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Subject: AP1000 Response to Request for Additional Information (SRP 2)

Westinghouse is submitting a response to the NRC request for additional information (RAI) on SRP Section 2. This RAI response is submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in this response is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

Enclosure 1 provides the response for the following RAI(s):

RAI-SRP2.2-RSAC-01 R1
RAI-SRP2.5-RGS1-21 R1

Questions or requests for additional information related to the content and preparation of this response should be directed to Westinghouse. Please send copies of such questions or requests to the prospective applicants for combined licenses referencing the AP1000 Design Certification. A representative for each applicant is included on the cc: list of this letter.

Very truly yours,

D. A. Lindgren /for

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/Enclosure

1. Response to Request for Additional Information on SRP Section 2

DO63
NRO

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ENCLOSURE 1

Response to Request for Additional Information on SRP Section 2

RAI Response Number: RAI-SRP2.2-RSAC-01
Revision: 1

Question:

To ensure compliance with the siting criteria of 10 CFR 100.20 and 10 CFR 100.21, RG 1.206 provides guidance regarding the information that should be utilized in assessing potential hazards in the vicinity of the site and an approach for the evaluation of the impact of these hazards on the NPP.

In AP1000 Design Control Document Section 2.2 the applicant discussed the impact on the proposed NPP from explosion hazards without tabulating the standard chemicals considered as sources nor the distance of the source from the nearest Category 1 structure.

The COLA FSAR Table 6.4-201 tabulated three categories of chemicals: the AP1000 standard supplemental chemicals, the standard COL chemicals, and the site specific chemicals. Some of the chemicals listed are both explosive as well as toxic, which may require additional evaluation for control room habitability.

In COLA FSAR Section 6.4, Table 6.4-201, the COLA applicant has established minimum distances from the source to the MCR intake based on the toxicity of the source chemical. For example for hydrogen gas, and hydrazine the computed safe distance is 375ft and 245ft respectively.

The potential explosion hazard from explosive chemicals included as part of the certified design, including hydrogen, has not been sufficiently described nor their minimum safe distances from the nearest SSC provided. Provide the calculated minimum safe distance for each chemical that is explosive such that an overpressure less than 1 psi peak (RG 1.91) is maintained.

Question Revision 1:

During a meeting April 15, 2010 the NRC staff requested that the following items be addressed for hydrogen and other onsite chemicals.

1) Provide a parametric/sensitivity analysis of stability class and wind speed for all chemicals.

2) Explain the venting of the hydrazine tank, and explain how the evaporation of hydrazine effects calculations for flammability.

3) Provide the results of the 500 cu. ft of hydrogen gas explosion scenario calculations.

4) Provide either any detection/alarm system to alert the operator to take action within two-minutes of a chemical release or demonstrate with HABIT run that the maximum allowed control room concentration is reached and below is IDLH.

Westinghouse Response: (Revisions 0, 1)

Revision 1

The Revision 0 response has been revised as needed to address the response to the action items. the changes in the Revision 0 response are marked. In addition, a summary of the results for each Revision 1 item is provided. The DCD mark-ups have also been updated as required by the responses to these items.

1. Westinghouse is revising the chemical toxicity and asphyxiation analysis for control room habitability (per Regulatory Guide 1.78, Rev. 1) to include the expanded parametric /sensitivity analysis. In the updated calculation, each chemical concentration at the control room air intake was evaluated for each atmospheric stability class at varying wind speeds.

   The results of the calculation are that some concentration values changed; however, the final conclusion of the calculation remains the same. No changes to the DCD or COL FSARs are required as a result of the updated calculation. These results should be considered preliminary until the review verification and archiving of the calculation are completed. The final revised document will be available for NRC review at the Westinghouse office in Rockville during the week of June 7, 2010.

2. The venting of the hydrazine tank and the effect of the evaporation of hydrazine on the calculations for flammability are discussed below. (Page 3)

3. The results of the 500 cu. ft of hydrogen gas explosion are included below in the tabulation of the AP1000 On-Site Chemical Explosion Evaluation Results. (Page 4)

4. As noted below, the result of the evaluation is that accidental releases of on-site chemicals do not challenge the habitability of the AP1000 MCR. There is no need for installation of spill detection equipment at any chemical storage tanks. (Page 6)

Table 6.4-1 of the DCD lists chemicals evaluated as part of the AP1000 design. These have been evaluated for potential of contributing to several types of hazards as follows:

1. Explosions
2. Flammable Vapor Cloud Ignition
3. Toxicity and Asphyxiation
4. Fires

<u>Accident Category 1 - Explosions</u>

The tabulated chemicals have been evaluated for explosion potential. Of these, the primary explosion hazard is hydrogen. Hydrazine, 3-Methoxypropylamine (MOPA) and Number 2 Diesel Fuel Oil are also potential explosion sources during fires. -In this evaluation waste oil was considered to be all fuel oil since the turbine lubricating oil was not found to be a potential explosion hazard. The other chemicals are in an aqueous solution such that they do not support combustion, and are intrinsically non-combustible.

The low pressure hydrogen storage is provided as part of the plant gas system along with nitrogen and carbon dioxide in a location away from safety-related systems, structures or components (SSC). See DCD Tier 2 Figure 1.2-2 Site Plan Item 21 for a possible location of the low pressure H2 storage. ~~The location shown on this DCD figure is the Standard Plant location.~~ The PGS Bulk Gas Storage Area may be relocated as required for site-specific needs as long as it is a safe distance from SSCs.

The hydrogen is stored as a liquid. The stored hydrogen has been evaluated using the method of Regulatory Guide 1.91 to determine the safe distance from the storage location to the nearest safety-related SSC. The nearest SSC is the Shield Building. The minimum safe distance determined by the Regulatory Guide 1.91 methodology is based on an over pressure resulting from the explosion of 1 psi at the minimum distance. The safety related structures for the AP1000 are constructed of reinforced concrete and steel plate and concrete composite modules. The 1.0 psi overpressure value is a very conservative assumption for this type of construction. The distance from the AP1000 design hydrogen storage location to any safety-related SSCs is greater than the minimum safe distance tabulated below.

