U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

14.3.3[1] PIPING SYSTEMS AND COMPONENTS (Tier 1)

REVIEW RESPONSIBILITIES

Primary - Civil Engineering and Geoscience Branch (ECGB)

Secondary - None

I. AREAS OF REVIEW

ECGB reviews the Design Control Document (DCD) submitted by the applicant. Review responsibilities may be consistent with those contained in Appendix B to SRP Section 14.3. ECGB has primary review responsibility for Tier 1 piping design and components and legends for figures. ECGB reviews Tier 1 for issues regarding structural, mechanical, materials, and chemical engineering. In addition, ECGB reviews Tier 1 for treatment of MOVs, POVs, and check valves, as well as dynamic qualification, welding, and safety classification of SSCs.

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 structural aspects of the SSCs of the design in SRP Section 14.3.2.

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

1. The Reactor Systems Branch (SRXB) determines the acceptability of Tier 1 information regarding the arrangement of reactor and core cooling SSCs in SRP Section 14.3.4.

2. The Plant Systems Branch (SPLB) determines the acceptability of Tier 1 information regarding the ability of SSCs to withstand the environmental effects of high-energy line breaks in SRP Section 14.3.7.

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).

Generic Piping Design

Design certification applicants may not provide the complete design information for piping design before design certification because the design may be dependent upon as-built and as-procured information. Instead, applicants may provide the processes and design acceptance criteria (DAC) by which the details of the design in this area would be developed, designed, and evaluated. The implementation of the processes is the responsibility of the COL applicant or licensee. The DAC are discussed further in Appendix A to SRP Section 14.3.

The reviewer should use the SRP guidelines to evaluate the piping design information in Tier 1 and Tier 2, and perform a detailed audit of the piping design criteria, including sample calculations. The staff should evaluate the adequacy of the structural integrity and functional capability of safety-related piping systems. The review is not limited to the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code Class 1, 2, and 3 piping and supports, but includes buried piping, instrumentation lines, the interaction of non-seismic Category I piping with seismic Category I piping, and any safety-related piping designed to industry standards other than the ASME Code. The staff's evaluation should include the analysis methods, design procedures, acceptance criteria, and related ITAAC (and DAC, if applicable) that are to be used for the completion and verification of the standard design piping design. The staff's evaluation should include both Tier 1 and DCD Tier 2 information regarding the applicable codes and standards, analysis methods to be used for completing the piping design, modeling techniques, pipe stress analyses criteria, pipe support design criteria, high-energy line break criteria, and leak-before-break (LBB) approach applicable to the standard design.

Design descriptions and the associated DAC should be specified in Tier 1. The scope of the standard design to which the piping design information applies should be stated in Tier 1. This may be done on a generic basis using a single ITAAC applicable to multiple systems of the design, or applied to individual system ITAAC. If done using a generic piping design ITAAC, the Tier 1 should address its application to piping systems classified as both nuclear safety-related and non-nuclear safety systems. The nuclear safety-related piping systems must remain functional during and following an SSE, and should be designated in Tier 1 as seismic

Category I and further classified as ASME Code Class 1, 2, or 3 in the individual systems of the standard design. Tier 1 should ensure that the piping systems will be designed to perform their safety-related functions under all postulated combinations of normal operating conditions, system operating transients, postulated pipe breaks, and seismic events. The material in Tier 1 should also address the consequential effects of pipe ruptures such as jet impingement, potential missile generation, and pressure and temperature effects.

The scope of the piping to be verified by the generic Piping ITAAC includes all ASME Code Class 1, 2, and 3 piping systems and high-energy piping systems. The ASME Code Class piping systems are included in Tier 1 because the ASME Boiler and Pressure Vessel Code, Section III is referenced in 10 CFR 50.55a. Nuclear power plant components classified as Quality Groups A, B, and C are required by 10 CFR 50.55a to meet the requirements for ASME Code Classes 1, 2, and 3, respectively. In each system description, the functional drawing identifies the boundaries of the ASME Code classification for the piping systems. The piping pressure boundary and structural integrity are required to be maintained because they are directly involved in preventing or mitigating an accident or event under the defense-in-depth principle.

