NUREG-0800
(Formerly NUREG-75/087)

U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

14.3.2[1] STRUCTURAL AND SYSTEMS ENGINEERING (Tier 1)

REVIEW RESPONSIBILITIES

Primary - Civil Engineering and Geosciences Branch (ECGB)

Secondary - Plant Systems Branch (SPLB), Emergency Preparedness and Radiation Protection Branch (PERB), Safeguards Branch (PSGB)

I. AREAS OF REVIEW

ECGB reviews Tier 1 of the Design Control Document (DCD), and DCD Tier 2 Sections 3.7, 3.8 and 14.3 submitted by the applicant. Review responsibilities may be consistent with those contained in Appendix A to SRP Section 14.3. ECGB has primary review responsibility for building structures and structural aspects of major components such as the reactor pressure vessel (RPV). The review includes definitions, key dimensions, general provisions, and legends for figures in Tier 1. ECGB reviews Tier 1 information for issues regarding structural, mechanical, materials, and chemical engineering.

Review Interfaces

SRP Section 14.3 provides general guidance on review interfaces. ECGB performs related reviews and coordination activities, as requested by other branches, for issues in Tier 1 as discussed above. ECGB also performs the following reviews under the SRP sections indicated:

1. ECGB determines that Tier 1 information is adequate for site parameters for the design in SRP Section 14.3.1.

2. ECGB determines that Tier 1 information is adequate for piping design, including piping DAC if applicable, in SRP Section 14.3.3.

In addition, ECGB will coordinate other branches' evaluations that interface with the overall review of the systems as follows:

1. The Electrical Engineering Branch (EELB) determines the acceptability of Tier 1 information regarding the separation requirements and locations of major electrical components and systems in SRP Section 14.3.6.

2. The Reactor Systems Branch (SRXB) determines the acceptability of Tier 1 information regarding the arrangement of reactor and core cooling systems, including design considerations for preventing intersystem loss-of-coolant accidents in SRP Section 14.3.4.

3. The Containment Systems and Severe Accident Branch (SCSB) determines the acceptability of Tier 1 information regarding the requirements for and arrangement of severe accident design features in SRP Section 14.3.11.

Secondary Review Branch Responsibilities

1. The SPLB determines the acceptability of Tier 1 information regarding the arrangement of major plant SSCs, the design features of SSCs and ability of structures to withstand fires, internal and external flooding, internal and external missiles, pipe breaks, and the design of building HVAC systems in SRP Section 14.3.7.

2. The PERB determines acceptability of Tier 1 information regarding the emergency preparedness and radiation protection aspects of the structures in SRP Section 14.3.8.

3. The PSGB determines the acceptability of Tier 1 information regarding the design features for safeguards in SRP Section 14.3.

II. ACCEPTANCE CRITERIA

The acceptance criteria for ITAAC are based on meeting 10 CFR 52.97(b)(1), which sets forth the comprehensive requirements for ITAAC. For design certification reviews, the scope of ITAAC is limited to the scope of the certified design as required by 10 CFR 52.47(b).

The reviewer should primarily utilize the NRC rules and regulations to review the top level commitments in Tier 1. Other sources of review guidelines include RGs, SRP guidelines, and PRA insights from the standard design safety and severe accident analyses and operating experience. If applicable, the staff also must adhere to policy decisions by the Commission. Examples of these are contained in the SRM related to SECY-90-016, "Evolutionary Light Water Reactor Certification Issues and Their Relationship to Current Regulatory Requirements," as modified by the Commission guidance in the SRM related to SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor Designs." The SRM related to SECY-93-087 is dated July 21, 1993.

Design descriptions, figures (including key dimensions) and ITAAC should be developed and grouped by systems and building structures. For building structures, the structural capability is typically verified by performing an analysis to reconcile the as-built data with the structural design bases for each safety-related building. System-specific performance tests are typically conducted to demonstrate that the system can perform its intended function. For major components, the verification of design, fabrication, testing, and performance requirements should be partially addressed in conjunction with the specific system ITAAC. The review checklists for fluid systems, electrical systems, and building structures in Appendix C of SRP Section 14.3 should be used as aids for establishing consistency and completeness for the Tier 1 information.

Review of the Standard Design Structural Integrity

The scope of structural design covers the major structural systems in the standard design plant, including the RPV, ASME Code Class 1, 2, and 3 piping systems, and major building structures (primary containment, reactor building, control building, turbine building, service building, and radwaste building). For PWRs, this includes the reactor vessel (RV), ASME Code Class 1, 2, and 3 piping systems, and major building structures (primary containment, nuclear island structures, turbine building, component cooling water (CCW) heat exchanger structures, diesel fuel storage structures (DFSSs), and radwaste building). The RPV, piping systems, and primary containment (For PWRS, RV, piping systems, and primary containment) are included because they provide the defense-in-depth principle for nuclear plants. The major building structures house those systems and components that are important to safety.

