U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

3.12 ASME CODE CLASS 1, 2, AND 3 PIPING SYSTEMS, PIPING COMPONENTS AND THEIR ASSOCIATED SUPPORTS

REVIEW RESPONSIBILITIES

Primary - Organization responsible for mechanical engineering reviews

Secondary - None

I. AREAS OF REVIEW

The reviewer evaluates the information presented in the applicant's Safety Analysis Report (SAR) concerning the design and analyses of piping systems. The design of piping systems should include Seismic Category I, Category II, and nonsafety systems.

1. The specific areas of review for piping systems and support design are divided into four subheadings:

A. Piping Analysis Methods. The information presented in the SAR concerning the piping analysis methods for Seismic Category I, Category II, and nonsafety systems is reviewed. In addition to the guidance in this SRP section, the areas of review for seismic system analysis provided in SRP Section 3.9.2 are to be used as guidance for reviewing the seismic loading portions of the piping analysis methods.

The specific areas of review are:

i. Experimental Stress Analysis Methods

ii. Modal Response Spectrum Method

iii. Response Spectra Method-Independent Support Motion Method

iv. Time History Method

v. Inelastic Analysis Method

vi. Small Bore Piping Method

vii. Nonseismic/Seismic Interaction (II/I)

viii. Category I Buried Piping.

B. Piping Modeling Techniques

The information presented in the SAR related to criteria and procedures for the modeling of piping systems and piping supports is reviewed. The areas of review for modeling, provided in SRP Section 3.9.2 are to be used as guidance for reviewing piping modeling techniques.

The description and verification of all computer programs used for the analysis of Seismic Category I piping designated as Code Class 1, 2, and 3 and non-Code items are reviewed. The areas of review provided in SRP Section 3.9.1 are to be used as guidance for reviewing computer codes.

The specific areas of review are:

i. Computer Codes

ii. Dynamic Piping Model

iii. Piping Benchmark Program

iv. Decoupling Criteria

C. Piping Stress Analyses Criteria

The information presented in the SAR related to piping stress analyses criteria are reviewed. The areas of review for piping stress analyses criteria provided in SRP Sections 3.9.1, 3.9.2, 3.9.3 are used as guidance.

The specific areas of review are:

i. Seismic Input

ii. Design Transients

iii. Loadings and Load Combinations

iv. Damping Values

v. Combination of Modal Responses

vi. High-Frequency Modes

vii. Fatigue Evaluation for American Society of Mechanical Engineers (ASME) Code Class 1 Piping

viii. Fatigue Evaluation of ASME Code Class 2 and 3 Piping

ix. Thermal Oscillations in Piping Connected to the Reactor Coolant System (RCS)

x. Thermal Stratification

xi. Safety Relief Valve Design, Installation, and Testing

xii. Functional Capability

xiii. Combination of Inertial and Seismic Anchor Motion (SAM) Effects

xiv. Operating Basis Earthquake as a Design Load

xv. Welded Attachments

xvi. Modal Damping for Composite Structures

xvii. Temperature for Thermal Analyses

xviii. Intersystem Loss-of-Coolant-Accident (LOCA)

xix. Effects of Environment on Fatigue Design

D. Piping Support Design

The information presented in the SAR related to piping support design methods, procedures and criteria is reviewed. The areas of review for piping support design provided in SRP Section 3.9.3 are used as guidance. The specific areas of review are:

i. Applicable Codes

ii. Jurisdictional Boundaries

iii. Loads and Load Combinations

iv. Pipe Support Baseplate and Anchor Bolt Design

v. Use of Energy Absorbers and Limit Stops

vi. Use of Snubbers

vii. Pipe Support Stiffness

viii. Seismic Self-Weight Excitation

ix. Design of Supplementary Steel

x. Consideration of Friction Forces

xi. Pipe Support Gaps and Clearances

xii. Instrumentation Line Support Criteria

xiii. Pipe Deflection Limits

xiv. Clamp-induced Local Pipe Stress Evaluation

2. Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC). For DC and combined license (COL) reviews, the staff reviews the applicant's proposed ITAAC associated with the structures, systems, and components (SSCs) related to this SRP section in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this SRP section. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.

3. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action items and requirements and restrictions (e.g., interface requirements and site parameters).

For a COL application referencing a DC, a COL applicant must address COL action items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

Review Interfaces

Other SRP sections interface with this section as follows:

1. Evaluation Seismic System Analysis is performed under SRP Section 3.7.2.

2. Evaluation of the seismic cyclic ground input loading and the seismic cyclic loading used for fatigue analysis for components and supports is performed under SRP Section 3.7.3.

3. Evaluation of the seismic design loading for Seismic Category I structures is performed under SRP Sections 3.8.1-3.8.5.

4. Verification of the adequacy of the computer programs used in the analyses is performed under SRP Section 3.9.1.

5 Verification of the dynamic testing and analysis of systems, components, and equipment is performed under SRP Section 3.9.2.

6. Evaluation of the adequacy of the design of ASME Code, Class 1, 2, and 3 components, component supports, and core support structures is performed under SRP Section 3.9.3.

7. Evaluation of the design criteria for pressure-relieving devices, operability of pumps, and valves that have an active function during and after a faulted plant condition is performed under SRP Section 3.10.

8. Verification of the adequacy of the program for the integrity of bolting and threaded fasteners is performed under SRP Section 3.13.