A limited amount of pressurized gaseous hydrogen is supplied to the chemical and volume control system in the auxiliary building from bottles (high pressure tanks) adjacent to the turbine building and near the nuclear island. As is noted in DCD Subsection 3.5.1.1.2.2, a limited supply of hydrogen is connected to the hydrogen supply line. This quantity would not lead to an explosion inside a building even if the full contents of the bottled hydrogen supply is assumed to remain in the compartment in which it is released. The high pressure hydrogen supply was evaluated for explosions per the NRC approved method in EPRI NP-5283-SRA "Guidelines for Permanent BWR Hydrogen Water Chemistry Installations - 1987 Revision" (Reference 2). Credit was taken for the reinforced concrete structural design of the Auxiliary Building wall nearest the hydrogen gas cylinder as permitted by EPRI NP-5283-SRA.

Each chemical tank in the chemical feed system storage area is vented to the outside of the turbine building at a high location, far removed from the tank. The potential for a hydrazine solution explosion occurs upon consideration of a sequence of events including a fire next to the tank which heats its contents to boiling following by an impact that ruptures the tank and spills its contents. All hydrazine in the aqueous solution is in the form of hydrazine monohydrate. The largest amount of combustible hydrazine monohydrate vapor occurs when the tank assembly is almost empty and the void space is filled with the vapor. The tank rupture spills the vapor. The hydrazine monohydrate is heavier than air and settles inside the chemical area containment dike. If the hydrazine monohydrate vapor was semi-contained within a smaller volume after a spill, such that its concentration is above the LEL, there is a potential of an explosion. When the vapor heat of combustion is converted to an equivalent amount of TNT, the method of Reg. Guide 1.91 can be applied to determine the safe distance.

Morpholine was also considered using the same methodology as for hydrazine and the potential for semi-confined vapor explosion exists.

3-Methoxypropylamine (MOPA) is not one of the primary chemicals planned for use at the AP1000, but it is considered as a possible alternate for pH adjustment. MOPA was also considered using the same methodology as for hydrazine and the potential for semi-confined vapor explosion exists.

The evaluation of fuel oil vapor explosion hazard resulted in finding a potential explosion due to exposure of the storage tank to an external fire. An explosion results from the fuel oil vapor reaching its auto-ignition temperature.

AP1000 On-Site Chemical Explosion Evaluation Results

Chemical	Tank Capacity	Reg. Guide 1.91 Minimum Safe Distance	Notes
Liquid Hydrogen, H_2	1500 gallons, as liquid	577 feet	1500 gallons is AP1000 storage capacity. Hydrogen storage distance to Shield Building is greater than 635 feet.
Liquid Hydrogen, H_2	2000 gallons, as liquid	635 feet	Presented as a basis of comparison only.
Pressurized Gaseous Hydrogen, H_2	Pressurized Contents = 500 scf	6 feet	Safe distance found using method in EPRI NP-5283-SRA, not Reg. Guide 1.91.
Hydrazine, N_2H_4	800 gallons, as 35 w% solution	45 feet	Combustible vapor is hydrazine monohydrate
Morpholine, $O(CH_2CH_2)_2NH$	800 gallons, as a 10 w% solution	66 feet	
3-Methoxy propylamine (MOPA), $C_4H_{11}NO$	800 gallons, as a 20 w% solution	87 feet	
No. 2 Diesel Fuel Oil	60,000 gallons	280 feet	
Waste Oil	1850 gallons	102 feet	Considered as all No. 2 Fuel Oil

Changes to the DCD to address the information above on chemical explosions are provided below.

Accident Category 2 - Flammable Vapor Cloud Ignition

Regulatory Guides 1.206 and 1.70 both require consideration of accidental releases of flammable liquids or vapors that result in the formation of unconfined vapor clouds. Assuming delayed ignition, the extent of the cloud and the concentrations of gas that could reach the plant under worst-case meteorological conditions were evaluated for the effects on the plant of explosion and deflagration of the vapor cloud. The treatment of the vapor cloud as being unconfined is justified because there are no nearby structures between the gas storage and the nearest SSC capable of trapping or preventing dispersion of hydrogen.

The only potential source of an unconfined, flammable gas cloud is the storage tank for liquid hydrogen. An unlikely, but credible accident scenario of shearing off a bottom nozzle was evaluated. The scenario conservatively included tank pressure at its design pressure instead of normal operating pressure and the tank being filled to its capacity. The rate of liquid hydrogen release was calculated and compared to the experimental and analysis results of several test releases of 1500 gallons of liquid hydrogen as reported in Reference 1. The Reference 1 results of the liquid hydrogen release tests and analysis of explosion or deflagration of the subsequent vapor clouds include a recommendation for establishment of an exclusion zone of 175 feet in all directions around a 1500 gallon liquid hydrogen storage tank. This exclusion zone distance includes consideration of the horizontal path of the spill observed during the testing. The boiling liquid hydrogen moves at ground level until sufficient heat is transferred from the surroundings to produce the low density required for buoyancy. Once the hydrogen becomes buoyant, it rises very rapidly away from the ground. Traffic paths (pedestrian and vehicular) and structures should not be located within the exclusion zone. Potential for damage due to delayed ignition of the vapor cloud outside of the exclusion zone was stated to be insignificant.

For AP1000, the calculated rate of liquid hydrogen release through the postulated sheared nozzle is lower than the experimental release rates that produced the 175 foot exclusion zone recommendation. Because the AP1000 hydrogen storage location is greater than 577 feet from the Shield Building, there is no concern for delayed ignition of a flammable hydrogen cloud compromising the safety-related functions of any SSCs.

The other chemicals in Table 6.4-1 of the DCD have been evaluated for potential to produce unconfined, flammable vapor clouds upon accidental release. None of the chemicals except hydrogen have a flash point at or below the ambient high temperature. Therefore, ambient temperature spills cannot produce a flammable cloud. Although hydrocarbon based fluids will generate flammable vapors when they are heated above the flash point, it is reasonable to assume that the source of the heat (e.g. fire) will consume the vapors as generated and an unconfined vapor cloud cannot be formed.

The other fluids in Table 6.4-1 of the DCD are in forms that do not support combustion and do not produce any flammable vapors or are less flammable than the hydrocarbon based fluids in the presence of heat.

Changes to the DCD to address the information above on vapor cloud ignition are provided below.