In establishing the top level requirements for structural design, the staff used the General Design Criteria (GDC) of 10 CFR Part 50, Appendix A, as its basis. The primary general design criteria pertaining to the major structural system design are GDC 1, "Quality Standards and Records," GDC 2, "Design Bases for the Protection Against Natural Phenomena," GDC 4, "Environmental and Dynamic Effects Design Basis," GDC 14, "Reactor Coolant Pressure Boundary," GDC 16, "Containment Design," and GDC 50, "Containment Design Basis."

> GDC 1 requires, in part, the need for structures, systems and components important to safety to be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed.
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> GDC 2 requires, in part, the need to design structures, systems, and components important to safety to withstand the effects of natural phenomena such as earthquakes, tornados, hurricanes, and floods without loss of capability to perform their safety functions, including the appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena.
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> GDC 4 requires, in part, the need to protect structures, systems, and components important to safety from dynamic effects including the effects of missiles, pipe whipping, and discharging fluids that may result from equipment failures and from events and conditions outside the nuclear power unit.

GDC 14 requires, in part, the need for the reactor coolant pressure boundary to be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture.

GDC 16 requires, in part, the need for the reactor containment to provide an essentially leak-tight barrier against uncontrolled release of radioactivity to the environment.

GDC 50 requires, in part, the need for the reactor containment structure including access openings and penetrations to be designed so that the containment structure and its internal compartments can accommodate, without exceeding the design leakage rate and with sufficient margin, the calculated pressure and temperature conditions resulting from any loss-of-coolant accident.

Using the above GDC as its basis, the following top-level attributes should be verified by ITAAC:

(1) pressure boundary integrity (GDC 14, 16 and 50)
(2) normal loads (GDC 2)
(3) seismic loads (GDC 2)
(4) suppression pool hydrodynamic loads (GDC 4)
(5) flood, wind, and tornado (GDC 2)
(6) rain and snow (GDC 2)
(7) pipe rupture (GDC 4)
(8) codes and standards (GDC 1)

In addition, to ensure that the final as-built plant conforms to the certified design, applicants should provide ITAAC to reconcile the as-built plant with the structural design basis. A summary of the top-level structural design requirements for the major structural systems that are verified by the structures and systems in Tier 1 and the piping design information in Tier 1.

Pressure Boundary Integrity

To ensure that the applicable requirements of GDC 14, 16, and 50 have been adequately addressed, ITAAC should be established to verify the pressure boundary integrity of the RPV, piping, and primary containment (For PWRs, RV, piping, and primary containment) for the standard design. GDC 16 and 50 apply to the primary containment and GDC 14 applies to the RPV (RV for PWRs) and the reactor coolant pressure boundary piping systems. The pressure integrity for these major structural systems are needed to ensure the defense-in-depth principle.

For the RPV and piping, hydrostatic tests performed in conjunction with the ASME Boiler and Pressure Vessel Code, Section III, should be required by ITAAC. See the standard ITAAC for hydrostatic tests in Appendix D to SRP Section 14.3. For the primary containment, a structural integrity test should be required by ITAAC to be performed on the pressure boundary components of the primary containment in accordance with the ASME Boiler and Pressure Vessel Code, Section III. Because the requirements of GDC 14, 16, and 50 do not apply to the reactor, control, turbine, service, and radwaste buildings (nuclear island structures, turbine building, CCW heat exchanger structures, DFSSs, and radwaste building for PWRs), ITAAC are not required to verify the pressure integrity for these other buildings.

Normal Loads

To ensure that the applicable requirements of GDC 2 have been adequately addressed, ITAAC should be established to verify that the normal and accident loads have been appropriately combined with the effects of natural phenomena.
For piping systems, ITAAC should require an analysis to reconcile the as-built piping design with the design-basis loads (which include the appropriate combination of normal and accident loads). See SRP Section 14.3.3 for additional information. For the RPV, the fabrication may be performed primarily in the vendor's shop where adherence to design drawings is tightly controlled. Therefore, ITAAC for the as-built reconciliation of normal loads with accident loads for the RPV are inappropriate. Instead, ITAAC should verify that the ASME Code-required reports exist to document that the RPV has been designed, fabricated, inspected, and tested to Code requirements to ensure adequate safety margin.