9. Verification of the Compliance with the Codes and Standards Rule Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a is performed under SRP Section 5.2.1.

10. Evaluation of the number and size of valves specified for the reactor coolant pressure boundary (RCPB) and their pressure-relieving capacity is performed under SRP Section 5.2.2.

11. Evaluation of the design of systems and components that interface with the RCS with regard to intersystem LOCA is performed under SRP Sections 5.4.7 and 6.3.

12. Evaluation of the process used to minimize the degradation of materials due to corrosion is based upon the environmental conditions to which equipment will be exposed. This review is performed under SRP Section 6.1.1.

13. Verification of the adequacy of the analyses of subcompartment differential pressures resulting from postulated pipe breaks is performed under SRP Section 6.2.1.2.

14. Verification that the number and size of valves specified for the steam and feedwater systems have adequate pressure-relieving capacity is performed under SRP Section 10.3.

The specific acceptance criteria and review procedures are contained in the referenced SRP sections.

II. ACCEPTANCE CRITERIA

Requirements

Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations:

1. 10 CFR 50.55a and General Design Criterion (GDC) 1 as they relate to piping systems, pipe supports, and components being designed, fabricated, erected, constructed, tested, and inspected to quality standards commensurate with the importance of the safety function to be performed.

2. GDC 2 and 10 CFR Part 50, Appendix S with regard to design transients and resulting load combinations for piping and pipe supports necessary to withstand the effects of earthquakes combined with the effects of normal or accident conditions.

3. GDC 4, with regard to piping systems and pipe supports important to safety, being designed to accommodate the effects of, and to be compatible with, the environmental conditions of normal as well as postulated events, such as LOCA and dynamic effects.

4. GDC 14, with regard to the RCPB of the primary piping systems being designed, fabricated, constructed, and tested to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture.

5. GDC 15, with regard to the RCSs and associated auxiliary, control, and protection systems shall be designed with sufficient margin to assure that the design condition of the RCPB are not exceeded during any condition of normal operation, including anticipated operational occurrences.

6. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the DC is built and will operate in accordance with the DC, the provisions of the Atomic Energy Act (AEA), and the U.S. Nuclear Regulatory Commission (NRC) regulations;

7. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee

shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the combined license, the provisions of the AEA, and the NRC regulations.

SRP Acceptance Criteria

Specific SRP acceptance criteria acceptable to meet the relevant requirements of the NRC regulations identified above are as follows for the review described in this SRP section. The SRP is not a substitute for the NRC regulations, and compliance with it is not required. However, an applicant for a light-water cooled reactor is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the SRP acceptance criteria and evaluate how the proposed alternatives to the SRP acceptance criteria provide acceptable methods of compliance with the NRC regulations.

A. Piping Analysis Methods

i. Experimental Stress Analysis Methods

If experimental stress analysis methods are used in lieu of analytical methods for Seismic Category I ASME Code and non-Code piping system designs, the applicant should provide sufficient information to show the validity of the design. It is recommended, prior to use of the experimental stress analysis methods, that details of the method as well as the scope and extent of its application, be submitted for approval. The experimental stress analysis methods provided in Appendix II to ASME Code, Section III, Division 1 are applicable.

ii. Modal Response Spectrum Method

The SRP acceptance criteria provided in SRP Section 3.9.2, Subsection II.2.A(i) are applicable.

iii. Response Spectra Method - Independent Support Motion Method

This method may be used in lieu of the response spectra method when there is more than one supporting structure. The acceptance criteria provided in Section 2, “Staff Recommendations on Response Combinations,” of NUREG-1061, Volume 4, “Report of the U.S. Nuclear Regulatory Commission Piping Committee” are applicable.

iv. Time History Method

The SRP acceptance criteria provided in SRP Section 3.7.2, Subsection II.6 are applicable.

v. Inelastic Analysis Method

If inelastic analysis methods are used for the piping design, the applicant will provide sufficient information to show the validity of the analysis. It is recommended, prior to use of the inelastic analysis method that details of the method, as well as the scope and extent of its application and acceptance criteria, be submitted for approval. The inelastic analysis methods provided in SRP Section 3.9.1, Subsection II.4 are applicable.

vi. Small Bore Piping Method

The SRP acceptance criteria provided in SRP Section 3.9.2, Subsection II.2.A are applicable.

vii. Nonseismic/Seismic Interaction (II/I)

The acceptance criteria provided in Section 3.9.2, Subsection II.2.K are applicable.

viii. Category I Buried Piping

The acceptance criteria provided in SRP Section 3.7.3, Subsection II.12 are applicable.

B. Piping Modeling Techniques

i. Computer Codes

The acceptance criteria provided in SRP Section 3.9.1, Subsection II.2 are applicable.

ii. Dynamic Piping Model

The acceptance criteria provided in SRP Section 3.9.2, Subsection II.2 are applicable.

iii. Piping Benchmark Program

The computer programs are benchmarked with the appropriate NRC benchmarks. The acceptance criteria provided in SRP 3.9.1, Subsection II.2 are applicable.

iv. Decoupling Criteria

The acceptance criteria provided in SRP Section 3.7.2, Subsection II.3.B are applicable.

