REVISED RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**311-8278**
SRP Section:	**03.12 - ASME Code Class 1, 2, and 3 Piping Systems and Piping Components and Their Associated Supports**
Application Section:	**DCD Tier 2 Section 3.12**
Date of RAI Issue:	**11/16/2015**

Question No. 03.12-9

ASME BPV Code Section III, as mandated by 50.55a, requires that piping be evaluated for seismic loads. DCD Section 3.7B.7.3 shows that ASME Class 1, 2, and 3 piping systems are evaluated for the hard rock high frequency (HRHF) seismic response spectra. DCD Section 3.7B.1 identifies that the HRHF response spectra exceed the certified seismic design response spectra (CSDRS) for frequencies above approximately 10 Hz.

1. DCD Section 3.7B.7 discusses the HRHF evaluation of selected SSCs. DCD Sections 3.7B.1 and 3.7B6 show that piping is among the SSCs that were selected to be evaluated for the effects of HRHF as part of the design certification application. DCD 3.7B.7.3 though shows that HRHF effects are to be evaluated by the combined license (COL) applicant. The applicant is requested to provide a justification for this inconsistency.

2. For the piping that was selected to be evaluated in the graded approach identified in DCD Section 14.3.2.3, the applicant is requested to clarify whether both CSDRS and HRHF response spectra are included in the completed piping analyses. In the event that the HRHF response spectra was not included in the piping analysis, the applicant is requested to provide a technical justification for its exclusion from the scope of the design certification application.

Response – (Rev. 2)

Since the graded approach is applied to the piping design, the HRHF evaluation of piping systems was performed by KHNP in accordance with the scope of the graded approach; including, ASME Class 1 piping (RCS main loop, pressurizer surge line, direct vessel injection line, and shutdown cooling lines) and specific Class 2 and 3 piping systems (main steam and main feedwater piping located inside containment and in the main steam valve house). Technical report, APR1400-E-S-NR-14004-P, “Evaluation of Effects of HRHF Response Spectra on SSCs" and DCD Tier 2, Subsection 3.7B is being revised to include the HRHF evaluation of the listed piping systems.

Revision 1 to the original response was submitted to address the issues discussed during a clarification call. Revision 2 to the submitted response reflects completion of the HRHF analyses for the piping within the scope of the graded approach as listed in the initial response. A revised response to items 1 - 2 are as follows:

1. The HRHF for some Central and Eastern United States rock sites show higher amplitude at high frequency than the CSDR (certified seismic design response spectra). The HRHF piping evaluations performed by KHNP for those systems within the scope of the graded approach were found to meet the ASME Section III Code allowable stress limits for both HRHF and CSDRS response spectra. The surge line and primary loop piping loads from the HRHF seismic input are bounded by the loads from the CSDRS seismic input. Technical report, APR1400-E-S-NR-14004-P, "Evaluation of Effects of HRHF Response Spectra on SSCs" will be revised to include the HRHF evaluation of the piping systems within the scope of graded approach.

   The intent of the DCD statement in 3.7B.7.3 was for the COL applicant to perform HRHF analyses for piping systems other than those within the scope of the graded approach. The intention stated in the original RAI response was to clarify the DCD after the KHNP performed analyses were completed. However, since adopting the graded approach, the piping systems within the scope of the graded approach are the only systems requiring HRHF analyses in the DC phase. The COL applicant is to perform HRHF evaluation for piping systems other than those within the scope of graded approach and is being added as COL 3.7B(3).

2. The statement "There is no impact on the DCD" meant that there was no revision to any DCD content as a result of the submitted response at the time of the initial response; however, the DCD will be changed to reflect the HRHF evaluations that have been completed. As stated in the response to sub-item 1, the DCD could be changed at the time of Revision 1 and additional information is also being incorporated into the DCD and applicable TeR as a result of this revision. It should be noted that the changes made to the DCD as a result of Revision 1 of this response and other RAI responses have been incorporated into DCD Revision 1, which is being used for the attached mark-ups.