An acceptable approach to Tier 1 information for piping design is to specify distinct ITAAC that ensure the design process for piping systems occurs as described in the design description. For example, the first ITAAC specified in Tier 1 should require that an ASME Code certified stress report exists to ensure that the ASME Code Class 1, 2, or 3 piping systems and components are designed to retain their pressure integrity and functional capability under internal design and operating pressures and design basis loads. The specific contents and requirements of the certified stress report are contained in the ASME Code. The particular certified stress report to be used to satisfy the ITAAC should be specified in Tier 2. An acceptable version of an ASME Code certified stress report is the design document required by ASME Code, Section III, Subarticle NCA-3550. A certified piping stress report provides assurance that requirements of the ASME Code, Section III for design, fabrication, installation, examination, and testing have been met and that the design complies with the design specifications.

A second ITAAC should require that a pipe break analysis report exists that documents that SSCs that are required to be functional during and following an SSE have adequate high-energy pipe break mitigation features. The design description should discuss the criteria used to postulate pipe breaks, the analytical methods used to perform pipe breaks, and the method to confirm the adequacy of the results of the pipe break analyses. The design description should be verified in a Pipe Break Analysis Report that provides assurance that the high-energy line break analyses have been completed. For postulated pipe breaks, the Pipe Break Analysis Report shall confirm that: (1) piping stresses in the containment penetration area shall be within their allowable stress limits, (2) pipe whip restraints and jet shield designs shall be capable of mitigating pipe break loads, (3) loads on safety-related SSCs shall be within their design load limits, and (4) SSCs are protected or are qualified to withstand the environmental effects of postulated failures. The Pipe Break Analysis Report shall conclude that, for each postulated piping failure, the reactor can be shut down safely and maintained in a safe, cold shutdown condition without offsite power. Detailed information that supports this ITAAC should be contained in DCD Tier 2 Chapter 3.

If the design uses Leak-Before-Break (LBB) methods, a third ITAAC should require that a LBB evaluation report exists which documents that LBB acceptance criteria are complied with for the as-built piping and piping materials. Bounding limits should be specified in Tier 2 using preliminary piping analysis results to establish a window of acceptable piping stress values for selected piping materials. The ITAAC verifies that these values are complied with using actual material properties and final piping configurations, and reconciles the as-built piping data with the LBB assumptions. Detailed information that supports this ITAAC should be contained in DCD Tier 2 Chapter 3.

A fourth ITAAC should require that an as-built piping stress report exists that documents the results of an as-built reconciliation analysis confirming that the final piping system has been built in accordance with the ASME Code certified stress report. The report provides an overall verification by inspection that the as-constructed piping system, including supports, are consistent with the certified design commitments. Specific attributes to be inspected should be described in the DCD Tier 2. Although similar to the first ITAAC, this verification also provides assurance that the as-built documentation used for construction has been reconciled with the documentation used for design analysis and with the certified stress report discussed above. The inspection will also involve a review of the as-built, high-energy pipe break mitigation features (e.g., pipe whip restraints and jet impingement shields) to ensure that the installed features are consistent with the pipe break analysis report. The methodology and specific attributes to be inspected are described in the DCD Tier 2. Alternatively, if an NRC-approved leak-before-break report exists, then the dynamic effects from those postulated high-energy pipe breaks could be excluded. The documentation for this as-built reconciliation review may become part of the certified stress report.