C. Piping Stress Analysis Criteria

i. Seismic Input

The acceptance criteria provided in SRP Section 3.7.2 Subsection II.5 are applicable.

ii. Design Transients

The acceptance criteria provided in SRP Section 3.9.1, Subsection II.1 are applicable.

iii. Loadings and Load Combinations

The acceptance criteria provided in SRP Section 3.9.3, Subsection II.1 are applicable.

iv. Damping Values

The acceptance criteria provided in SRP Section 3.9.2, Subsection II.2.L are applicable.

v. Combination of Modal Responses

The acceptance criteria provided in SRP Section 3.9.2, Subsection II.2.E are applicable.

vi. High-Frequency Modes

The acceptance criteria provided in SRP Section 3.9.3, Subsection II.2 are applicable.

vii. Fatigue Evaluation for ASME Code Class 1 Piping

The acceptance criteria in Section III of the ASME Code are applicable. RG 1.207, "Guidelines for Evaluating Fatigue Analyses Incorporating the Life Reduction of Metal Components due to the Effects of the Light-water Reactor Environment for New Reactors," provides guidance for use in determining the acceptable fatigue life of ASME Class 1 piping, with consideration of the light-water reactor (LWR) environment.

viii. Fatigue Evaluation of ASME Code Class 2 and 3 Piping

The acceptance criteria provided in Section III of the ASME Code are applicable.

ix. <u>Thermal Oscillations in Piping Connected to the RCS</u>

As described in NRC Bulletin (BL) 88-08, the applicant should identify and evaluate any connected, unisolable piping that could be subjected to temperature stratification or oscillation. If the design is susceptible to such stratification or oscillation, the application should describe a program meeting the criteria in BL 88-08 to provide continuing assurance that this piping will not be subjected to unacceptable thermal stresses.

x. <u>Thermal Stratification</u>

BL 79-13 identified the potential for cracks from thermal fatigue in pressurized water reactor feedwater lines, generally induced by stresses from thermal stratification during cold, low-flow feedwater injections. The applicant should identify whether the feedwater system design is susceptible to this cracking. If the design is susceptible, the application should describe a program for performing the inspections noted in BL 79-13, Revision 2, as applicable to designated applicants for operating licensees.

BL 88-11 identified the potential for stresses induced by thermal stratification in the pressurizer surge line. The applicant should demonstrate that fatigue and stresses associated with thermal stratification and thermal striping have been considered in the piping analyses that demonstrate compliance with applicable code limits. In addition, the applicant should describe a monitoring program to verify that the extent of thermal stratification, thermal striping, and piping deflections remain consistent with the design and results in no adverse consequences..

xi. <u>Safety Relief Valve Design, Installation, and Testing</u>

The acceptance criteria provided in SRP Section 3.9.3, Subsection II.2 are applicable.

xii. <u>Functional Capability</u>

The acceptance criteria provided in NUREG-1367, “Functional Capability of Piping Systems,” may be used to ensure piping functionality under level D loading conditions. Alternative criteria will be reviewed on a case by case basis.

xiii. <u>Combination of Inertial and SAM Effects</u>

The acceptance criteria provided in SRP Section 3.9.2, Subsection II.2.G are applicable for enveloped support motion analysis. The acceptance criteria provided in Section 2 “Staff Recommendations on Response Combinations” of NUREG-1061, Volume 4 are applicable for independent support motion analysis.

xiv. Operating Basis Earthquake as a Design Load

In SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs," dated April 2, 1993, the staff discussed eliminating the operating-basis earthquake (OBE) from the design bases when the OBE is established at less than or equal to one third of the safe-shutdown earthquake (SSE). In the associated Staff Requirements Memorandum (SRM) dated July 21, 1993, the Commission approved the staff's recommendations associated with eliminating the OBE in piping and support analyses.

An example of the implementation of this Commission policy is provided in NUREG-1503, "Final Safety Evaluation Report Related to the Certification of the Advanced Boiling Water Reactor Design," Section 3.1.1.2.

Appendix S to 10 CFR Part 50, "Earthquake Engineering Criteria for Nuclear Power Plants," first issued in 1996 and revised in 2007, implements Commission policy related to the use of OBE ground motion for applications submitted after January 10, 1997. If the OBE is defined as greater than one-third of the SSE, paragraph IV.(a)(2) requires analysis and design to demonstrate that SSCs remain functional and within applicable stress, strain, and deformation limits. Loads from the OBE, therefore, would be included in the piping stress analysis. If the OBE is defined as one-third or less of the SSE, explicit response or design analyses are not required.

xv. Welded Attachments

Support members, connections, or attachments welded to piping should be designed such that their failure under unanticipated loads does not cause failure at the pipe pressure boundary. The applicant may use Code Cases for the design of the welded attachments. Acceptable Code Cases are listed in RG 1.84.

xvi. Modal Damping for Composite Structures

The acceptance criteria provided in SRP Section 3.7.2, Subsection II.13 are applicable.

xvii. Temperature for Thermal Analyses

The stress-free reference temperature for a piping system should be defined as 70°F. For piping systems that operate at temperatures above 70°F, a thermal expansion analysis should be performed in accordance with ASME Section III. If thermal expansion analyses are not performed for such systems (i.e., a higher stress-free reference temperature is selected), the applicant should justify the higher temperature. The justification will be reviewed on a case by case basis to confirm that this higher temperature is suitable for the piping configuration, design support loads, piping displacement, etc..

xviii. Intersystem LOCA

In SECY-90-016, “Evolutionary Light Water Reactor (LWR) Certification Issues and Their Relationship to Current Regulatory Requirements,” dated January 2, 1990, the NRC staff presented positions on intersystem LOCA for evolutionary LWRs that the Commission approved in the associated SRM dated June 26, 1990 (and later for passive plants in the SRM on SECY-93-087). To the extent practicable, low-pressure systems should be designed to withstand full RCS pressure. Meeting this acceptance criterion provides assurance that over pressurization of low-pressure piping systems due to RCPB isolation failure will not result in rupture of the low-pressure piping outside containment.

xix. Effects of Environment on Fatigue Design

The guidance provided in RG 1.207 is applicable.