Accident Category 3 - Toxicity and Asphyxiation

The issues of toxicity and asphyxiation have been combined for evaluation of main control room (MCR) habitability. Each chemical was evaluated as complete instantaneous emptying of its storage tank at its storage location. Conservative simplifications were applied to the evaluation. The concentration of a chemical was found at the MCR ventilation system air intake louver. This air intake louver is on the northeast corner of the Auxiliary Building at an elevation of about 55.5 feet above grade. If the maximum concentration calculated at the MCR air intake was less than a level that was either toxic[1] or leading to asphyxiation, it was considered to be acceptable. The worst case meteorological conditions were applied to maximize the concentration at the MCR ventilation intake. For spills within the turbine building, another conservative simplification was the removal of all walls, floors and equipment between the spill and the MCR intake louver. The diffusion of vapors became a straight line movement to the ventilation intake. The time duration modeled for each chemical spill was long enough for the concentration at the MCR air intake to peak before declining or the concentration was much less than IDLH after one hour. The result of the evaluation is that accidental releases of on-site chemicals do not challenge the habitability of the AP1000 MCR. There is no need for installation of spill detection equipment at any chemical storage tank.

On-Site Chemicals* Evaluated for Toxicity and Asphyxiation	
Chemical	**Evaluated Storage Distance to MCR Ventilation Intake Louver**
Hydrogen	814 feet
Nitrogen	814 feet
Carbon Dioxide	814 feet
Oxygen Scavenger	203 feet
pH Addition	203 feet
Sulfuric Acid	436 feet **
Sodium Hydroxide	436 feet **
Dispersant	436 feet **

[1] As defined by NIOSH as Immediately Dangerous to Life or Health Concentrations (IDLH)

On-Site Chemicals* Evaluated for Toxicity and Asphyxiation	
Chemical	**Evaluated Storage Distance to MCR Ventilation Intake Louver**
Fuel Oil (Combustion Products)	318 feet
Corrosion Inhibitor	203 feet
Scale Inhibitor	203 feet
Biocide/Disinfectant	436 feet **
Algaecide	436 feet **

* From DCD Table 6.4-1
** Circulating water system chemical storage area

Changes to the DCD to address the information above on hydrogen asphyxiation potential are provided below.

Accident Category 4 - Fires

Regulatory Guides 1.206 and 1.70 both require consideration of accidents leading to fires and attendant high heat fluxes and smoke. The evaluation also requires consideration of flammable gas or chemical-bearing clouds. The extent of smoke or a cloud concentration that could reach the MCR ventilation intake under worst-case meteorological conditions was evaluated for the habitability of the AP1000 MCR.

A hydrogen fire at the storage tank for liquid hydrogen is not an issue with regard to the combustion product of hydrogen with air; water vapor. The combustion of other materials around the storage tank would be the source of potentially toxic byproducts. The amount of material available for combustion near the cryogenic gas storage area is dwarfed by the contents of a diesel fuel oil storage tank. The diesel oil storage tanks are closer to the MCR ventilation system intake, 318 feet for the fuel oil vs. 814 feet for the gas storage area. An analysis of a diesel oil fire burning over the entire area within the fuel oil containment dike produced a result that the AP1000 MCR remains habitable. Therefore, evaluation of combustion of materials in the gas storage area is unnecessary.

The other chemicals in Table 6.4-1 of the DCD have been evaluated for potential to produce nonflammable gas or chemical-bearing clouds due to fires. These chemicals are present in much smaller quantities than the fuel oil storage. None of the chemicals except hydrogen have a flash point at or below the ambient high temperature. Therefore, none of the chemicals will support combustion. These other fluids in Table 6.4-1 of the DCD are in forms that do not produce any flammable vapors or are less flammable than the fuel oil in the presence of heat. Fires of or near on-site chemicals do not challenge the habitability of the AP1000 MCR.

Changes to the DCD to address the information above on hydrogen flammability potential are provided below.

References:

1. "Safety and Security Analysis: Investigative Report by NASA on Proposed EPA Hydrogen-Powered Vehicle Fueling Station", EPA420-R-04-016, October 2004, US EPA Office of Transportation and Air Quality

2. "Guidelines for Permanent BWR Hydrogen Water Chemistry Installations - 1987 Revision", EPRI NP-5283-SRA, Electric Power Research Institute, Inc., 3420 Hillview Avenue, Palo Alto, California 94304

Design Control Document (DCD) Revision: (Revisions 0, 1)

Revise Note 2 in Figure 1.2-2 as shown below.

2. PGS BULK GAS STORAGE AREA
(LIQUID N2, CO2, H2) ~~ARE~~ IS LOCATED IN
THIS AREA OR OTHER AREA A SAFE DISTANCE
FROM THE NUCLEAR ISLAND.

Revise Section 2.2 as shown below.

2.2 Nearby Industrial, Transportation, and Military Facilities

The plant has inherent capability to withstand certain types of external accidents due to the specified design conditions associated with earthquakes, wind loading, and radiation shielding. Acceptability for external accidents associated with a given site will be covered in the Combined License application.

Each Combined License applicant referencing the AP1000 will provide analyses of accidents external to the nuclear plant. The determination of the probability of occurrence of potential accidents which could have severe consequences will be based on analyses of available statistical data on the occurrence of the accident together with analyses of the effects of the accident on the plant's safety-related structures and components. If an accident is identified for which the probability of severe consequences is unacceptable, specific changes to the AP1000 will be identified in the Combined License safety analysis report. The criteria for not requiring changes to the AP1000 design is that the total annual frequency of occurrence is less than 10^{-6} per year for an external accident leading to severe consequences. The following accident categories will be considered in determining the frequency of occurrence, as appropriate:

Explosions – Accidents involving detonations of high explosives, munitions, chemicals, or liquid and gaseous fuels will be considered for facilities and activities in the vicinity of the plant where such materials are processed, stored, used, or transported in quantity.

The AP1000 includes onsite storage facilities for compressed and liquid hydrogen. Accidents involving accidental detonations of hydrogen from these storage facilities are evaluated as part of the AP1000 certified design. Combined License applicants referencing the AP1000 Design Certification are not required to provide analyses of accidents involving these storage facilities provided that the locations and size of the storage facilities are consistent with the safe distances defined by the AP1000 certified design. The bulk gas storage area for the plant gas system (PGS) is located sufficiently far from the nuclear island that an explosion would not result in damage to safety-related structures, systems, and components.

