Nuclear Operating Company

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October 8, 2009
U7-C-STP-NRC-090169

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
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South Texas Project
Units 3 and 4
Docket Nos. 52-012 and 52-013
Response to Request for Additional Information

Attached is the supplemental response to the NRC staff question included in Request for Additional Information (RAI) letter number 152 related to Combined License Application (COLA) Part 2, Tier 2, Section 3.9. The Attachment provides a Reviewers Guide that describes the Pre-Service Testing (PST) and In-Service Testing (IST) Programs. The Reviewers Guide also describes key provisions of testing related to functional qualification of ASME Code active components, e.g., pumps, valves and dynamic restraints (snubbers). The supplemental information completes the response to RAI 03.09.06-1, identified in letter U7-C-STP-NRC-090097, dated August 17, 2009.

The Reviewer's Guide is organized into three sections; Dynamic Testing and Analysis (Section 3.9.2), Pump and Valve Operability Assurance (Section 3.9.3.2), and Testing of Pumps and Valves (Section 3.9.6). The PST/IST Program description was developed utilizing various sections of the ABWR DCD and the STP Units 3 and 4 COLA. The information from these documents was consolidated into a Reviewers Guide to facilitate review of the entire PST/IST Programs. The attached Reviewers Guide provides a format, in plain text, of DCD and COLA information. Various edits (underlined additions or strikeout deletions) to denote changes to the COLA and provides supplemental information to fully describe the PST/IST Programs.

Changes to the COLA will be incorporated in the next routine revision of the COLA following the NRC acceptance of the RAI response.

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STI 32548854

There are no commitments in this letter.

If you have any questions, please contact me at (361) 972-7136, or Bill Mookhoek at (361) 972-7274.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 10/8/09

Scott Head
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jep

Attachment: RAI 03.09.06-1, Supplement 1

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STP Units 3 and 4

Reviewer's Guide for Pre-Service Testing (PST)/In-Service Testing (IST) Programs

The Reviewers Guide provides a format, in plain text, of the ABWR DCD and STP Units 3 and 4 COLA information. Edits to this information are provided by underlined additions or strikeout deletions to denote changes/supplemental information. These changes will be incorporated in the next routine revision of the COLA following NRC acceptance of the RAI response.

3.9.2 Dynamic Testing and Analysis

Systems, components, and equipment retain their structural and functional integrity when subjected to dynamic loads that can occur during normal operation, plant transients, and external events, such as earthquakes. This is confirmed through type tests, analyses and startup testing, which verify that the systems, components, and equipment meet the regulatory requirements for the dynamic loads that are postulated to occur during both normal plant operations and transient conditions. This section describes the general startup functional tests and the vibration and dynamic analyses to be performed on specified high-energy and moderate-energy piping and the associated piping supports and restraints, and on reactor internals to verify they meet structural and functional requirements. Section 14.2 contains test abstracts that describe in general terms the planned tests that will be performed. Section 14.2 also describes the programmatic controls that will be used to develop the individual startup tests. The individual startup tests will contain review and acceptance criteria imposed by the detailed design.

The tests, inspections, and analyses described in this section comply with the following regulations:

- GDC 1 and 10 CFR 50.55a require that systems and components important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions performed. In addition, 10 CFR 50, Appendix B addresses the issue of QA as it applies to the dynamic testing and analysis of systems, structures, and components (SSC). The vibration, thermal expansion, and dynamic effects test programs for startup functional testing of high-energy and moderate-energy piping and their supports and restraints described in this section comply with this approved QA program. Dynamic analyses methods are described in this section for Seismic Category 1 systems, components, equipment, and their supports (including supports for conduit and cable trays and ventilation ducts).
- GDC 2 requires that systems and components important to safety be designed to withstand the effects of expected natural phenomena, combined with effects of normal and accident conditions, without losing the ability to perform their safety functions. In addition, 10 CFR 50, Appendix S requires systems and components important to safety withstand certain vibratory ground motions associated with design basis earthquakes. This section describes vibration testing programs for safety-related systems and components and presents dynamic analysis methods for Seismic Category I systems, components, equipment, and their supports. These tests, analyses, and comparisons are in accordance with sound engineering practices and demonstrate that these systems and components are designed to withstand natural phenomena in combination with normal and accident conditions.
- GDC 4 requires that the nuclear power plant systems and components important to safety be designed to accommodate the effects of and be compatible with the environmental conditions of normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents (LOCAs). The test programs described herein and in Section 14.2 verify the ability of components and systems to withstand the temperatures, pressures, vibrations, and thermal expansions associated with normal plant operation and maintenance as well as the transient conditions arising from anticipated operational events, such as valve and pump actuations.

Testing and analysis to confirm that the safety-related systems and components will withstand anticipated loads are described in this section, Section 3.6.2, Section 3.9.3.2, and in Appendix 3C.

- GDC 14 requires that the reactor coolant pressure boundary (RCPB) be designed, fabricated, erected, and tested to have an extremely low probability of abnormal leakage, rapidly propagating failure, or gross rupture. Dynamic testing of RCPB components is performed to demonstrate that they will withstand the applicable design-basis seismic and dynamic loads, in combination with other environmental and natural phenomena loads, without leakage, rapidly propagating failure, or gross rupture.
- GDC 15 requires that the reactor coolant system 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. The RCPB is designed to resist seismic, LOCA, and other appropriate environmental loads individually and in combination. Dynamic analyses are described to confirm the structural design adequacy of the RCPB. Vibration, thermal expansion, and dynamic effects testing are also described to verify the design.
- The requirements of GDCs 1, 2, 4, 14, and 15 are also satisfied through vibration, thermal expansion, and dynamic effects testing conducted during startup functional testing for high- and moderate-energy piping and their supports and restraints. The purposes of these tests are to confirm that the piping, components, restraints, and supports have been designed to withstand the dynamic loadings and operational transient conditions encountered during service and to confirm that no unacceptable restraint of normal thermal motion occurs.

3.9.2.1 Piping Vibration, Thermal Expansion, and Dynamic Effects

The overall test program is divided into two phases: the preoperational test phase and the initial startup test phase. Piping vibration, thermal expansion and dynamic effects testing will be performed during both of these phases, as described in Chapter 14. Subsections 14.2.12.1.51, 14.2.12.2.10 and 14.2.12.2.11 relate the specific role of this testing to the overall test program. Discussed below are the general requirements for this testing. It should be noted that, because one goal of the dynamic effects testing is to verify the adequacy of the piping support system, such components are addressed in the subsections that follow. However, the more specific requirements of the design and testing of the piping support system are described in Subsection 3.9.3.4.1.

3.9.2.1.1 Vibration and Dynamic Effects Testing

The purpose of these tests is to confirm that the piping, components, restraints and supports of specified high- and moderate-energy systems have been designed to withstand the dynamic effects of steady-state flow-induced vibration (FIV) and anticipated operational transient conditions. The general requirements for vibration and dynamic effects testing of piping systems are specified in Regulatory Guide 1.68, "Preoperational and Initial Startup Test Programs for Water-Cooled Power Reactors". More specific vibration testing requirements are defined in ~~ANSI/~~ASME OM~~3~~-S/G-2007, Standards and Guides for Operation and Maintenance of Nuclear Power Plants, Part 3, "Requirements for Preoperational and Initial Startup Vibration Testing of Nuclear Power Plant Piping Systems". Preparation of detailed test specifications will be in full accordance with this standard and will address such issues as prerequisites, test conditions, precautions, measurement techniques, monitoring requirements, test hold points and acceptance criteria. The development and specification of the types of measurements required, the systems and locations to be monitored, the test acceptance criteria, and the corrective actions that may be necessary are discussed in more detail below.

3.9.2.1.1.1 Measurement Techniques

There are essentially three methods available for determining the acceptability of steady state and transient vibration for the affected systems. These three measurement techniques are (1) visual observation, (2) local measurements, or (3) remotely monitored/recorded measurements. The technique used in each case will depend on such factors as (1) the safety significance of the particular system, (2) the expected mode and/or magnitude of the vibration, (3) the accssessability of the system during designated testing conditions, or (4) the need for a time history recording of the vibratory behavior. Typically, the systems where vibration has the greatest safety implication will be subject to more rigorous testing and precise instrumentation requirements and, therefore, will require remote monitoring techniques. Local measurement techniques, such as the use of a hand-held vibrometer, are more appropriate in cases where it is expected that the vibration will be less complex and of lesseor magnitude. Many systems that are accssessable during the preoperational test phase and that do not show significant intersystem interactions will fall into this category. Visual observations are utilized where vibration is expected to be minimal and the need for a time history record of transient behavior is not anticipated. However, unexpected visual observations or local indications may require that a more sophisticated technique be used. Also, the issue of accssessability should be considered. Application of these measurement techniques is detailed in the appropriate testing specification consistent with the guidelines contained in ANSI/ASME OM3-S/G-2007, Standards and Guides for Operation and Maintenance of Nuclear Power Plants, Part 3.

3.9.2.1.1.2 Monitoring Requirements

As described in Subsections 14.2.12.1.51, 14.2.12.2.10 and 14.2.12.2.11, all safety-related piping systems will be subjected to steady-state and transient vibration measurements. The scope of such testing shall include safety-related instrumentation piping and attached small-bore piping (branch piping). Special attention should be given to piping attached to pumps, compressors, and other rotating or reciprocating equipment. Monitoring location selection considerations should include the proximity of isolation valves, pressure or flow control valves, flow orifices, distribution headers, pumps and other elements where shock or high turbulence may be of concern. Location and orientation of instrumentation and/or measurements will be detailed in the appropriate test specification. Monitored data should include actual deflections and frequencies as well as related system operating conditions. The time duration of data recording should be sufficient to indicate whether the vibration is continuous or transient. Steady-state monitoring should be performed at critical conditions such as minimum or maximum flow, or abnormal combinations or configurations of system pumps or valves. Transient monitoring should include anticipated system and total plant operational transients where critical piping or components are expected to show significant response. Steady-state conditions and transient events to be monitored will be detailed in the appropriate testing specifications consistent with

~~OM3~~-ASME S/G-2007, Standards and Guides for Operation and Maintenance of Nuclear Power Plants, Part 3 guidelines.

3.9.2.1.1.3 Test Evaluation and Acceptance Criteria

The piping response to test conditions shall be considered acceptable if the review of the test results indicates that the piping responds in a manner consistent with predictions of the stress report and/or that piping stresses are within ASME Code Section III (NB-3600) limits. Acceptable limits are determined after the completion of piping systems stress analysis and are provided in the piping test specifications.

To ensure test data integrity and test safety, criteria have been established to facilitate assessment of the test while it is in progress. For steady-state and transient vibration, the pertinent acceptance criteria are usually expressed in terms of maximum allowable displacement/deflection. Visual observation should only be used to confirm the absence of significant levels of vibration and not to determine acceptability of any potentially excessive vibration. Therefore, in some cases, other measurement techniques will be required with appropriate quantitative acceptance criteria.

There are typically two levels of acceptance criteria for allowable vibration displacements/deflections. Level I criteria are bounding type criteria associated with safety limits, while Level 2 criteria are stricter criteria associated with system or component expectations. For steady-state vibration, the Level 1 criteria are based on the endurance limit (68.6 MPaG) to assure no failure from fatigue over the life of the plant. The corresponding Level 2 criteria are based on one half the endurance limit (34.3 MPaG). For transient vibration, the Level 1 criteria are based on either the ASME Code Section III upset primary stress limit or the applicable snubber load capacity. Level 2 criteria are based on a given tolerance about the expected deflection value.

3.9.2.1.1.4 Reconciliation and Corrective Actions

During the course of the tests, the remote measurements will be regularly checked to verify compliance with acceptance criteria. If trends indicate that criteria may be violated, the measurements should be monitored at more frequent intervals. The test will be held or terminated as soon as criteria are violated. As soon as possible after the test hold or termination, appropriate investigative and corrective actions will be taken. If practicable, a walkdown of the piping and suspension system should be made in an attempt to identify potential obstructions or improperly operating suspension components. Hangers and snubbers should be positioned such that they can accommodate the expected deflections without bottoming out or extending fully. All signs of damage to piping supports or anchors shall be investigated.

Instrumentation indicating criteria failure shall be checked for proper operation and calibration, including comparison with other instrumentation located in the proximity of the excessive vibration. The assumptions used in the calculations that generated the applicable limits should be verified against actual conditions and discrepancies noted should be accounted for in the criteria limits. This may require a reanalysis at actual system conditions.

Should the investigation of instrumentation and calculations fail to reconcile the criteria violations, physical corrective actions may be required, including (1) identification and reduction or elimination of offending forcing functions, (2) detuning of resonant piping spans by appropriate modifications, (3) addition of bracing, or (4) changes in operating procedures to avoid troublesome conditions. Any such modifications will require retest to verify vibrations have been sufficiently reduced.

3.9.2.1.2 Thermal Expansion Testing

A thermal expansion preoperational and startup testing program performed through the use of visual observation and remote sensors has been established to verify that normal unrestrained thermal movement occurs in specified safety-related high- and moderate-energy piping systems. The purpose of this program is to ensure the following:

(1) The piping system during system heatup and cooldown is free to expand and move without unplanned obstruction or restraint in the x, y, and z directions.

(2) The piping system does shakedown after a few thermal expansion cycles.

(3) The piping system is working in a manner consistent with the assumption of the stress analysis.

(4) There is adequate agreement between calculated values and measured values of displacements.

(5) There is consistency and repeatability in thermal displacements during heatup and cooldown of the systems.

The general requirements for thermal expansion testing of piping systems are specified in Regulatory Guide 1.68, "Preoperational and Initial Startup Testing Programs for Water-Cooled Power Reactors." More specific requirements are defined in ~~ANSI/~~ASME OM~~7~~-S/G-2007, Standards and Guides for Operation and Maintenance of Nuclear Power Plants, Part 7, "Requirements for Thermal Expansion Testing of Nuclear Power Plant Piping Systems." Detailed test specifications will be prepared in full accordance with this standard and will address such issues as prerequisites, test conditions, precautions, measurement techniques, monitoring requirements, test hold points, and acceptance criteria. The development and specification of the types of measurements required, the systems and locations to be monitored, the test acceptance criteria, and the corrective actions that may be necessary are discussed in more detail below.

3.9.2.1.2.1 Measurement Techniques

Verification of acceptable thermal expansion of specified piping systems can be accomplished by several methods. One method is to physically walkdown the piping system and verify by visual observation that free thermal movement is unrestrained. This might include verification that piping supports such as snubbers and spring hangers are not fully extended or bottomed out and that the piping (including branch lines and instrument lines) and its insulation is not in hard contact with other piping or support structures. Another method would involve local measurements, using a hand-held scale or ruler, against a fixed reference or by recording the position of a snubber or spring can. A more precise method would be using permanent or temporary instrumentation that directly measures displacement, such as a lanyard potentiometer, that can be monitored via a remote indicator or recording device. The technique to be used will depend on such factors as the amount of movement predicted and the acc~~ss~~essability of the piping.