Impact on DCD

DCD Tier 2, Table 1.8-2, Subsections 3.7B.7.3 and 3.7B.8 will be revised as shown in Attachment 1.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

The technical report, APR1400-E-S-NR-14004-NP, "Evaluation of Effects of HRHF Response Spectra on SSCs" will be revised as shown in Attachment 2.

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Item No.	Description
COL 3.7B(2)	The COL applicant is to verify the applicability of evaluation of the items potential to HF sensitivity
COL 3.8(1)	The COL applicant is to perform concrete long-term material testing in a way which verifies physical properties of materials used during the design stage and the characteristics of long term deformation of concrete.
COL 3.8(2)	The COL applicant is to provide the detailed design results and evaluation of the ultimate pressure capacity of penetrations, including the equipment hatch, personnel airlocks, electrical and piping penetrations in accordance with RG 1.216.
COL 3.8(3)	The COL applicant is to provide detailed analysis and design procedure for the equipment hatch, personnel airlocks, and electrical penetrations.
COL 3.8(4)	The COL applicant is to provide detailed analysis and design procedure for the transfer tube penetration assembly.
COL 3.8(5)	The COL applicant is to provide the design of site-specific seismic Category I structures such as the essential service water building and the component cooling water heat exchanger building, essential service water conduits, component cooling water piping tunnel, and Class 1E electrical duct runs.
COL 3.8(6)	The COL applicant is to evaluate any applicable site-specific loads such as explosive hazards in proximity to the site, projectiles and missiles generated from activities of nearby military installations, potential non-terrorism related aircraft crashes, and the effects of seiches, surges, waves, and tsunamis.
COL 3.8(7)	The COL applicant is to perform the analysis and design of the steel plate for the new fuel storage pit.
COL 3.8(8)	The COL applicant is to determine the environmental condition associated with the durability of concrete structures and provide the concrete mix design that prevents concrete degradation including the reactions of sulfate and other chemicals, corrosion of reinforcing bars, and influence of reactive aggregates.
COL 3.8(9)	The COL applicant is to determine construction techniques to minimize the effects of thermal expansion and contraction due to hydration heat, which could result in cracking.
COL 3.8(10)	For safety and serviceability of seismic Category I structures during the operation of the plant, the COL applicant is to provide appropriate testing and inservice inspection programs to examine the condition of normally inaccessible, below-grade concrete for signs of degradation and to conduct periodic site monitoring of ground water chemistry. Inservice inspection of the accessible portion of concrete structures is also to be performed.
COL 3.8(11)	The COL applicant is to verify that the coefficient of friction between the lean concrete and waterproofing membrane is bounded by 0.55.
COL 3.8(12)	The COL applicant is to provide reasonable assurance that the design criteria listed in Table 2.0-1 are met or exceeded.
COL 3.8(13)	The COL applicant is to verify that the coefficient of friction between the lean concrete and the supporting medium at the site is equal to or higher than 0.55.
COL 3.8(14)	The COL applicant is to confirm that uneven settlement due to construction sequence of the NI basemat falls within the values specified in Table 2.0-1.

COL 3.7B(3)	The COL applicant is to evaluate the HRHF response spectra for piping systems other than those within the scope of the graded approach.

c. The piping system layout includes valves or other concentrated masses that have closely spaced supports and therefore cause high local natural frequencies. The layout generally yields significant cumulative mass in the high frequency range.

American Society of Mechanical Engineers (ASME) Class 1, 2, and 3 piping systems are required to be evaluated for the HRHF seismic response spectra.

3.7B.7.4 Safety-Related Equipment

As a result of the high frequency ground motion, the seismic input to SSCs may also contain high-frequency excitations. The use of prior testing results should be justified by demonstrating that the frequency content of the PSD of the test waveform is sufficient.

Safety-related equipment is evaluated for the effect of high frequency input motion to demonstrate their safety-related functionality.

For the evaluation of the equipment and components functionality for those cases where the GMRS/FIRS-based ISRS exceed the CSDRS-based ISRS below 50 Hz, further equipment and component functionality evaluations are needed. The screening process is applied for identification and evaluation of high-frequency sensitive mechanical and electrical equipment/components. For the new qualification test of equipment and components, the RRS that is generated to meet GMRS/FIRS-based ISRS as well as the CSDRS-based ISRS are applied.

