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.:	**225-8254**
SRP Section:	**12.03 – 12.04 – Radiation Protection Design Features**
Application Section:	**12.3 – 12.4**
Date of RAI Issue:	**09/24/2015**

Question No. 12.03-17

10 CFR 20.1101(b) requires that the licensee use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA).

SRP Section 12.3-12.4 indicates that the acceptability of the facility design features will be based on evidence that the applicant has fulfilled dose limiting requirements and that major exposure accumulating functions (maintenance, refueling, etc) have been considered in the plant design. It also indicates that the evidence should include radiation protection features incorporated into the design, taking into account the state of technology, that will keep potential radiation exposure from these activities ALARA in accordance with 10 CFR 20.1101(b). It states that such features include the ability to reduce source intensity and design measures to reduce the production, distribution, and retention of activated corrosion products.

Plants with high fluid temperatures and high surface heat flux at the fuel clad (high duty cores) have a portion of the total heat transfer to the coolant occur by sub-cooled nucleate boiling. This leads to more severe duty on the fuel and surface boiling which is known to enhance the formation of corrosion product deposits (crud) on the cladding surface. During the pre-application review, staff requested that the applicant identify if the APR1400 has a high duty core, as defined in EPRI Report 1008102, “PWR Axial Offset Anomaly (AOA) Guidelines.” In the pre-acceptance discussions, the applicant indicated that the APR1400 was a medium duty core, however based on the review of information in FSAR Chapter 4, staff calculates the core to be a high duty core.

Therefore, please provide information on design features to reduce crud buildup in the core or to reduce dose rates, monitor radiation levels, or reduce airborne activity levels during refueling. Please update the FSAR, as appropriate, to discuss design features that are not already discussed.

As an alternative, the applicant may justify why the APR1400 design is not susceptible to such crud deposits within the core.

Response - (Rev.1)

The High duty core can be classified using a calculation for the index of boiling duty according to PWR AOA (Axial Offset Anomaly) Guidelines from EPRI.

From the following equation, the high duty core index can be calculated.

HDCI(High Duty Core Index) = (peak assembly heat flux)*1000/[(assembly flow rate)

*(T_{sat} - {T_x + T_{out}})]

Where,

peak heat flux = (core average heat flux)*(peak assembly power), in BTU/hr-ft^2 or W/m^2

assembly flow rate = (system flow rate at T_{cold})/number of assemblies, in gph or m^3/s

T_{sat} = saturation temperature at system pressure, in °F or °C

T_{out} = vessel temperature in the hot legs (ave.), in °F or °C

T_x = a temperature correction, 23 °F or 12.8 °C

1000 = scaling factor applied to the numerator to present the index as a whole number

HDCI Values to determine high, medium and low duty plants are:

High Duty Plant: ≥150 BTU/ft^2-gal-°F

Medium Duty Plant: 120 - 149 BTU/ft^2-gal-°F

Low Duty Plant: ≤119 BTU/ft^2-gal-°F

The APR1400 HDCI can be calculated from the following inputs:

Input: Core power = 3,983 MW_{th} (From DCD Table 4.4-1)

Number of assemblies = 241(From DCD Table 4.1-1)

Number of rods/assembly = 236(From DCD 4.2.2.3)

Active Fuel Height = 12.5 ft (From DCD Table 4.2-1)

Total flow = 446,300 gpm (From DCD Table 4.4-1)

Peak assembly power = 1.2353(From ROCS calculation result)

Vessel Tout = 615 °F (From DCD Table 4.4-1)

Tsat @ 2250 psi = 653 °F

Rod Outer Diameter = 0.374 inch (From DCD Table 4.2-1)

Derived Values: Core power (BTU/hr) = 3,983 * 3,412,142 =1.359 * E+10

Total fuel surface area (ft^2) = 241 * 236 * 12.5 * 0.374 * π/12 = 69,611

Average heat flux (BTU/hr-ft^2) = 1.359 * E+10/69611 = 195,235

Peak assembly heat flux (BTU/hr-ft^2) = 195235 * 1.2353 = 241,174

Assembly flow (gpm) = 446,300/241 = 1,852

HDCI = 241174 * 1000/[1852 * 60 * (653 - {23 + 615})] = **145** BTU/ft^2 - gal - °F

The APR1400 has a HDCI value of 145 BTU/ft^2-gal-°F, which is within the range of a medium duty plant. Therefore, APR1400 design is not susceptible to crud deposits within the core that would be seen in a heavy duty plant.

For clarity, the peak assembly power of 1.2353 is the maximum assembly power during the first cycle for steady-state. And the rod radial power factor of 1.55 used in the shielding analyses is the ratio of the average power per unit length produced by a particular fuel rod to the average power per unit length produced by the average-powered fuel rod in the core. This definition will be added in DCD section 12.3.2.3.

Impact on DCD

DCD section 12.3.2.3 will be revised as indicated in Attachment

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

There is no impact on any Technical, Topical, or Environment Report.

provided for all accessible plant areas capable of radiation levels greater than 1 Gy/hr. Areas with the potential for radiation greater than 1 Gy/hr are listed in Table 12.3-5.

Transient sources greater than 1 Gy/hr are considered in the shielding design to provide reasonable assurance that adequate shielding is provided. One such source is a spent fuel assembly. During transfer of a spent fuel assembly through the fuel transfer tube, adjacent areas may have elevated radiation levels. Streaming from this source up through the joint between the reactor containment building and the auxiliary building has been a concern for the current generation of nuclear plants. The APR1400 design uses connected building structures to reduce the potential for streaming. In addition, sufficient concrete shielding is provided to maintain radiation levels in adjacent areas ALARA during spent fuel transfer. This permits personnel to perform maintenance and inspection activities in a lower-radiation area and reduces the potential for high-radiation levels adversely affecting refueling outage schedules. An inspection area is provided for the fuel transfer tube. Access control is provided by the personnel airlock through the reactor containment building.

Insert this proposed sentence : "It should be noted that the rod radial power factor of 1.55 used for the shielding analysis is the ratio of the average power per unit length, while the peak assembly power of 1.2353 is the maximum assembly power during the first cycle for steady-state."

Sufficient shielding provides reasonable assurance that the areas adjacent to the spent fuel transfer tube are accessible and expected radiation zones are consistent with those in Figure 12.3-52 during transfer of a spent fuel assembly. The shielding design of the fuel transfer tube is based on the 100 hr decayed spent fuel source strengths provided in Table 12.2-9. The gamma source strengths given in units of [MeV/W-sec] are converted to [photons/sec] by multiplying the gamma source strength values by the thermal power per fuel assembly in [W] and dividing by the source energy in [MeV]. Then, the shielding source term is determined by multiplying this calculated value by the radial power peaking factor of 1.55 and by the number of fuel assemblies transferred through the transfer tube, which is two (2).

Typically, pipe chases do not need to be accessed frequently. The APR1400 design minimizes locating components such as valves in pipe chases to minimize plant personnel access to pipe chases and to reduce the potential for radiation exposure. When access is needed, radiation protection personnel conduct a survey of the area to determine the strength and location of radiation sources within the pipe chase. Temporary shielding is used to minimize personnel exposure. If the primary source of radiation in the pipe chase is spent resin or slurry transfer piping, precautions are taken by operating personnel to provide reasonable assurance that no spent resin is transferred while personnel are in the