Measurement of piping temperature is also of importance when evaluating thermal expansion. This may be accomplished either indirectly via the temperature of the process fluid or by direct measurement of the piping wall temperature, and such measurements may be obtained either locally or remotely. The choice of technique used shall depend on such considerations as the accuracy required and the a<u>cc</u>~~ss~~essability of the piping.

3.9.2.1.2.2 Monitoring Requirements

As described in Subsections 14.2.12.1.51 and 14.2.12.2.10, all safety-related piping shall be included in the thermal expansion testing program. Thermal expansion of specified piping systems should be measured at both the cold and hot extremes of their expected operating conditions. Physical walkdowns and recording of hanger and snubber positions should also be conducted where possible considering a<u>cc</u>~~ss~~essability and local environmental and radiological conditions in the hot and cold states. Displacements and appropriate piping/process temperatures shall be recorded for those systems and conditions specified. Sufficient time shall have passed before taking such measurements to ensure the piping system is at a steady-state condition. In selecting locations for monitoring piping response, consideration shall be given to the maximum responses predicted by the piping analysis. Specific consideration should also be given to the first run of pipe attached to component nozzles and pipe adjacent to structures requiring a controlled gap.

3.9.2.1.2.3 Test Evaluation and Acceptance Criteria

To ensure test data integrity and test safety, criteria have been established to facilitate assessment of the test while it is in progress. Limits of thermal expansion displacements are established prior to start of piping testing to which the actual measured displacements are compared to determine acceptability of the actual motion. If the measured displacement does not vary from the acceptance limit values by more than the specified tolerance, the piping system is responding in a manner consistent with the predictions and is therefore acceptable. The piping response to test conditions shall be considered acceptable if the review of the test results indicates that the piping responds in a manner consistent with the predictions of the stress report and/or that piping stresses are within ASME Code Section III (NB-3600) limits. Acceptable thermal expansion limits are determined after the completion of piping systems stress analysis and are provided in the piping test specifications. Level 1 criteria are bounding criteria based on ASME Code Section III stress limits. Level 2 criteria are stricter criteria based on the predicted movements using the calculated deflections plus a selected tolerance.

3.9.2.1.2.4 Reconciliation and Corrective Actions

During the course of the tests, the remote measurements will be regularly checked to verify compliance with acceptance criteria. If trends indicate that criteria may be violated, the measurements should be monitored at more frequent intervals. The test will be held or terminated as soon as criteria are violated. As soon as possible after the test hold termination, appropriate investigative and corrective actions will be taken. If practicable, a walkdown of the affected piping and suspension system should be made in an attempt to identify potential obstruction to free piping movement. Hangers and snubbers should be positioned within their expected cold and hot settings. All signs of damage to piping or supports shall be investigated.

Instrumentation indicating criteria failure shall be checked for proper operation and calibration, including comparison with other instrumentation located in the proximity of the out-of-bounds movement. Assumptions, such as piping temperature, used in the calculations that generated the applicable limits should be compared with actual test conditions. Discrepancies noted should be accounted for in the criteria limits, including possible reanalysis.

Should the investigation of instrumentation and calculations fail to reconcile the criteria violations or should the visual inspection reveal an unintended restraint, physical corrective actions may be required. This might include (1) complete or partial removal of an interfering structure, (2) replacing, readjusting or repositioning piping system supports, (3) modifying the pipe routing, or (4) modifying system operating procedures to avoid the temperature conditions that resulted in the unacceptable thermal expansion.

3.9.2.1.3 Thermal Stratification in Feedwater Piping

This special test is part of the startup program to monitor the conditions and effects of temperature stratification that may exist during certain operating conditions in:

(1) The feedwater piping header inside and outside the containment.

(2) The short horizontal runs of the riser piping inside the containment where feedwater enters the vessel nozzles.

Stratification in the feedwater piping can occur during plant startup when hot CUW is added to the cold feedwater line. The hot CUW flows on top of the colder water in the feedwater line and does not mix with the cold water until mixing of the two streams occurs at the outer swing check isolation valve. Stratification for this condition can thus affect only the feedwater piping outside containment.

A second condition of plant operation which can cause stratification in the feedwater piping is when the plant is in hot standby condition following a scram. After a scram, the temperature of the entire feedwater line is hot when cold water is introduced to make up for decay heat boiloff in the RPV. The colder water flows along the bottom of the large diameter horizontal feedwater pipe at low flow rate, creating stratification. The temperature difference between the top and bottom of the pipe will decrease along the pipe in the direction of flow, but stratification could still exist in the feedwater piping inside the containment, since the swing check valves are not effective in mixing the cold water flowing along the bottom of the pipe.

The test program will consist of measurement of:

(1) Temperature around the circumference of the feedwater pipe at various locations inside and outside the containment.

(2) Strains at points of highest stress inside the containment.

(3) Measurements of pipe displacements and movements inside and outside the containment due to pipe bowing because of stratification.

This test will be performed in accordance with the general requirements of Regulatory Guide 1.68 and the more specific requirements in ~~ANSI/~~ASME OM~~7~~-S/G-2007, Standards and Guides for Operation and Maintenance of Nuclear Power Plants, Part 7. Detailed test procedures will be prepared in accordance with these documents. The development and specifications of the types of measurements required, the systems and locations to be monitored, the test acceptance criteria, and the corrective actions that may be necessary are discussed in Subsection 3.9.2.1.2.

The feedwater thermal stratification test is not required if the applicant can show that a test performed at a previous plant meets the requirements of this paragraph and is applicable to this plant.

3.9.2.2 Seismic Qualification of Safety-Related Mechanical Equipment (Including Other RBV Induced Loads)

This subsection describes the criteria for dynamic qualification of safety-related mechanical equipment and associated supports, and also describes the qualification testing and/or analyses applicable to the major components on a component-by-component basis. Seismic and other events that may induce Reactor Building Vibration (RBV) are considered (Appendix 3B). In some cases, a module or assembly consisting of mechanical and electrical equipment is qualified as a unit (e.g., ECCS pumps). These modules are generally discussed in this subsection and Subsection 3.9.3.2, rather than providing discussion of the separate electrical parts in Section 3.10. Electrical supporting equipment such as control consoles, cabinets, and panels are discussed in Section 3.10.

3.9.2.2.1 Tests and Analysis Criteria and Methods

The ability of equipment to perform its safety function during and after the application of a dynamic load is demonstrated by tests and/or analysis. The analysis is performed in accordance with Section 3.7. Selection of testing, analysis, or a combination of the two, is determined by the type, size, shape, and complexity of the equipment being considered. When practical, the equipment operability is demonstrated by testing. Otherwise, operability is demonstrated by mathematical analysis.

Equipment which is large, simple, and/or consumes large amounts of power is usually qualified by analysis or static bend test to show that the loads, stresses and deflections are less than the allowable maximum. Analysis and/or static bend testing is also used to show that there are no natural frequencies below 33 Hz for seismic loads and 60 Hz for other RBV loads. (The 60 Hz frequency cutoff for dynamic analysis of suppression pool dynamic loads is the minimum requirement based on a generic Reference 3.9-8, using the missing strain energy method, performed for representative BWR equipment under high-frequency input loadings.) If a natural frequency lower than 33 Hz in the case of seismic loads and 60 Hz in the case of other RBV-induced loads is discovered, dynamic tests and/or mathematical analyses may be used to verify operability and structural integrity at the required dynamic input conditions.

When the equipment is qualified by dynamic test, the response spectrum or time history of the attachment point is used in determining input motion. (See Section 3.10)

Natural frequency may be determined by running a continuous sweep frequency search using a sinusoidal steady-state input of low magnitude. Dynamic load conditions are simulated by testing using random vibration input or single frequency input (within equipment capability) over the frequency range of interest. Whichever method is used, the input amplitude during testing envelopes the actual input amplitude expected during the dynamic loading condition. (See Section 3.10)

The equipment being dynamically tested is mounted on a fixture which simulates the intended service mounting and causes no dynamic coupling to the equipment. (See Section 3.10)

Equipment having an extended structure, such as a valve operator, may be analyzed by applying static equivalent dynamic loads at the center of gravity of the extended structure. In cases where the equipment structural complexity makes mathematical analysis impractical, a combination of testing and analysis in accordance with IEEE-344 is used to determine operational capability at maximum equivalent dynamic load conditions.

3.9.2.2.1.1 Random Vibration Input

When random vibration input is used, the actual input motion envelopes the appropriate floor input motion at the individual modes. However, single frequency input such as sine beats can be used, provided one of the following conditions are met:

(1) The characteristics of the required input motion are dominated by one frequency.

(2) The anticipated response of the equipment is adequately represented by one mode.

(3) The input has sufficient intensity and duration to excite all modes to the required magnitude so that the testing response spectra will envelop the corresponding response spectra of the individual modes.

3.9.2.2.1.2 Application of Input Modes

When dynamic tests are performed, the input motion is applied to one vertical and one horizontal axis simultaneously. However, if the equipment response along the vertical direction is not sensitive to the vibratory motion along the horizontal direction and vice versa, then the input motion is applied to one direction at a time. In the case of single frequency input, the time phasing of the inputs in the vertical and horizontal directions are such that a purely rectilinear resultant input is avoided.

3.9.2.2.1.3 Fixture Design

The fixture design simulates the actual service mounting and causes no dynamic coupling to the equipment.

3.9.2.2.1.4 Prototype Testing

Equipment testing is conducted on prototypes of the equipment to be installed in the plant.

3.9.2.2.2 Qualification of Safety-Related Mechanical Equipment

The following subsections discuss the testing or analytical qualification of the safety-related major mechanical equipment and other ASME Code Section III equipment, including equipment supports.

3.9.2.2.2.1 CRD and CRD Housing

(This Subsection is not pertinent to the discussion of pumps, valves and dynamic restraints and is not included as part of reviewers guide.)

3.9.2.2.2.2 Core Support (Fuel Support and CR Guide Tube)

(This Subsection is not pertinent to the discussion of pumps, valves and dynamic restraints and is not included as part of reviewers guide.)

3.9.2.2.2.3 Hydraulic Control Unit (HCU)

(This Subsection is not pertinent to the discussion of pumps, valves and dynamic restraints and is not included as part of reviewers guide.)

3.9.2.2.2.4 Fuel Assembly (Including Channel)

(This Subsection is not pertinent to the discussion of pumps, valves and dynamic restraints and is not included as part of reviewers guide.)

3.9.2.2.2.5 Reactor Internal Pump and Motor Assembly

The reactor internal pump (RIP) and motor assembly, including its appurtenances and support, is classified as Seismic Category I, but not active, and is designed to withstand the seismic forces, including other RBV loads. The qualification of the assembly is done analytically and with a dynamic test.

3.9.2.2.2.6 ECCS Pump and Motor Assembly

A prototype ECCS (RHR and HPCF) pump motor assembly is qualified for seismic and other RBV loads via a combination of dynamic analysis and dynamic testing. The complete motor assembly is qualified via dynamic testing in accordance with IEEE-344. The qualification test program includes demonstration of startup capability as well as operability during dynamic loading conditions (see Subsection 3.9.3.2.1.4 for details).

The pump and motor assemblies, as units operating under seismic and other RBV load conditions, are qualified by dynamic analysis, and results of the analysis indicate that the pump and motor are capable of sustaining the above loadings without exceeding the allowable stresses (see Subsections 3.9.3.2.1.1 and 3.9.3.2.1.2 for details).

3.9.2.2.2.7 RCIC Pump and Turbine Assembly (as modified in COLA Rev. 3)

The RCIC turbine-pump is qualified for seismic and other RBV loads via a combination of static analysis and dynamic testing (Subsection 3.9.3.2.1.5). The turbine assembly consists of rigid masses (wherein static analysis is utilized) interconnected with control levers and electronic control systems, necessitating final qualification via dynamic testing. Static loading analyses are employed to verify the structural integrity of the turbine-pump assembly and the adequacy of bolting under operating, seismic, and other RBV loading conditions. The complete turbine-pump assembly is qualified via dynamic testing in accordance with IEEE-344. The qualification test program includes a demonstration of startup capability, as well as operability during dynamic loading conditions

3.9.2.2.2.8 Standby Liquid Control Pump and Motor Assembly

The SLCS positive displacement pump and motor assembly, which is mounted on a common base plate, is qualified analytically by static analysis of seismic and other RBV loadings, as well as the design operating loads of pressure, temperature, and external piping loads. The results of this analysis confirm that the stresses are less than the allowables (Subsection 3.9.3.2.2).

3.9.2.2.2.9 RMC and RHR Heat Exchanger

(This Subsection is not pertinent to the discussion of pumps, valves and dynamic restraints and is not included as part of reviewers guide.)

3.9.2.2.2.10 Standby Liquid Control Storage Tank

(This Subsection is not pertinent to the discussion of pumps, valves and dynamic restraints and is not included as part of reviewers guide.)

3.9.2.2.2.11 Main Steam Isolation Valves

The main steam isolation valves (MSIVs) are qualified for seismic and other RBV loads. The fundamental requirement of the MSIV following an SSE or other faulted RBV loadings is to close and remain closed after the event. This capability is demonstrated by the test and analysis as outlined in Subsection 3.9.3.2.4.1.

3.9.2.2.2.12 Standby Liquid Control Valve (Injection Valve)

The motor-operated standby liquid control valve is qualified by type test to IEEE-344 for seismic and other RBV loads. The qualification test as discussed in Subsection 3.9.3.2.4.3 demonstrates the ability to remain operable after the application of horizontal and vertical dynamic loading in excess of the required response spectra. The valve and motor assemblies are qualified by dynamic analysis, and the results of the analysis indicate that the valve is capable of sustaining the dynamic loads without overstressing the pressure retaining components.

3.9.2.2.2.13 Main Steam Safety/Relief Valves

Due to the complexity of the structure and the performance requirements of the valve, the total assembly of the SRV (including electrical and pressure devices) is tested at dynamic accelerations equal to or greater than the combined SSE and other RBV loadings determined for the plant. Tests and analyses demonstrate the satisfactory operation of the valves during and after the test (Subsection 3.9.3.2.4.2).

3.9.2.2.2.14 Fuel Pool Cooling and Cleanup System Pump and Motor Assembly

A static analysis is performed on the pump and motor assembly of the Fuel Pool Cooling and Cleanup (FPC) System. This analysis shows that the pump and motor will continue to operate if subjected to a combination of SSE, other RBV, and normal operating loads. Analysis also ensures that pump running clearances, which include deflection of the pump shaft and pump pedestal, are met during seismic and other RBV loadings.