Similarly, for safety-related buildings, ITAAC should require an analysis for reconciling the as-built plant with the structural design basis loads (which include the combination of normal and accident loads with the effects of natural phenomena). The analysis results should be documented in a structural analysis report, the scope and contents of which must be described in Tier 2. The staff may determine that the design of certain structures does not require verification by ITAAC, based on their safety significance. In particular, these ITAAC should apply only to safety-related structures and are not applicable to the service and turbine buildings (radwaste and turbine building for PWRs). However, ITAAC for other design aspects of structures may be appropriate.

Seismic Loads

To ensure that the applicable requirements of GDC 2 have been adequately addressed, ITAAC are established to verify that the safety-related systems and structures have been designed to seismic loadings. Component qualification for seismic loads should be addressed by ITAAC for verifying the basic configuration of systems. See the standard ITAAC for basic configuration in Appendix D to SRP Section 14.3 for additional information, and the discussion in SRP Section 14.3.3.

As discussed above for normal loads on piping systems and the RPV, ITAAC should require an analysis to reconcile the as-built piping design with the design basis loads (which include seismic loads). See also the discussion in SRP Section 14.3.3. For the RPV, ITAAC for the as-built reconciliation of seismic loads for the RPV are deemed to be inappropriate as previously discussed. Instead, ITAAC verify that the ASME Code-required reports exist for the RPV ensuring that the RPV has been designed, fabricated, inspected, and tested to ASME Code requirements.

For safety-related buildings, ITAAC require an analysis for reconciling the as-built plant with the structural design-basis loads (which include seismic loads). The analysis results are to be documented in a structural analysis report, as discussed above. These ITAAC apply only to safety-related structures and are not applicable to the service and turbine buildings (radwaste and turbine building for PWRs). However, because the leakage path for fission products includes components within the turbine building, the turbine building is required to withstand the effects of a safe-shutdown earthquake. Therefore, ITAAC should be established to verify that, under seismic loads, the collapse of the turbine building will not impair the safety-related functions of any structures or equipment located adjacent to or within the turbine building.

For non-seismic Category I SSCs, the need for ITAAC to verify that their failure will not impair the ability of near-by safety-related SSCs to perform their safety-related functions should be assessed based on the specific design. If the design detail and as-built and as-procured information for many non-safety-related systems (e.g., field-run piping and balance-of-plant systems) is not provided by the applicant for design certification and the spatial relationship between such systems and seismic Category I SSCs cannot be established until after the as-built design information is available, the non-seismic to seismic (II/I) interaction cannot be evaluated until the plant has been constructed. Accordingly, the design criteria for ensuring acceptable II/I interactions and a commitment for the COL applicant to describe the process for completion of the design of balance-of-plant and non-safety related systems to minimize II/I interactions and proposed procedures for an inspection of the as-built plant for II/I interactions should be specified as a COL action item in Tier 2.

Suppression Pool Hydrodynamic Loads (BWRs only)

To ensure that the applicable requirements of GDC 4 have been adequately addressed, ITAAC should be established to verify that the safety-related systems and structures have been designed to suppression pool hydrodynamic loadings, which include safety relief valve discharge and loss-of-coolant accident (LOCA) loadings. Component qualification for suppression pool hydrodynamic loads may be addressed by ITAAC established for verifying the basic configuration of systems.

As discussed above for seismic loads on piping systems and the RPV, ITAAC should require an analysis to reconcile the as-built piping design with the design- basis loads (which include suppression pool hydrodynamic loads). For the RPV, ITAAC should verify that the ASME Code-required reports exist to ensure that the RPV has been designed, fabricated, inspected, and tested to ASME Code requirements.

For the reactor building and primary containment including the internal structures, ITAAC should require an analysis for reconciling the building as-built configuration with the structural design basis loads (which include suppression pool hydrodynamic loads). The as-built analysis results should be documented in a structural analysis report as discussed above. This report may be able to be satisfied using the ASME Code-required reports for the reconciliation analysis for the primary containment. The effects of suppression pool hydrodynamic loads do not extend beyond the reactor building, and, thus, ITAAC are not required to verify these loadings for the other standard design building structures.

ITAAC also should require the verification of the horizontal vent system, water volume, and the safety-relief valve discharge line quencher arrangement to ensure adequacy of the suppression pool hydrodynamic loads used for design.

Flood, Wind, Tornado, Rain, and Snow

To ensure that the applicable requirements of GDC 2 have been adequately addressed, ITAAC should be established to verify that the safety-related systems and structures have been designed to withstand the effects of natural phenomena other than those associated with seismic loadings. The effects include those associated with flood, wind, tornado, rain, and snow.