D. Piping Support Design

The piping system supports must provide adequate margins of safety to maintain the functionality of the piping components under all combinations of loadings.

i. Applicable Codes

The design of ASME Code, Section III, Class 1, 2, and 3, piping supports should comply with the design criteria requirements of ASME Code, Section III, Subsection NF.

ii. Jurisdictional Boundaries

The jurisdictional boundaries between pipe supports and interface attachment points should comply with ASME Code, Section III, Subsection NF.

iii. Loads and Load Combinations

The criteria provided in SRP Section 3.9.3, Subsection II.1 are applicable.

iv. Pipe Support Baseplate and Anchor Bolt Design

The design of the pipe support baseplates and anchor bolts should comply with guidance provided in NRC BL 79-02, Revision 2.

v. Use of Energy Absorbers and Limit Stops

Piping systems that use energy absorbers and limit stops should be analyzed with methods specific to the design of these components. The evaluation typically consists of iterative response spectra analyses of the piping and support system. The analyses will be reviewed on a case by case basis to ensure the response of the specific devices is addressed.

vi. Use of Snubbers

The acceptance criteria provided in SRP Section 3.9.3, Subsection II.3 are applicable.

vii. Pipe Support Stiffness

The acceptance criteria provided in SRP Section 3.9.3, Subsection II.3 are applicable.

viii. Seismic Self-Weight Excitation

The acceptance criteria provided in SRP Section 3.9.2, Subsection II.2.A, are applicable for evaluating loads caused by the seismic excitation of the pipe support.

ix. Design of Supplementary Steel

The design of structural steel for use as pipe supports should comply with the ASME Code, Section III, Subsection NF.

x. Consideration of Friction Forces

The design of sliding type supports, such as guides or box supports, should include evaluation of the friction loads induced by the pipe on the support (e.g., during thermal expansion of the piping). The applicant should provide the friction coefficients used in the evaluation.

xi. Pipe Support Gaps and Clearances

Small gaps are generally provided for frame type supports. The gap allows for radial thermal expansion of the pipe and for pipe rotation. This gap must account for the diametrical expansion of the pipe due to temperature and pressure. The acceptance criteria for the gap and clearance size (total of opposing sides) between the pipe and the support will be reviewed on a case by case basis depending on the specific pipe diameter, temperature, and pressure in the design, as well as expected piping displacement. For example, large-diameter piping systems may justify a 0.125-inch gap, but smaller-diameter piping systems will need smaller gaps to provide adequate support.

xii. Instrumentation Line Support Criteria

The acceptance criteria provided in ASME Code, Section III, Subsection NF are applicable.

xiii. Pipe Deflection Limits

The allowable deflections of the piping at support locations resulting from design loadings should be controlled to ensure that the pipe deflections do not cause the failure of the supports. This criteria applies to following type of pipe supports: limit stops, snubbers, rods, hangers, and sway struts. In the analysis of the support, the applicant should confirm that the loading on the support is within an acceptable range based on the manufacturer's design limits for the specific support.

xiv. Clamp-induced Local Pipe Stress Evaluation

If stiff pipe clamps of the type identified in Information Notice (IN) 83-80 and Generic Safety Issue (GSI) 89 (as described in NUREG-0933, "Resolution of Generic Safety Issues") are used in the design, the clamp design should be evaluated to ensure that the local pipe stresses induced by the clamp are included in the combination of stresses in the piping analysis.

Technical Rationale

The technical rationale for application of these acceptance criteria to the areas of review addressed by this SRP section is discussed in the following paragraphs:

1. 10 CFR 50.55a and GDC 1 require that SSCs be designed, fabricated, constructed, tested, and inspected to quality standards commensurate with the importance of the safety function to be performed.

   SRP Section 3.12 provides guidance for the staff's review of loading conditions, stresses, and stress limits for the piping systems, piping components and their associated supports. Loading conditions and stress limits are described in this SRP section, and ASME Code, Section III, Division 1, Subsection NF. SRP Section 3.12 also provides guidance for the staff's review of interfacing issues such as design specifications, mechanical properties, and testing, as appropriate. SRP Section 3.9.3 provides related guidance on component supports as well as the installation of pressure relief devices. The guidance cites the provisions of the ASME Code to compute stresses and stress limits, and complies with GDC 1 and 10 CFR 50.55a.

   Meeting the requirements of 10 CFR 50.55a and GDC 1 provides assurance that piping systems, piping components, and their associated supports important to safety are capable of performing their intended functions.

2. Compliance with GDC 2 requires that SSCs important to safety be designed to withstand the effects of expected natural phenomena combined with the appropriate effects of normal and accident conditions, without loss of capability to perform their safety functions.