3.9.2.2.2.15 Other ASME III Equipment

Other equipment, including associated supports, is qualified for seismic and other RBV loads to ensure its functional integrity during and after the dynamic event. The equipment is tested, if necessary, to ensure its ability to perform its specified function before, during, and following a test.

Dynamic load qualification is done by a combination of test and/or analysis (Subsection 3.9.2.2.1). Natural frequency, when determined by an exploratory test, is in the form of a single-axis continuous-sweep frequency search using a sinusoidal steady-state input at the lowest possible amplitude which is capable of determining resonance. The search is conducted on each principal axis with a minimum of two continuous sweeps over the frequency range of interest at a rate no greater than one octave per minute. If no resonances are located, then the equipment is considered as rigid and single frequency tests at every one third octave frequency interval are acceptable. Also, if all natural frequencies of the equipment are greater than 33 Hz for seismic loads and 60 Hz for other RBV loads, the equipment may be considered rigid and analyzed statically as such. In this static analysis, the dynamic forces on each component are obtained by concentrating the mass at the center of gravity and multiplying the mass by the appropriate floor acceleration. The dynamic stresses are then added to the operating stresses and a determination made of the adequacy of the strength of the equipment. The search for the natural frequency is done analytically if the equipment shape can be defined mathematically and/or by prototype testing.

If the equipment is a rigid body while its support is flexible, the overall system can be modeled as a single-degree-of-freedom system consisting of a mass and a spring. The natural frequency of the system is computed; then the acceleration is determined from the floor response spectrum curve using the appropriate damping value. A static analysis is then performed using this acceleration value. In lieu of calculating the natural frequency, the peak acceleration from the spectrum curve is used. The critical damping values for welded steel structures from Table 3.7-1 are employed.

In case the equipment cannot be considered as a rigid body, it can be modeled as a multi-degree-of-freedom system. It is divided into a sufficient number of mass points to ensure adequate representation. The mathematical model can be analyzed using the modal analysis technique or direct integration of the equations of motion. Specified structural damping is used in the analysis unless justification for other values can be provided. A stress analysis is performed using the appropriate inertial forces or equivalent static loads obtained from the dynamic analysis of each mode.

For a multiple-degree-of-freedom modal analysis, the modal response accelerations can be taken directly from the applicable floor response spectrum. The maximum spectral values within ±10% band of the calculated frequencies of the equipment are used for computation of modal dynamic response inertial loading. The total dynamic stress is obtained by combining the modal stresses. The dynamic stresses are added to the operating stresses using the loading combinations stipulated in the specific equipment specification and then compared with the allowable stress levels.

If the equipment being analyzed has no definite orientation, the worst possible orientation is considered. Furthermore, equipment is considered to be in its operational configuration (i.e., filled with the appropriate fluid and/or solid). The investigation ensures that the point of maximum stress is considered. Lastly, a check is made to ensure that partially filled or empty equipment do not result in higher response than the operating condition. The analysis includes an evaluation of the effects of the calculated stresses on mechanical strength, alignment, electrical performance (microphonics, contact bounce, etc.), and noninterruption of function. Maximum displacements are computed and interference effects determined and justified.

Individual devices are tested separately, when necessary, in their operating condition. Then the component to which the device is assembled is tested with a similar but inoperative device installed upon it.

The equipment, component, or device to be tested is mounted on the vibration generator in a manner that simulates the final service mounting. If the equipment is too large, other means of simulating the service mounting are used. Support structures such as air conditioning units, consoles, racks, etc., could be vibration tested without the equipment and/or devices being in operation, provided they are performance tested after the vibration test. However, the components are in their operational configuration during the vibration test. The goal is to determine that, at the specified vibratory accelerations, the support structure does not amplify the forces beyond that level to which the devices have been qualified.

Equipment could alternatively be qualified by presenting historical performance data which demonstrates that the equipment satisfactorily sustains dynamic loads which are equal to or greater than those specified for the equipment, and that the equipment performs a function equal to or better than that specified for it.

Equipment for which continued function is not required after a seismic and other RBV loads event, but whose postulated failure could produce an unacceptable influence on the performance of systems having a primary safety function, is evaluated. Such equipment is qualified to the extent required to ensure that an SSE, including other RBV loads, in combination with normal operating conditions, would not cause unacceptable failure. Qualification requirements are satisfied by ensuring that the equipment in its functional configuration, complete with attached appurtenances, remains structurally intact and affixed to the interface. The structural integrity of internal components is not required; however, the enclosure of such components is required to be adequate to ensure their confinement. Where applicable, fluid or pressure boundary integrity is demonstrated. With a few exceptions, simplified analytical techniques are adequate.

Historically, it has been shown that the main cause for equipment damage during a dynamic excitation has been the failure of its anchorage. Stationary equipment is designed with anchor bolts or other suitable fastening strong enough to prevent overturning or sliding. The effect of friction on the ability to resist sliding is neglected. The effect of upward dynamic loads on overturning forces and moments is considered. Unless specifically specified otherwise, anchorage devices are designed in accordance with the requirements of ASME Code Section III, Division 1, Subsection NF, or the AISC Manual of Steel Construction and ACI 318.

Dynamic design data are provided in the form of acceleration response spectra for each floor area of the equipment. Dynamic data for the ground or building floor to which the equipment is attached is used. For the case of equipment having supports with different dynamic motions, the most severe floor response spectrum is applied to all of the supports.

Refer to Subsections 3.9.3.2.3.1.4 and 3.9.3.2.5.1.1 for additional information on the dynamic qualification of active pumps and valves, respectively.

3.9.2.2.2.16 Supports

Subsections 3.9.3.2.4 and 3.9.3.2.5 address analyses or tests that are performed for component supports to assure their structural capability to withstand seismic and other dynamic excitations.

3.9.2.3 Dynamic Response of Reactor Internals Under Operational Flow Transients and Steady-State Conditions

(This Subsection is not pertinent to the discussion of pumps, valves and dynamic restraints and is not included as part of reviewers guide.)

3.9.2.4 Preoperational Flow-Induced Vibration Testing of Reactor Internals

(This Subsection is not pertinent to the discussion of pumps, valves and dynamic restraints and is not included as part of reviewers guide.)

3.9.2.5 Dynamic System Analysis of Reactor Internals Under Faulted Conditions

(This Subsection is not pertinent to the discussion of pumps, valves and dynamic restraints and is not included as part of reviewers guide.)

3.9.2.6 Correlations of Reactor Internals Vibration Tests with the Analytical Results

(This Subsection is not pertinent to the discussion of pumps, valves and dynamic restraints and is not included as part of reviewers guide.)

3.9.3 ASME Code Class 1, 2, and 3 Components, Component Supports, and Core Support Structures

3.9.3.1 Loading Combinations, Design Transients, and Stress Limits

(This Subsection is not pertinent to the discussion of pumps, valves and dynamic restraints and is not included as part of reviewers guide.)

3.9.3.2 Pump and Valve Operability Assurance

Active mechanical (with or without electrical operation) equipment are Seismic Category I and each is designed to perform a mechanical motion for its safety-related function during the life of the plant under postulated plant conditions. Equipment with faulted condition functional requirements include active pumps and valves in fluid systems such as the RHR System, ECCS, and MS system.

This subsection discusses operability assurance of active ASME Code Section III pumps and valves, including motor, turbine or operator that is a part of the pump or valve (Subsection 3.9.2.2). The EQ Program, developed in accordance with Reference 3.9-6, defines the specific environmental parameters which are implemented and assures they are enveloped by the program.

Safety-related valves and pumps are qualified by testing and analysis and by satisfying the stress and deformation criteria at the critical locations within the pumps and valves. Operability is assured by meeting the requirements of the programs defined in Subsection 3.9.2.2, design and qualification requirements, Subsection 3.9.6, Sections 3.10 and 3.11, and the following subsections.

Pumps and valves that perform an active safety-related function are functionally qualified to perform their required functions. For component designs that were not previously qualified, the qualification programs meet the requirements of QME-1-2007. For component designs previously qualified to standards other than ASME QME-1-2007, the following approach is used.

- The general requirements specifications include requirements related to design and functional qualification of safety-related pumps and valves that incorporate lessons learned from nuclear power plant operations and research programs.
- Qualification specifications (e.g., design specifications) consistent with Appendices QV-I and QV-A of QME-1-2007 are prepared to ensure the operating conditions and safety functions for which the pumps and valves are to be qualified are communicated to the manufacturer or qualification facility.
- Suppliers are required to submit, for review and approval, application reports, as described in QME-1-2007, that describe the basis for the application of specific predictive methods and/or qualification test data to a specific application.
- The application reports provided by the suppliers for adherence to specification requirements are reviewed to ensure the methods used are applicable and justified and to verify any extrapolation techniques used are justified. A gap analysis is performed to identify any deviations from QME-1-2007 in the component qualification. Each deviation is evaluated

for impact on the overall component qualification. If the conclusion of the gap analysis is that the component qualification is inadequate, then the component may be qualified using a test-based methodology, as allowed by QME-1-2007.

- Independent sizing calculations, using bounding design parameters (such as sliding friction coefficients), are performed to verify supplier actuator sizing.

Functional qualification addresses key lessons learned from industry efforts, particularly on air and motor-operated valves, many of which are discussed in Section QV-G of QME-1-2007.

For example:

- Evaluation of valve performance is based on a combination of testing and analysis, using design similarity to apply test results to specific valve designs.
- Testing to verify proper valve setup and acceptable operating margin is performed using diagnostic equipment to measure stem thrust and/or torque.
- Sliding friction coefficients used to evaluate valve performance (e.g. disk-to-seat friction coefficients for gate valves and bearing coefficients for butterfly valves) account for the effects of temperature, cycle history, load and internal parts geometry.
- Actuator sizing allows margin for aging/degradation, test equipment accuracy and other uncertainties, as appropriate.
- Material combinations that may be susceptible to galling or other damage mechanisms under certain conditions are not used.

Subsection 3.9.2.2 and Section 3.10 provide details on the seismic qualification of pumps, valves and snubbers, and Section 3.11 provides details on the environmental qualification (EQ).

Section 4.4 of GE's Environmental Qualification Program (Reference 3.9-6) applies to this subsection, and the seismic qualification methodology presented therein is applicable to mechanical as well as electrical equipment.

3.9.3.2.1 ECCS Pumps, Motors and Turbine

Dynamic qualification of the ECCS (RHR, RCIC and HPCF) pumps with motor or turbine assembly is also described in Subsections 3.9.2.2.2.6 and 3.9.2.2.2.7.

3.9.3.2.1.1 Consideration of Loading, Stress, and Acceleration Conditions in the Analysis

In order to avoid damage to the ECCS pumps during the faulted plant condition, the stresses caused by the combination of normal operating loads, SSE, other RBV loads, and dynamic system loads are limited to the material elastic limit. A three-dimensional finite-element model of the pump and associated motor (see Subsections 3.9.2.2 and 3.9.3.2.1.5 for RCIC pump and turbine, respectively) and its support is developed and analyzed using the response spectrum and the dynamic analysis method. The same is analyzed due to static nozzle loads, pump thrust loads, and dead weight. Critical location stresses are compared with the allowable stresses and the critical location deflections with the allowables, and accelerations are checked to evaluate operability. The average membrane stress σm for the faulted condition loads is limited to 1.2S or approximately 0.75 σ_y (σ_y = yield stress), and the maximum stress in local fibers (σm + bending stress σb) is limited to 1.8S or approximately 1.1. The maximum faulted event nozzle loads are also considered in an analysis of the pump supports to assure that a system misalignment cannot occur. (See Section 3.10)

Performing these analyses with the conservative loads stated and with the restrictive stress limits as allowables assures that critical parts of the pump and associated motor or turbine will not be damaged during the faulted condition and that the operability of the pump for post-faulted condition operation will not be impaired.

3.9.3.2.1.2 Pump/Motor Operation During and Following Dynamic Loading

Active ECCS pump/motor rotor combinations are designed to rotate at a constant speed under all conditions. Motors are designed to withstand short periods of severe overload. The high rotary inertia in the operating pump rotor and the nature of the random short duration loading characteristics of the dynamic event prevent the rotor from becoming seized. The seismic and other RBV loadings can be predicted to require only a slight increase, if any, in the torque (i.e., motor current) necessary to drive the pump at the constant design speed; therefore, the pump is expected to operate at the design speed during the faulted event loads.

The functional ability of the active pumps after a faulted condition is assured, since only normal operating loads and steady-state nozzle loads exist. For the active pumps, the faulted condition loads are greater than the normal condition loads only due to the SSE and other RBV transitory loads. These faulted events are infrequent and of relatively short duration compared to the design life of the equipment. Since it is demonstrated that the pumps would not be damaged during the faulted condition, the post-faulted condition operating loads will be no worse than the normal plant operating limits. This is assured by requiring that the imposed nozzle loads (steady-state loads) for normal conditions and post-faulted conditions be limited to the magnitudes of the normal condition nozzle loads. The post-faulted condition ability of the pumps to function under these applied loads is proven during the normal operating plant conditions for active pumps.

3.9.3.2.1.3 ECCS Pumps

All active ECCS (RHR, RCIC and HPCF) pumps are qualified for operability by first being subjected to rigid tests both prior to installation in the plant and after installation in the plant. The in-shop tests include: (1) hydrostatic tests of pressure-retaining parts of 125% of the design pressure; (2) seal leakage tests; and (3) performance tests while the pump is operated with flow to determine total developed head, minimum and maximum head and net positive suction head (NPSH) requirements. Also monitored during these operating tests are bearing temperatures (except water cooled bearings) and vibration levels. Both are shown to be below specified limits. After the pump is installed in the plant, it undergoes the cold hydro tests, functional tests, and the required periodic inservice inspection and operation. These tests demonstrate reliability of the pump for the design life of the plant.

In addition to these tests, these pumps are analyzed for operability during a faulted condition by assuring that (1) the pump will not be damaged during the dynamic (SSE and LOCA) event, and (2) the pump will continue operating despite the dynamic loads.

3.9.3.2.1.4 ECCS Motors

Qualification of the Class 1E motors used for the ECCS motors complies with IEEE-323. The qualification of all motor sizes is based on completion of a type test, followed up with review and comparison of design and material details, and seismic and other RBV loads analyses of production units, ranging from 447 to 2610 kW, with the motor used in the type test. All manufacturing, inspection, and routine tests by motor manufacturer on production units are performed on the test motor.