Evaluation of potential explosions due to exposure of chemical storage tanks to exterior fires has determined that all of these postulated accidents are safe distances away from safety-related items.

The AP1000 certified design does not include liquid oxygen or propane storage facilities.

Flammable Vapor Clouds (Delayed Ignition) – Accidental releases of flammable liquids or vapors that result in the formation of unconfined vapor clouds in the vicinity of the plant.

A flammable vapor cloud (delayed ignition) due to the accidental release of hydrogen from the PGS bulk gas storage area is evaluated as part of the AP1000 certified design. A detonation of such a hydrogen vapor cloud would not result damage to safety-related structures, systems, and components. No other chemical has the possibility of developing unconfined flammable vapor clouds.

Toxic Chemicals – Accidents involving the release of toxic chemicals from nearby mobile and stationary sources.

Fires – Accidents leading to high heat fluxes or smoke, and to nonflammable gas or chemical-bearing clouds from the release of materials as the consequence of fires in the vicinity of the plant.

Airplane Crashes – Accidents involving aircraft crashes leading to missile impact or fire in the vicinity of the plant.

The AP1000 safe distance for material in onsite storage facilities for explosions, flammable vapor clouds and fires are tabulated in Table 2.2-1

Add Table 2.2-1 as follows:

Table 2.2-1

AP1000 On-Site Explosion Safe Distances

Material	Explosion Minimum Safe Distance [a]	Flammable Vapor Cloud Safe Distance [a]	AP1000 Distance to SSC
Liquid Hydrogen, H_2	577 feet	175 feet	635 feet
Pressurized Gaseous Hydrogen, H_2	6 feet	Not Applicable	10 feet
Hydrazine, N_2H_4	45 feet	Not Applicable	176 feet
Morpholine, $O(CH_2CH_2)_2NH$	646 feet	Not Applicable	176 feet
3-Methoxy propylamine (MOPA), $C_4H_{11}NO$	87 feet	Not Applicable	176 feet
No. 2 Diesel Fuel Oil	280 feet	Not Applicable	318 feet
Waste Oil	102 feet	Not Applicable	201 feet

a. Safe Distance is to nearest point of Nuclear Island SSC.

Revise Subsection 3.5.1.1.2.2 as shown below.

3.5.1.1.2.2 Explosions

Missiles can potentially be generated by a hydrogen explosion. Missiles that could prevent achieving or maintaining a safe shutdown or result in significant release of radioactivity are precluded by design of the plant systems that use or generate hydrogen.

- The battery compartments are ventilated by a system that is designed to preclude the possibility of hydrogen accumulation. Therefore, a hydrogen explosion in a battery compartment is not postulated.

- Gaseous ~~H~~hydrogen is supplied to the nuclear island from bottles (high pressure ~~the plant gas storage~~ tanks) adjacent to the turbine building ~~area to~~and near the nuclear island. The hydrogen supply is not located in an indoor compartment that contains safety-related systems or components. The quantity that could be released in the event of a failure of the hydrogen supply ~~line is limited to the contents of a single bottle. One hydrogen bottle at a time is connected to the hydrogen supply line. This quantity~~ would not lead to an explosion even if the full contents of ~~a single bottle~~the connected storage ~~are~~ is assumed to remain in the compartment in which it is released. Mixing within a compartment is achieved by normal convection caused by thermal forces from hot surfaces and air movement due to operation of HVAC systems. The hydrogen supply line is not routed through compartments that do not have air movement due to HVAC systems.

- The bulk gas plant storage ~~tank~~ area for the plant gas~~es~~ system (PGS) stores liquid hydrogen for use in generator cooling. This storage area is located sufficiently far from the nuclear island that an explosion would not result in missiles more energetic than the tornado missiles for which the nuclear island is designed. The liquid hydrogen is converted to gas in the storage area and then piped to the generator in the turbine building. The turbine building includes sufficient ventilation to prevent an explosive concentration of hydrogen in the event of a leak.

- A detonation of a flammable vapor cloud (delayed ignition) due to the accidental release of hydrogen from the PGS bulk gas storage area would not result in missiles more energetic than the tornado missiles for which the nuclear island is designed.

Revise the eighth paragraph 6.4.4 as shown below.

The protection of the operators in the main control room from offsite toxic gas releases is discussed in Section 2.2. The sources of onsite chemicals are described in Table 6.4-1, and their locations are shown on Figure 1.2-2. Analysis of these sources is in accordance with Regulatory Guide 1.78 (Reference 5) and the methodology in NUREG-0570, "Toxic Vapor Concentrations in the Control Room Following a Postulated Accidental Release" (Reference 6), and the analysis shows that these sources do not represent a toxic, asphyxiation, or flammability hazard to control room personnel.

Table 6.4-1

ONSITE CHEMICALS

Material	State	Location
Hydrogen	Liquid/Gas	Gas storage/Yard at turbine building
Nitrogen	Liquid	Gas storage.
CO_2	Liquid	Gas storage.
Oxygen Scavenger	Liquid	Turbine building
pH Addition	Liquid	Turbine building, CWS area[a]
Sulfuric Acid	Liquid	Turbine building, CWS area[a]
Sodium Hydroxide	Liquid	Turbine building, CWS area[a]

Table 6.4-1

ONSITE CHEMICALS

Material	State	Location
Dispersant[(a)]	Liquid	Turbine building, CWS area[(a)]
Fuel Oil	Liquid	DG fuel oil storage tank/DG building/ Annex building
Corrosion Inhibitor	Liquid	Turbine building, CWS area[(a)]
Scale Inhibitor	Liquid	Turbine building, CWS area[(a)]
Biocide/Disinfectant	Liquid	Turbine building, CWS area[(a)]
~~Algicide~~Algaecide	Liquid	Turbine building, CWS area[(a)]

Note:

a. Site-specific

Revise the fourth paragraph of Subsection 9.3.2.2.1 as shown below.

The low pressure hydrogen gas portion of the plant gas system is a packaged system consisting of a liquid hydrogen storage tank and vaporizers to supply hydrogen gas to the main generator for generator cooling and the demineralized water transfer and storage system to support removal of dissolved oxygen. The packaged hydrogen system is located in the gas storage area in the yard.