   SRP Section 3.12 provides guidance for the staff's review of loading combinations, stresses and stress limits for the piping systems, piping components and their associated supports connected to systems to ensure the functionality of subject components and structures which are important to safety. These loading combinations include consideration of the effects of expected natural phenomena combined with the appropriate effects of normal and accident conditions. The stresses and stress limits (computed in accordance with the Code) are evaluated to ensure that equipment is designed to withstand these conditions without loss of capability to perform their intended functions. This guidance is designed to comply with GDC 2.

   Meeting the requirements of GDC 2 provides assurance that piping systems, piping components and associated supports are designed to withstand the effects of expected natural phenomena combined with the appropriate effects of normal and accident conditions, without loss of capability to perform their safety functions.

3. Compliance with GDC 4 requires that the nuclear power plant SSCs important to safety be designed to accommodate the effects of and be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including LOCA. SRP Section 3.12 provides guidance for the staff's review of the piping systems, piping components and their associated supports connected to systems to ensure the functionality of subject components and structures which are important to safety. This guidance includes consideration of loading effects and the resulting stresses (computed in accordance with the Code) associated with normal operation, maintenance, testing, and postulated accidents, including LOCA. This guidance is designed to comply with GDC 4.

   Meeting the requirements of GDC 4 provides assurance that piping systems, piping components and their associated supports and structures important to safety are capable of performing their intended safety functions.

4. Compliance with GDC 14 requires that the RCPB be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage, rapidly propagating failure, and gross rupture.

   SRP Section 3.12 provides guidance for the staff's review of ASME Code Class 1 piping systems, piping components and their associated supports connected to systems to ensure the functionality of components and component supports. This guidance cites the requirements of the Code to compute stresses and stress limits that are based on the loads and load combinations described in the SRP section. Meeting these requirements provides assurance that piping systems connected to components that are part of the RCPB will be designed so as to have an extremely low probability of abnormal leakage, rapidly propagating failure, and gross rupture. This guidance is designed to comply with GDC 14.

Meeting the requirements of GDC 14 provides assurance that piping systems that are connected to components that are part of the RCPB are capable of performing their intended safety functions.

5. Compliance with GDC 15 requires that the RCS be designed with sufficient margin to ensure that the design conditions of the RCPB are not exceeded during any condition of normal operation, including anticipated operational occurrences.

   SRP Section 3.12 provides guidance for the staff's review of the design and analysis of ASME Class 1 piping systems and associated supports connected to RCS components. This guidance cites the requirements of the ASME Code used to compute stresses and stress limits that are based on the loads and load combinations described in this SRP section. Meeting these requirements provides additional assurance that piping systems and associated supports (connected to components that are part of the RCS) will remain functional with sufficient margins of safety to ensure that the design conditions of piping systems and their associated supports connected to RCPB components are not exceeded during any condition of normal operation, including anticipated operational occurrences. This guidance is designed to comply with GDC 15.

   Meeting the requirements of 10 CFR Part 50, Appendix A, GDC 15 provides assurance that the piping systems will remain functional under all postulated design condition and ensures that RCPB components are capable of performing its intended safety function.

III. REVIEW PROCEDURES

The reviewer will select material from the procedures described below, as may be appropriate for a particular case.

These review procedures are based on the identified SRP acceptance criteria. For deviations from these acceptance criteria, the staff should review the applicant’s evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

The piping systems, piping components and their associated supports connected to components, must provide adequate margins of safety to maintain the functionality of components under all combinations of loadings.

A. Piping Analysis Methods

i. Experimental Stress Analysis methods

Review the procedures, details of the method and the scope and extent of experimental stress analysis. Review the validity of the design if the method is used in lieu of analytical methods for Seismic Category I, ASME Code and non-Code piping system designs. The experimental stress analysis method should comply with ASME Code, Section III, Division 1, Appendix II.

ii. Modal Response Spectra Method

Follow the review procedures provided in SRP Section *3.9.2, Subsection III.2.

iii. Response Spectra Method-Independent Support Motion Method
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Review the applicable criteria for independent support motion method of analysis (i.e., response spectra) for all Category I piping systems and supports to ensure that the criteria used for the analysis is consistent with the acceptance criteria given in Section 2, "Staff Recommendations on Response Combinations," of NUREG-1061, Volume 4.

iv. Time History Method

Follow the review procedures provided in SRP Section 3.9.2, Subsection III.2.

v. Inelastic Analyses Method

Follow the review procedures provided in SRP Section 3.9.1, Subsection III.4.

vi. Small Bore Piping Method

Follow the review procedures provided in SRP Section 3.9.2, Subsection III.2.

vii. Nonseismic/**Seismic Interaction (II/I)

Follow the review procedures provided in SRP Section 3.9.2, Subsection III.2.K.

viii. Category I Buried Piping

Follow the review procedures provided in SRP Section 3.7.3, Subsection III.12.

B. Piping Modeling Technique

i. Computer Codes

Follow the review procedures provided in SRP Section 3.9.1, Subsection III.2.

ii. Dynamic Piping Model

Follow the review procedures provided in SRP Section 3.9.2, Subsection III.2.

iii. Piping Benchmark Program

Under the benchmark program NRC staff constructed a series of piping systems mathematical models, which are representative of typical piping designs. These models were used as an input to computer stress analysis programs. These models were analyzed using approved dynamic analysis methods and representative loads. The results obtained by the applicant's analysis (using its own computer program) are compared with NRC's results.