Evaluation process for evaluating equipment and components that are screened in is described in Technical Report APR1400-E-S-NR-14004-P (Reference 3) with a basis for the criteria used for each screening step that is used to identify equipment/components with potential to HF sensitivity.

The COL applicant is to perform the HRHF evaluation of safety related equipment. (COL 3.7B(1)). The seismic qualification test/analysis will be performed for the components to envelop the in-structure response spectra resulting from the entire set of certified seismic design response spectra (CSDRS), including ground motions for the COL sites with high frequency content.

A graded approach is taken to the scope of piping systems and components design. Therefore, the piping systems within the scope of the graded approach are evaluated for the HRHF seismic response spectra.
The combined license (COL) applicant is to evaluate the HRHF response spectra for piping systems other than those within the scope of the graded approach (COL 3.7B(3)).

that is prepared for HRHF-based ISRS including margins HRHF-based ISRS, conduct screening test if necessary or any analysis to verify acceptability.

3.7B.8 Combined License Information

COL 3.7B(1) The COL applicant is to perform the HRHF evaluation of safety-related equipment.

COL 3.7B(2) The COL applicant is to verify the applicability of evaluation of the items potential to HF sensitivity.

COL 3.7B(3) The COL applicant is to evaluate the HRHF response spectra for piping systems other than those within the scope of the graded approach.

3.7B.9 References

1. Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants," Rev. 2, U.S. Nuclear Regulatory Commission, July 2014.

2. EPRI Draft White Paper, "Considerations for NPP Equipment and Structures Subjected to Response Levels Caused by High Frequency Ground Motions," Transmitted to NRC, March 2007.

3. APR1400-E-S-NR-14004-P, "Evaluation of Effects of HRHF Response Spectra on SSCs," Rev. 2, KHNP, February 2017.

4. EPRI TR-1023389, "Evaluation of Seismic Hazards at Central and Eastern U.S. Nuclear Power Sites," Electric Power Research Institute, June 2011.

5. NUREG/CR-6728, "Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-consistent Ground Motion Spectra Guidelines," U.S. Nuclear Regulatory Commission, March 2007.

6. NUREG-0800, Standard Review Plan, Section 3.7.1, "Seismic Design Parameters," Draft Rev. 4, U.S. Nuclear Regulatory Commission, December 2012.

7. EPRI TR-102631, "Soil-Structure. Interaction Analysis Incorporating Spatial Incoherence of Ground Motions," Electric Power Research Institute, October 1997.

8. EPRI TR-1015110, "Effects of Spatial Incoherence on Seismic Ground Motions," by Electric Power Research Institute, November 2007.

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6 EVALUATION

This section describes the results of evaluations of the SSCs subjected to the seismic response demands of the HRHF response spectra. The HRHF response spectra for the following SSCs are evaluated:

- Building structures
  - RCB internal structure
  - RCB containment structure
  - Auxiliary building
  - EDGB/DFOT room
- Reactor coolant system
  - Reactor vessel internals and core
  - Reactor coolant system supports
  - Reactor coolant system ~~nozzles~~ component nozzles and loop piping
- Piping systems
- Safety-related equipment

6.1 Building Structures

Maintaining the structural integrity of the NI buildings is important to plant safety. The RCB internal structure, RCB containment structure and auxiliary building are evaluated for the effect of high frequency input ground motion.

The evaluation consists of comparisons of the responses from high frequency input ground motion to those obtained from the APR1400 CSDRS for the building structures.

The comparisons are performed to demonstrate that seismic responses from the CSDRS envelop those from the high frequency input motion. The NI structures are considered to be qualified for the high frequency input ground motion if the seismic responses from the CSDRS envelop those from the high frequency input motion.

To evaluate an effect on the RCB internal structures (i.e., PSW, IRWST, and SSW), seismic forces and moments of these structures are compared as shown in Tables 6-1, 6-2, and 6-3. Although the comparisons of forces and moments from high frequency input motion are greater than the CSDRS, the design results of the RCB internal structures are not affected by the seismic responses from the HRHF seismic input. Since the design margin of the RCB internal structures for CSDRS input motion covers the exceeded forces and moments, the arrangements of rebar are not changed due to seismic responses from the HRHF seismic input. The maximum stress of the rebar in the RCB internal structures occurs at the SSW, and the value is 51.49 ksi which is less than the allowable stress of 54 ksi.