The type test is performed on a 932 kw vertical motor in accordance with IEEE-323, first simulating a normal operation during the design life, then subjecting the motor to a number of vibratory tests, and then to the abnormal environmental condition possible during and after a LOCA. The test plans for the type test are as follows:

(1) Thermal aging of the motor electrical insulation system (which is a part of the stator only) is based on extrapolation in accordance with the temperature life characteristic curve from IEEE-275 for the insulation type used on the ECCS motors. The amount of aging equals the total estimated operation days at maximum insulation surface temperature.

(2) Radiation aging of the motor electrical insulation equals the maximum estimated integrated dose of gamma during normal and abnormal conditions.

(3) The normal operational induced current vibration effect on the insulation system is simulated by 1.5g horizontal vibration acceleration at current frequency for one hour duration.

(4) The dynamic load deflection analysis on the rotor shaft is performed to ensure adequate rotation clearance, and is verified by static loading and deflection of the rotor for the type test motor.

(5) Dynamic load aging and testing is performed on a biaxial test table in accordance with IEEE-344. During this test, the shake table is activated to simulate the maximum design limit for the SSE and other RBV loads with as many motor starts and operation combinations consistent with the plant events of Table 3.9-1 and the ECCS inadvertent injections and tests planned over the life of the plant.

(6) An environmental test simulating a LOCA condition with a duration of 100 days is performed with the test motor fully loaded, simulating pump operation. The test consists of startup and six hours operation at 1000C ambient temperature and 100% steam environment. Another startup and operation of the test motor after one hour standstill in the same environment is followed by sufficient operation at high humidity and temperature based on extrapolation in accordance with the temperature life characteristic curve from IEEE-275 for the insulation type used on the ECCS motors.

3.9.3.2.1.5 RCIC Turbine (as modified in COLA Rev. 3)

The RCIC turbine-pump is qualified by a combination of static analysis and dynamic testing as described in Subsection 3.9.2.2.2.7. The turbine-pump assembly consists of rigid masses (wherein static analysis is utilized) interconnected with control levers and electronic control systems, necessitating final qualification by dynamic testing. Static loading analysis has been employed to verify the structural integrity of the turbine assembly, and the adequacy of bolting under operating and dynamic conditions. The complete turbine-pump assembly is qualified via dynamic testing, in accordance with IEEE-344. The qualification test program includes demonstration of startup capability, as well as operability during dynamic loading conditions. Operability under normal load conditions is assured by comparison to operability of similar turbines in operating plants.

3.9.3.2.2 SLC Pump and Motor Assembly and RCIC Turbine-Pump Assembly (as modified in COLA Rev. 3)

These equipment assemblies are small, compact, rigid assemblies with natural frequencies well above 33 Hz. With this fact verified, each equipment assembly is qualified by the static analysis for seismic and other RBV loads. This qualification assures structural loading stresses within Code limitations, and verifies operability under seismic and other RBV loads (Subsections 3.9.2.2.2.8 and 3.9.2.2.2.7).

3.9.3.2.3 Other Active Pumps

The active pumps not previously discussed are ASME Class 2 or 3 and Seismic Category I. They are designed to perform their function including all required mechanical motions during and after a dynamic (seismic and other RBV) loads event and to remain operative during the life of the plant.

The program for the qualification of Seismic Category I components conservatively demonstrates that no loss of function results either before, during, or after the occurrence of the combination of events for which operability must be assured. No loss of function implies that the pressure boundary integrity will be maintained, that the component will not be caused to operate improperly, and that components required to respond actively will respond properly as appropriate to the specific equipment. In general, operability assurance is established during and after the dynamic loads event for active components.

3.9.3.2.3.1 Procedures

Procedures have been established for qualifying the mechanical portions of Seismic Category I pumps such as the body which forms a fluid pressure boundary, including the suction and discharge nozzles, shaft and seal retainers, impeller assembly (including blading, shaft, and bearings for active pumps), and integral supports. All active pumps are qualified for operability by first being subjected to rigid tests both prior to installation and after installation in the plant. Electric motors for active pumps and instrumentation, including electrical devices which must function to cause the pump to accomplish its intended function, are discussed separately in Subsection 3.9.3.2.5.1.2.3.

3.9.3.2.3.1.1 Hydrostatic Test

All seismic-active pumps shall meet the hydrostatic test requirements of ASME Code Section III according to the class rating of the given pump.

3.9.3.2.3.1.2 Leakage Test

The fluid pressure boundary is examined for leaks at all joints, connections, and regions of high stress such as around openings or thickness transition sections while the pump is undergoing a hydrostatic test or during performance testing. Leakage rates that exceed the rates permitted in the design specification are eliminated and the component retested to establish an observed leakage rate. The actual observed leakage rate, if less than permitted, is documented and made a part of the acceptable documentation package for the component.

3.9.3.2.3.1.3 Performance Test

The pump is demonstrated capable of meeting all hydraulic requirements while operating with flow at the total developed head, minimum and maximum head, NPSH, and other parameters as specified in the equipment specification.

Bearing temperature (except water cooled bearings) and vibration levels are also monitored during these operating tests. Both are shown to be below specified levels.

3.9.3.2.3.1.4 Dynamic Qualification

The safety-related active pumps are analyzed for operability during dynamic loading event by assuring that the pump is not damaged during the seismic event and the pump continues operating despite the dynamic loads.

A test or dynamic analysis is performed for a pump to determine the dynamic seismic and other RBV load from the applicable floor response spectra. Response spectra for the horizontal vibration are used in two orthogonal horizontal directions simultaneously with the response spectra for the vertical vibration. The effects from the three simultaneous accelerations are combined by the square-root-of-the-sum-of-the-squares method. The pump is demonstrated by test or analysis that the faulted condition nozzle loads do not impair the operability of the pumps during or following the faulted condition. (See Section 3.10) Components of the pump are considered essentially rigid when having a natural frequency above 33 Hz. A static shaft deflection analysis of the motor rotor is performed with the conservative SSE accelerations acting in horizontal and vertical direction simultaneously.

The deflections determined from the static shaft analysis are compared to the allowable rotor clearances. The allowable rotor clearances are limited by the deflection which would cause the rotor to just make contact with the stator. In order to avoid damage during the faulted plant condition, the stresses caused by the combination of normal operating loads, SSE and dynamic system loads are limited to the material elastic limit.

The average membrane stress (σ_m) for the faulted conditions loads is limited to 1.2S or approximately 0.75 σ_y (σ_y = yield stress), and the maximum stress in local fibers (σm + bending stress σb) is limited to 1.8S or approximately 1.1 σ_y. The maximum dynamic nozzle loads are also considered in an analysis of the pump supports to assure that a system misalignment cannot occur. (See Section 3.10)

If the natural frequency is found to be below 33 Hz, an analysis is performed to determine the amplified input accelerations necessary to perform the static analysis.

In completing the seismic qualification procedures, the pump motor and all components vital to the operation of the pump are independently qualified for operation during the maximum seismic event by IEEE-344.

If the testing option is chosen, sine-beat testing for electrical equipment is performed by satisfying one or more of the following requirements to demonstrate that multi-frequency response is negligible or that the sine-beat input is of sufficient magnitude to conservatively account for this effect.

(1) The equipment response is basically due to one mode.

(2) The sine-beat response spectra envelope the floor response spectra in the region of significant response.

(3) The floor response spectra consist of one dominant mode and has a peak at this frequency. (See Section 3.10)

The degrees of cross coupling in the equipment shall determine if a single or multi-axis test is required. Multi-axis testing is required if there is considerable cross coupling. If coupling is very light, then single axis testing is justified. Or, if the degree of coupling can be determined, then single-axis testing can be used with input sufficiently increased to include the effect of coupling on the response of the equipment.

The combined stresses of the support structures are designed to be within the limits of ASME Code Section III, Subsection NF, component Support Structures, and/or other comparable limits of industry standards, such as the AISC Specification for Buildings, plus Addenda for building support structures.

An analysis or test is accomplished which conservatively demonstrates structural integrity and/or functionality of the equipment supports.

The impeller, shaft, and bearings for active pumps are analyzed to determine adequacy while operating with the seismic and other RBV loading effects applied in addition to the applicable operating loads including nozzle loads. Functional requirements are partially demonstrated by a suitable analysis which conservatively shows the following:

(1) The stresses in the shaft do not exceed the minimum yield strength of the material used for its construction.

(2) The deflections of the shaft and/or impeller blades do not cause the impeller assembly to seize.

(3) The bearing temperature does not attain limits which may allow stresses in the bearing or bearing support to exceed minimum yield strength levels or jeopardize lubrication.

3.9.3.2.3.2 Documentation

All of the preceding requirements (Subsection 3.9.3.2.3.1) are satisfied to demonstrate that functionality is assured for active pumps. The documentation is prepared in a format that clearly shows that each consideration has been properly evaluated and tests have been validated by a designated quality assurance representative. The analysis is included as a part of the certified stress report for the assembly.

3.9.3.2.4 Major Active Valves

Some of the major safety-related active valves (Table 6.2-2, 6.2-3 and 3.2-1) discussed in this subsection for illustration are the MSIVs and SRVs, and SLC valves and HPCF valves (motor-operated). These valves are designed to meet ASME Code Section III requirements and perform their mechanical motion in conjunction with a dynamic (SSE and other RBV) load event. These valves are supported entirely by the piping (i.e., the valve operators are not used as attachment points for piping supports) (Subsection 3.9.3.4.1). The dynamic qualification for operability is unique for each valve type; therefore, each method of qualification is detailed individually below.

3.9.3.2.4.1 Main Steam Isolation Valve

The typical Y-pattern MSIVs described in Subsection 5.4.5.2 are evaluated by analysis and test for capability to operate under the design loads that envelop the predicted loads during a DBA and SSE.

The valve body is designed, analyzed and tested in accordance with ASME Code Section III Class 1 requirements. The MSIVs are modeled mathematically in the MS System analysis. The loads, amplified accelerations and resonance frequencies of the valves are determined from the overall steamline analysis. The piping supports (snubbers, rigid restraints, etc.) are located and designed to limit amplified accelerations of and piping loads in the valves to the design limits.

As described in Subsection 5.4.5.3, the MSIV and associated electrical equipment (wiring, solenoid valves, and position switches) are dynamically qualified to operate during an accident condition.

3.9.3.2.4.2 Main Steam Safety/Relief Valve

The typical SRV design described in Subsection 5.2.2.4.1 is qualified by type test to IEEE-344 for operability during a dynamic event. Structural integrity of the configuration during a dynamic event is demonstrated by both Code (ASME Class 1) analysis and test.

(1) Valve is designed for maximum moments on inlet and outlet which may be imposed when installed in service. These moments are resultants due to dead weight plus dynamic loading of both valve and connecting pipe, thermal expansion of the connecting pipe, and reaction forces from valve discharge.

(2) A production SRV is demonstrated for operability during a dynamic qualification (shake table) type test with moment and "g" loads applied greater than the required equipment's design limit loads and conditions.

A mathematical model of this valve is included in the MS System analysis, as with the MSIVs. This analysis assures that the equipment design limits are not exceeded.

3.9.3.2.4.3 Standby Liquid Control Valve (Injection Valve)

The typical SLC injection valve design is qualified by type test to IEEE-344. The valve body is designed, analyzed and tested per ASME Code Section III Class 1. The qualification test demonstrates the ability to remain operable after the application of the horizontal and vertical dynamic loading exceeding the predicted dynamic loading.

3.9.3.2.4.4 High Pressure Core Flooder Valve (Motor-Operated)

The typical HPCF valve body design, analysis and testing is in accordance with the requirements of the ASME Code Section III Class 1 or 2 components. The Class 1E electrical motor actuator is qualified by type test in accordance with IEEE-382, as discussed in Subsection 3.11.2. A mathematical model of this valve is included in the HPCF piping system analysis. The analysis results are assured not to exceed the horizontal and vertical dynamic acceleration limits acting simultaneously for a dynamic (SSE and other RBV) event, which is treated as an emergency condition. Subsection 3.9.3.2.5 discusses the operability qualification of the HPCF valve for seismic and other dynamic loads.

3.9.3.2.5 Other Active Valves

Other safety-related active valves are ASME Class 1, 2 or 3 and are designed to perform their mechanical motion during dynamic loading conditions. The operability assurance program ensures that these valves will operate during a dynamic seismic and other RBV event.

3.9.3.2.5.1 Procedures

Qualification tests accompanied by analyses are conducted for all active valves. Procedures for qualifying electrical and instrumentation components which are depended upon to cause the valve to accomplish its intended function are described in Subsection 3.9.3.2.5.1.2.3.

3.9.3.2.5.1.1 Tests

Prior to installation of the safety-related valves, the following tests are performed: (1) shell hydrostatic test to ASME Code Section III requirements; (2) back seat and main seat leakage tests; (3) disc hydrostatic test; (4) functional tests to verify that the valve will open and close within the specified time limits when subject to the design differential pressure; and (5) operability qualification of valve actuators for the environmental conditions over the installed life. Environmental qualification procedures for operation follow those specified in Section 3.11. The results of all required tests are properly documented and included as a part of the operability acceptance documentation package.

3.9.3.2.5.1.2 Dynamic Load Qualification

The functionality of an active valve during and after a seismic and other RBV event is demonstrated by test or by a combination of analysis and test. The qualification of electrical and instrumentation components controlling valve actuation is discussed in Subsection 3.9.3.2.5.1.2.3. The valves are designed using either stress analyses or the pressure temperature rating requirements based upon design conditions. A test or analysis of the extended structure is performed for the expected dynamic loads acting on the extended structure. See Subsection 3.9.2.2 further details.

When qualification of mechanisms that must change position to complete their safety-related function is based on dynamic testing or equivalent static load testing, operability testing is performed for the loads defined by the applicable events and conditions per Subsection 3.9.1.1 and Table 3.9-1.

The dynamic qualification testing procedure for valve operability is outlined below. A subject valve assembly is mounted in a test stand or fixture in a manner that conservatively represent typical valve installation(s). Each test valve assembly includes the actuator and accessories that are attached to an inservice valve. Additional discussion of test criteria and method is provided in Subsection 3.9.2.2, and also in the portions of Subsections 3.10.1 and 3.10.2 applicable to active valve assemblies.

The maximum stress limits allowed in these analyses confirm structural integrity and are the limits developed and accepted by the ASME for the particular ASME Class of valve analyzed.

The stress limits for operability are provided in footnote 12 of Table 3.9-2. (See Section 3.10)

Dynamic load qualification is accomplished in the following way:

(1) All the active valves are typically designed to have a fundamental frequency which is greater than the high frequency asymptote (ZPA) of the dynamic event. This is shown by suitable test or analysis.

(2) The actuator and yoke of the valve system is statically loaded to an amount greater than that due to a dynamic event. The load is applied at the center of gravity of the actuator alone in the direction of the weakest axis of the yoke. The simulated operational differential pressure is simultaneously applied to the valve during the static deflection tests.