A separate high pressure hydrogen packaged system supplies hydrogen to the chemical and volume control to support removal of dissolved oxygen in the RCS. The hydrogen for this system is stored as a compressed gas in high pressure tanks (gas bottles). The high pressure hydrogen supply package system is located outdoors ~~at the hydrogen storage tank area~~adjacent to the turbine building.

The gas storage area in the yard is located a sufficient distance away from safety-related structures, systems and components that they are protected from the effects of explosion, flammable vapor cloud, and fire. The gas storage area is located a sufficient distance away from the air inlet to the control room so that the control room operators are protected from potential toxic effects and asphyxiation. The location of the gas storage area shown in Figure 1.2-2 is an acceptable location but that location is not part of the certified design. The location of the gas storage area is a site-specific determination.

Revise Subsection 9.3.2.3 as shown below.

9.3.2.3 Safety Evaluation

The plant gas system is required for normal plant operation and startup of the plant. The plant gas system is not required for safe shutdown of the plant. Therefore, it is not designed to meet seismic Category I requirements or single failure criterion. The plant gas system serves no safety-related function and has no safety design basis.

The nitrogen, the carbon dioxide, and the hydrogen system storage is located outside of the main buildings. The storage tanks are analyzed as a potential missile source. Refer to Section 3.5. Accidents involving accidental detonations of hydrogen from the onsite storage of compressed or liquid hydrogen are evaluated for damage to safety–related structures, systems and components. Refer to Section 2.2. For explosions, the plant gas system is designed for conformance with Regulatory Guide 1.91.

The effects of the plant gas system on main control room habitability are addressed in Section 6.4. The main control room habitability evaluation considers the flammability and asphyxiation potential ~~including explosive gases and burn conditions~~ for the~~o~~se gases. ~~For explosions, the plant gas system is designed for conformance with Regulatory Guide 1.91.~~

PRA Revision: None

Technical Report (TR) Revision: None

RAI Response Number: RAI-SRP2.5-RGS1-21
Revision: 1

Question:

1. In AP1000 DCD Rev. 17, Tier 1, Table 5.0-1 and Tier 2, Table 2-1, the site parameters for "Liquefaction Potential" and "Fault Displacement Potential" are specified as "Negligible," which has changed from "None" as specified in DCD Rev. 16. For COL applicants referring to the AP1000 DCD to meet the requirements of 10 CFR 100.23(d), please justify this change and clarify the definition of "negligible" for both liquefaction potential and fault displacement potential.

2. In AP1000 DCD Rev. 17, Tier 1, Table 5.0-1 and Tier 2, Table 2-1, the site parameter for dynamic bearing capacity is labeled as "Maximum Allowable Dynamic Bearing Capacity for Normal Plus Safe Shutdown Earthquake (SSE)." Please change the label title to 'Minimum Allowable' or justify why 'Maximum Allowable' is the correct site parameter to define the site's dynamic bearing capacity.

3. In AP1000 DCD Rev. 17, Tier 1, Table 5.0-1, under site parameters for Seismic SSE, the table states that "The hard rock high frequency (HRHF) ground motion spectra (GMRS) are shown in Figure 5.0-3 and Figure 5.0-4 defined at the foundation level for 5% damping. The HRHF GMRS provides an alternative set of spectra for evaluation of site-specific GMRS. A site is acceptable if its site-specific GMRS falls within the AP1000 HRHF GMRS." For COL applicants referring to the AP1000 DCD to meet the requirements of Appendix A to 10 CFR Part 100, (a) Please justify the use of the term "GMRS" under site parameters in Table 5.0-1. The GMRS is strictly site specific, and a standard design should provide design response spectra (even if they are developed based on a specific site GMRS) that can be used to compare the site-specific GMRS to determine the suitability of the site. (b) Please clarify whether the HRHF response spectra are a second set of design spectra in addition to that presented in Figures 5.0-1 and 5.0-2, and therefore could lead to a second set of CSDRS; or only apply for hard rock sites.

Question (Revision 1):

In response to Revision 0 of the response the NRC returned the following.

Westinghouse's latest response to RAI-SRP2.5-RGS1-21 is incomplete. For a COL applicant to reference Westinghouse's HRHF analysis, TWO conditions must be met. Only ONE condition is discussed in the RAI response. The SECOND condition is that the COL applicant must meet the shear wave velocity profile of the underlying media that Westinghouse used in the HRHF analysis.

In the single HRHF analysis performed by WES, the minimum shear wave velocity is 7,900 fps, right under the foundation, and exceeds 8,000 fps below that. The staff accepts 8,000 fps as the definition of "hard rock". Any site that does NOT meet this shear wave velocity profile, CANNOT reference WES's HRHF analysis.

WES needs to identify this SECOND condition when addressing the applicability of its HRHF analysis to a specific site. Therefore, DCD Tier 1 TABLE 5.0-1 and Tier 2 TABLE 2.0-1 need to be revised to describe the SECOND condition

Westinghouse Response:

1. The requirement for Liquefaction Potential and Fault Displacement Potential was changed from "None" to "Negligible" in Tier 1, Table 5.0-1 and Tier 2, Table 2-1 because of the difficulty of demonstrating that the potential is absolutely "None" for either parameter. During discussions on this topic, the NRC staff identified their concern that sites with the potential for liquefaction or fault displacement should not be used for a certified design that is not designed for either liquefaction or fault displacement.

   The AP1000 design has not been evaluated for a site where there is a liquefaction potential of the soil below the nuclear island. A COL applicant must describe the soil and rock structure beneath the nuclear island in their application. DCD Subsection 2.5.4.6 describes the geotechnical information that should be provided by the COL applicant. Liquefaction potential for the site is evaluated for the site specific SSE ground motion (specific site GMRS). A COL applicant will satisfy the requirement for no liquefaction by providing information concerning the properties and stability of supporting soils and rock consistent with the guidance of Regulatory Guide 1.206.

   Tier 1 Table 5.0-1, Tier 2, Subsection 2.5.4.4, and Tier 2, Table 2-1 are revised as shown below to address the NRC staff's concern and clarify the actions required of the COL applicant relative to liquefaction.