Comparisons of the RCB containment structures are presented in Table 6-4. The comparisons of the containment structures show that seismic forces and moments resulting from the CSDRS input motion are greater than forces and moments obtained from high frequency input ground motion.

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Equivalent accelerations of auxiliary building to seismic response story forces are evaluated for comparison of equivalent accelerations from the CSDRS and HRHF response spectra. The comparisons for the auxiliary building are presented in Table 6-5. Equivalent accelerations from HRHF input ground motion envelop those from the CSDRS except the vertical acceleration of Fuel Handling Area 3 (El. 195'-0" to 213'-0"). The effect due to the increment of equivalent acceleration in the global z direction can be absorbed in the design of the shear walls because each wall member has stiffness enough to resist the additional seismic load due to high frequency seismic input in the axial direction.

Equivalent accelerations of EDGB/DFOT room are also compared in Table 6-6 for the CSDRS and HRHF response spectra. Although some of the equivalent accelerations from HRHF input motion are greater than those from the CSDRS, the design results of the EDGB are not affected by the seismic responses from the HRHF seismic input. Since the provided reinforcement of the EDGB for the CSDRS is greater than the required reinforcement for the HRHF, the arrangements of rebar are not changed. The design critical section which has a lowest provided/required rebar ratio of 1.10 occurs at EL. 100'-0" to 135'-0" center wall of the EDGB due to the CSDRS seismic input. The critical section location is maintained for the HRHF seismic input and the provided/required rebar ratio is 1.02 which is still greater than the design limit of 1.00.

6.2 Reactor Coolant System

The reactor vessel internals (RVI) support the core which is important to safety. The RVI consists of complicated components whose natural frequencies are in the relatively high frequency range. The RCS component supports are evaluated because they provide the support for the RCS components to maintain their intended safety-related functions. The nozzles are evaluated because piping failures generally occur at high stress locations such as at nozzles of a component and they represent the sensitivity of the reactor coolant loop piping to high frequency excitation. For selected items, the HRHF response is evaluated by comparing the design loads with the loads obtained from the HRHF incoherent analysis. It is concluded that the supports ~~and nozzles~~ , nozzles and loop piping are acceptable for the HRHF seismic loads if the design loads from the CSDRS envelop those from the HRHF input ground motion.

6.2.1 Reactor Vessel Internals and Core

The RVI and core were selected because they are important to safety and their analyses are representative of major primary components. Because the natural frequencies of the RVI components are in the relatively high frequency range, the RVI may be sensitive to high frequency excitation.

Detailed analyses were performed to obtain the responses of the RVI and core to HRHF loads. The RVI HRHF analysis was done using the HRHF excitation of the reactor vessel (RV) obtained from the response of the RCB and RCS to HRHF loads. Then, the response of the core was calculated using the detailed core model and the core plate motion obtained from the RVI analysis.

The time history analyses of the RVI and core were performed for each HRHF mode, and the responses of all modes were combined for the resultant response. The maximum response of each mode was used for the combination. The broadening of the input excitation was also considered for the RVI and core analyses by frequency variation as implemented for the CSDRS loads.

The RVI resultant responses of HRHF loads were compared with those of the CSDRS loads. Most forces and moments of the RVI components for HRHF loads were calculated to be less than those for the CSDRS loads. It was already determined that the structural integrities of the RVI and core are maintained for the CSDRS loads. The evaluations were performed for RVI components such as the core support barrel flange and cylinder because the forces and moments on the components from HRHF loads exceeded those from CSDRS loads. The results of the evaluations showed that the increases in component loads due to HRHF loads were insignificant for the structural integrity of the components.

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The core resultant responses of HRHF loads were compared with those of the CSDRS loads. The resultant responses for the comparison were grid impact forces. Since the natural frequency of the fuel assembly is in the relatively low range, the core responses for the HRHF loads were predicted to be less than those of the CSDRS loads. The resultant grid impact forces of the HRHF loads were calculated to be less than those of the CSDRS loads. No grid impact of the fuel assemblies occurs for all the modes except the first mode.

