific design features can only be achieved by testing a model, prototype, initial production unit or pre-operational testing.

   a. Where the adequacy of design is to be verified by a qualification test, the testing shall be identified, documented, and clearly communicated to the implementing organization.

b. Testing shall demonstrate adequacy of performance under the most adverse design conditions.

- All pertinent operating modes shall be considered in determining these design conditions where it is intended that the test program confirm the adequacy of the overall design

- Where the test is only intended to verify a specific design feature, the other features of the design shall be verified by other means.

c. Qualification testing shall be performed in accordance with written test procedures which incorporate or reference the requirements and acceptance limits contained in the applicable design documents.

- The test procedures shall include provisions for assuring that prerequisites for the given test have been met and that necessary monitoring is performed.

- Prerequisites include such items as calibrated instrumentation, appropriate equipment, trained personnel, condition of test equipment and item to be tested, suitable environmental conditions and provisions for data acquisition.

- Test results shall be documented and evaluated by the responsible designer to assure that test requirements have been satisfied.

d. If testing indicates that modification to the item is necessary to obtain acceptable performance, the modification change shall be documented and the item modified and retested or otherwise verified to assure satisfactory performance.

e. When tests are being performed on models or mock-ups, scaling laws shall be established and verified. The test configuration shall be clearly defined and documented. The results of model test work shall be subject to error analysis, where applicable, prior to use in final design work.

6.4 Design Verification and Documentation

NOTE

Regardless of other design verification methods employed, overall approach, design input selection and design assumptions shall receive a critical design review.

6.4.1 Overview - Purpose, Design Approach and Verification Scope.

1. Perform an overall 'big picture' review of the item(s) being verified.

2. Ensure that the purpose and approach used for design development are appropriate and consistent.

3. Determine the method and extent of verification necessary considering the discussion in Section 6.2.

4. On Form APF 05F-001-01:

   - Identify the Document(s) being verified by document number, revision and title.

   - Provide a descriptive overview. Include the purpose of the item(s) being verified and clearly identify the scope, method, and extent of verification.

6.4.2 Team verification

1. The scope of team design verifications shall be clearly defined and documented, with the scope of each verifier clearly identified.

2. When multiple verifiers are used, the Supervisor/Designated Licensed Engineer shall appoint a team leader to consolidate verification results into a single Form APF 05F-001-01, "Design Verification Report".

6.4.3 Design Inputs

1. Verify that Design Inputs have been identified, are proper and appropriate, are specified with the level of detail necessary, and are correctly documented.

2. Verify that controlled documents used are the latest revision.

3. Verify that all design input requirements are clearly satisfied.

6.4.4 Design Assumptions

1. Identify design assumptions, intended or implied, on which the final design is based.

2. Determine which design assumptions are critical.

3. Evaluate all critical design assumptions for validity and proper application.

6.4.5 Other Crucial Areas

1. Determine which other aspects are crucial and evaluate them for validity and proper application. Examples:

   - logic used
   - supporting data
   - results
   - conclusions

6.4.6 Document on Form APF 05F-001-01 the Crucial Areas evaluated in detail by the verifier.

1. The 'Crucial Areas' documented on Form APF 05F-001-01 are to be those design inputs, assumptions, and other aspects that, in the judgment of the verifier, are especially important, and were therefore selected for methodical validation and/or verification.

2. Consider the discussion in Section 6.2 on the 'Extent of Verification' and in Section 6.3.3 on 'Design Review' when selecting these 'Crucial Areas'.

6.4.7 Document on Form APF 05F-001-01 the alternate or independent items used for verification of the crucial areas.

1. These alternate or independent items may include alternate calculations or tests.

2. Design verification of calculations which utilize a specialized computer program shall use an alternate calculation.

6.4.8 Document on Form APF 05F-001-01 a summary of important comments and comment resolution.

NOTE

Comments and comment resolution can be a convenient way to document additional design considerations or other 'what-if' questions without having to revise the document being verified.

6.4.9 Document on Form APF 05F-001-01 a summary of the design verification efforts including results and conclusions.

6.4.10 Alternate verification documentation may be specified by the controlling procedure.

6.5 Design Verifications by Outside Engineering Organizations

6.5.1 Outside organizations performing design verification activities shall have a QA program incorporating 10CFR50 Appendix B Criterion III Design Control measures and be listed on the Supplier Information List(SIL).

1. Verification activities and documentation requirements shall be established and defined by appropriate procurement documents.