Selected material in DCD Tier 2 Chapter 3 provides design information and defines design processes that are acceptable for use in meeting the piping DAC in Tier 1. However, Tier 2 information may be changed by a COL applicant or licensee referencing the certified design in accordance with a "50.59-like" process specified in the rule certifying the design. The staff's evaluation of the standard design for piping systems is based on the design processes and acceptance criteria material in the DAC and Tier 2. Consequently, the staff should consider designating selected aspects of these piping design processes as Tier 2* information. Tier 2* information is Tier 2 information that, if considered for a change by a COL applicant or licensee, requires NRC approval prior to implementation of the change. Consideration should also be given to allowing the designation of Tier 2* to expire at the first full power when the detailed design is complete and performance characteristics of the facility are known. Although applicants for design certification should propose designating similar Tier 2* information to that in the DCDs for the evolutionary designs, the NRC bears the final responsibility for designating which material is Tier 2*. The basis for the use of Tier 2* should be discussed in the staff's safety evaluation report. The Tier 2* information is discussed further in Appendix A to SRP Section 14.3.

Regulations, Codes and Standards - The use of codes and standards in the CDM should be minimized, with exceptions granted on a case-by-case basis. Instead, the applicable requirements from the regulations, codes, or standards should be stated in the CDM, rather than reference them. This ensures that requirement is clear, and allows flexibility if the reference changes. References to various parts of ASME Section III are possible for verification of issues such as pressure boundaries, and references to ASME Section XI for pre-service inspection requirements. Also, references to 10 CFR Part 20 may be required for use in radiation protection. The specific code edition, volume, version, date, etc., should be specified in the SSAR, rather than Tier 1. This provides for specific requirements that are acceptable, yet allows the code to be updated via the change process in the rule certifying the design. It is important to note that, due to the provisions of 10 CFR 52.63 and the rule certifying the design, changes to the codes and standards in 10 CFR 50.55a would not necessarily be requirements for the certified design.

Verifications of Components and Systems

In addition to the generic approach to piping design in Tier 1 described above, the verification of piping and component classification, fabrication, dynamic and seismic qualification, and selected testing and performance requirements are also addressed by specific ITAAC in the individual Tier 1 systems, as discussed below.

PIPING AND COMPONENT SAFETY CLASSIFICATION

General Design Criterion 1 of 10 CFR Part 50, Appendix A requires that SSCs important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. Nuclear power plant components classified as Quality Groups A, B, and C are required by 10 CFR 50.55a to meet the requirements for ASME Code Class 1, 2, and 3, respectively. Therefore, the safety classification of SSCs should be described in each system's design description, and the functional drawings should identify the boundaries of the ASME Code classification that are applicable to the safety class. The ASME Code classes in the ASME Code, Section III, allow a choice of rules that provide assurance of structural integrity and quality commensurate with the relative importance assigned to the individual items of the nuclear power plant. The ASME Boiler and Pressure Vessel Code class requirements may be verified by either a generic piping design ITAAC as described above, or by each system ITAAC. The use of other codes and standards (e.g., AISC Steel Construction Manual for building structural steel) are considered within the Tier 2 scope, and the DCD Tier 2 contains descriptions of the applicable codes and standards for these other safety-related structures, systems, and components that are not designed to the ASME Boiler and Pressure Vessel Code, Section III.

FABRICATION (WELDING)

General Design Criterion 14 of 10 CFR Part 50, Appendix A requires that the reactor coolant pressure boundary be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage. In addition, General Design Criterion 30 requires that components which are part of the reactor coolant pressure boundary be designed, fabricated, erected, and tested to the highest quality standards practical.

The ASME Code class welds are included in Tier 1 because the ASME Boiler and Pressure Vessel Code, Section III is referenced in 10 CFR 50.55a. Nuclear power plant components classified as Quality Groups A, B, and C are required by 10 CFR 50.55a to meet the requirements for ASME Code Classes 1, 2, and 3, respectively. In each system description, the functional drawing identifies the boundaries of the ASME Code classification. The integrity of the pressure boundary is required to be maintained because it is directly involved in preventing or mitigating an accident or event under the defense-in-depth principle. ASME Code Class 1, 2, and 3 structural welds (e.g., pipe support welds) are not included within Tier 1 scope because they were deemed to be indirectly involved in preventing or mitigating an accident or event (e.g., Pipe supports provide protection of the piping; but, it is the piping itself that is needed for accident mitigation). Thus, ASME Code Class 1, 2, and 3 structural welds are included in the Tier 2 scope.

