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Your ref: Docket No. 52-006
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April 12, 2010

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

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,

Robert Sisk

Robert Sisk, Manager
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/Enclosure

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

D063
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: 0

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.

Westinghouse Response:

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. One is considered an explosion hazard; hydrogen. The other chemicals are in an aqueous solution such that they do not support combustion, are intrinsically non-combustible or have a flash point sufficiently high above the highest ambient temperature that combustible air/chemical mixtures are not possible.

In particular hydrazine is stored in an aqueous solution in a well ventilated portion of the turbine building.

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 system, structure or component (SSC). See DCD Tier 2 Figure 1.2-2 Site Plan Item 21 for the 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 a site-specific departure.

The hydrogen is stored as a liquid. The stored hydrogen has been evaluated per 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.

AP1000 On-Site Chemical Explosion Evaluation Results			
Chemical	**Quantity**	**Reg. Guide 1.19 Minimum Safe Distance**	**Notes**
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.
Hydrogen, H_2	2000 gallons, as liquid	635 feet	

A limited amount of 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 hydrogen is connected to the hydrogen supply line. This quantity would not lead to an explosion even if the full contents of the bottled hydrogen supply is assumed to remain in the compartment in which it is released.

Changes to the DCD to address the information above on hydrogen explosions is provided below.

<u>Accident Category 2 - Flammable Vapor Cloud Ignition</u>

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 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. 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 considered 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 635 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 the 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 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 was less than a level that was either toxic or leading to asphyxiation, it was considered to be acceptable. The worst case meteorological conditions were applied that maximized 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 result of the evaluation is that accidental releases of on-site chemicals do not challenge the habitability of the AP1000 MCR.

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 **
Fuel Oil	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

Design Control Document (DCD) Revision:

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 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.

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.

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.

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 a 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 are 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
Nitrogen	Liquid	Gas storage.
CO_2	Liquid	Gas storage.

Table 6.4-1 **ONSITE CHEMICALS**		
Material	**State**	**Location**
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)]
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~~<u>Algaecide</u>	Liquid	Turbine building, CWS area[(a)]

Note:
a. Site-specific

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. <u>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.</u>

The effects of the plant gas system on main control room habitability are addressed in Section 6.4<u>. The main control room habitability evaluation considers the flammability and asphyxiation potential</u> ~~including explosive gases and burn conditions~~ for th<u>e</u>~~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