Therefore, the effects of HRHF loads on the structural integrity of the RVI and core are insignificant.

6.2.2 ~~Component Supports and Nozzles of RCS~~ RCS Components Supports, Nozzles and Loop Piping

The RCS structural supports support RCS components during normal operation and transients and during SSE and design basis accident conditions. RCS component supports are necessary to preserve the safety function of the RCS components. The arrangement of the RCS, including acronyms of the components, is shown in Figure 6-1. A comparison of the support loads on the RCS supports is provided in Table 6-7. The design loads for the RCS supports and nozzles are bounding at all locations.

The RV is supported by four vertical columns located under the vessel inlet nozzles. The columns are designed to be flexible in the horizontal direction to allow horizontal thermal expansion during heat-up and cool-down. They also support the reactor vessel in the vertical direction.

The steam generator (SG) is supported at the bottom by a sliding base bolted to an integrally attached conical skirt. The sliding base rests on low friction bearings, which allows unrestrained thermal expansion of the RCS. Two keyways in the sliding base mate with embedded keys to guide the movement of the steam generator during expansion and contraction of the RCS and to limit the movement of the bottom of the steam generator during SSE and branch line pipe break (BLPB) events.

The reactor coolant pump (RCP) supports consist of four vertical columns, four horizontal columns and two horizontal snubbers.

The pressurizer (PZR) is supported by a cylindrical skirt which is welded to the pressurizer and bolted to the building structure. Four keys welded to the upper shell of the pressurizer provide additional restraint for an SSE, pressurizer pilot-operated safety and relief valve (POSRV) actuation and BLPB conditions. The component supports of the RCS are shown in Figure 6-2.

The RCS component nozzles of the RV, SG, and RCP are included in the evaluation since a component nozzle has greater potential for failure than at other locations and the cold leg, hot leg, and crossover leg are relatively sensitive to high frequencies when compared with other components.

The locations and acronyms of the RCS component nozzles are shown in Figure 6-3. A comparison of the component nozzle loads with the design basis loads is provided in Table 6-8. Table 6-8 shows that the nozzle design loads envelop the loads from the HRHF incoherent analysis at all locations.

The section locations and coordinate systems for RCS loop piping force and moment are shown in Figure 6-11. A comparison of the loop piping forces and moments with the design basis loads is provided in Table 6-9. Table 6-9 shows that the loop piping design loads envelope the loads from the HRHF incoherent analysis at all locations.

6.3 Piping Systems

Since piping lines and piping supports throughout the plant are designed according to the relevant guidelines, a stress analysis of a sample of lines is representative of all lines in the plant. Evaluating the susceptibility to excitation caused by high frequency seismic input requires the following factors to be present:

- The local HRHF-based ISRS need to have exceedances relative to the CSDRS-based ISRS in the high frequency range.
- The system must have modes or natural frequencies in the high frequency range.

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- The system layout must include valves or other concentrated masses that would require closely spaced supports and therefore, cause high local natural frequencies. This generally yields significant cumulative mass in the high frequency range.

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ASME Class 1, 2, and 3 piping systems are required to be evaluated for the HRHF-based ISRS.

~~In the APR1400, the design acceptance criteria are applied to the piping design area. The evaluation for the HRHF response spectra is to be accomplished by the combined license (COL) applicant.~~

6.4 Safety-related Equipment

In some situations, the site specific spectra may exceed the certified design spectra in the high-frequency range. As a result of the high frequency ground motion, the seismic input to SSCs may also contain high-frequency excitations. The vast majority of prior existing seismic qualification tests used input frequencies up to only 33 Hz. The use of these prior testing results should be justified by demonstrating that the frequency content of the PSD of the test waveform is sufficient.

Safety-related equipment is evaluated for the effect of high frequency input motion to demonstrate their safety-related functionality.

For the evaluation of the equipment and components functionality for those cases where the GMRS/FIRS-based ISRS exceed the CSDRS-based ISRS below 50 Hz, further equipment and component functionality evaluations are needed. The screening process is applied for identification and evaluation of high-frequency sensitive mechanical and electrical equipment/components. If a new test is planned for the qualification of equipment and components, the RRS that is generated to meet GMRS/FIRS-based ISRS as well as the CSDRS-based ISRS are applied.