For each benchmark problem, modal frequencies, maximum pipe moments, maximum support loads, maximum equipment nozzle loads, and maximum deflections should meet the range of acceptable values specified in the NRC benchmark program.

iv. Decoupling Criteria

Review the analyses of the piping systems that provide support to other piping systems. In developing mathematical models for the analyses, the reviewer should limit the size of the model by decoupling small branch lines from larger run lines. For cases where smaller piping is supported by larger piping, there are two methods to evaluate this condition. Either a coupled dynamic model of the entire piping system is performed or the piping system is assumed to be broken up into two parts with the input from the larger piping system used to analyze the smaller piping system. The acceptance criteria provided in SRP 3.7.2 Subsection II.3.B is applicable.

C. Piping Stress Analyses Criteria

i. Seismic Input

Follow the review procedures provided in SRP Section 3.9.2, Subsection III.2.

ii. Design Transients

Follow the review procedures provided in SRP Section 3.9.1, Subsection III.1.

iii. Loading and Load Combination

Follow the review procedures provided in SRP Section 3.9.3, Subsection III.1.

iv. Damping Values

Follow the review procedures provided in SRP Section 3.9.2, Subsection III.2.

v. Combination of Modal Responses

Follow the review procedures provided in SRP Section 3.9.2, Subsection III.2.

vi. High-Frequency Modes

Follow the review procedures provided in SRP Section 3.9.2, Subsection III.2.

vii. Fatigue Evaluation for ASME Code Class 1 Piping

Follow the review procedures provided in SRP Section 3.9.3, Subsection III.1.

viii. Fatigue Evaluation for ASME Code Class 2 and 3 Piping

Follow the review procedures provided in SRP Section 3.9.3, Subsection III.1.

ix. Thermal Oscillations in Piping Connected to the RCS

Review the procedures to account for piping systems susceptible to thermal oscillations, cycling, and striping. Also review the development and implementation of a program to provide continued assurance of integrity of piping systems. This program should address thermal oscillations, cycling, and striping of the piping system and should address the recommendations of NRC BL 88-08.

x. Thermal Stratification

Review the procedures to account for piping systems susceptible to thermal stratification. Also review the development and implementation of a program to provide continued assurance of integrity of susceptible piping systems. This program should address the recommendations of NRC BL 79-13 and BL 88-11.

xi. Safety Relief Valve Design, Installation, and Testing

Follow the review procedures provided in SRP Section 3.9.3, Subsection III.2.

xii. Functional Capability

Follow the review procedures provided in SRP Section 3.9.3, Subsection III.1(C)

xiii. Combination of Inertial and SAM Effects

Review the piping design to ensure that when piping is supported at multiple locations within a single structure or is attached to separate structures, the piping analysis includes the effects of relative building movements at supports and anchors (seismic anchor motion), as well as the effects of seismic inertial loads. The acceptance criteria provided in SRP Section 3.9.2, Subsection II.2.G are applicable. As an alternative, the acceptance criteria provided in Section 2, "Staff recommendations on Response Combinations," of NUREG-1061, Volume 4 may be used.

xiv. OBE as a Design Load

Review the design criteria used to address earthquake cycles and seismic anchor motions associated with the single earthquake design. 10 CFR Part 50, Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," allows the use of OBE ground motion. The acceptance criteria in SRP Section 3.9.2, Subsection II.3 are applicable.

xv. Welded Attachments

Review the design, criteria and procedures used for the support members, connections, or attachments welded to piping to ensure compliance with the ASME Code. Acceptable Code Cases are listed in RG 1.84.

xvi. Modal Damping for Composite Structures

Review the procedure and analysis to account for damping in different elements of the model of a coupled system. The acceptance criteria of SRP Section 3.7.2, Subsection II.13 are applicable.

xvii. Temperature for Thermal Analyses

Review the criteria used to determine whether thermal analyses of the piping systems are required. The applicant should provide the technical basis for the criteria.

xviii. Intersystem LOCA

Review the design features of the low pressure piping system to ensure that the low pressure piping systems that interface with RCPB is designed to withstand the full RCS pressure.

xix. Effects of Environment on Fatigue Design

Review the design criteria for the fatigue analyses of the piping system components to verify that the effects of the environment on the fatigue design of the piping systems have been addressed. The guidance provided in RG 1.207 is applicable.

D. Piping Support Design

i. Applicable Codes

Follow the review procedures provided in SRP Section 3.9.3, Subsection III.1.

ii. Jurisdictional Boundaries

Review the jurisdictional boundaries between pipe supports and interface attachment points to ensure compliance with requirements of ASME Code, Section III, Subsection NF.

iii. Loads and Load Combinations

Follow the review procedures provided in SRP Section 3.9.3, Subsection III.1.

iv. Pipe Support Baseplate and Anchor Bolt Design

Review the design of the pipe support baseplates to ensure consistency with NRC BL 79-02, Revision 2.

v. Use of Energy Absorbers and Limit Stops

Review the design of the energy absorbers and limit stops to ensure that the design criteria have an adequate technical basis.

vi. Use of Snubbers

Review the design criteria, analytical considerations, modeling techniques, operational and performance testing and maintenance standards for snubbers used as a piping support. The objective of the review is to ensure that the SAR contains adequate discussions and commitments to address the criteria specified in SRP 3.9.3, Subsection II.3.B.

vii. Pipe Support Stiffness

Follow the review procedures provided in SRP Section 3.9.3, Subsection III.3.