(3) The valve is then operated while in the deflected position (i.e., from the normal operating position to the safe position). The valve is verified to perform its safety-related function within the specified operating time limits.

(4) Motor operators and other electrical appurtenances necessary for operation are qualified as operable during a dynamic event by appropriate qualification tests prior to installation on the valve. Alternately, the valve including the motor operator and all other accessories is qualified by a shake table test.

The piping, stress analysis, and pipe support design maintain the motor operator accelerations below the qualification levels with adequate margin of safety.

If the fundamental frequency of the valve, by test or analysis, is less than that for the ZPA, a dynamic analysis of the valve is performed to determine the equivalent acceleration to be applied during the static test. The analysis provides the amplification of the input acceleration considering the natural frequency of the valve and the frequency content of the applicable plant floor response spectra. The adjusted accelerations have been determined using the same conservatism contained in the horizontal and vertical accelerations used for rigid valves. The adjusted acceleration is then used in the static analysis and the valve operability is assured by the methods outlined in Steps (2) through (4), using the modified acceleration input. Alternatively, the valve including the actuator and all other accessories is qualified by shake table test.

Valves which are safety-related but can be classified as not having an overhanging structure, such as check valves and pressure-relief valves, are considered as follows:

3.9.3.2.5.1.2.1 Active Check Valves

Due to the particular simple characteristics of the check valves, the active check valves are qualified by a combination of the following tests and analysis:

(1) Stress analyses including the dynamic loads where applicable

(2) In-shop hydrostatic tests

(3) In-shop seat leakage test

(4) Periodic in-situ valve exercising and inspection to assure the functional capability of the valve

3.9.3.2.5.1.2.2 Active Pressure-Relief Valves

The active pressure-relief valves (RVs) are qualified by the following procedures. These valves are subjected to test and analysis similar to check valves, stress analyses including the dynamic loads, in-shop hydrostatic seat leakage, and performance tests. In addition to these tests, periodic in-situ valve inspections, as applicable, and periodic valve removal, refurbishment, performance testing, and reinstallation are performed to assure the functional capability of the valve. Tests of the RV under dynamic loading conditions demonstrate that valve actuation can occur during application of the loads. The tests include pressurizing the valve inlet with nitrogen and subjecting the valve to accelerations equal to or greater than the dynamic event (SSE plus other RBV) loads.

3.9.3.2.5.1.2.3 Qualification of Electrical and Instrumentation Components Controlling Valve Actuation

A practical problem arises in attempting to describe tests for devices (relays, motors, sensors, etc.) as well as for complex assemblies such as control panels. It is reasonable to assume that a device, as an integral part of an assembly, can be subjected to dynamic loads tests while in an operating condition and its performance monitored during the test. However, in the case of complex panels, such a test is not always practical. In such a situation, the following alternate approach is recommended.

The individual devices are tested separately in an operating condition and the test levels recorded as the qualification levels of the devices. The panel, with similar devices installed but inoperative, is vibration tested to determine if the panel response accelerations, as measured by accelerometers installed at the device attachment locations, are less than the levels at which the devices were qualified. Note that the purpose of installing the nonoperating devices is to assure that the panel has the structural characteristics it will have when in use. If the acceleration levels at the device locations are found to be less than the levels to which the device is qualified, then the total assembly is considered qualified. Otherwise, either the panel is redesigned to reduce the acceleration level to the device locations and retested, or the devices is requalified to the higher levels.

3.9.3.2.5.2 Documentation

All of the preceding requirements (Subsection 3.9.3.2.5.1) are satisfied to demonstrate that functionality is assured for active valves. The documentation is prepared in a format that clearly shows that each consideration has been properly evaluated and tests have been validated by a designated quality assurance representative. The analysis is included as a part of the certified stress report for the assembly.

3.9.3.3 Design and Installation of Pressure Relief Devices

3.9.3.3.1 Main Steam Safety/Relief Valves

SRV lift in a main steam (MS) piping system results in a transient that produces momentary unbalanced forces acting on the MS and SRV discharge piping system for the period from opening of the SRV until a steady discharge flow from the reactor pressure vessel to the suppression pool is established. This period includes clearing of the water slug from the end of the discharge piping submerged in the suppression pool. Pressure waves traveling through the MS and discharge piping following the relatively rapid opening of the SRV cause this piping to vibrate.

The analysis of the MS and discharge piping transient due to SRV discharge consists of a stepwise time-history solution of the fluid flow equation to generate a time history of the fluid properties at numerous locations along the pipe. The fluid transient properties are calculated based on the maximum set pressure specified in the steam system specification and the value of ASME Code flow rating increased by a factor to account for the conservative method of establishing the rating. As a conservative approach, it is assumed that all SRVs mounted on a MS line actuate simultaneously. Simultaneous actuation of all SRVs is considered to induce maximum stress in the MS piping. Further, a subsequent actuation condition rather than initial actuation for all SRVs is conservatively assumed. This is a conservative approach, considering that all SRVs will not actuate simultaneously with subsequent actuation condition in the SRV piping, because individual SRVs have different relief set pressure values. These features should preclude simultaneous subsequent actuation of all SRVs. The methodology for calculating hydrodynamic loading on SRV discharge piping due to subsequent SRV actuations is consistent with previously approved methodology for earlier BWR (Mark II/III) designs. The effect of subsequent valve actuation is included by assuming hot SRV discharge pipe condition before valve actuation which results in higher loads on the piping. SRV loads are calculated assuming initial SRV pipe metal temperature to be 149°C for the pipe in the drywell region and 93°C for the pipe in the wetwell region, consistent with that used for earlier BWRs. These temperature values are based on measured data from in-plant SRV blowdown tests. Reaction loads on the pipe are determined at each location corresponding to the position of an elbow. These loads are composed of pressure-times-area, momentum-change, and fluid-friction terms.

The method of analysis applied to determine response of the MS piping system, including the SRV discharge line, to relief valve operation is time-history integration. The forces are applied at locations on the piping system where fluid flow changes direction, thus causing momentary reactions. The resulting loads on the SRV, the main steamline, and the discharge piping are combined with loads due to other effects as specified in Subsection 3.9.3.1. In accordance with Tables 3.9-1 and 3.9-2, the Code stress limits for service levels corresponding to load combination classification as normal, upset, emergency, and faulted are applied to the main steam and discharge pipe.

3.9.3.3.2 Other Safety/Relief Valves

An SRV is identified as a pressure relief valve or vacuum breaker. SRVs in the reactor components and subsystems are described and identified in Subsection 5.4.13.

The operability assurance program discussed in Subsection 3.9.3.2.5.1 applies to safety/relief valves. The qualification of active relief valves is specifically outlined in Subsection 3.9.3.2.5.1.2.2.

ABWR SRVs (safety valves with auxiliary actuating devices and pilot operated valves) are designed and manufactured in accordance with ASME Code Section III Division 1 requirements.

Specific rules for pressure relieving devices are as specified in Article NB-7000 and NB-3500 (pilot-operated and power-actuated pressure relief valves).

The design of ABWR SRVs incorporates SRV opening and pipe reaction load considerations required by ASME Section III, Appendix O, including the additional criteria of SRP Section 3.9.3, Paragraph II.2 and those identified under Subsection NB-3658 for pressure and structural integrity. SRV operability is demonstrated either by dynamic testing or analysis of similarly tested valves or a combination of both in compliance with the requirements of SRP Subsection 3.9.3.

3.9.3.3.3 Rupture Disks

There are no rupture disks in the ABWR plant design that must function during and after a dynamic event (SSE including other RBV loads) at design basis conditions. However, the rupture disk in the containment overpressure protection system may operate following severe accident seismic conditions.

3.9.3.4 Component Supports

The design of bolts for component supports is specified in ASME Code Section III, Subsection NF. Stress limits for bolts are given in NF-3225. The rules and stress limits which must be satisfied are those given in NF-3324.6 multiplied by the appropriate stress limit factor for the particular service loading level and stress category specified in Table NF-3225.2-1.

Moreover, on equipment which is to be, or may be, mounted on a concrete support, sufficient holes for anchor bolts are provided to limit the anchor bolt stress to less than 68.6 MPa on the nominal bolt area in shear or tension.

Concrete anchor bolts (including under-cut type anchor bolts) which are used for pipe support base plates will be designed to the applicable factors of safety defined in IE Bulletin 79-02, "Pipe Support Base Plate Designs Using Concrete Expansion Anchor Bolts", Revision 2, November 8, 1979. Justification shall be provided for the use of safety factors for concrete anchor bolts other than those specified in IE Bulletin 79-02. This justification shall be submitted to the NRC staff for review and approval prior to the installation of the concrete anchor bolts. Pipe support base plate flexibilities are accounted for in the calculation of concrete anchor bolt loads, in accordance with IE Bulletin 79-02. (See Subsection 3.9.1.7)

3.9.3.4.1 Piping

Supports and their attachments for essential ASME Code Section III, Class 1,2, and 3 piping are designed in accordance with Subsection NF (Augmented by the following: (1) application of Code Case N-476, Supplement 89.1 which governs the design of single angle members of ASME Class 1,2,3 and MC linear component supports; and (2) when eccentric loads or other torsional loads are not accommodated by designing the load to act through the shear center or meet "Standard for Steel Support Design", analyses will be performed in accordance with torsional analysis methods such as: "Torsional Analysis of Steel Members, USS Steel Manual", Publication T114-2/83.) up to the interface of the building structure, with jurisdictional boundaries as defined by Subsection NF. (See Subsection 3.9.1.7) The loading combinations for the various operating conditions correspond to those used for design of the supported pipe. The component loading combinations are discussed in Subsection 3.9.3.1. The stress limits are per

ASME III Code Section, Subsection NF and Appendix F. Supports are generally designed either by load rating method per Code Paragraph NF-3280 or by the stress limits for linear supports per paragraph NF-3143. The critical buckling loads for the Class 1 piping supports subjected to faulted loads, which are more severe than normal, upset and emergency loads, are determined by using the methods discussed in Appendices F and XVII of the Code. To avoid buckling in the piping supports, the allowable loads are limited to two-thirds of the determined critical buckling loads.

Maximum calculated static and dynamic deflections at support locations are checked to confirm that the support has not rotated beyond the vendor's recommended cone of action or the recommended arc of loading. (See Subsection 3.9.1.7)

Supports for ASME Code Section III instrumentation lines are designed and analyzed in accordance with ASME Code Section III, Subsection NF. (See Subsection 3.9.1.7)

The design of all supports for non-nuclear piping satisfies the requirements of ANSI/ASME B31.1, Power Piping Code, Paragraphs 120 and 121.

For the major active valves identified in Subsection 3.9.3.2.4, the valve operators are not used as attachment points for piping supports.

The design criteria and dynamic testing requirements for the ASME III Subsection NF piping supports are as follows:

(1) **Piping Supports**—All piping supports are designed, fabricated, and assembled so that they cannot become disengaged by the movement of the supported pipe or equipment after they have been installed. All piping supports are designed in accordance with the rules of Subsection NF of the ASME Code up to the building structure interface as defined by the jurisdictional boundaries in Subsection NF. (See Section 3.9.1.7)

(2) **Spring Hangers**—The operating load on spring hangers is the load caused by dead weight. The hangers are calibrated to ensure that they support the operating load at both their hot and cold load settings. Spring hangers provide a specified down travel and up travel in excess of the specified thermal movement. Deflections due to dynamic loads are checked to confirm that they do not bottom out.

(3) **Snubbers**—Mechanical and hydraulic type snubbers will be used when required as shock arrestors for nuclear safety-related piping systems. Snubbers are designed in accordance with ASME Section III, Subsection NF, Component Standard Supports. (See Section 3.9.1.7) Snubbers consist of a velocity-limiting or acceleration-limiting cylinder pinned to a pipe clamp at the pipe end and pinned to a clevis attached to the building structure at the other end. Snubbers operate as structural supports during dynamic events such as an earthquake, but during normal operation act as passive devices which accommodate normal expansions and contractions without resistance. The operating loads on snubbers are the loads caused by dynamic events (e.g., seismic, RBV due to LOCA and SRV discharge, discharge through a relief valve line or valve closure) during various operating conditions. Snubbers restrain piping against response to the vibratory excitation and to the associated differential movement of the piping system support anchor points. The criteria for locating snubbers and ensuring adequate load capacity, the structural and

mechanical performance parameters used for snubbers and the installation and inspection considerations for the snubbers are as follows:

(a) Required Load Capacity and Snubber Location

The loads calculated in the piping dynamic analysis, described in Subsection 3.7.3.8, cannot exceed the snubber load capacity for design, normal, upset, emergency and faulted conditions.

For hydraulic snubbers with load ratings greater than 222.4 kN, dynamic cyclic load tests will be conducted to verify the performance of the control valve. These hydraulic snubbers will be subjected to dynamic cyclic load tests at loads greater than or equal to one-half the calculated safe shutdown earthquake load on the snubbers. (See Section 3.9.1.7)

Snubbers are generally used in situations where dynamic support is required because thermal growth of the piping prohibits the use of rigid supports. The snubber locations and support directions are first decided by estimation so that the stresses in the piping system will have acceptable values. The snubber locations and support directions are refined by performing the dynamic analysis of the piping and support system as described above in order that the piping stresses and support loads meet the Code requirements.

The pipe support design specification requires that snubbers be provided with position indicators to identify the rod position. (See Section 3.9.1.7) This indicator facilitates the checking of hot and cold settings of the snubber, as specified in the installation manual, during plant preoperational and startup testing.

(b) Inspection, Testing, Repair and/or Replacement of Snubbers

The pipe support design specification requires that the snubber supplier prepare an installation instruction manual. This manual is required to contain complete instructions for the testing, maintenance, and repair of the snubber. It also contains inspection points and the period of inspection. (See Section 3.9.1.7)

The pipe support design specification requires that hydraulic snubbers be equipped with a fluid level indicator so that the level of fluid in the snubber can be ascertained easily.

The spring constant achieved by the snubber supplier for a given load capacity snubber is compared against the spring constant used in the piping system model. If the spring constants are the same, then the snubber location and support direction become confirmed. If the spring constants are not in agreement, they are brought in agreement, and the system analysis is redone to confirm the snubber loads. This iteration is continued until all snubber load capacities and spring constants are reconciled. (See Section 3.9.1.7)

A thermal motion monitoring program is established for verification of snubber movement, adequate clearance and gaps, including motion measurements and acceptance criteria to assure compliance with ASME Section III Subsection NF.