2. Documentation summarizing verification activities shall be submitted to WCNOC and reviewed by a qualified WCNOC Engineer to ensure that the design verification is adequate, complete, and has addressed all applicable design requirements and interfaces.

6.5.2 For outside organizations that do not have a recognized QA program incorporating 10CFR50 Appendix B Criterion III Design Control measures or are not on the SIL:

1. Personnel performing Design Verification shall be qualified for the activities being verified in accordance with the qualification program of AP 30F-001 WCNOC QA program and procedures.

2. Design Verification shall be performed and documented in accordance with this procedure.

6.6 Records Submittal

6.6.1 The Design Verification Report (DVR) Package shall be retained with the document being revised until approval and then submitted to Records Management. The "Design Verification Report" (DVR) package consists of the following, as applicable:

1. Form APF 05F-001-01, Design Verification Report

2. Any documents which support the design verification.

7.0 RECORDS

7.1 The DVR package (Form APF 05F-001-01) shall be processed as a QA or non-QA record depending on its safety classification.

7.2 DVR packages are life extension records when the document or change verified are considered life extension records.

8.0 FORMS

8.1 APF 05F-001-01, "Design Verification Report"

- END -

ATTACHMENT A
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DESIGN VERIFICATION GUIDELINES

This exhibit provides the guidelines to be used as part of the design verification of engineering design drawings and encompasses the key elements to be considered, including, but not limited to:

A.1 GENERAL ARRANGEMENT DRAWING

A.1.1 Equipment identification

A.1.2 Equipment location matches location depicted on area drawings

A.1.3 Pulling space for tube bundles, pump shafts, removing fans and motor rotors, etc. is indicated and adequate

A.1.4 Code required clearances exist between roads, right-of-ways, walkways and equipment, ladders, platforms and pipeways

A.1.5 Swing space of doors, cranes, etc. is considered

A.1.6 Erection, operating and/or emergency egress space is provided

A.1.7 Manway clearance is adequate

A.1.8 Operating space on platforms around instruments is suitable

A.1.9 OSHA requirements are considered

A.2 PIPING AND INSTRUMENT DIAGRAMS (P&IDS)

A.2.1 All lines, instrumentation, valves and miscellaneous components are labeled

A.2.2 Flow arrows and direction are correctly shown

A.2.3 Pipe specification breaks are clearly marked

A.2.4 Quality assurance identification is indicated where applicable

A.2.5 Containment penetrations by pipe are shown

A.2.6 Standardized symbols are used throughout

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DESIGN VERIFICATION GUIDELINES

A.3 PIPING DRAWINGS

A.3.1 Sufficiency of drawings relative to adequate plans, sections, elevations and details

A.3.2 Correct location of equipment

A.3.3 Grade platform, catwalk and pipeway elevations correctly shown

A.3.4 Drawing provides structural information for:

1. Pipe sleeves sizes and locations
2. Hanger sizes and locations
3. Miscellaneous steel requirements for hangers

A.3.5 Structural drawings verified for compatibility of pipe sleeves, hanger inserts and miscellaneous steel sizes and locations

A.3.6 Electrical drawings verified for interference with pipes and/or hangers

A.3.7 Line sloped as required

A.3.8 Steam lines are provided with drip legs and steam traps at all low points

A.3.9 Proper location of traps, separators, vents and drains

A.3.10 Correct identifications are shown for all views of lines, flows and spool numbers

A.3.11 Correct identifications are shown in two views for valves flanges differing from line specs, instrumentation and special fittings and valves, such as

1. Short radius and reducing ells
2. Reducing tees
3. Eccentric reducers
4. Control valves
5. Miscellaneous special items

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DESIGN VERIFICATION GUIDELINES

A.3.12 Equipment nozzles, including correctly identified elevation flange size, rating, facing, orientation and projection

A.3.13 Connections and flange rotations at equipment

A.3.14 Bolt-hole locations when turning valves or fittings at angles

A.3.15 Underground interface point coordinates

A.3.16 Suitable design in piping layout relative to:

1. Clearance and spacing of lines
2. Operation and maintenance accessibility of valves and equipment
3. Grouped piping where possible to form pipeways
4. Valve orientation

A.3.17 Clearance between pipe and equipment on structures

A.3.18 Change of elevation when changing direction

A.3.19 Adequate allowance for insulation and heat tracing shown when required

A.3.20 Piping shown as double line in critical areas of congestion

A.3.21 High points vented and low points drained

A.3.22 Use of applicable standards

A.3.23 Pump suction lines are designed to prevent air pockets ahead of the pump nozzles and provided with start-up strainers