   The AP1000 design has not been evaluated for a site where there is a fault displacement potential. A COL applicant must describe the regional and site geology in their application. DCD Subsection 2.5.3 describes the information on surface faulting that should be provided by the COL applicant. A COL applicant will satisfy the requirement for no surface faulting by completing geological, seismological, and geophysical Investigations that are consistent with the guidance of Regulatory Guide 1.206.

   Tier 1 Table 5.0-1, Tier 2, Subsection 2.5.3, and Tier 2, Table 2-1 are revised as shown below to address the NRC staff's concern and clarify the actions required of the COL applicant relative to fault displacement potential.

2. The parameter of interest in the subject tables is dynamic bearing pressure. Westinghouse agrees that including the modifier "Maximum Allowable" in the column identifying the parameter is unnecessary.

   The words Maximum Allowable will be deleted from the label for the Dynamic Bearing Capacity parameter in Tier 1 Table 5.0-1 and Tier 2 Table 2-1 as shown below.

3. (a) In Appendix 3I the terms GMRS or HRHF GMRS are generally used to mean enveloping spectra that bound a number of hard rock high frequency sites. GMRS is also used this way in Subsection 2.5.2 and in a note to Table 2-1. Westinghouse agrees that the use of these

terms could be confused with the use of the GMRS term for site specific information in COL applications.

The term "HRHF GMRS" will be replaced with the term "HRHF envelope response spectra" in the DCD as noted below.

(b) The HRHF response spectra are not a second set of design spectra in addition to that presented in Figures 5.0-1 and 5.0-2. The HRHF response spectra do not represent a second set of CSDRS. The HRHF response spectra provide spectra that have been determined to be non-damaging for the AP1000 design and acceptable for a hard rock high frequency site.

Consistent with the approach outlined in DC/COL-ISG -1 "Interim Staff Guidance on Seismic Issues Associated with High Frequency Ground Motion in Design Certification and Combined License Applications" evaluations made are of representative systems, structures, and components, selected by screening, as potentially sensitive to high frequency input in locations where there were exceedances in the high frequency region. The evaluation of the AP1000 seismic design for evaluation for high frequency seismic input is described in DCD Appendix 3I. The acceptability of this sample is considered sufficient to demonstrate that the AP1000 is qualified for the HRHF spectra included in Appendix 3I and presented in Tier 1 Figures 5.0-3 and 5.0-4.

Westinghouse Response (Revision 1):

The question about the limitation on the shear wave velocity was largely answered in the Revision 3 response to RAI-SRP3.7.1-SEB1-02. The revision to Tier 2 Subsection 2.5.2.1 in the Revision 3 response to RAI-SRP3.7.1-SEB1-02 is incorporated into the DCD revisions for this response. The clarification of GMRS versus envelope response spectra has been incorporated in this response. Footnote f. to Tier 2 Table 2-1 is also revised to address the limitation on shear wave velocity. Conforming changes to Tier 1 Table 5.0-1 are provided to address the limitation on shear wave velocity for use of the HRHF envelope response spectra.

During discussions with the NRC about the response to Revision 1 questions were raised abut the information on liquefaction potential and fault zone displacement potential in the Tier 1 and Tier 2 tables. The information was clarified as applying to beneath the seismic Category I and seismic Category II structures and the immediate surrounding area. The immediate surrounding area includes the effective soil supporting media. The effective soil supporting media may also be considered the foundation zone beneath the structure is the footprint of the building increasing with depth below the building.

Design Control Document (DCD) Revision:

Revise DCD Tier 1, the second paragraph of Section 5.0 as follows"

Structures, systems, and components for the AP1000 are evaluated for generic envelope response spectra ~~ground motion response spectra (GMRS)~~ with high frequency seismic input. The spectra shown in Figure 5.0-3 and Figure 5.0-4 provide hard rock high frequency (HRHF) envelope response spectra ~~GMRS~~ at the foundation level for both the horizontal and vertical directions for 5% damping. An actual site is acceptable if its site-specific GMRS falls within the AP1000 HRHF parameters in Figures 5.0-3 and 5.0-4. No additional design or analyses are required for the structures, systems, and components for sites that fall within the AP1000 HRHF parameters.

Revise DCD Tier 1, Table 5.0-1 as follows"

Table 5.0-1 (cont.) Site Parameters	
Soil	
Average Allowable Static Soil Bearing Capacity	The allowable bearing capacity, including a factor of safety appropriate for the design load combination, shall be greater than or equal to the average bearing demand of 8,900 lb/ft^2 over the footprint of the nuclear island at its excavation depth.
~~Maximum Allowable~~ Dynamic Bearing Capacity for Normal Plus Safe Shutdown Earthquake (SSE)	The allowable bearing capacity, including a factor of safety appropriate for the design load combination, shall be greater than or equal to the maximum bearing demand of 35,000 lb/ft^2 at the edge of the nuclear island at its excavation depth, or site-specific analyses demonstrate factor of safety appropriate for normal plus safe shutdown earthquake loads.
Lateral Variability	Soils supporting the nuclear island should not have extreme variations in subgrade stiffness. This may be demonstrated by one of the following: 1. Soils supporting the nuclear island are uniform in accordance with Regulatory Guide 1.132 if the geologic and stratigraphic features at depths less than 120 feet below grade can be correlated from one boring or sounding location to the next with relatively smooth variations in thicknesses or properties of the geologic units, or 2. Site-specific assessment of subsurface conditions demonstrates that the bearing pressures below the footprint of the nuclear island do not exceed 120% of those from the generic analyses of the nuclear island at a uniform site, or 3. Site-specific analysis of the nuclear island basemat demonstrates that the site specific demand is within the capacity of the basemat. As an example of sites that are considered uniform, the variation of shear wave velocity in the material below the foundation to a depth of 120 feet below finished grade within the nuclear island footprint and 40 feet beyond the boundaries of the nuclear island footprint meets the criteria in the case outlined below. Case 1: For a layer with a low strain shear wave velocity greater than or equal to 2500 feet per second, the layer should have approximately uniform thickness, should have a dip not greater than 20 degrees, and should have less than 20 percent variation in the shear wave velocity from the average velocity in any layer.
Shear Wave Velocity	Greater than or equal to 1000 ft/sec based on minimum low-strain soil properties over the footprint of the nuclear island at its excavation depth
Liquefaction Potential	~~Negligible~~ No liquefaction considered beneath the seismic Category I and seismic Category II structures and immediate surrounding area. The immediate surrounding area includes the effective soil supporting media associated with the seismic Category I and seismic Category II structures