These loadings do not apply to the RPV, the ASME Code Class 1, 2, and 3 piping systems and components, nor the primary containment because they are all housed within the safety-related buildings. For safety-related buildings, ITAAC should require an analysis for reconciling the as-built plant with the structural design basis loads (which include the flood, wind, tornado, rain, and snow loads). Based on their safety significance, these ITAAC need apply only to safety-related structures and need not be applicable to the service and turbine buildings (radwaste and turbine building for PWRs).

For flooding, site parameters are specified that require the maximum flood level and ground water level be below the finished plant grade level. ITAACs also require inspections to verify that divisional flood barriers and water-tight doors exist, and penetrations (except for water-tight doors) in the divisional walls are sealed up to the internal and external flood levels. In addition, for safety-related buildings, flood barriers are established up to the finished plant grade level to protect against water seepage, and flood doors and flood barrier penetrations are provided with flood protection features.

ITAAC should also require inspections to verify that water-tight doors exist, penetrations (except for water-tight doors) in the divisional walls are at least 2.5 m above the floor, and safety-related electrical, instrumentation, and control equipment are located at least 20 cm above the floor surface. In addition, for safety-related buildings, ITAAC should require that external walls below flood level are equal to or greater than 0.6 m to protect against water seepage, and penetrations in the external walls below flood level are provided with flood protection features.

Pipe Break

To ensure that the applicable requirements of GDC 4 have been adequately addressed, ITAAC should be established to verify that the safety-related SSCs have been designed to the dynamic effects of pipe breaks. Component qualification for the dynamic effects of pipe breaks should be addressed by ITAAC established for verifying the basic configuration of systems.

For the RPV, ITAAC that verify the basic configuration of the RPV system require an inspection of the critical locations that establish the bounding loads in the LOCA analyses for the RPV to ensure that the as-built areas not exceed the postulated break areas assumed in the LOCA analyses.

In addition, ITAAC should be established to verify by inspections of as-built, high-energy pipe break mitigation features and of the pipe break analysis report that safety-related SSCs be protected against the dynamic and environmental effects associated with postulated high-energy pipe breaks. ITAAC to verify pipe break loads are not required for the turbine, service, and radwaste buildings (turbine and radwaste buildings for PWRs) either because they are not safety-related structures or there are no high-energy lines located within the structure.

Codes and Standards

To ensure that the applicable requirements of GDC 1 have been adequately addressed, ITAAC should be established to verify that appropriate codes and standards are used in the design and construction of safety-related systems and components. In general, the staff considers those codes and standards endorsed by the regulations under 10 CFR 50.55a in determining which codes and standards were appropriate for Tier 1 verification. The ASME Boiler and Pressure Vessel Code, Section III for Code Class 1, 2, and 3 systems and components is established as the code for the design and construction of standard design piping systems and the RPV.

For safety-related building designs, the staff should base its safety findings on audits of standard design calculations which relied on specific codes and standards. These codes and standards are contained in the appropriate sections of DCD Tier 2 Chapter 3.

Inspections will be conducted as a part of ITAAC to verify that ASME Code-required documents exist that demonstrate that the RPV, piping systems and containment pressure boundaries have been designed and constructed to their appropriate Code requirements. For other ASME Code components and equipment, the verification of Code compliance will be performed in conjunction with the quality assurance programs and by the authorized inspection agency as required by the ASME Boiler and Pressure Vessel Code. This DCD Tier 2 material should be considered for designation as Tier 2* information. Tier 2* information is information that, if considered for a change by an applicant or licensee that references the certified standard design, would require NRC approval prior to implementation of the change. Tier 2* material is discussed further in SRP Section 14.3.

As-built Reconciliation

As discussed in various sections above, to ensure that the final as-built plant structures are built in accordance with the certified design as required by 10 CFR Part 52, structural analyses should be performed which reconcile the as-built configuration of the plant structures with the structural design bases of the certified design. The structural analyses should be documented in structural analysis reports. Structural analysis reports should be verified in conjunction with ITAAC for the primary containment and the reactor, control, radwaste, and turbine buildings (nuclear island structures, radwaste building, CCW heat exchangers, DFSSs, and turbine building for PWRs). The detailed supporting information on what is required for an acceptable analysis report should be contained in DCD Tier 2 Chapter 3.

Similarly for piping systems, an as-built analysis should be performed using the as-designed and as-built information. ITAAC should verify the existence of acceptable final as-built piping stress reports that conclude the as-built piping systems are adequately designed. See SRP Section 14.3.3 for additional information.

For the RPV, the key dimensions of the RPV system should be verified in conjunction with the basic configuration check of the system. The key dimensions of the RPV system and the acceptable variations of the key dimensions should be provided in the certified design description. Alternatively, acceptable variations and the bases for them should be provided in Tier 2.