A.3.24 Sufficient dimensioning of spool pipe lines without scaling and without reference to sources other than piping drawings

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DESIGN VERIFICATION GUIDELINES

A.3.25 Piping flexibility has been considered, including:

1. Adequate pipe spacing provided to allow for expansion and/or contraction
2. All cold springs are clearly noted and detailed when in two or more directions
3. Flexibility configuration
4. Stress calculations have been performed for critical conditions
5. Use of expansion loops versus expansion joints

A.3.26 Connection size and type of instrumentation

A.3.27 Instrument connection location agrees with instrument design

A.3.28 Proper location of orifice flanges for meter runs, including:

1. Sufficient amount of run up and down stream
2. Sufficient straight runs or use of straightening vanes
3. Pressure tap locations
4. Piping spacing when seal pots are employed

A.3.29 Adequate supports, guides and anchors including:

1. Equipment nozzle vicinity to prevent overstressing
2. Using pipeways to consolidate supports
3. Proper support spacing based on line size
4. At expansion loops and joints
5. Incorporation of calculation outputs for design and spacing of supports, guides and anchors
6. Adequate identification and location

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DESIGN VERIFICATION GUIDELINES

A.4 FLOOR AND EQUIPMENT - DRAIN DRAWINGS

A.4.1 Sufficiency of drawings relative to adequate plans, sections, elevations and details

A.4.2 Correct location of equipment

A.4.3 Operation and maintenance accessibility of valves and equipment

A.4.4 Drawing verified for compatibility with civil drawings for pipe sleeve sizes, locations and miscellaneous steel requirements

A.4.5 Line sloped when required

A.4.6 Work point elevations

A.4.7 Correct identification for all views of lines, flow, spool numbers and for two views of valves

A.4.8 Good design in piping layout relative to:

1. Clearance and spacing of lines, between pipes, structural steel and/or concrete floor
2. Lines grouped when possible
3. Accessibility for cleaning

A.4.9 Use of applicable standards

A.5 HEATING, VENTILATING AND AIR CONDITIONING (HVAC) DRAWINGS

A.5.1 Sufficiency of drawings relative to adequate plans, sections, elevations and details

A.5.2 Correct location of equipment

A.5.3 Correct line weights shown for work done

A.5.4 Civil/structural drawings verified for compatibility of floor openings for ducts and miscellaneous steel sizes and locations

A.5.5 Drawing provides civil/structure groups with the necessary information relative to floor openings, sizes, locations and miscellaneous steel requirements

A.5.6 Adequate hanger information with regard to location and possible interference

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DESIGN VERIFICATION GUIDELINES

A.6 ONE LINE DIAGRAMS

A.6.1 Review P&ID for compatibility of components and system functions

A.6.2 Correct identification of:

1. Device or equipment piece numbers
2. Description of device(s)
3. Circuit input/output descriptions

A.6.3 Correct notes, legends and tables for identification of:

1. Motor ratings
2. Circuit breaker capacities
3. Wire and cable sizes
4. Service voltages (input/output)

A.6.4 Use of electrical codes and standards relative to safety-related equipment, symbology and abbreviations

A.7 SCHEMATIC DIAGRAMS

A.7.1 Agrees with P&ID for quantity and type of equipment

A.7.2 Correct notes, legends and tables for identification of:

1. Switch contacts (N/O, N/C, type)
2. Switch positions
3. Switch escutcheon engraving
4. Service voltage
5. Relay contacts (N/O, N/C, type)

A.7.3 Identification of all terminal points (terminations)

A.7.4 Use of electrical codes and standards relative to safety-related equipment, symbology and abbreviations

A.7.5 Correct identification of equipment piece numbers and circuit voltage descriptions

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DESIGN VERIFICATION GUIDELINES

A.8 CONTROL LOGIC DIAGRAMS

A.8.1 Review P&ID for compatibility of components and system functions

A.8.2 Correction identification of device or equipment piece numbers and description of device and circuit voltage

A.8.3 Correct use of notes, legends and tables for identification of:

1. Annunciator points
2. Annunciator engraving
3. Service voltages
4. Computer points

A.8.4 Circuit logics - source to destination including initiating, inhibiting and controlling signals

A.8.5 Use of electrical codes and standards relative to safety-related equipment, symbology and abbreviations

- END -