Draft

Request for Additional Information No. 69 (773), Revision 0

9/5/2008

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 06.02.05 - Combustible Gas Control in Containment
Application Section: 6.2.5
SPCV Branch

QUESTIONS

06.02.05-1

Atmospheric Mixing of Hydrogen in Containment during design basis and significant beyond-design-basis accidents

10 CFR 50.44, (c)(1) requires a capability for ensuring a mixed atmosphere in containment during design-basis and significant beyond-design-basis accidents. The mixed atmosphere criteria in 10 CFR 50.44 (a)(2) are that the concentration of combustible gases in any part of the containment is below a level that supports combustion, or detonation that could cause the loss of containment integrity. SRP 6.2.5, Revision 3, II Acceptance Criterion 4 reiterates this requirement.

Provide analyses which demonstrates the mixing of hydrogen in the containment during design basis and beyond-design-basis accidents. These analyses should demonstrate that excessive stratification of combustible gases will not occur within the containment or within a containment subcompartment. The containment internal structures should have design features that promote the free circulation of the atmosphere. An analysis of these features for convective mixing should be provided.

These analyses should identify the sources and quantities of hydrogen used as input. Identify any systems required to ensure a mixed atmosphere. Address the function of the: passive autocatalytic recombiners (PARs); pressurizer relief tank rupture disks; rupture foils; convection foils; and, mixing dampers in providing the mixing of hydrogen in containment. The results should indicate, by compartment and region, e.g. the dome, the resulting hydrogen concentrations by volume.

Describe the design of the rupture foils, convection foils and mixing dampers in providing open ended compartments in containment. Identify the specific location of each foil or damper and describe their interaction. The description in FSAR section 6.2.5.2.1 implies that the rupture foils and the convection foils are installed at the top of the steam generator compartments. Address the functionality of all foils opening. Identify assumptions and resulting local hydrogen concentrations if only some foils open. Similarly, address the functionality of all mixing dampers. Identify any compartments subject to hydrogen release or generation which would no be open to the containment atmosphere.

Provide the individual PAR locations. The PAR locations shown schematically in FSAR Tier 2, Figure 6.2.5-1, Arrangement and Location of the Passive Autocatalytic Recombiners, are difficult to relate to the arrangement and location drawings reviewed (FSAR Tier 2, Figures 3.8-2 through 3.8-13, Reactor Building Plan & Section Drawings.) FSAR Tier 1, Table 2.3.1-1, CGCS Equipment Design, confirms neither the exact number of PARs, nor their actual locations. Identify which, and how many, PARs must operate to limit hydrogen concentration or promote mixing. Show that the assumed performance of PARs is verified by experimental evidence. Consider the impact of possible poisons on PAR performance. Discuss the time response on PAR efficiency.

Identify any compartments subject to hydrogen release or generation which would not be open to the containment atmosphere.

06.02.05-2

Combustible Gas Control

10 CFR 50.44 (c)(2) requires that the containment must limit hydrogen concentrations in containment during and following an accident that releases an equivalent amount of hydrogen as would be generated from a 100 percent fuel clad-coolant reaction, when uniformly distributed, to less than 10 percent by volume.

Identify significant beyond-design-basis accidents. The analysis should be based on severe accident methodology and rely only on equipment that will function in the accident environment, including hydrogen combustion. Select the limiting cases that bound the accident consequences. For the limiting cases, provide a detailed analysis of hydrogen generation, distribution and accumulation in various containment compartments. Show that:

a. resultant hydrogen concentration uniformly distributed is less than 10 percent,

b. local hydrogen concentrations do not reach detonation level which threaten containment integrity, and

c. by compartment and region, the resulting hydrogen concentration by volume.

Discuss the various beyond design basis scenarios considered and the rationale for the selection of the limiting case.

FSAR, Tier 2, section 19.2.4.4.1.3, Hydrogen Distribution, and FSAR Figure 19.2-5, Hydrogen Concentrations Through the US EPR Containment, address hydrogen concentration results in various compartments following a severe accident. Since Figure 19.2-5 “excludes” the compartments where release of hydrogen is predominant, provide the hydrogen concentration in the steam generator and reactor coolant pump rooms, the reactor pit and the spreading room for the same 50 hour time frame.