Table 5.0-1 (cont.)
Site Parameters

Seismic	
SSE	SSE free field peak ground acceleration of 0.30 g with modified Regulatory Guide 1.60 response spectra (See Figures 5.0-1 and 5.0-2). Seismic input is defined at finished grade except for sites where the nuclear island is founded on hard rock. If the site-specific spectra exceed the response spectra in Figures 5.0-1 and 5.0-2 at any frequency, or if soil conditions are outside the range evaluated for AP1000 design certification, a site-specific evaluation can be performed. This evaluation will consist of a site-specific dynamic analysis and generation of in-structure response spectra at key locations to be compared with the floor response spectra of the certified design at 5-percent damping. The site is acceptable if the floor response spectra from the site-specific evaluation do not exceed the AP1000 spectra for each of the locations or the exceedances are justified. The hard rock high frequency (HRHF) envelope response spectra ~~ground motion spectra (GMRS)~~ are shown in Figure 5.0-3 and Figure 5.0-4 defined at the foundation level for 5% damping. The HRHF envelope response spectra ~~GMRS~~ provide~~s~~ an alternative set of spectra for evaluation of site-specific GMRS. A site is acceptable if its site-specific GMRS falls within the AP1000 HRHF envelope response spectra~~GMRS~~. Evaluation of a site for application of the HRHF envelope response spectra includes consideration of the limitation on shear wave velocity identified for use of the HRHF envelope response spectra. <u>This limitation is defined by a shear wave velocity at the bottom of the basemat equal to or higher than 7,500 fps, while maintaining a shear wave velocity equal to or above 8,000 fps at the lower depths</u>.
Fault Displacement Potential	~~Negligible~~ No potential fault displacement considered beneath the seismic Category I and seismic Category II structures and immediate surrounding area. <u>The immediate surrounding area includes the effective soil supporting media associated with the seismic Category I and seismic Category II structures</u>

Revise the Captions for Tier 1 Figure 5.0-3 and 5.0-4 as follows:

Figure 5.0-3
Horizontal HRHF Envelope Response Spectra~~GMRS~~
Safe Shutdown Earthquake

Figure 5.0-4
Vertical HRHF Envelope Response Spectra~~GMRS~~

Revise the last paragraph of Tier 2, Subsection 2.5.2 as follows:

The AP1000 is evaluated for high frequency input using the response spectra specified in Appendix 3I, Figures 3I.1-1 and 3I.1-2. The seismic response spectra given in Figures 3I.1-1 and 3I.1-2 are envelope response spectra ~~bounding (GMRS)~~ with high frequency content.

Modify bullet 4 in DCD Subsection 2.5.2.1 as shown below. This information was previously provided in the Revision 3 response to RAI-SRP3.7.1-SEB1-02.

4. In lieu of (1) and (2) above, for a site where the nuclear island is founded on hard rock ~~with~~ defined by a shear wave velocity at the bottom of the basemat equal to or higher than 7,500 fps, while maintaining a shear wave velocity equal to or above 8,000 fps at the lower depths, ~~shear wave velocity greater than 8000 feet per second, the site-specific peak ground acceleration and~~ site specific spectra may be developed at the top of the competent rock and shown at the foundation level to be less than or equal to those given in Figures 3I.1-1 and 3I.1-2 over the entire frequency range. If a COL applicant has site GMRS exhibiting HRHF characteristics, but is not enveloped by the AP1000 HRHF envelope response spectra~~GMRS~~ or the AP1000 CSDRS, or has shear wave velocities that are not associated with hard rock may perform site specific studies to demonstrate that the high frequency is not damaging. This may be accomplished by:

   a. Demonstrating that the site floor response spectra, developed at the locations of the spectra given in TR115 (Sections 5.2 and 6.3) using the seismic input defined by the site GMRS, are enveloped by the AP1000 HRHF envelope response spectra or CSDRS spectra.

   b. If it is shown in step one that the spectra are not enveloped, evaluations similar to those described in Appendix 3I (documented in TR115, Reference 3), would be made to demonstrate that the high frequency input is non-damaging.

Revise Tier 2, Subsection 2.5.3 as follows:

2.5.3 Surface Faulting Combined License Information

Combined License applicants referencing the AP1000 certified design will address the following surface and subsurface geological, seismological, and geophysical information related to the potential for surface or near-surface faulting affecting the site:

- Geological, seismological, and geophysical investigations
- Geological evidence, or absence of evidence, for surface deformation
- Correlation of earthquakes with capable tectonic sources
- Ages of most recent deformation
- Relationship of tectonic structures in the site area to regional tectonic structures
- Characterization of capable tectonic sources
- Designation of zones of quaternary deformation in the site region

- Potential for surface tectonic deformation at the site

The AP1000 design has not been evaluated for a site where there is a fault displacement potential. A COL applicant will satisfy the requirement for no surface or near surface tectonic structure capable of displacements beneath the nuclear island and adjacent seismic Category II structures by completing geological, seismological, and geophysical investigations that are consistent with the guidance of Regulatory Guide 1.206.

Revise Tier 2, Subsection 2.5.4.4 as follows:

2.5.4.4 Liquefaction

The Combined License applicant will demonstrate for soil sites that the potential for liquefaction is negligible for both the soil underneath the Nuclear Island foundation and the soil of the side embedment engaged in passive resistance adjacent to the Nuclear Island.

The AP1000 design has not been evaluated for a site where there is a liquefaction potential of the soil below the nuclear island. A COL applicant will satisfy the requirement that liquefaction beneath the nuclear island and adjacent seismic Category II structures need not be considered by providing information concerning the properties and stability of supporting soils and rock consistent with the guidance of Regulatory Guide 1.206.