Evaluation process for evaluating equipment and components that are screened in is described in this report with a basis for the criteria used for each screening step that is used to identify equipment/components with potential to HF sensitivity. The method of generating the RRS at the location of support or attachment point within a structure or a cabinet that will be used in the evaluation is described.

The HRHF evaluations of the safety equipment shall be performed and the seismic qualification test/analysis will be performed for the components to envelop the in-structure response spectra resulting from the entire set of certified seismic design response spectra (CSDRS), including ground motions for the specific sites with high frequency content.

6.4.1 Evaluation Process Steps and Description

Identification and evaluation process of HF sensitive mechanical and electrical equipment and components are performed for safety-related equipment and components before performing seismic qualification. Refer to Figure 6-11 for the High Frequency Screening Process.

6.4.1.1 Potentially High-frequency Sensitive Equipment

Safety-related equipment and components that have been undergone prior qualification testing/analysis are classified to either HF sensitive or HF insensitive. The potentially HF sensitive equipment and components are evaluated for the HF sensitivity.
The concern with potentially HF-sensitive components is related to the functionality of the devices when subjected to HF motions. Concerns over functionality of components due to HF motions have been focused on:

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A graded approach is taken to the scope of piping systems and components design. Therefore, the piping systems within the scope of the graded approach are evaluated for the HRHF seismic response spectra. The combined license (COL) applicant is to evaluate the HRHF response spectra for piping systems other than those within the scope of the graded approach.

Comparisons of ASME Code Section III Division 1 stresses calculated the most highly stresses location in the direct vessel injection line, shutdown cooling line, main steam and main feedwater piping located inside containment and in the main steam valve house for CSDRS and HRHF response spectra are listed in Table 6-10 and 6-11 for ASME Class 1 and 2 piping systems.

The maximum surge line loads obtained from the HRHF seismic input are compared with the design loads determined from the results of the CSDRS seismic input. Because the design loads from CSDRS seismic input envelope the surge line loads from the HRHF seismic input (refer to Table 6-12), a stress evaluation is not performed.

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1) devices that have inadvertently changed state, permanently or temporarily (i.e., chattered) or had their output signals affected as a result of vibratory motions. This group is characterized as having bi-stable contacts or other mechanisms loaded by springs and/or electromagnetic forces which can be actuated/moved by inertial forces. Bi-stable devices such as relays, contactors, switches, potentiometers and similar devices, and those components whose output signal or settings (set-points) could be changed by HF vibratory motion are observed from seismic qualification tests and operating experience during which HF impact excitation (and likely high accelerations) caused relays to actuate resulting in inadvertent actions. From the industry experience, relays, contact devices, pressure transducers, and potentiometer are observed to be sensitive to high frequency motion.

2) non-ductile components such as ceramic insulators and cast iron components that have failed due to HF shock-type loads. The latter group of devices has been screened by either avoiding use of brittle materials, or by seismic and operational qualification testing of components (such as breakers and switchgear) whose operation involves impact loads and also requires potentially brittle insulating materials.

Non-ductile components and internal parts include those made of such materials as cast iron and ceramics. Standard commercial components which require non-ductile parts for function (e.g., circuit breakers) will be tested in accordance with traditional test standards; components otherwise fabricated of brittle materials should be avoided or justified on a case-by-case basis.

Based on the above considerations, the component types suggested in Table 6-~~9~~ 13 are considered potentially sensitive to HF motions and should be screened following the procedures and criteria provided in this report. For all safety-related equipment that is designed to have part(s) of its assembly with components classified to be potentially sensitive to HF motions are to be evaluated for the adequacy in accordance with the procedures described in this report. List of HF sensitive equipment is provided to Technical Report APR1400-E-X-NR-14001-P, “Equipment Qualification Program”, Table 3, “Equipment Qualification Equipment List”. The items potential to HF sensitivity listed in Table 6-~~9~~ 13 shall be verified for its applicability of evaluation in accordance with site specific condition and/or equipment supplier’s design characteristics.