viii. Seismic Self-Weight Excitation

Review the procedure used to evaluate the mass of the pipe supports and miscellaneous steel as a self-weight excitation loading on the steel and the structures supporting the steel to verify that these loads have been addressed.

ix. Design of Supplementary Steel

Review the procedure used for the design of supplementary structural steel to verify the design is in accordance with the provisions of ASME Code, Section III, Subsection NF.

x. Consideration of Friction Forces

Review the procedure used in the analysis of sliding type supports to consider friction loads induced by the pipe on the supports. Review the coefficients of friction used in the evaluation to ensure that these are reasonable values commonly used in the nuclear industry.

xi. Pipe Support Gaps and Clearances

Review the procedure used to assess the design for the minimum gap (total of opposing sides) between the pipe and the support to verify that the temperature and pressure of the pipe have been adequately addressed.

xii. Instrumentation Line Support Criteria

Follow the review procedures provided in SRP Section 3.9.3, Subsection III.3.

xiii. Pipe Deflection Limits

Review the procedure to determine allowable deflections of the piping at support locations for static and dynamic loading to verify that the applicant has an adequate technical basis for the criteria.

xiv. Clamp-induced Local Pipe Stress Evaluation

Review the procedure to ensure that interface design procedures are used to control the flow of design information from the support design group (which has the responsibility for the design of stiff clamps) to the pipe stress analysis group and local pipe stresses induced by stiff pipe clamps or straps under all loading conditions are evaluated to address generic safety issue 89 as delineated in NUREG-0933.

5. For review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the Final Safety Analysis Report (FSAR) meets the acceptance criteria. DCs have referred to the FSAR as the design control document. The reviewer should also consider the appropriateness of identified COL action items. The reviewer may identify additional COL action items; however, to ensure these COL action items are addressed during a COL application, they should be added to the DC FSAR.

   For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an early site permit or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

   For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support conclusions of the following type to be included in the staff's SER. The reviewer also states the bases for those conclusions.

The staff should conclude that the specified design and service combinations of loadings as applied to ASME Code Class 1, 2, and 3 piping systems are acceptable and meet the requirements of 10 CFR 50.55a and GDC 1, 2, 4, 14, and 15. This conclusion is based on the following.

The applicant has proposed quality assurance programs to correlate the test measurements with the analysis results. The programs constitute an acceptable basis for demonstrating the compatibility of the results from tests and analyses, through consistency between mathematical models used for different loadings, and the validity of the interpretation of the test and analysis results. The applicant has therefore met the relevant requirements of GDC 1 with respect to piping systems being designed and tested to quality standards commensurate with the importance of the safety functions to be performed.

The applicant has met the criteria with respect to the design and analyses of systems and components important to safety. These are designed to withstand the effects of earthquakes and the appropriate combinations of the effects of normal and postulated accident conditions with the effects of the safe shutdown earthquake, and therefore meet the requirements of GDC 2 and GDC 4.

The applicant has met the relevant requirements of GDC 2 and 4 and 10 CFR Part 50, Appendix S, by including seismic events in design transients which serve as design basis to withstand the effects of natural phenomena.

The applicant has met the criteria with respect to the design of the RCPB by ensuring that there is a low probability of rapidly propagating failure, gross rupture and that design conditions are not exceeded during normal operation, including anticipated operational occurrences. The applicant has provided an acceptable vibration, thermal expansion, and dynamic effects test program which will be conducted during startup and initial operation on specified high-and moderate-energy piping, and all associated systems, restraints and supports and therefore has met the relevant requirements of GDC 14 and 15.

The applicant met the requirements of 10 CFR 50.55a and GDC 1, 2, 4, 14, and 15 with respect to piping systems important to safety and these systems are designed to quality standards commensurate with the importance of the safety function to be performed.

For DC and COL reviews, the findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this SRP section.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

V. IMPLEMENTATION

The staff will use this SRP section in performing safety evaluations of DC applications and license applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52. Except when the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.

The provisions of this SRP section apply to reviews of applications submitted six months or more after the date of issuance of this SRP section, unless superseded by a later revision. .

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants":

   A. GDC 1, "Quality standards and records";

   B. GDC 2, "Design bases for protection against natural phenomena";

C. GDC 4, "Environmental and missile design bases";

D. GDC 14, "Reactor coolant pressure boundary"; and

E. GDC 15, "Reactor coolant system design."

2. 10 CFR Part 52, “Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants.”

3. Appendix A to SRP Section 3.9.3, "Stress Limits for ASME Class 1, 2, and 3 Components and Component Supports, of Safety-Related Systems and Core Support Structures Under Specified Service Loading Combinations."

4. ASCE Standard 4-86, "Seismic Analysis of Safety-Related Nuclear Structures and Commentary on Standard for Seismic Analysis of Safety-Related Nuclear Structures," American Society of Civil Engineers, September 1986.

5. ASME Boiler and Pressure Vessel Code, Section III, Division 1, Appendix O, "Rules for the Design of Safety Valve Installations.” American Society of Mechanical Engineers

6. ASME Boiler and Pressure Vessel Code, Section III, Division 1, "Nuclear Power Plant Components," American Society of Mechanical Engineers.

7. ASME Boiler and Pressure Vessel Code, Section III, "Rules for Construction of Nuclear Power Plant Components," Division 1, Appendix N, "Dynamic Analysis Methods," American Society of Mechanical Engineers.

