GE Nuclear Energy

General Electric Company
175 Curtner Avenue, San Jose, CA 95125

May 11, 1993

Docket No. STN 52-001

Chet Poslusny, Senior Project Manager
Standardization Project Directorate
Associate Directorate for Advanced Reactors
and License Renewal
Office of the Nuclear Reactor Regulation

Subject: Submittal Supporting Accelerated ABWR Review Schedule - **Valve Operability Assurance**

Dear Chet:

Enclosed are SSAR markups that reflect the resolution obtained in the May 3, 1993 telephone call between Maryann Herzog, Jim Brammer, Dave Terao and myself pertaining to valve operability assurance.

Please provide copies of this tranmsmittal to Jim Brammer and Dave Terao.

Sincerely,

Jack Fox

Jack Fox
Advanced Reactor Programs

cc: Norman Fletcher(DOE)
Maryann Herzog (GE)

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Subsections 3.9.2.5, 3.9.3, and 3.9.5.

Deformations under faulted conditions are evaluated in critical areas and the necessary design deformation limits, such as clearance limits, are satisfied.

3.9.1.4.1 Control Rod Drive System Components

3.9.1.4.1.1 Fine Motion Control Rod Drive

The fine motion control rod drive (FMCRD) major components that are part of the reactor coolant pressure boundary are analyzed and evaluated for the faulted conditions in accordance with the ASME Code, Section III, Appendix F.

3.9.1.4.1.2 Hydraulic Control Unit

The hydraulic control unit (HCU) is analyzed and tested for withstanding the faulted condition loads. Dynamic tests establish the "g" loads in horizontal and vertical directions as the HCU capability for the frequency range that is likely to be experienced in the plant. These tests also insure that the scram function of the HCU can be performed under these loads. Dynamic analysis of the HCU with the mounting beams is performed to assure that the maximum faulted condition loads remain below the HCU capability.

3.9.1.4.2 Reactor Pressure Vessel Assembly

The reactor pressure vessel assembly includes: (1) the reactor pressure vessel boundary out to and including the nozzles and housings for FMCRD, internal pump and in-core instrumentation; (2) support skirt; and (3) the shroud support, including legs, cylinder, and plate. The design and analysis of these three parts comply with subsections NB, NF, and NG, respectively, of the ASME Code, Section III. For faulted conditions, the reactor vessel is evaluated using elastic analysis. For the support skirt and shroud support, an elastic analysis is performed, and buckling is evaluated for compressive load cases for certain locations in the assembly.

3.9.1.4.3 Core Support Structures and Other Safety Reactor Internal Components

The core support structures and other safety class reactor internal components are evaluated for faulted conditions. The basis for determining the faulted loads for seismic events and other dynamic events is given in Section 3.7 and Subsection 3.9.5, respectively. The allowable Service Level D limits for evaluation of these structures are provided in Subsection 3.9.5.

3.9.1.4.4 RPV Stabilizer and FMCRD - and In-Core Housing Restraints (Supports)

The calculated maximum stresses meet the allowable stress limits stated in Table 3.9-1 and 3.9-2 under faulted conditions for the RPV stabilizer and supports for the fine motion control rod drive housing and In-Core housing for faulted conditions. These supports restrain the components during earthquake, pipe rupture of other reactor building vibration events.

3.9.1.4.5 Main Steam Isolation Valve, Safety/Relief Valve and Other ASME Class 1 Valves

Elastic analysis methods and standard design rules, as defined in ASME Code Section III, are utilized in the analysis of the pressure boundary, Seismic Category I, ASME Class 1 valves. The Code-allowable stresses are applied to assure integrity under applicable loading conditions including faulted condition. Subsection 3.9.3.2.4 discusses the operability qualification of the major active valves including main steam isolation valve and the main steam safety/relief valve for seismic and other dynamic conditions. The allowable stresses for various operating conditions, including faulted, for active ASME class 1 valves are provided in footnote 7 of Table 3.9-2.

3.9.1.4.6 ECCS and SLC Pumps, RRS and RHR Heat Exchangers, RCIC Turbine, and RRS Motor

The ECCS (RHR, RCIC and HPCF) pumps, SLC pumps, RHR heat exchangers, and RCIC turbine are

analyzed for the faulted loading conditions. The ECCS and SLC pumps are active ASME Class 2 components. The allowable stresses for active pumps are provided in a footnote to Table 3.9-2.