(c) Snubber Design and Testing

To assure that the required structural and mechanical performance characteristics and product quality are achieved, the following requirements for design and testing are imposed by the design specification:

(i) The snubbers are required by the pipe support design specification to be designed in accordance with all of the rules and regulations of ASME Code Section III, Subsection NF. This design requirement includes analysis for the normal, upset, emergency, and faulted loads. These calculated loads are then compared against the allowable loads to make sure that the stresses are below the code allowable limit. (See Section 3.9.1.7)

— All snubbers are load rated by testing in accordance with the snubber manufacturer's testing program and in compliance with the applicable sections of ASME QME-1-2007, Subsection QDR and ASME OM Code, Subsection ISTD.

(ii) The snubbers are tested to insure that they can perform as required during the seismic and other RBV events, and under anticipated operational transient loads or other mechanical loads associated with the design requirements for the plant. The following test requirements are included: (See Section 3.9.1.7)

— The codes and standards used for snubber functional qualification and production testing are as follows:

a. ASME B&PV Code Section III, Subsection NF.

b. ASME QME-1-2007, Subsection QDR and ASME OM Code, Subsection ISTD.

— Snubbers are subjected to force or displacement versus time loading at frequencies within the range of significant modes of the piping system.

— Dynamic cyclic load tests are conducted for large bore hydraulic snubbers to determine the operational characteristics of the snubber control valve. (See Section 3.9.1.7) All large bore hydraulic snubbers include full Service Level D load testing, including verifying bleed rates, control valve closure within the specified velocity ranges and drag forces/breakaway forces are acceptable in accordance with ASME, QME-1-2007 and ASME OM Codes.

— Displacements are measured to determine the performance characteristics specified.

— Tests are conducted at various temperatures to ensure operability over the specified range.

- Peak test loads in both tension and compression are required to be equal to or higher than the rated load requirements.
- The snubbers are tested for various abnormal environmental conditions. Upon completion of the abnormal environmental transient test, the snubber is tested dynamically at a frequency within a specified frequency range. The snubber must operate normally during the dynamic test. (See Section 3.9.1.7) Production and qualification test programs for both hydraulic and mechanical snubbers are carried out by the snubber vendors in accordance with the snubber installation instruction manual required to be furnished by the snubber supplier. Acceptance criteria assure compliance with ASME Section III Subsection NF, and other applicable codes, standards and requirements.

(d) Snubber Installation Requirements

An installation instruction manual is required by the pipe support design specification. This manual is required to contain instructions for storage, handling, erection, and adjustments (if necessary) of snubbers. Each snubber has an installation location drawing which contains the installation location of the snubber on the pipe and structure, the hot and cold settings, and additional information needed to install the particular snubber. (See Section 3.9.1.7)

(e) Snubber Pre-service Examination

The pre-service examination plan of all snubbers covered by the Chapter 16 technical specifications will be prepared. This examination will be made after snubber installation but not more than 6 months prior to initial system preoperational testing. The pre-service examination will verify the following:

(i) There are no visible signs of damage or impaired operability as a result of storage, handling, or installation.

(ii) The snubber location, orientation, position setting, and configuration (attachments, extensions, etc.) are according to design drawings and specifications.

(iii) Snubbers are not seized, frozen or jammed.

(iv) Adequate swing clearance is provided to allow snubber movements.

(v) If applicable, fluid is to be at recommended level and not leaking from the snubber system.

(vi) Structural connections such as pins, fasteners and other connecting hardware such as lock nuts, tabs, wire, cotter pins are installed correctly.

(vii) If the period between the initial pre-service examination and initial system pre-operational tests exceeds 6 months because of unexpected situations, reexamination of Items i, iv, and v will be performed.

Snubbers which are installed incorrectly or otherwise fail to meet the above requirements will be repaired or replaced and re-examined in accordance with the above criteria. (See Section 3.9.1.7)

(f) Snubber Inservice Examination

The program for inservice examination and testing of snubbers after construction is prepared in accordance with the requirements of ASME OM Code, 2004 Edition, Subsection ISTD, and RG 1.192. The intervals for visual examination are the subject of Code Case OMN-13, which is accepted under the RG 1.192.

(g) Snubber support data

A plant-specific table prepared as part of the inspection and test program for snubbers will include the following information:

(i) the general functional requirement (i.e., shock, vibration, dual purpose) for each system and component using snubbers including the number and location of each snubber. If either dual-purpose or arrestor type indicate whether the snubber or component was evaluated for fatigue strength,

(ii) operating environment,

(iii) applicable codes and standards,

(iv) list type of snubber (i.e., hydraulic, mechanical), materials of construction, standards for hydraulic fluids and lubricants, and the corresponding supplier,

(v) environmental, structural, and performance design verification tests,

(vi) production unit functional verification tests and certification,

(vii) packaging, shipping, handling, and storage requirements,

(viii) description of provisions for attachments and installation, and

(ix) quality assurance and assembly quality control procedures for review and acceptance by the purchaser.

(4) **Struts**

(This Subsection is not pertinent to the discussion of pumps, valves and dynamic restraints and is not included as part of reviewers guide.)

(5) **Frame Type (Linear) Pipe Supports**

(This Subsection is not pertinent to the discussion of pumps, valves and dynamic restraints and is not included as part of reviewers guide.)

(6) **Special Engineered Pipe Supports**

(This Subsection is not pertinent to the discussion of pumps, valves and dynamic restraints and is not included as part of reviewers guide.)

3.9.3.4.2 Reactor Pressure Vessel Support Skirt

(This Subsection is not pertinent to the discussion of pumps, valves and dynamic restraints and is not included as part of reviewers guide.)

3.9.3.4.3 Reactor Pressure Vessel Stabilizer

(This Subsection is not pertinent to the discussion of pumps, valves and dynamic restraints and is not included as part of reviewers guide.)

3.9.3.4.4 Floor-Mounted Major Equipment (Pumps, Heat Exchangers, and RCIC Turbine) (as modified in COLA Rev. 3)

Since the major active valves are supported by piping and not tied to building structures, valve "supports" do not exist (Subsection 13.4S.X.3.4.1).

The HPCF, RHR, SLC, FPCCU, SPCU, and CUW pumps; RCW, RHR, CUW, and FPCCU heat exchangers; and RCIC turbine-pump are all analyzed to verify the adequacy of their support structure under various plant operating conditions. In all cases, the load stresses in the critical support areas are within ASME Code allowables.

Seismic Category I active pump supports are qualified for dynamic (seismic and other RBV) loads by testing when the pump supports together with the pump meet the following test conditions:

(1) Simulate actual mounting conditions.

(2) Simulate all static and dynamic loadings on the pump.

(3) Monitor pump operability during testing.

(4) The normal operation of the pump during and after the test indicates that the supports are adequate (any deflection or deformation of the pump supports which precludes the operability of the pump is not accepted).

(5) Supports are inspected for structural integrity after the test. Any cracking or permanent deformation is not accepted.

Dynamic qualification of component supports by analysis is generally accomplished as follows:

(1) Stresses at all support elements and parts such as pump holddown and baseplate holddown bolts, pump support pads, pump pedestal, and foundation are checked to be within the allowable limits as specified in ASME Code Section III, Subsection NF.

(2) For normal and upset conditions, the deflections and deformations of the supports are assured to be within the elastic limits, and to not exceed the values permitted by the designer based on design verification tests. This ensures the operability of the pump.

(3) For emergency and faulted plant conditions, the deformations do not exceed the values permitted by the designer to ensure the operability of the pump. Elastic/plastic analyses are performed if the deflections are above the elastic limits.

3.9.3.5 Other ASME III Component Supports

(This Subsection is not pertinent to the discussion of pumps, valves and dynamic restraints and is not included as part of reviewers guide.)

3.9.4 Control Rod Drive (CRD)

(This Subsection is not pertinent to the discussion of pumps, valves and dynamic restraints and is not included as part of reviewers guide.)

3.9.5 Reactor Pressure Vessel Internals

(This Subsection is not pertinent to the discussion of pumps, valves and dynamic restraints and is not included as part of reviewers guide.)

3.9.6 Testing of Pumps and Valves (as modified in COLA Rev. 3)

This section describes the functional qualification provisions and inservice testing (IST) programs for safety-related pumps, valves, and dynamic restraints (snubbers). This includes both ASME Code, Section III, Class 1, 2, or 3, and non-ASME Code, safety-related pumps, valves, and snubbers. The provisions and programs described here verify that these components are in a state of operational readiness to perform their safety functions throughout the life of the plant.

In Preservice testing of safety-related pumps and valves will be performed in accordance with the requirements of ASME OM Code–2004, Subsections ISTA, ISTB, ISTC and ISTD./ANSI OMa-1988 Addenda to ASME/ANSI OM-1987, Parts 1, 6, and 10. Inservice testing will be performed in accordance with the latest approved code in effect 12 months prior to fuel load. Table 3.9-8 will be revised to lists the inservice testing parameters and frequencies for the safety-related pumps and valves. The reason for each code defined testing exception or justification for each code exemption request will be is noted in the description of the affected pump or valve. Valves having a containment isolation function are also noted in the listing. Inservice inspection is discussed in Subsection 5.2.4 and Section 6.6.

Details of the inservice testing program, including test schedules and frequencies, will be reported in the inservice inspection and testing plan to be provided prior to Fuel Loadby the applicant referencing the ABWR design. The plan will integrate the applicable test requirements for safety-related pumps and valves, including those listed in the technical specifications, Chapter 16, and the containment isolation system, Subsection 6.2.4. For example, the periodic leak testing of the reactor coolant pressure isolation valves (See Appendix 3M for design changes made to prevent intersystem LOCAs) in Table 3.9-9 will be performed in accordance with Chapter 16 Surveillance Requirement SR 3.4.4.1. This plan will include baseline pre-service testing to support the periodic inservice testing of the components. Depending on the test results, the plan will provide a commitment to disassemble and inspect the safety-related pumps and valves when limits of the OM Code are exceeded, as described in the following paragraphs. The primary elements of this plan, including the requirements of Generic Letter 89-10 and 96-05 for motor operated valves, are delineated in the subsections to follow. (See Subsection 3.9.7.3 for COL license information requirements.)

3.9.6.1 Testing of Safety-Related Pumps

This section describes the IST of pumps to assess their operational readiness, in compliance with ASME OM Code Subsections ISTA and ISTB. The program applies to pumps that are required to perform a specific function of bringing the reactor to the safe shutdown condition, in maintaining the safe shutdown condition, or in mitigating the consequences of a DBA. Pumps that are designated as Class 1, 2, and 3, and non-class pumps that perform a safety-related function are included in the IST program.

For each pump, the design basis and required operating conditions (including tests) under which the pump will be required to function will be established. These designs (design basis and required operating) conditions include flow rate and corresponding head for each system mode of pump operation and the required operating time for each mode, acceptable bearing vibration levels, seismic/dynamic loads, fluid temperature, ambient temperature, and pump motor minimum voltage.

Associated systems that contain pumps in the IST program include the necessary valving, instrumentation, test loops, fluid inventory, or other provisions to perform the required testing. Each pump is categorized as either a Group A or Group B pump. A pump that meets both Group A and Group B pump definitions is categorized as a Group A pump. Group A pumps are operated continuously or routinely during normal operation, cold shutdown, or refueling operations. Group B pumps are in standby systems that are not operated routinely, except for testing. When a Group A test is required, a comprehensive test may be substituted. When a Group B test is required, a Group A or comprehensive test may be substituted. A PST may be substituted for an inservice test.

IST testing conforms to the following:

- IST frequency is established in accordance with requirements set forth by Reference 3.9-13, Subsections ISTA and ISTB.
- IST interval is determined by calendar years following placement of the unit into commercial service.
- IST intervals are established in compliance with the following:
    - Initial test interval is the 10 years following commencement of unit commercial service.
    - Successive test intervals are 10 years following the previous test interval.
- Each IST interval may be extended or decreased by as much as one year. Adjustments will not cause successive intervals to be altered by more than one year from the original pattern of intervals.
- For units that are out of service continuously for six months or more, the IST interval during which the outage occurred may be extended for a period equivalent to the outage, and the original pattern of intervals extended accordingly for successive intervals.

An initial set of reference values are established for each pump during the PST period or before implementing IST. Parameters to be measured during IST program testing include pump speed (if required), discharge and differential pressures, flow rate, and vibration at IST conditions, as required by ISTB-3000 for each specific pump category. Range and accuracy requirements for instruments used to measure pressure, flow rate, speed, vibration, and differential pressure are provided in Reference 3.9-13, Table ISTB-3510-1. Instrument accuracy, range, location, fluctuations, and frequency response range requirements are established in accordance with ISTB-3510. The specific testing requirements and acceptable criteria are identified in ISTB-5000. Reference values are to be determined only when the equipment being tested is known to be operating acceptably. Following the PST, the IST commences when the pump is required to be operable to fulfill the required function. When a pump has been replaced, repaired, or has undergone maintenance that could affect the pump's performance, a new reference value will be determined or the previous value reconfirmed by an inservice test performed before the time it is returned to service or immediately if not removed from service.

~~The COL applicant will establish the following design and qualification requirements and will provide~~ As part of the final testing program, acceptance criteria will be provided for the following design and qualification ~~these~~ requirements. For each size, type, and model, ~~the COL applicant will perform~~ testing encompassing design conditions will be performed that demonstrates acceptable flow rate and corresponding head, bearing vibration levels, and pump internals wear rates for the operating time specified for each system mode of pump operation. From these tests~~, the COL applicant will also develop~~ baseline (reference) hydraulic and vibration data will be developed for evaluating the acceptability of the pump after installation. ~~The COL applicant will ensure that~~ Adequate minimum flow rate and thrust bearing capacity will be verified for the pump specified for each application~~ is not susceptible to inadequate minimum flow rate and inadequate thrust bearing capacity~~. With respect to minimum flow pump operation, the sizing of each minimum recirculation flow path is evaluated to assure that its use under all analyzed conditions will not result in degradation of the pump. The flow rate through minimum recirculation flow paths can also be periodically measured to verify that flow is in accordance with the design specification.

The ABWR safety-related pumps and piping configurations accommodate in-service testing at a flow rate at least as large as the maximum design flow for the pump application. The safety-related pumps are provided with instrumentation to verify that the net positive suction head (NPSH) is greater than or equal to the NPSH required during all modes of pump operation. These pumps can be disassembled for evaluation when ISTB ~~Part 6~~ testing results in a deviation which falls within the "required action range." The Code provides criteria limits for the test parameters identified in Table 3.9-8. ~~A program will be developed by the COL applicant to establish t~~ The frequency and the extent of disassembly and inspection will be established based on suspected degradation ~~of all~~ for each safety-related pump~~s~~, and will be includ~~ing~~ed in a program along with the basis for the frequency and the extent of each disassembly.