The integrity of the pressure boundary in the plant will be ensured, in part, through a verification of the welding quality. This verification is performed as a part of the basic configuration ITAAC of each specific system. The basic configuration ITAAC is one of the standard ITAAC listed in Appendix D to SRP Section 14.3, is required for most systems in Tier 1. The provisions of the basic configuration check must be specified in Tier 1, and include non-destructive examination (NDE) of the as-built pressure boundary welds for the ASME Code Class 1, 2, and 3 SSCs in the design description.

The acceptance criteria for the welds are the ASME Code, Section III weld examination requirements. The specific weld examination requirements for a particular ASME Code Class 1, 2, and 3 component and weld type are considered Tier 2 and are tabulated in Tier 2. The specific weld examination requirements are considered Tier 2 because they could change depending on future revisions to the ASME Code, Section III requirements.

Other welding activities (non-ASME Code) include:

(1) pressure-boundary welds other than ASME Code, Section III welds,
(2) structural and building steel welds,
(3) electrical cable tray and conduit support welds,
(4) heating, ventilation, and air-conditioning support welds, and
(5) refueling cavity and spent fuel pool liner welds.

These other types of welding are included in the Tier 2 scope. Tier 2 describes the applicable codes and standards for the other types of welding and the weld acceptance criteria. Similar to the ASME Code Class 1, 2, and 3 structural welds, the function of these other welds is needed for protection of safety-related systems, structures, and components but are not directly involved (or are redundant) in preventing an accident or event. Accordingly, these other types of welding were deemed inappropriate for Tier 1 scope.

HYDROSTATIC TEST

The integrity of the pressure boundary is required to be maintained because it is directly involved in preventing or mitigating an accident or event under the defense-in-depth principle. The pressure boundary integrity will also be ensured, in part, through a hydrostatic test verifying

the leak-tightness of the ASME Code piping systems. A hydrostatic test is generally specified by the ASME Code, Section III, for ASME Code Class 1, 2, and 3 SSCs. This test verifies that pressure integrity is maintained in the process of fabricating the overall piping system, including any welding and bolting requirements. However, the ASME piping stress report in the generic piping ITAAC described above does not include the results of hydrostatic tests. Therefore, the standard ITAAC for hydrostatic test in Appendix D to SRP Section 14.3 should be required in each system ITAAC that contains ASME Code class 1, 2, or 3 SSCs. The hydrostatic test ITAAC may also be required in other appropriate Tier 1 systems.

EQUIPMENT SEISMIC AND DYNAMIC QUALIFICATION

The basic configuration ITAAC listed in Appendix D to SRP Section 14.3 includes verifications of the dynamic qualification (e.g., seismic, LOCA, and safety relief valve discharge loads) of seismic Category I mechanical and electrical equipment (including connected instrumentation and controls) described in the design descriptions and figures. This inspection verifies the ability of mechanical and electrical equipment in its as-built condition, including anchorages, to perform their safety functions during and following a safe shutdown earthquake. Detailed supporting information for dynamic qualification requirements, including seismic qualification records, is contained in DCD Tier 2 Chapter 3. The Tier 2 information describing dynamic qualification of equipment should be considered for designation as Tier 2*. Tier 2* information is discussed further in Appendix A to SRP Section 14.3.

MOVs AND OTHER VALVES

The verification of the design qualification of valves is performed in conjunction with the basic configuration check for mechanical equipment as discussed above. For MOVs in particular, a special inspection is required as a part of the basic configuration check to verify the records of vendor tests that demonstrate the ability of MOVs to function under design conditions. The list of MOVs in Tier 1 should include, but is not limited to, those with active safety related functions. These may be listed in Tier 2 in the IST plan or other locations. The material in DCD Tier 2 Chapter 3 should provide detailed supporting information for the CDM regarding the methods to be used by the COL applicant or licensee for the design, qualification, and testing of MOVs to demonstrate their design basis capability. This material should be considered for designation as Tier 2* information. Tier 2* information is discussed further in Appendix A to SRP Section 14.3.