The reactor coolant pressure boundary components of the reactor recirculation system (RRS) pump motor assembly, and recirculation motor cooling (RMC) subsystem heat exchanger are ASME Class 1 and Class 3, respectively, and are analyzed for the faulted loading conditions. All equipment stresses are within the elastic limits.

3.9.1.4.7 Fuel Storage and Refueling Equipment

Storage, refueling, and servicing equipment which is important to safety is classified as essential components per the requirements of 10CFR50 Appendix A. This equipment and other equipment which in case of a failure would degrade an essential component is defined in Section 9.1 and is classified as Seismic Category I. These components are subjected to an elastic dynamic finite-element analysis to generate loadings. This analysis utilizes appropriate floor response spectra and combines loads at frequencies up to 33 Hz for seismic loads and up to 60 Hz for other dynamic loads in three directions. Imposed stresses are generated and combined for normal, upset, and faulted conditions. Stresses are compared, depending on the specific safety class of the equipment, to Industrial Codes, ASME, ANSI or Industrial Standards, AISC, allowables.

3.9.1.4.8 Fuel Assembly (Including Channel)

GE BWR fuel assembly (including channel) design bases, and analytical and evaluation methods including those applicable to the faulted conditions are the same as those contained in References 1 and 2.

3.9.1.4.9 ASME Class 2 and 3 Vessels

Elastic analysis methods are used for evaluating faulted loading conditions for Class 2 and 3 vessels. The equivalent allowable stresses using elastic techniques are obtained from NC/ND-3300 and NC-3200 of the ASME Code Section III. These allowables are above elastic limits.

3.9.1.4.10 ASME Class 2 and 3 Pumps

Elastic analysis methods are used for evaluating faulted loading conditions for Class 2 and 3 pumps. The equivalent allowable stresses for nonactive pumps using elastic techniques are obtained from NC/ND-3400 of the ASME Code Section III. These allowables are above elastic limits. The allowables for active pumps are provided in a footnote to Table 3.9-2.

3.9.1.4.11 ASME Class 2 and 3 Valves

Elastic analysis methods and standard design rules are used for evaluating faulted loading conditions for Class 2, and 3 valves. The equivalent allowable stresses for nonactive valves using elastic techniques are obtained from NC/ND-3500 of ASME Code, Section III. These allowables are above elastic limits. The allowables for active valves are provided in footnote 7 of Table 3.9-2.

3.9.1.4.12 ASME Class 1, 2 and 3 Piping

Elastic analysis methods are used for evaluating faulted loading conditions for Class 1, 2, and 3 piping. The equivalent allowable stresses using elastic techniques are obtained from NB/NC/ND-3600 (for Class 2 and 3 piping) of the ASME Code Section III. The allowables for functional capability of the ~~essential~~ piping are ~~the ASME Code section III Service Level D stress limits. GE/EPRI Pipe Tests confirmed that functional capability is assured when the stresses are less than the Service Level D allowables.~~ provided in footnote 6 of Table 3.9-2.

3.9.1.5 Inelastic Analysis Methods

Inelastic analysis is only applied to ABWR components to demonstrate the acceptability of three types of postulated events. Each event is an extremely low-probability occurence and the equipment affected by these events would not be reused. These three events are:

(1) Postulated gross piping failure.

(2) Postulated blowout of a reactor internal recirculation (RIP) motor casing due to a weld failure.

(3) Postulated blowout of a control rod drive (CRD) housing due to a weld failure.

to accomplish its safety functions as required by any subsequent design condition event.

(and active Class 1, 2 and 3 valves)

For active Class 2 and 3 pumps* specific stress criteria to meet the functional requirements are identified in a footnote to Table 3.9-2. For piping ~~and valves there are no~~ the specific stress criteria for functional requirements. ~~The ASME code allowable stresses are applied to assure functional capability under emergency and faulted design conditions.~~ are identified in footnote 6 of Table 3.9-2.

Attachment 1

3.9.3.1.2 Reactor Pressure Vessel Assembly

The reactor vessel assembly consists of the reactor pressure vessel, vessel support skirt, and shroud support.