The program may be revised throughout the plant life to minimize disassembly based on past disassembly experience. ~~(See Subsection 3.9.7.3(1) for COL license information requirements.)~~

3.9.6.2 Testing of Safety-Related Valves

This section describes the IST of valves to assess their operational readiness, in compliance with Reference 3.9-13, Subsections ISTA and ISTC. The program applies to valves classified as ASME Code Class 1, 2, or 3 valves and non-ASME valves that perform a safety-related function.

Valve testing requirements include exercise, leakage, and position verification. Other specific testing requirements for power-operated valves require stroke-time testing and may require diagnostic testing to determine valve operating conditions to verify operability under design-basis conditions. IST program valves are classified as either active or passive. Active valves change disk position to accomplish a specific function in shutting down a reactor to the safe-shutdown condition, maintaining the safe shutdown condition, or mitigating the consequences of an accident. Passive valves maintain disk position and do not change the disk position to accomplish the required safety functions. Passive valves are not included in the valve exercise testing.

Pre-conditioning of valves or their associated actuators or controls prior to IST is not allowed. Pre-conditioning includes manipulation, pre-testing, maintenance, lubrication, cleaning, exercising, stroking, operating, or disturbing the valve to be tested in any way except as may occur in an unscheduled, unplanned, and unanticipated manner during normal operation. The IST program complies with the requirements of Reference 3.9-13, Subsection ISTC, to the extent practicable. If a valve cannot be tested during normal operation, justification for testing during cold shutdown or a refueling outage is included in the test plan. The IST program incorporates nonintrusive techniques to periodically assess the degradation and performance of selected valves.

Valves within the scope of the IST program are categorized as follows:

- Category A valves, for which seat leakage in the closed position is limited to a specific maximum amount to fulfill their required functions.
- Category B valves, for which seat leakage in the closed position is inconsequential to fulfill their required functions.
- Category C valves, which are self-actuating in response to some system characteristic to fulfill their required functions, such as pressure for relief valves or flow direction for check valves. Category C valves are addressed in Section 3.9.6.2.1 (check valves) and Section 3.9.6.2.5 (safety and relief valves).
- Category D valves, which are actuated by an energy source capable of only one operation, such as rupture disks or explosively actuated valves.

Category A and Category B valves are tested as follows:

- Valves are tested by full-stroke exercising during operation at power to the positions required to fulfill their functions. If full-stroke testing is not practicable, testing may be limited to part-stroke exercising of the valves during operation at power and full-stroke exercising during cold shutdowns.
- If valve exercising is not practicable during operation at power then the testing may be limited to full-stroke exercising of the valves during cold shutdowns. Valve exercising may be limited to part-stroke during cold shutdowns and full-stroke during refueling outages.
- Valve exercising is not required if the time period since the previous full-stroke exercise is less than three months and no activities that could change operating parameters have been performed. During extended shutdowns, valves that are required to be operable must remain capable of performing their intended safety function.
- Exercising valves during cold shutdown commences within 48 hours of achieving cold shutdown and continues until testing is complete or the plant is ready to return to operation at power.
- Valve testing required to be performed during a refueling outage is completed before returning the plant to operation at power.

Valve testing uses reference values determined from the results of PST or IST. These tests are performed under conditions as near as practicable to those expected during the IST. Reference values are established only when the valve is known to be operating acceptably. When a valve or its control system has been replaced, repaired, or has undergone maintenance that could affect valve performance, a new reference value is determined or the previous value is reconfirmed by an inservice test. This test is performed before the valve is returned to service or immediately if the valve is not removed from service. Deviations between the previous and new reference values are identified and analyzed. Verification that the new values represent acceptable operation is documented. The plant corrective action program documents valve failures.

3.9.6.2.1 Check Valves

(1) Design and Qualification

For each check valve with an active safety-related function, the design basis and required operating conditions (including testing) under which the check valve will be required to perform will be established.

~~The COL applicant will establish~~ As part of the final testing program, the following design and qualification requirements will be established, along with corresponding ~~and will provide~~ acceptance criteria for these requirements. ~~By t~~ Testing of each size, type, and model ~~the COL applicant~~ will ensure the design adequacy of the check valve under design (design basis and required operating) conditions. These design conditions include all the required system operating cycles to be experienced by the valve (numbers of each type of cycle and duration of each type cycle), environmental conditions under which the valve will be required to function, severe transient loadings expected during the life of the valve such as water hammer or pipe break, lifetime expectation between major refurbishments, sealing and leakage requirements, corrosion requirements, operating medium with flow and velocity definition, operating medium temperature and gradients, maintenance requirements, vibratory loading, planned testing and methods, test frequency and periods of idle operation. The design conditions may include other requirements as identified during detailed design of the plant systems. This testing of each size, type and model shall include test data from the manufacturer, field test data for dedication ~~by the COL applicant~~, empirical data supported by test, or tests (such as prototype) of similar valves that support qualification of the required valve where similarity must be justified by technical data. ~~The COL applicant will ensure p~~ Proper check valve application will be verified, including selection of the valve size and type based on the system flow conditions, installed location of the valve with respect to sources of turbulence, and correct orientation of the valve in the piping (i.e., vertical vs horizontal) as recommended or required by the manufacturer. ~~The COL applicant will ensure that v~~ Valve design features, material, and surface finish will be reviewed to assure they accommodate non-intrusive diagnostic testing methods available in the industry or as specified. ~~The COL applicant will also ensure that f~~ Flow through the valve will be verified as ~~is~~ determinable from installed instrumentation and ~~that the~~ valve disk positions will be verified as ~~are~~ determinable without disassembly such as by use of nonintrusive diagnostic methods. Valve internal parts are designed with self-aligning features for purpose of assured correct installation. The ~~COL applicant will compare the~~ maximum loading on the check valve under design basis and ~~the~~ required operating conditions will be compared to the allowable structural capability limits for the individual parts of the check valve. The qualification acceptance criteria noted above will include baseline data developed during qualification testing and will be used for verifying the acceptability of the check valves after installation.

(2) Pre Operational Testing

Check valve testing requires verification that disk movement is in the direction required for the valve to perform its safety function. For check valves that perform a safety function in the open and closed directions, the valve is tested by initiating flow and observing whether or not the disk moves to the full-open position. ~~The COL applicant will test e~~ Each check valve will be tested in the in the open and~~/or~~ close direction~~, as required by the safety function,~~ under all normal operating system conditions. To the extent practical, testing of the valves as described in this section will be performed under fluid temperature conditions that would exist during a cold shutdown as well as under fluid temperature conditions that would be experienced by the valve during other modes of plant operation. The testing will identify the flow needed to open the valve to the full-open position. During flow conditions, the valve disk moves to and maintains contact with the backseat without fluctuating, while allowing the flow rate and maximum differential pressure across the valve to remain within acceptable design limits for the system. When flow ceases or reverses, the valve disk moves to the valve seat to fulfill the test requirements.

For valves that have a safety function in only the open direction, the valve is exercised by initiating flow and observing whether or not the disk moves to the full-open position. Check valves that have a safety function in only the closed direction are exercised by initiating flow and observing whether or not the disk moves to at least the partially open position. When flow ceases or reverses, the valve disk moves to the valve seat.

The testing will include the effects of rapid pump starts and stops as required by expected system operating conditions. The testing will include any other reverse flow conditions that may be required by expected system operating conditions. The ~~COL applicant will examine the~~ disk movement will be examined during valve testing to verify the leak-tightness of valve when fully closed. By using methods such as non-intrusive diagnostic equipment, ~~the COL applicant will examine~~ the open valve disk stability will be verified under the flow conditions during normal and other required system operating conditions.

The parameters and acceptance criteria for demonstrating that the above functional performance requirements have been met are as follows:

(a) During all test modes that simulate expected system operating conditions, the valve disk fully opens or fully closes as expected based on the direction of the differential pressure across the valve.

(b) Leak-tightness of valve when fully closed is within established limits, as applicable.

(c) Valve disk positions are determinable without disassembly.

(d) Valve testing must verify free disk movement whenever moving to and from the seat.

(e) The disk is stable in the open position under normal and other required system operating fluid flow conditions.

(f) The valve is correctly sized for the flow conditions specified, i.e., the disk is in full open position at normal full flow operating condition.

(g) Valve design features, material, and surfaces accommodate non-intrusive diagnostic testing methods available in the industry or as specified.

(h) Piping system design features accommodate all the applicable check valve testing requirements as described in Table 3.9-8.

(3) Inservice Testing

All ABWR safety-related piping systems incorporate provisions for testing to demonstrate the operability of the check valves under design conditions. If these test methods are impractical for certain check valves, or if sufficient flow cannot be achieved or verified, a sample disassembly examination program verifies valve disk movement. The sample disassembly examination program groups check valves by category of similar design, application, and service condition.

During the disassembly process, the full-stroke motion of the valve disk is verified. Nondestructive examination is performed on the hinge pin to assess wear, and seat contact surfaces are examined to verify adequate contact. Full-stroke motion of the valve disk is re-verified immediately prior to completing reassembly. At least one valve from each group is disassembled and examined at each refueling outage, and the valves in each group are disassembled and examined at least once every eight years. A condition monitoring program may be established to modify testing or disassembly inspection periods when sufficient operating data have been collected for a valve type. The condition monitoring program is prescribed by post-maintenance program or ASME OM Code Appendix II requirements for each equipment type. Before returning to service, valves disassembled for examination or valves that received maintenance that could affect their performance are exercised with a full or part stroke. Details and bases of the sampling program are documented and recorded in the test plan.

When operating conditions, valve design, valve location, or other considerations prevent direct observation or measurements by use of conventional methods to determine adequate check valve function, diagnostic equipment and nonintrusive techniques are used to monitor internal conditions. Nonintrusive techniques include operating parameters (e.g., fluid flow, disk position, disk movement, and disk impact forces). Nonintrusive techniques also detect valve degradation. Diagnostic equipment and techniques used for valve operability determinations are verified as effective and accurate under the PST program. Testing is performed, to the extent practical, under normal operation, cold shutdown, or refueling conditions applicable to each check valve. Testing includes effects created by sudden starting and stopping of pumps, if applicable, or other conditions, such as flow reversal. When maintenance that could affect valve performance is performed on a valve in the IST program, post-maintenance testing is conducted prior to returning the valve to service.

~~Inservice testing will incorporate the use of advance non-intrusive techniques to periodically assess degradation and the performance characteristics of the check valves. The Part 10 tests will be performed, and check valves that fail to exhibit the required performance can be disassembled for evaluation.~~ The Code provides criteria limits for the test parameters identified in Table 3.9-8. ~~A program will be developed by the COL applicant to establish~~ The frequency and the extent of disassembly and inspection will be established based on suspected degradation of all safety-related check valves, and will be included in a program along with ~~including~~ the basis for the frequency and the extent of each disassembly. The program may be revised throughout the plant life to minimize disassembly based on past disassembly experience.

3.9.6.2.2 Motor-Operated Valves

For each motor-operated valve assembly (MOV) with an active safety related function, the design basis and required operating conditions (including testing) under which the MOV will be required to perform are established for the development and implementation of the design, qualification and preoperational testing.

(1) Design and Qualifications

~~The COL applicant will establish the following design and qualification requirements and will provide~~ As part of the final testing program, acceptance criteria will be provided for the following design and qualification ~~these~~ requirements. ~~By t~~ Testing each size, type, and model ~~the COL applicant~~ will determine the torque and thrust (as applicable to the type of MOV) requirements to operate the MOV and will ensure the adequacy of the torque and thrust that the motor-operator can deliver under design (design basis and required operating) conditions. ~~The COL applicant will also test e~~ Each size, type, and model will be tested under a range of differential pressure and flow conditions up to the design conditions. These design conditions include fluid flow, differential pressure (including pipe break), system pressure, fluid temperature, ambient temperature, minimum voltage, and minimum and maximum stroke time requirements. This testing of each size, type and model shall include test data from the manufacturer, field test data for dedication ~~by the COL applicant~~, empirical data supported by test, or test (such as prototype) of similar valves that support qualification of the required valve where similarity must be justified by technical data. ~~From t~~ This testing ~~the COL applicant~~ will demonstrate that the results of testing under in situ or installed conditions can be used to ensure the capability of the MOV to operate under design conditions. The ~~COL applicant will ensure that structural capability limits of the~~ individual parts of the MOV will be verified not to ~~be~~ exceed~~ed~~ structural capability limits under design conditions. The ~~COL applicant will ensure that the~~ valve specified for each application will be verified as ~~is~~ not susceptible to pressure locking and thermal binding. ~~‡~~

~~‡ See Subsection 3.9.6.2.2.~~

(2) Pre-operational Testing

~~The COL applicant will test e~~ Each MOV will be tested in the open and close directions under static and maximum achievable conditions using diagnostic equipment that measures torque and thrust (as applicable to the type of MOV), and motor parameters. ~~The COL applicant will test the~~ Each MOV will be tested sufficiently, under various differential pressure and flow to maximum achievable conditions, ~~and perform a sufficient number of tests~~ to determine the torque and thrust requirements at design conditions. The ~~COL applicant will determine the~~ torque and thrust requirements to close the valve, for the position at which there is diagnostic indication of hard seat contact, will be determined. The determination of design torque and thrust requirements will be made for such parameters as differential pressure, fluid flow, undervoltage, temperature and seismic dynamic effects for MOVs that must operate during these transients. The design torque and thrust requirements will be adjusted for diagnostic equipment inaccuracies. For the point of control switch trip, ~~the COL applicant will determine~~ any loss in torque produced by the actuator, and thrust delivered to the stem, for increasing differential pressure and flow conditions (referred to as load sensitive behavior) will be determined. The ~~COL applicant will compare the~~ design torque and thrust requirements will be compared to the control switch trip torque and thrust, subtracting margin for load sensitive behavior, control switch repeatability, and degradation. The ~~COL applicant will measure t he~~ total thrust and torque delivered by the MOV under static and dynamic conditions (including diagnostic equipment inaccuracy and control switch repeatability) will be measured to compare to the allowable structural capability limits for the individual parts of the MOV. ~~The COL applicant will test for p~~ Proper control room position indication of the MOV will be tested.

The parameters and acceptance criteria for demonstrating that the above functional performance requirements have been met are as follows:

(a) As required by the safety function: the valve must fully open; the valve must full close with diagnostic indication of hard seat contact.

(b) The control switch settings must provide adequate margin to achieve design requirements including consideration of diagnostic equipment inaccuracy, control switch repeatability, load sensitive behavior, and margin for degradation.

(c) The motor output capability at degraded voltage must equal or exceed the control switch setting including consideration of diagnostic equipment inaccuracy, control switch repeatability, load sensitive behavior and margin for degradation.