For component qualification, tests, analyses, or a combination of tests and analyses should be performed for seismic Category I mechanical and electrical equipment (including connected instrumentation and controls) to demonstrate that the as-built equipment and associated anchorages are qualified to withstand design basis dynamic loads without loss of safety function. These test and analyses should be performed as a part of ITAAC to verify the basic configuration of the system in which the equipment is located. See Section 14.3.3 for additional information.

III. REVIEW PROCEDURES

1. Follow the general procedures for review of Tier 1 contained in the Review Procedures section of SRP Section 14.3. Ensure that the DCD is consistent with Appendix A to SRP Section 14.3. Review responsibilities may be consistent with those in Appendix B to SRP Section 14.3.

2. Ensure that all Tier 1 information is consistent with Tier 2 information. Figures and diagrams should be reviewed to ensure that they accurately depict the functional arrangement and requirements of the systems, including definitions, general provisions, key dimensions, and legends for figures. Reviewers should use the building structures, fluid systems and electrical systems checklists in Appendix C to SRP Section 14.3 as an aid in establishing consistent and comprehensive treatment of issues.

3. Ensure that the building structures and major components are clearly described in Tier 1, including the key performance characteristics and safety functions of SSCs based on their safety significance.

4. The reviewer should ensure that appropriate guidance is provided to other branches such that structural engineering issues in Tier 1 are treated in a consistent manner among branches.

5. Reviewers should ensure that the review of Tier 1 is coordinated with the ECGB review of site parameters in SRP Section 14.3.1 and piping design in SRP Section 14.3.3.

6. Reviewers should ensure that inputs from the secondary review branches (PERB and SPLB) as discussed in the "Areas of Review" section above are reflected in Tier 1 information. Reviewers should ensure that review interfaces with EELB, SRXB, and SCSB are coordinated as discussed in the "Areas of Review" section above.

IV. EVALUATION FINDINGS

Each review branch verifies that sufficient information has been provided to satisfy the requirements of this SRP section, and concludes that Tier 1 is acceptable. A finding similar to that discussed in the Evaluation Findings section of SRP Section 14.3 should be included in a separate section of the SER.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

This SRP section will be used by the staff when performing safety evaluations of design certification and combined license applications submitted by applicants pursuant to 10 CFR 52. Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

The provisions of this SRP section apply to reviews of applications docketed six months or more after the date of issuance of this SRP section.

VI. REFERENCES

1. 10 CFR Part 50, §50.55a, "Codes and Standards."

2. 10 CFR Part 52, §52.47 "Contents of Applications."

3. 10 CFR Part 52, §52.97 "Issuance of Combined Licenses."

4. 10 CFR Part 50, Appendix A, General Design Criterion 1, "Quality Standards and Records."

5. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for the Protection Against Natural Phenomena."

6. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Dynamic Effects Design Basis."

7. 10 CFR Part 50, Appendix A, General Design Criterion 14, "Reactor Coolant Pressure Boundary."

8. 10 CFR Part 50, Appendix A, General Design Criterion 16, "Containment Design."

9. 10 CFR Part 50, Appendix A, General Design Criterion 50, "Containment Design Basis."

10. NUREG-1503, "Final Safety Evaluation Report Related to the Certification of the Advanced Boiling Water Reactor", Volumes 1 and 2, July 1994.

11. NUREG-1462, "Final Safety Evaluation Report Related to the Certification of the System 80+ Design," Volumes 1 and 2, August 1994.

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SRP Draft Section 14.3.21
Attachment A - Proposed Changes in Order of Occurrence

Item numbers in the following table correspond to superscript numbers in the redline/strikeout copy of the draft SRP section.

Item	Source	Description
1.	**Integrated Impact 1535**	The scope and content of this proposed SRP section is derived from the requirements of 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants," as well as the guidance in staff SECY papers related to design certification and combined license reviews, and the staff positions established in the Final Safety Evaluation Reports (FSERs) for the evolutionary reactor designs.SRP Section 14.3.2 provides guidance specific to the review of plant structural and system engineering design information and related inspections, tests, analyses, and acceptance criteria (ITAAC) provided in applications submitted in accordance with the requirements of 10 CFR 52.

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SRP Draft Section 14.3.21

Attachment B - Cross Reference of Integrated Impacts

Integrated Impact No.	Issue	SRP Subsections Affected
1535	Develop Acceptance Criteria and Review Procedures for review of Certified Design Material (CDM) including associated inspections, tests, analyses and acceptance criteria (ITAAC) for plant structural and system engineering.	All.