The reactor pressure vessel, vessel support skirt, and shroud support are constructed in accordance with the ASME Boiler and Pressure Vessel Code Section III. The shroud support consists of the shroud support plate and the shroud support cylinder and its legs. The reactor pressure vessel assembly components are classified as an ASME Class 1. Complete stress reports on these components are prepared in accordance with ASME Code requirements. NUREG-0619 (Reference 5) is also considered for feedwater nozzle and other such RPV inlet nozzle design.

The stress analysis is performed on the reactor pressure vessel, vessel support skirt, and shroud support for various plant operating conditions (including faulted conditions) by using the elastic methods except as noted in Subsection 3.9.1.4.2. Loading conditions, design stress limits, and methods of stress analysis for the core support structures and other reactor internals are discussed in Subsection 3.9.5.

3.9.3.1.3 Main Steam (MS) System Piping

The piping systems extending from the reactor pressure vessel to and including the outboard main steam isolation valve are constructed in accordance with the ASME Boiler and Pressure Vessel Code Section III, Class 1 criteria. Stresses are calculated on an elastic basis and evaluated in accordance with NB-3600 of the ASME Code Section III.

The MS system piping extending from the outboard main steam isolation valve to the turbine stop valve is constructed in accordance with the ASME Boiler and Pressure Vessel Code Section III, Class 2 Criteria.

Turbine stop valve (TSV) closure in the main steam (MS) piping system results in a transient that produces momentary unbalanced forces acting on the MS piping system. Upon closure of the TSV, a pressure wave is created and it travels at sonic velocity toward the reactor vessel through each MS line. Flow of steam into each MS line from the reactor vessel continues until the steam compression wave reaches the reactor vessel. Repeated reflection of the pressure wave at the reactor vessel and the TSV produce time varying pressures and velocities, throughout the MS lines.

The analysis of the MS piping TSV closure transient consists of a stepwise time-history solution of the steam flow equation to generate a time-history of the steam properties at numerous locations along the pipe. Reaction loads on the pipe are determined at each elbow. These loads are composed of pressure-times-area, momentum change and fluid-friction terms.

The time-history direct integration method of analysis is used to determine the response of the MS piping system to TSV closure. The forces are applied at locations on the piping system where steam flow changes direction thus causing momentary reactions. The resulting loads on the MS piping are combined with loads due to other effects as specified in Subsection 3.9.3.1.

3.9.3.1.4 Recirculation Motor Cooling (RMC) Subsystem

The RMC system piping loop between the recirculation motor casing and the heat exchanger is constructed in accordance with the ASME Boiler and Pressure Vessel Code Section III, Subsection NB-3600. Stresses are calculated on an elastic basis and evaluated in accordance with NB-3600 of the ASME Code, Section III.

3.9.3.1.5 Recirculation Pump Motor Pressure Boundary

The motor casing of the recirculation internal pump is a part of and welded into an RPV

Attachment 1

3.9.3.1.1.7 Environmental Effects on Fatigue Evaluation of Carbon Steel Piping

Environmental effects on the fatigue design of ASME Section III Class 1 carbon steel piping will be evaluated in accordance with GE document, 408HA414 (Reference 9). Additional fatigue evaluations for environmental effects are not required for any of the following conditions: (a) Water temperature is below 245°C, (b) Fittings, such as elbows and tees, that are conservatively designed and analyzed using the ASME Section III stress indicies and (c) For transients having total cycle times of 10 seconds or less and no tensile hold time, provided that the oxygen content of the water does not exceed 0.3 ppm.

Environmental effects are considered by increasing the local peak stress through four factors used as multipliers to the stress indicies. The four factors are: (1) the notch factor, (2) the mean stress factor, (3) the environmental correction factor, and (4) the butt weld strength reduction factor.

(Item No. 14.1.3.3.5.7-2)

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 3.9.3.2.5.1.3.

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 may be is demonstrated by an analysis or by test or by a combination of analysis and test. The qualification of electrical and instrumentation components controlling valve actuation is discussed in Subsection 3.9.3.2.5.1.3. The valves are designed using either stress analyses or the pressure temperature rating requirements based upon design conditions. An test or analysis of the extended structure is performed for ~~static equivalent~~ the expected dynamic loads ~~applied at the center of gravity of~~ acting on the extended structure. See Subsection 3.9.2.2 for further details.

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 7 of Table 3.9-2.