06.02.05-3

Equipment Survivability

To meet the requirements of 10 CFR Part 50.44 (c)(3) regarding equipment survivability, systems and components necessary for establishing and maintaining safe shutdown of the plant and containment structural integrity following a severe accident shall be capable of performing their functions during and after exposure to the environmental conditions created by the burning of hydrogen. Environmental conditions caused by local detonations of hydrogen must also be included, unless such detonations can be shown to be unlikely to occur. The amount of hydrogen to be considered must be equivalent to that generated from a fuel clad-coolant reaction involving 100% of the fuel cladding surrounding the active fuel region.

Provide a list of the systems necessary for establishing and maintaining safe shutdown of the plant and containment structural integrity during and following a severe accident. Provide a list of the components in these systems that are exposed to the containment environment.

Justify that these components will operate following a severe accident in containment, including the environmental conditions created by hydrogen burning. Provide pressure, temperature, and other environmental conditions these components would be subject to.

Explain why the equipment and instrumentation listed in the US EPR FSAR, chapter 19, Table 19.2-3, Severe Accident Instrumentation and Equipment is not identical to the equipment discussed in section 19.2.4.4.5 titled Equipment Survivability. For example, containment isolation valves are identified among the equipment inside containment which must withstand severe accident conditions, but they are not identified in Table 19.2-3.

In the US EPR FSAR, chapter 19, subsection 19.2.4.4.5.2, fifth paragraph, it is stated "…only equipment relied upon to actively mitigate the consequences of hydrogen in the containment atmosphere is required to survive such occurrences per 10 CFR 50.44". Explain how this design meets the equipment survivability requirements of 10 CFR 50.44 (c)(3).

06.02.05-4

Structural Analysis

10 CFR 50.44, (c)(5) requires an analysis which demonstrates containment structural integrity following an accident that releases the hydrogen generated from 100 % fuel clad-coolant reaction accompanied by hydrogen burning.

Regulatory Guide 1.7, Rev. 3, Control of Combustible Gas Concentrations in Containment, describes methods which are acceptable to NRC staff for implementing 10 CFR 50.44 (c). RG 1.7, section C.5, finds acceptable concrete containments that meet the containment structural integrity requirements of the ASME, Boiler and Pressure Vessel Code, Section III, Division 2, subsubarticle CC-3720, Factored Load Category, by considering internal pressure and dead load alone as having met the minimum design conditions for this accident.

Regulatory Guide 1.136, Rev 3, Design Limits, Loading Combinations, Materials, Construction, and Testing of Concrete Containments, describes an approach acceptable to the NRC staff to consider structural loads and determine the containment response in order to demonstrate containment structural integrity. RG 1.136, Position C.5.B (1)

provides loads and load combinations for pressure loads that result from a fuel clad-coolant reaction, accompanied by an uncontrolled hydrogen burn. The applicable load combination for the Factored Load Category is:

$$D + P_{g1} + [P_{g2} \text{ or } P_{g3}]$$

D = dead load
P_{g1} = pressure resulting from an accident that releases hydrogen generated from 100% fuel clad-metal water reaction
P_{g2} = pressure resulting from uncontrolled hydrogen burning
P_{g3} = pressure resulting from post accident inerting, assuming carbon dioxide is the inerting agent

US EPR DCD Tier 2 Figure 19.2-7, the Tolerance Limit Plot for AICC Pressure shows the global maximum pressure is 105 psia. Confirm that this corresponds to P_{g2} for the Factored Load combination above. Provide $P_{g1}$and P_{g2} (if produced during the severe accident). Compare this total load combination to the ultimate capacity pressure of 119 psig (Tier 2, Table 3.8-6, Containment Ultimate Pressure Capacity).

Confirm that the load combination above meets the requirements of the ASME Boiler and Pressure Vessel Code, Section III, Division 2, Subsubarticle CC-3720, Factored Load Category, considering pressure and dead load alone.

06.02.05-5

Additions
Expand FSAR Tier 1 Table 2.3.1-2, CGCS ITAAC, to include the location of all the rupture and convection foils.

Complete FSAR Tier 1, Table 2.3.1-1, CGCS Equipment Design to include every PAR and the location of each.

06.02.05-6

Corrections
Correct the following errors in FSAR Tier 1, Table 2.3.1-1, CGCS Equipment Design:

1. The PAR location “Annulus Space Accumulator Tank Loop 4 (180 to 270)” should be Loop 1.

2. The PAR location “Annulus Space Accumulator Tank Loop 4 (270 to 0)” should be Loop 2.

3. The “Rupture Disks” should be “Rupture Foils”. The location of the discharge of the *rupture disks* of the pressurizer relief tank is relevant but does not match the association and location.