8. NRC Bulletin 88-08, “Thermal Stresses in Piping Connected to Reactor Coolant Systems.”

9. NRC Bulletin 88-11, "Pressurizer Surge Line Thermal Stratification,” December 20, 1988.

10. NRC Information Notice No. 83-80, Use of Specialized “Stiff” Pipe Clamps

11. NUREG-0484, "Methodology for Combining Dynamic Loads."

12. NUREG-0609, "Asymmetric Blowdown Loads on PWR Primary Systems."

13. NUREG-1367, "Functional Capability of Piping Systems.”

14. NUREG/CR-5416, "Technical Evaluation of Generic Issue 113: Dynamic Qualification and Testing of Large Bore Hydraulic Snubbers," Nitzel, M. E.; Ware, A. G. EG&G Idaho, Inc.; Page, J. D. NRC; September 1992 (EGG-2571).109.

15. NUREG/CR-1161D. W. Coats, "Recommended Revisions to Nuclear Regulatory Commission Seismic Design Criteria,"

16. NUREG/CR3074 "Application of Reduction Methods to Nuclear Power Plant Structures."

17. NUREG-0933, Resolution of Generic Safety Issues (Formerly entitled “A Prioritization of Generic Safety Issues”)

18. RG 1.124, "Design Limits and Loading Combinations for Class 1 Linear-Type Component Supports."

19. RG 1.130, "Design Limits and Loading Combinations for Class 1 Plate-and Shell-Type Component Supports."

20. RG 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants."

21. RG 1.84, "Design and Fabrication Code Case Acceptability, ASME Section III, Division 1."

22. RG 1.92, "Combining Modal Responses and Spatial Components in Seismic Response Analysis."

23. RG 1.122, "Development of Floor Design Response Spectra for Seismic Design of Floor-Supported Equipment or Components."

24. RG 1.207, “Guidelines for Evaluating Fatigue Analyses Incorporating the Life Reduction of Metal Components Due to the Effects of the Light-Water Reactor Environment for New Reactors.”

25. SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs," April 2, 1993; SRM-93-087 issued on July 21, 1993.

26. SRP Section 3.2.1, "Seismic Classification.”

27. SRP Section 3.2.2, "System Quality Group Classification.”

28. SRP Section 3.7.1, "Seismic Design Parameters.”

29. SRP Section 3.7.2, "Seismic System Analysis.”

30. SRP Section 3.7.3, "Seismic Subsystem Analysis.”

31. SRP Section 3.9.1, "Special Topics for Mechanical Components.”

32. SRP Section 3.9.2, "Dynamic Testing and Analysis of Systems, Components, and Equipment.”

33. SRP Section 3.9.3, "ASME Code Class 1, 2 and 3 Components, Component Supports, and Core Support Structures.”

34. SRP Section 3.10, "Seismic and Dynamic Qualification of Mechanical and Electrical Equipment Important to Safety.”

PAPERWORK REDUCTION ACT STATEMENT

The information collections contained in the Standard Review Plan are covered by the requirements of 10 CFR Part 50 and 10 CFR Part 52, and were approved by the Office of Management and Budget, approval number 3150-0011 and 3150-0151.

PUBLIC PROTECTION NOTIFICATION

The NRC may not conduct or sponsor, and a person is not required to respond to, a request for information or an information collection requirement unless the requesting document displays a currently valid OMB control number.

SRP SECTION 3.12
Description of Changes

Section 3.12 "ASME CODE CLASS 1, 2, AND 3 PIPING SYSTEMS, PIPING COMPONENTS AND THEIR ASSOCIATED SUPPORTS"

This SRP section affirms the technical accuracy and adequacy of the guidance previously provided in Section 3.12 Original Issue, dated March 2007 of this SRP. See the Agencywide Documents Access and Management System (ADAMS) Accession No. ML070040002.

These sections have been updated to reflect the requirements of "Resolution of Generic Safety Issues: Issue 89, Stiff Pipe Clamps" (GI-89), located in ADAMS Accession No. ML101720320, and RG 1.207, "Guidelines for Evaluating Fatigue Analyses Incorporating the Life Reduction of Metal Components due to the Effects of the Light-water Reactor Environment for New Reactors" (RG 1.207), located in ADAMS, Accession No. ML070380586.

Technical changes incorporated in this revision include:

I. <u>AREAS OF REVIEW</u>

1. The specific review of conduits and tunnels were removed from the list of Piping Analysis Methods.

2. As per the requirements of GI-89, Clamp-induced Local Pipe Stress Evaluation was added as a review area under Piping Support Design.

II. <u>ACCEPTANCE CRITERIA</u>

1. Additional specifics were added to references provided throughout the SRP Acceptance Criteria section.

2. As per the requirements of GI-89, Clamp-induced Local Pipe Stress Evaluation was added as acceptance criteria under Piping Support Design.

III. <u>REVIEW PROCEDURES</u>

1. The specific review of conduits and tunnels were removed from the list of Piping Analysis Methods.

2. Additional specifics were added to references provided throughout the section.

3. Acceptance criteria provided in SRP 3.7.2 was added as decoupling criteria in the Piping Modeling Technique section.

4. As per the requirements of GI-89, Clamp-induced Local Pipe Stress Evaluation was added to the review procedure under Piping Support Design.

IV. REFERENCES

1. Two references were added to support the requirements of GI-89, which were added throughout.