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. These motor operators then have individual Seismic Category I supports attached to decr[illegible] dynamic loads between the oper[illegible] valves themselves.

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

Alternately, the valve including the motor operator and all other accessories is qualified by a shake table test.

Table 3.9-2

LOAD COMBINATIONS AND ACCEPTANCE CRITERIA FOR SAFETY-RELATED, ASME CODE CLASS 1, 2 AND 3 COMPONENTS, COMPONENT SUPPORTS, AND CLASS CS STRUCTURES (Continued)

NOTES:

(6) ~~Deleted~~ insert new note 6 see "attachment to Table 3.9-2"

(7) For active Class 2 and 3 pumps (and active Class 1, 2 and 3 valves,) the stresses are limited by criteria: $\sigma m \leq 1.2S$ (or 0.75 Sy) and (σm or σL) + $\sigma b \leq 1.8S$ (or 1.1 Sy), where the notations are as defined in the ASME Code, Section III, subsections NB and NC or ND, respectively.

* 5/10/93

(8) The most limiting load combination case among SRV(1), SRV(2) and SRV (ALL). For main steam and branch piping evaluation, additional loads associated with relief line clearing and blowdown into the suppression pool are included.

(9) The most limiting load combination case among SRV(1), SRV(2) and SRV (ADS). See Note (8) for main steam and branch piping.

(10) The reactor coolant pressure boundary is evaluated using in the load combination the maximum pressure expected to occur during ATWS.

(11) The piping systems that are qualified to the leak-before-break criteria of Subsection 3.6.3 are excluded from the pipe break events to be postulated for design against LOCA dynamic effects, viz., SBL, IBL and LBL.

replace with new note 12

(12) ~~This applies only to the main steam lines and components mounted on it. The low probability that the TSVC and SRV loads can exist at the same time results in this combination being considered under service level D.~~

LOAD DEFINITION LEGEND:

Normal (N) - Normal and/or abnormal loads associated with the system operating conditions, including thermal loads, depending on acceptance criteria.

SOT System Operational Transient (see Subsection 3.9.3.1).

IOT Infrequent Operational Transient (see Subsection 3.9.3.1).

ATWS - Anticipated Transient Without Scram.

TSVC - Turbine stop valve closure induced loads in the main steam piping and components integral to or mounted thereon.

RBV Loads - Dynamic loads in structures, systems and components because of reactor building vibration (RBV) induced by a dynamic event.

~~OBE RBV loads induced by operational basis earthquake.~~

~~NLF - Non LOCA Fault~~

NOTES 6 & 12 FOR TABLE 3.9.2

(6) All ASME Code Class 1,2 and 3 Piping systems which are essential for safe shutdown under the postulated events are designed to meet the requirements of NUREG-1367 (Reference 7). Piping system dynamic moments can be calculated using an elastic response spectrum or time history analysis.

(12) For ASME Code 1,2 and 3 piping the following changes and additions to ASME Code Section III Subsections NB-3600, NC-3600 and ND-3600 are necessary and shall be evaluated to meet the following stress limits:

(a) ASME Code Class 1 Piping:

$$S_{SAM} = C_2 \frac{D_o}{2I} M_c \leq 6.0 S_m \quad \text{Eq. (12a)}$$

added

where: S_{SAM} is the nominal value of seismic anchor motion stress

M_c is the combined moment range equal to the greater of (1) the resultant range of thermal and thermal anchor movements plus one-half the range of the SSE anchor motion, or (2) the resultant range of moment due to the full range of the SSE anchor motions alone.

C_2, D_o and I are defined in ASME Code Subsection NB-3600

SSE inertia and seismic anchor motion loads shall be included in the calculation of ASME Code Subsection NB-3600 equations (10) and (11).

(b) ASME Code Class 2 and 3 Piping:

$$S_{SAM} = i \frac{M_c}{Z} \leq 3.0 S_h \; (\not> 2.0 S_y) \quad \text{Eq. (10b)}$$

added

where S_{SAM} and M_c are as defined in (a) above, and

i and Z are defined in ASME Code Subsections NC/ND-3600

SSE inertia and seimic anchor motion loads shall not be included in the calculation of ASME Code Subsections NC/ND-3600 Equations (9) ~~and~~ (10) and (11).

Service Levels A and B

added