(d) The maximum torque and thrust (as applicable for the type MOV) achieved by the MOV including diagnostic equipment inaccuracies and control switch repeatability must not exceed the allowable structural capability limits for the individual parts of the MOV.

(e) The remote position indication testing must verify that proper disk position is indicated in the control room.

(f) Stroke time measurements taken during valve opening and closing must meet minimum and maximum stroke time requirements.*

(3) Inservice Testing

The inservice testing of MOVs will rely on diagnostic techniques that are consistent with the state of the art and which will permit an assessment of the performance of the valve under actual loading. Periodic testing per GL89-10 Paragraphs D and J 96-05 will be conducted under adequate differential pressure and flow conditions that allow a justifiable demonstration of continuing MOV capability for design basis conditions. The COL applicant will determine the optimal frequency of this periodic verification. The frequency and test conditions will be sufficient to demonstrate continuing design basis and required operating capability. See Subsection 3.9.7/3 for COL license information requirements. The Code provides criteria limits for the test parameters identified in Table 3.9-8 for code inservice testing. Periodic verification (PV) will be in accordance with the "Joint Owners' Group (JOG) Motor Operated Valve Periodic Verification Program Summary," MPR-2524-B, November 2007. According to the JOG MOV PV program guidance, static testing of MOVs is performed at a frequency dependent on margin and risk significance. Specifically:

> "A classification process is used to determine how each MOV is to be tested. Valves that are not susceptible to degradation based on JOG Program testing are identified and static PV test intervals are specified. Applications of gate and butterfly valves that are susceptible to increases or variations in required thrust or torque are identified, and users are to add margin allowances (gate valves) or to verify by DP test (butterfly and gate valves) that the valve performance is stable."

A program will be developed by the COL applicant to establish t The frequency and the extent of disassembly and inspection will be established based on suspected degradation of each all safety-related MOVs, and included in a program, along with including the basis for the frequency and the extent of each disassembly. The program may be revised throughout the plant life to minimize disassembly based on past disassembly experience.

* See Subsection 3.9.6.2.2.

3.9.6.2.3 Power Operated Valves

(1) Design and Qualification

For each power-operated (includes pneumatic- hydraulic-, piston-, and solenoid-operated) valve assembly (POV) with an active safety-related function, the design basis and required operating conditions (including testing) under which the POV will be required to perform will be established.

The COL applicant will establish the following design and qualification requirements and will provide As part of the final testing program, acceptance criteria will be provided for these following design and qualification requirements. By t Testing each size, type, and model the COL applicant will determine the force (as applicable to the type of POV) requirement to operate the POV and will ensure the adequacy of the force that the operator can deliver under design (design basis and required operating) conditions. The COL applicant will also test e Each size, type, and model will be tested under a range of differential pressure and flow conditions up to the design conditions. These design conditions include fluid flow, differential pressure (including pipe break), system pressure, fluid temperature, ambient temperature, minimum air supply system (or accumulator) pressure, spring force, and minimum and maximum stroke time requirements. This testing of each size, type and model shall include test data from the manufacturer, field test data for dedication by the COL applicant, empirical data supported by test, or test (such as prototype) of similar valves that support qualification of the required valve where similarity must be justified by technical data. From tThis testing, the COL applicant will demonstrate that the results of testing under in-situ conditions can be used to ensure the capability of the POV to operate under design conditions. The COL applicant will ensure that the structural capability limits of the assembly and the individual parts of the POV will be verified not to be exceeded structural capability limits under design conditions. The COL applicant will ensure that packing adjustment limits are specified for each valve application will be verified as for the valve for each application such that it is not susceptible to stem binding.

(2) Pre-operational Testing

The COL applicant will test e Each POV will be tested in the open and close directions under static and maximum achievable conditions using diagnostic equipment that measures or provides information to determine total friction, stroke time, seat load, spring rate, and travel under normal pneumatic or hydraulic pressure (as applicable to the type of POV), and minimum pneumatic or hydraulic pressure. The COL applicant will test the Each POV will be tested sufficiently, under various differential pressure and flow up to maximum achievable conditions, and perform a sufficient number of times tests to determine the force requirements at design conditions. The COL applicant will determine the force requirements to close the valve, for the position at which there is a diagnostic indication of full valve closure (as required for the safety function of the applicable valves), will be determined. The determination of design force requirements will be made for such parameters as differential pressure, fluid flow, minimum pneumatic or hydraulic pressure, power supply, temperature, and seismic/dynamic effects for POVs that must operate during these transients. The design force requirements will be adjusted for diagnostic equipment inaccuracies.

The COL applicant will measure the total force delivered by the POV under static and dynamic conditions (including diagnostic equipment inaccuracies) will be measured to compare to the allowable structural capability limits for the assembly and individual parts of the POV. The COL applicant will test for p Proper control room position indication of the POV will be verified.

The parameters and acceptance criteria for demonstrating that the above functional performance requirements have been met are as follows:

(a) As required by the safety function, the valve must fully open and/or the valve must fully close with diagnostic indication of hard seat contact.

(b) The assembly must demonstrate adequate margin to achieve design requirements including consideration of diagnostic equipment inaccuracies and margin for degradation.

(c) The assembly must demonstrate adequate output capability of the power-operator at minimum pneumatic or hydraulic pressure of electrical supply (or loss of motive force for fail-safe positioning) with consideration of diagnostic equipment inaccuracies and margin for degradation.

(d) The maximum force (as applicable for the type of POV) achieved by the POV including diagnostic equipment inaccuracies must not exceed the allowable structural capability limits for the assembly and individual part of the POV.

(e) The remote position indication testing must verify that proper disk position is indicated in the control room and other remote locations relied upon by operators in any emergency situation.

(f) Stroke-time measurements taken during valve opening and closing must meet minimum and maximum stroke-time requirements.

(g) For solenoid-operated valves (SOVs), the Class 1E electrical requirements are to be verified. The SOV should be verified to be capable of performing for design requirements for energized or de-energized and rated appropriately for the electrical power supply amperage and voltage.

(h) Provide leak-tight seating which must meet specified maximum leakage rate, or meet leakage rate to ensure an overall containment maximum leakage.

(3) Inservice Testing

All ABWR safety-related piping systems incorporate provisions for testing to demonstrate the operability of the POVs under design conditions. Inservice testing will incorporate the use of advance non-intrusive techniques to periodically assess degradation and the performance characteristics of the POVS. The ISTC~~Part 10~~ tests will be performed, and valves that fail to exhibit the required performance can be disassembled for evaluation. The Code provides criteria limits for the test parameters identified in Table 3.9-8. ~~A program will be developed by the COL applicant to establish t~~The frequency and the extent of disassembly and inspection will be established based on suspected degradation of all safety-related POVs, and included in a program along with ~~including~~ the basis for the frequency and the extent of each disassembly. The program may be revised throughout the plant life to minimize disassembly based on past disassembly experience. ~~(See Subsection 3.9.7/3 for COL license information requirements.)~~

3.9.6.2.4 Isolation Valve Leak Tests

The leaktight integrity will be verified for each valve relied upon to provide a leaktight function. These valves include:

(1) Pressure isolation valves—valves that provide isolation of pressure differential from one part of a system from another or between systems. Pressure isolation valves (PIVs) are

the two normally closed valves, in series, within the RCPB that isolate the reactor coolant system from an attached low-pressure system. PIVs are classified as A or A/C in accordance with the provisions of Subsection ISTC-1300 of Reference 3.9-13. PIV seat leakage rate tests are conducted in accordance with Subsection ISTC-3630, which specifies a PIV leakage limit of 0.5 gpm per inch of nominal valve diameter up to 5 gpm maximum for each PIV, when a permissible leakage rate is not otherwise specified. PIV leakage tests are described further in the Technical Specifications.

(2) Temperature isolation valves—valves whose leakage may cause unacceptable thermal loading on supports or stratification in the piping and thermal loading on supports or whose leakage may cause steam binding of pumps. Temperature isolation valves are classified as A or A/C in accordance with the provisions of Subsection ISTC-1300 of Reference 3.9-13. Seat leakage rate tests are conducted in accordance with Subsection ISTC-3630, which specifies a PIV leakage limit of 0.5 gpm per inch of nominal valve diameter up to 5 gpm maximum for each PIV, when a permissible leakage rate is not otherwise specified.

(3) Containment isolation valves—valves that perform a containment isolation function in accordance with the Evaluation Against Criterion 54, Subsection 3.1.2.5.5.2, including valves that may be exempted from Appendix J, Type C, testing but whose leakage may cause loss of suppression pool water inventory. CIVs are leak tested in accordance with 10 CFR Part 50, Appendix J.

~~Leakage rate testing for valve group (1) is addressed in Subsection 3.9.6. Valve groups (2) and (3) will be tested in accordance with Part 10, Paragraph 4.2.2.3.b~~ The fusible plug valves that provide a lower drywell flood for severe accidents are described in Subsection 9.5.12. The valves are safety-related due to the function of retaining suppression pool water as shown in Figure 9.5-3. The fusible plug valve is a nonreclosing pressure relief device and the Code requires replacement of each at a maximum of 5-year interval.

3.9.6.2.5 Inservice Testing Program for Safety and Relief Valves [New Section]

Safety and relief valves protect systems that are required to provide a safety function. Stroke tests are performed for dual-function safety and relief valves. Safety and relief valve tests are conducted in accordance with Appendix I to Reference 3.9-13. Power-operated relief valves subject to the IST program are tested in accordance with Subsection ISTC-5100 for Category B valves and Subsection ISTC-5240 for Category C valves. Using test equipment, including gages, transducers, load cells, and calibration standards, to determine valve set-pressure is acceptable if the overall combined accuracy does not exceed ±one percent of the indicated (measured) set pressure.

A list of safety and relief valves included in the IST program is provided in Table 3.9-8.

3.9.6.2.6 Inservice Testing Program for Manually Operated Valves [New Section]

Manual valves are exercised at least every two years. Exercise of a manual valve includes a complete cycle from fully open to fully closed.

A list of manual valves included in the IST program is provided in Table 3.9-8.

3.9.6.7 Inservice Testing Program Implementation [New Section]

Inservice testing will be performed in accordance with the latest approved code in effect 12 months prior to fuel load. ASME OM Code inservice test intervals are as required by ISTA-3120; the initial 120-month test interval beginning following the start of commercial service. The duration of each 120-month test interval may be modified by as much as one year as allowed by the Code, provided these adjustments do not cause successive intervals to be altered by more than one year from the original pattern of intervals.

3.9.6.8 Non-Code Testing of Power-Operated Valves [New Section]

Although the design basis capability of active, safety-related power-operated valves is verified as part of the design and qualification process, power-operated valves that perform an active safety function are tested again after installation in the plant, as required, to ensure valve setup is acceptable to perform their required functions, consistent with valve qualification. These tests, which are typically performed under static (no flow or pressure) conditions, also document the "baseline" performance of the valves to support future maintenance and trending programs. During the testing, critical parameters needed to ensure proper valve setup are measured. Depending on the valve and actuator type, these parameters may include seat load, running torque or thrust, valve travel, actuator spring rate, bench set and regulator supply pressure. Uncertainties associated with performance of these tests and use of the test results (including those associated with measurement equipment and potential degradation mechanisms) are considered appropriately. Uncertainties may be considered in the specification of acceptable valve setup parameters or in the interpretation of the test results (or a combination of both). Uncertainties affecting both valve function and structural limits are considered.

Additional valve testing may be performed, for example, as part of the plant's air operated valve program in response to Regulatory Issue Summary 2000-003 or as part of the plant's preventive maintenance program.

3.9.8 References

3.9-1 "BWR Fuel Channel Mechanical Design and Deflection", NEDE-21354-P, September 1976.

3.9-2 "BWR/6 Fuel Assembly Evaluation of Combined Safe Shutdown Earthquake (SSE) and Loss-of-Coolant Accident (LOCA) Loadings", NEDE-21175-P, November 1976.

3.9-3 NEDE-24057-P (Class III) and NEDE-24057 (Class I) Assessment of Reactor Internals. Vibration in BWR/4 and BWR/5 Plants, November 1977. Also NEDO-24057-P, Amendment 1, December 1978, and NEDE-2-P 24057 Amendment 2, June 1979.

3.9-4 "General Electric Company, Analytical Model for Loss-of-Coolant Analysis in Accordance with 10CFR50, Appendix K", NEDE-20566P, Proprietary Document, November 1975.

3.9-5 "BWR Feedwater Nozzle and Control Rod Drive Return Line Nozzle Cracking", NUREG-0619.

3.9-6 "General Electric Environmental Qualification Program", NEDE-24326-1-P, Proprietary Document, January 1983. (See Section 3.10 and Appendix 3K. This reference is same as Reference 3.11-2 (Subsection 3.11.7))

3.9-7 Functional Capability of Piping Systems, U.S. Nuclear Regulatory Commission, NUREG-1367, November 1992. (See Subsection 3.9.1.7)

3.9-8 "Generic Criteria for High Frequency Cutoff of BWR Equipment", NEDE- 25250, Proprietary Document, January 1980.

3.9-9 General Electric Company, Plain Carbon Steels, 408HA414, Rev. 1. (See Subsection 3.9.1.7)

3.9-10 EPRI NP-5639, "Guidelines for Piping System Reconciliation", May 1988. (See Subsection 3.9.1.7)

3.9-11 NUREG/CR-6049, Piping Benchmark Problems for the GE ABWR, August 1993. (See Subsection 3.9.1.7)

3.9-12 NCIG-01, Visual Weld Acceptance Criteria for Structural Welding at Nuclear Power Plants, Revision 2. (See Section 3.10 and Appendix 3K. This reference is same as Reference 3.11-2 (Subsection 3.11.7))

3.9-13 ASME OM Code, "Code for Operation and Maintenance of Nuclear Power Plants," The American Society of Mechanical Engineers, 2004 edition.

3.9-14 NUREG-1482, Revision 1, "Guidelines for Inservice Testing at Nuclear Power Plants," Nuclear Regulatory Commission, January 2005.

3.9-15 Generic Letter 96-05, "Periodic Verification of Design Basis Capability of Safety-Related Motor-Operated Valves," Nuclear Regulatory Commission, September 18, 1996.

3.9-16 Generic Letter 89-10, "Safety-Related Motor-Operated Valve Testing and Surveillance," Nuclear Regulatory Commission, June 28, 1989.

3.9-17 Generic Letter 90-09, "Alternative Requirements for Snubber Visual Inspection Intervals and Corrective Actions," Nuclear Regulatory Commission, May 14, 1990.

3.9-18 ASME QME-1, "Qualification of Active Mechanical Equipment Used in Nuclear Power Plants," 2007 Edition

3.9-19 MPR-2524-B. "Joint Owners' Group (JOG) Motor Operated Valve Periodic Verification Program Summary," November 2007