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.:	**141-8098**
SRP Section:	**12.03-12.04 - Radiation Protection Design Features**
Application Section:	**12.3**
Date of RAI Issue:	**08/07/2015**

Question No. 12.03-9

REQUIREMENT

10 CFR 52.47(a)(5) requires that the FSAR contain the kinds and quantities of radioactive materials expected to be produced in the operation and the means for controlling and limiting radioactive effluents and radiation exposures within the limits set forth in 10 CFR 20.

10 CFR 20.1101(b) indicates in part that engineering controls should be used to maintain radiation exposures ALARA.

10 CFR 50, Appendix A, Criterion 61 requires in part that radioactive waste systems and other systems which may contain radioactivity contain suitable shielding for radiation protection.

GUIDANCE

SRP 12.3-12.4 indicates that the shielding should be specified for each of the radiation sources identified in Chapter 11 and Section 12.2, and other applicable sections.

SRP 12.3-12.4 also indicates that the acceptability of the facility design will be based on evidence that the applicant has fulfilled the dose limiting requirements. The SRP indicates that this includes evidence that major exposure accumulating functions (maintenance, refueling, radioactive material handling and processing, inservice inspection, calibration, decommissioning, and recovery from accidents) have been considered in plant design that the evidence should also 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).

Finally, SRP 12.3-12.4 states that, the areas inside the plant structures, as well as in the general plant yard, should be subdivided into radiation zones, with maximum design dose rate zones and the criteria used in selecting maximum dose rates identified. Maximum zone dose rates should be defined for each zone, depending on anticipated occupancy and access control.

Regulatory Guide 8.8 provides guidance on minimizing radiation exposure to the extent practicable and on appropriate plant shielding design.

INFORMATION NEEDED

Based on a review of the Chapter 12 normal operation radiation zone figures, staff has several questions related to the figures including, the minimum shield thicknesses provided in FSAR Table 12.3-4 as well as several questions related to access routes and zoning for certain areas. The questions are as follows:

1. In FSAR Figure 12.3-1 there is a door in room 055-A18A (the tendon gallery entrance area). Please indicate if this is an entrance into containment.

2. In FSAR Figure 12.3-1 please indicate how a worker would be expected to get from room 055-A07D to room 055-A08D and from room 055-A07C to room 055-A57C (all radiological areas). It is not clear that there is access between these areas without going through emergency exits through clean (non-radiological) areas.

3. In FSAR Figure 12.3-9 most of room 195-A08B (Auxiliary Building Controlled Area (II)Normal Exhaust Accumulation Room) is labeled as between a 0.20 mSv/hour and 1 mSv/hour radiation area, except for two areas in the south east and south west corners of the room which are labeled less than 0.0025 mSv/hour. The 0.0025 mSv/hour area in the south east corner also extends into a large portion of the room to the east on that same elevation, room 156-A08B (new fuel container laydown and inspection area). The lines separating the areas are irregular and do not appear to indicate any kind of shielding or any particular distance from sources that would result in a dose drop. Please explain why the areas in the southeast and southwest corners of room 195-A08B and southern portion of room 156-A08A are labeled as less than 0.0025 mSv/hour.

4. In FSAR Figure 12.3-10, room 063-P73 (Instrument Calibrator Facility), labeled as an area where dose rates could potentially exceed 5 Sv/hour, is surrounded by rooms with dose rates labeled as less than 0.05 mSv/hour or less. In FSAR Table 12.3-4, the north, south, west, and ceiling of 063-P73 all have minimum concrete thicknesses of 36 inches or greater (the south and west walls are 48 inches), however, the east wall only has a minimum thickness of 18 inches. Please describe how the 18 inch shield thickness for the east wall was determined. Since room 063-P73 is a potentially very high radiation area, if unique assumptions for the shielding for room 063-P73 were used, please update the FSAR with this information.

5. In FSAR Figure 12.3-10, Note 1 is included in corridor (063-P46). However, the FSAR does not provide any notes for Figure 12.3-10. Please indicate what this note represents in the FSAR.

6. FSAR Figure 12.3-13 includes note 1 indicating that the truck bays (100-P08) and future extension area (100-P07) will be reclassified from zone 2 to zone 7 during transfer and drumming of spent filter and spent resin. Staff has the following questions regarding this:

a. In order for the note to be more clearly identified, please write “Note 1” in the truck bays and future extension area.

b. While FSAR Table 12.3-4 provides shielding for the truck bays which appears appropriate for a zone 7 room, FSAR Table 12.3-4 provides no minimum shielding thicknesses for the future extension area. Please provide this information.