Revise Tier 2, Table 2-1 as follows:

Table 2-1 (Sheet 1 of 4) **SITE PARAMETERS**	
Air Temperature	
Maximum Safety [(a)]	115°F dry bulb/86.1°F coincident wet bulb[(g)] 86.1°F wet bulb (noncoincident)
Minimum Safety [(a)]	-40°F
Maximum Normal [(b)]	101°F dry bulb/80.1°F coincident wet bulb 80.1°F wet bulb (noncoincident) [(d)]
Minimum Normal [(b)]	-10°F
Wind Speed	
Operating Basis	145 mph (3 second gust); importance factor 1.15 (safety), 1.0 (nonsafety); exposure C; topographic factor 1.0
Tornado	300 mph
Seismic	
SSE	0.30g peak ground acceleration [(c)(f)]

Fault Displacement Potential	~~Negligible~~ No potential fault displacement considered beneath the the seismic Category I and seismic Category II structures and immediate surrounding area. The immediate surrounding area includes the effective soil supporting media associated with the seismic Category I and seismic Category II structures.
Soil	
Average Allowable Static Bearing Capacity	The allowable bearing capacity, including a factor of safety appropriate for the design load combination, shall be greater than or equal to the average bearing demand of 8,900 lb/ft^2 over the footprint of the nuclear island at its excavation depth.
~~Maximum Allowable~~ Dynamic Bearing Capacity for Normal Plus SSE	The allowable bearing capacity, including a factor of safety appropriate for the design load combination, shall be greater than or equal to the maximum bearing demand of 35,000 lb/ft^2 at the edge of the nuclear island at its excavation depth, or Site-specific analyses demonstrate factor of safety appropriate for normal plus safe shutdown earthquake loads.
Shear Wave Velocity	Greater than or equal to 1,000 ft/sec based on minimum low-strain soil properties over the footprint of the nuclear island at its excavation depth
Liquefaction Potential	~~Negligible~~ No liquefaction considered beneath the the seismic Category I and seismic Category II structures and immediate surrounding area. The immediate surrounding area includes the effective soil supporting media associated with the seismic Category I and seismic Category II structures

Revise Note f. to Tier 2, Table 2-1 as follows:

(f) Sites that fall within the hard rock high frequency envelope response spectra ~~GMRS~~ given in Figure 3I.1-1 and Figure 3I.1-2 and satisfy the limitation on shear wave velocity in Subsection 2.5.2.1 are acceptable.

Revise the first paragraph of Tier 2, Section 3I.1 Introduction as follows:

The seismic analysis and design of the AP1000 plant is based on the Certified Seismic Design Response Spectra (CSDRS) shown in subsection 3.7.1.1. These spectra are based on Regulatory Guide 1.60 with an increase in the 25 hertz region. Ground Motion Response Spectra (GMRS) for some Central and Eastern United States rock sites show higher amplitude at high frequency than the CSDRS. Evaluations are described in this appendix for a ~~GMRS~~ envelope response spectra with high frequency for the seismic input. The resulting spectra of this site is shown in Figure 3I.1-1 and Figure 3I.1-2 and compares this hard rock high frequency (HRHF) envelope response spectra ~~GMRS~~ at the foundation level against the AP1000 CSDRS for both the horizontal and vertical directions for 5% damping. The HRHF envelope response spectra~~GMRS~~ exceed the CSDRS for frequencies above about 15 Hz.

Revise Tier 2, Section 3I.2 as follows:

3I.2 High Frequency Seismic Input

Presented in Figures 3I.1-1 and 3I.1-2 is a comparison of the horizontal and vertical HRHF envelope response spectra ~~GMRS from the HRHF site~~ and the AP1000 CSDRS~~R~~. The HRHF envelope response spectra ~~GMRS~~ presented is calculated at foundation level -(39.5' below grade), at the upper most competent material and treated as an outcrop for calculation purposes.

For each direction, the HRHF envelope response spectra ~~GMRS~~ exceed~~s~~ the design spectra in higher frequencies (greater than 15 Hz horizontal and 20 Hz vertical). The spectra are used for the HRHF envelope response spectra~~GMRS~~. If necessary, the HRHF envelope response spectra ~~GMRS spectra~~ are enhanced at low frequencies so that HRHF envelope response spectra ~~GMRS~~ fully envelopes all of the hard rock sites.

Revise the second paragraph of Tier 2, Section 3I.4 Evaluation Methodology as follows:

The high frequency seismic analyses that are performed use time history or broadened response spectra. The analysis is not performed using the ~~envelope~~ combination spectra of the CSDRS and the HRHF envelope response spectra~~GMRS~~. Separate analyses with each spectra are used.

Revise the second paragraph of Tier 2, Section 3I.6.3 Piping Systems as follows:

The piping systems chosen for evaluation are those that are susceptible to high frequency as measured by their mass participation in the higher frequencies, are representative piping systems that contain valves and equipment nozzles, and are located in areas susceptible to high frequency HRHF ~~GMRS~~ spectra level response. At least two candidate piping analysis packages are identified for evaluations that meet these screening criteria.

Revise the third paragraph of Tier 2, Subsection 3I.6.4 Electrical and Electro-Mechanical Equipment as follows:

The AP1000 HRHF screening program for determination and evaluation of potential high frequency sensitive equipment is in compliance with the NRC requirements in Section 4.0, "Identification and Evaluation of HF Sensitive Mechanical and Electrical Equipment/Components," of COL/DC-ISG-1 (Reference 3). The AP1000 HRHF screening program is also consistent with the guidelines developed as part of an industry review document in the EPRI White Paper, "Seismic Screening of Components Sensitive to High Frequency Vibratory Motions" (Reference 4), transmitted to the NRC on June 28, 2007, for determining the safety-related equipment and components that may be HRHF sensitive, and screening procedures to ensure that any safety-related equipment and components sensitive to HRHF seismic excitation are screened out. This industry review of HF exceedance and further evaluations of SSCs performed by Westinghouse concluded that HRHF envelope response spectra ~~GMRS is~~ are less harmful than the CSDRS except for the functionality of potential HRHF-sensitive components.

Revise the Captions for Tier 2, Figure 3I.1-1 and 3I.1-2 as follows:

Figure 3I.1-1

Comparison of Horizontal AP1000 CSDRS and HRHF Envelope Response Spectra~~GMRS~~

Figure 3I.1-2

Comparison of Vertical AP1000 CSDRS and HRHF Envelope Response Spectra~~GMRS~~

PRA Revision:

None

Technical Report (TR) Revision:

None