In-situ testing of installed MOVs, power-operated valves, and check valves to verify that they can perform their intended functions under various fluid flow, differential pressure, electrical, and temperature conditions should be conducted as appropriate in the applicable system ITAAC. Standard ITAAC are provided in Appendix D to SRP Section 14.3 for verification of the performance of these valves. These may be performed as part of the pre-operational test program. Tier 2 information should be provided that defines that these tests will be conducted under maximum achievable pre-operational conditions and describes the analyses that will be performed to show how the test results demonstrate that the valves will function under design basis conditions (See Tier 2 Section 3.9.6). Since significant operating problems with other types of valves, or with pumps in general, the proper operation of these components may be

implicitly tested, if applicable, as part of other functional tests in the system ITAAC. They may also be tested in the pre-operational or power ascension test program.

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, and all important SSCs are treated appropriately. Reviewers should use the Review Checklists in Appendix C to SRP Section 14.3 as an aid in establishing consistent and comprehensive treatment of issues.

3. Ensure that Tier 1 clearly delineates the important aspects of piping design, specifies its applicability to the standard design, and establishes appropriate acceptance criteria. ASME code classification, safety classification, and seismic classification of the piping systems should be clearly indicated on the figures, or described in the design descriptions. These should be consistent with DCD Tier 2 Section 3.2. Ensure that system boundaries and interfaces are indicated clearly in Tier 1, and that the figures are in accordance with the legends.

4. The reviewer should ensure that appropriate guidance is provided to other branches such that piping design issues in Tier 1 are treated in a consistent manner among branches, especially applicable standard ITAAC and piping issues for figures.

5. Ensure that standard ITAAC entries in Appendix D to SRP Section 14.3 related to piping systems and components are included where appropriate in the systems of the standard design, in particular, the basic configuration ITAAC (for dynamic qualification of SSCs and welding), hydrostatic test ITAAC, MOV ITAAC, POV ITAAC, and check valve ITAAC. Ensure adequate supporting information is in Tier 2, generally Chapter 3 and the initial test program in Section 14.2.

6. Ensure that design features from the resolutions of selected policy and technical issues are adequately addressed in Tier 1, based on safety significance. Ensure that the appropriate Commission guidance, requirements, bases and resolutions for these items are documented clearly in the SER.

7. Ensure that any Tier 2* information is clearly designated in Tier 2, and consider expiration of these items at first full power, if appropriate. The staff's basis for designating the information as Tier 2* and the rationale for its decision that it requires prior NRC approval to change should be specified in the SER (See also the discussion in Appendix A to SRP Section 14.3).

8. Ensure appropriate interface with the secondary review branches listed in the "Areas of Review" section above (SPLB and SRXB).

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. In addition, if DAC are used, a separate finding on the DAC should be included in 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 14, "Reactor Coolant Pressure Boundary."

6. 10 CFR Part 50, Appendix A, General Design Criterion 30, "Quality of Reactor Coolant Pressure Boundary."

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

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

9. SECY-92-196, "Development of Design Acceptance Criteria (DAC) for the Advanced Boiling Water Reactor (ABWR)," dated May 28, 1992.

SRP Draft Section 14.3.31
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 1536**	The scope and content of this proposed SRP section is derived from the requirements of 10CFRPart 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 14.3.3 provides guidance specific to the review of plant piping system and component design information and related inspections, tests, analyses, and acceptance criteria (ITAAC) provided in applications submitted in accordance with the requirements of 10CFR52.

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Integrated Impact No.	Issue	SRP Subsections Affected
1536	Develop Acceptance Criteria and Review Procedures for review of Certified Design Material (CDM) including associated inspections, tests, analyses and acceptance criteria (ITAAC) for plant piping and system components.	All