7. The purpose of the waste drum transfer room (100-P60) is unclear. It does not appear to be discussed in Chapters 11 and 12 of the FSAR. It appears on FSAR Figure 12.3-13, elevation 100 foot, and appears to be separated from the waste drum storage area (100-P09) and truck bays (100-P08) by a solid wall and it is unclear if the crane servicing the waste drum storage area and truck bays is capable of servicing the waste drum transfer room, particular because the waste drum transfer room does not extend up to elevation 120 foot, as the drum storage area and truck bays do. Please discuss the purpose of the waste drum transfer room and how drums are transferred from this room to the waste drum storage area and the truck bays.

8. FSAR Table 12.3-4 indicates that no shielding is needed east of the holdup volume tank. Please indicate why no shielding is needed in this area.

9. In reviewing FSAR Table 12.3-4, staff notes that none of the rooms in containment require shielding above or below them. Please discuss why shielding is not needed above or below these sources.

10. Please update the FSAR to discuss any shielding around the pressurizer, steam generators, and reactor coolant pumps. For example, please discuss any shielding between these components and the operating floor and the containment annulus area.

11. Please indicate in the FSAR if containment entries are allowed during operation and if so identify which areas are accessible.

12. Many of the walls in the Chapter 12 radiation zone figures include two unknown symbols. One symbol resembles an “X” with a box around it. For example, in FSAR Figure 12.3-1, on the wall between rooms 055-A07D and 055-A01D there is one of these symbols. In addition, on the wall between room 055-A07D and 050-A01D, there are two of these symbols. The other symbol has a bunch of dots, usually with three lines going through the dots. For example on Figure 12.3-1 between rooms 050-A01D and 055-A14D there is one of these symbols. It is unclear if these symbols could represent some kind of removable shield wall, door, or some other design feature pertinent to the radiological review. Please identify what these symbols represent and include their meaning on the legend for each of the figures.

13. Many of the rooms with the more significant radiation sources include continuous and dashed lines that would appear to indicate some type of shielding. For example, in Figure 12.3-1, the Room 055-A51B (Equipment Drain Tank Room), on the south side leading from the door, there are continuous and dashed lines. They appear to be denoting some type of shield wall for a labyrinth entrance way into the room, however, it is unclear why some lines are dashed and some are continuous. In addition, it is

unclear how thick these walls are or how any description in the FSAR of how thick these labyrinth walls have to be to achieve the desired appropriate radiation levels at the entrance to the room or within the labyrinth. Please update the FSAR to include this information.

Response – (Rev. 1)

1. According to DCD Figure 12.3-1, the room number for the Tendon Gallery Entrance Area is 055-A10C, not 055-A18A (Pipe Chase & Valve Room). Room 055-A10C only serves as an entrance to the tendon gallery within the outer containment wall. There is no entrance to the inside of containment through this door.

2. There are pathways from Room 055-A07D to Room 055-A08D and from Room 055-A07C to Room 055-A57C on the 55'-0" Elevation below the Mezzanine Floor at the 70'-0" Elevation as shown in Figure 1 and Figure 2 below, respectively.

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Figure 1. Pathways from 055-A07D to 055-A08D

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Figure 2. Pathway from 055-A07C to 055-A57C

3. The areas in the south east and south west corners below the irregular lines in Figure 12.3-9 indicate the roof areas above Room 195-A08B (Auxiliary Building Controlled Area (II) Normal Exhaust ACU Room) and Room 156-A08B (New Fuel Container Laydown and Inspection Area) as shown in Figure 3 below. The irregular lines were used to present the roof (Elevation 213'-6") in the same Figure 12.3-9, which is based on elevation 195'-0", to be consistent with the General Arrangement (GA) Drawing presented in Figure 1.2-19.

TS

Figure 3. Roof Areas above Auxiliary Building El. 195'-0"

4. The shielding design of Room 063-P73 is based on the use of a multi-source gamma calibrator. The gamma source of the calibrator is located in a lead cylinder block and the calibrator has a collimator, which is placed facing the west shield wall during calibration operation as shown in Figure 4 below. Therefore, since the east wall is located in the opposite direction, there is no direct exposure from the calibration source. Based on the shielding calculation for the instrument calibrator facility room conducted using MCNP code, it was concluded that the minimum required thickness of 18 inches is sufficient to meet the radiation zoning criteria for the east wall.

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Figure 4. Schematic Drawing Showing Direction of Calibration Operation

5. The “Note 1” in Figure 12.3-10 will be deleted.

6. a. “Note 1” will be added in Figure 12.3-13.

   b. The minimum required shield thicknesses for the Future Extension Area (100-P07), which are determined based on the same design basis and source as the adjacent Truck Bay (100-P08), will be added in Table 12.3-4. Please refer to the response to Question 12.03-08 for the corresponding markup.

7. The purpose of the Waste Drum Transfer Room (100-P60) is to receive and lift packaged DAW compact drums from the DAW Dryer and Dewatering Equipment Room (085-P24), which is located just below the Waste Drum Transfer Room. From Room 085-P24, which includes the DAW compactor, the packaged DAW drums are lifted through a removable hatch using a lifting tool into Room 100-P60. From the Waste Drum Transfer Room (100-P60), the drums are then transferred via cart through the corridor to the Compound Building Truck Bay (100-P08) adjacent to the Waste Drum Storage Area (100-P09).