HF insensitive equipment and components are also evaluated for the adequacy of the qualification in terms of their natural frequency. Detail evaluation process for HF insensitive equipment is described in 6.4.1.2.

6.4.1.1.1 Use of Existing Qualification Data

Safety-related equipment and components have been seismically qualified in accordance with IEEE Standard 344 random multi-frequency type test. Input motions containing additional HF content which is greater than specified for low frequency (LF) design motions were included in seismic testing either intentionally or unintentionally. Also HF content has been combined with seismic test motions for some equipment to demonstrate equipment intended function for concurrent seismic and non-seismic loads (e.g. hydrodynamic loads) during a seismic event. In order to define HF sensitivity vulnerability, test result could be confirmed to envelop the RRS generated for both HRHF-based ISRS and CSDRS-based ISRS including proper margins. However, proper frequency contents with sufficient energy which were used for input to the shaking table shall be demonstrated to allow use of existing test data.

6.4.1.1.2 Screening Test

HF vibration screening tests can be conducted to identify any HF sensitivities or abnormalities of the components in case when only the RRS based on CSDRS-based ISRS are confirmed to be satisfied. A high frequency screening test can also be used to demonstrate lack of component sensitivity to high frequency vibration. The procedures for screening test prepared by the equipment manufacturer shall be reviewed to identify the adequacy of the criteria used for the test. The RRS for the screening test shall be

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7 CONCLUSION

Evaluations are performed for portions of structures, components, piping, and systems for the HRHF seismic response. The sample that was evaluated consists of the following:

- Building structures
  - RCB internal structure
  - RCB containment structure
  - Auxiliary building
  - EDGB/DFOT room
- Reactor coolant system
  - Reactor vessel internals and core
  - Reactor coolant system supports
  - Reactor coolant system ~~nozzles~~ Component nozzles and loop piping
- Piping systems
- Safety-related equipment

The evaluation of the building structures is performed through a comparison of the seismic responses obtained from HRHF incoherent analysis to those obtained from the design-basis seismic analysis. It is concluded that the existing design for nuclear island structures based on the CSDRS includes the seismic responses considering HRHF input ground motion.

For selected items of the reactor coolant system, the HRHF seismic responses are evaluated by comparing the design loads obtained from design-basis seismic analysis with the loads from the HRHF incoherent analysis. It is concluded that the supports and nozzles including loop piping are acceptable for the HRHF seismic loads and the design loads from the CSDRS envelop those from the HRHF input ground motion.

The evaluations are performed for HRHF seismic response on ASME Class 1 and 2 piping systems are performed within the scope of the graded approach. Although seismic input response spectra of HRHF in high frequency range are greater than CSDRS, the piping stress results based on ASME Code are within the allowable stresses for both CSDRS and HRHF response spectra. And surge line loads obtained from CSDRS seismic input envelope the loads from HRHF seismic input. Therefore, it is concluded that graded approach piping systems are acceptable for the HRHF seismic loading.

The evaluations for HRHF input ground motion on ~~piping systems~~ (Delete) and safety-related equipment are to be accomplished by the COL applicant.

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"B"
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Table 6-9

Comparison of Design Force and Moment for Reactor Coolant System Loop Piping

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Table 6-9 (Cont'd)

Comparison of Design Force and Moment for Reactor Coolant System Loop Piping

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Table 6-10

Comparison of Stress Analysis Results for Class 1 Piping Systems

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Table 6-11

Comparison of Stress Analysis Results for Class 2 Piping Systems

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Table 6-12

Comparison of Design Moment for Surge Line

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Table 6-12 (Cont'd)

Comparison of Design Moment for Surge Line

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Table 6-12 (Cont'd)

Comparison of Design Moment for Surge Line

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Table 6-9 13

Potentially HF Sensitive Component

- Electro-mechanical relays (e.g., control relays, time delay relays, protective relays)
- Electro-mechanical contactors (e.g., Motor Control Center(MCC) starter)
- Circuit breakers (e.g., molded case and power breaker – low and medium voltage)
- Auxiliary contacts (e.g., for Molded Case Circuit Breaker (MCCBs), fused disconnects, contactors/starters)
- Control switches (e.g., benchboard panel, operator switches)
- Transfer switches (e.g., low and medium voltage switches with instrumentation)
- Process switches and sensors (e.g., pressure/diff. pressure, temperature, level, limit/position, and flow)
- Potentiometers
- Digital solid-state devices (mounting and connections only)
- microprocessors-based components
- Connectors and connections (including circuit board connections for digital and analog equipment)
- Unrestrained components

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"C"
(1 of 3)

TS

Figure 6-11 Reactor Coolant System Loop Piping Section/End Locations and Coordinate Systems

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"C"
(2 of 3)

TS

Figure 6-11 Rea ctor Coolant System Loop Piping Section/End Locations and Coordinate Systems (Cont'd)

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"C"
(3 of 3)

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Figure 6-11 Rea ctor Coolant System Loop Piping Section/End Locations
and Coordinate Systems (Cont'd)

Add "C" in the previous page

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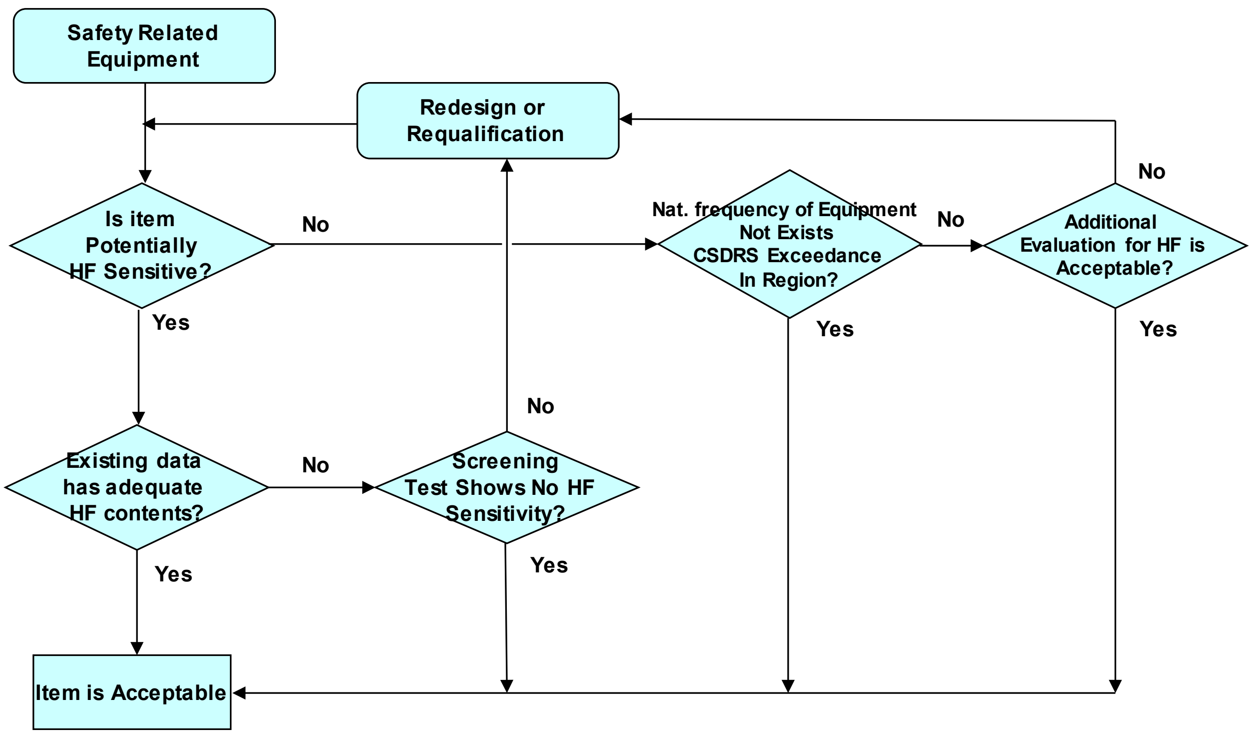

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Figure 6-~~11~~ 12 High-Frequency Screening Process

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Figure 6-13 Location of Surge Line Loads