In the Truck Bay, the radwaste crane is used for moving the packaged DAW waste drums into the Waste Drum Storage Area (100-P09) and placing the drum in an appropriate storage location.

During the transportation of the drum, a shielded drum cask may be used when the surface dose of the package drum exceeds the dose range established for the corridor in order to minimize operational exposure incurred during the packaged waste drum transportation.

8. The Holdup Volume Tank (HVT) does not contain any radioactive sources during normal operation. It is used to control the pH of the IRWST water by dissolving the Tri-Sodium Phosphate (TSP) stored in the HVT only during post-accident conditions. The shield thickness provided for the west wall of the HVT in Table 12.3-4 is for the primary shield wall. The thicknesses for the north and south walls are determined to provide limited access into the HVT during refueling maintenance from the RCS piping. Since there are no sources in the left and right sides of the east wall, no specific shielding is required for the east wall.

9. Since the ICI cavity, Reactor Cavity, and HVT are open to the containment atmosphere, shielding requirements for these areas are not provided. However, since the areas below these rooms are the outside ground beneath the containment floor, Table 12.3-4 will be updated. Please see Item No. 1 of Question 12.03-08 for the corresponding markup.

   Since the IRWST is located below the Reactor Drain Tank (RDT) and Letdown Heat Exchanger (LHX) Rooms, the shielding for the floors of these rooms are not required. However, shielding is required for the ceilings of the RDT and LHX rooms, and the ceiling and floor of the Regenerative Heat Exchanger (RHX) room, additional shield wall thicknesses for these rooms will be included in DCD Table 12.3-4, please see Item No. 1 of Question 12.03-08 for the corresponding markup.

10. The pressurizer is separated from the operating floor with a minimum of 33-inch shield wall. Steam generators, reactor coolant pumps and associated RCS piping are also separated from the operating floor and the annulus area by the secondary shield wall with a minimum thickness of 48 inches. Minimum shield wall thicknesses for these areas will be added in DCD Table 12.3-4. Please see Item No. 1 of Question 12.03-08 for the markup. In addition, DCD Subsection 12.3.2.1 will be updated.

11. Limited access to the containment is allowed during power operation. Annulus areas outside the secondary shield walls are allowed with a limited occupancy. Access to these areas is restricted through administrative controls as well as a physical lock on the door. DCD Subsection 12.3.2.3 will be updated accordingly.

12. The symbol that resembles an “X” with dotted lines indicates a removable shield wall, which is used to bring large equipment into or out of the adjacent cubicle. Since this symbol is typically used in layout drawings (e.g. Figure 1.2-12), the addition of a legend only for this symbol is not necessarily required in the radiation zone drawings. The density of the removable shield wall (RSW) is required to be greater than the permanent concrete shield wall. The gap between the RSW and the concrete structure

is designed to be less than 1/2” with an offset. MCNP analysis of this design has been performed for domestic plant construction projects, and through this analysis it has been demonstrated that the gap does not cause additional occupational exposure.

The other noted symbol comprised of dots with lines diagonally through them are used to indicate permanent concrete shield walls. It is only used to help visually differentiate the concrete walls from the other lines used to indicate radiation zoning and does not indicate any additional radiation protection features other than the shielding design.

13. In the cubicles where significantly high radiation sources are located, a double labyrinth entrance is considered. If the height of the labyrinth wall is lower than the height of the ceiling, a roof slab of the labyrinth is provided. In order to indicate the labyrinth wall under the labyrinth roof the dashed lines are used in the drawings. If the wall of the labyrinth reaches the ceiling, the solid lines are used to show the labyrinth wall. The design criteria for the labyrinth of APR1400 is as follows, “The scattered dose rate through the passageway and the transmitted dose rate through the shield wall from all contributing sources shall be below the upper limit of the radiation zone specified for each area.” This design criteria will be added in DCD Subsection 12.3.1.1.h.

    Additionally, based on the telephone conference call on April 7, 2016, KHNP added the west side of the primary shield wall in DCD Tier 1 Table 2.2.1-1.

Impact on DCD

DCD Figure 12.3-10, 12.3-13, Subsection 12.3.2.1, 12.2.2.3, and 12.3.1.1will be revised as indicated in Attachments 1 through 6, respectively.

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 Environmental Report.

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 12.3-10 Radiation Zones (Normal) Compound Building El. 63'-0"

Security-Related Information – Withhold Under 10 CFR 2.390

Figure 12.3-13 Radiation Zones (Normal) Compound Building El. 100'-0"

The four (4) I&C equipment rooms house the safety related instrument and control systems, which require infrequent access to perform the vital function. The design dose for these areas shall not exceed TEDE of 50 mSv. The I&C equipment rooms are located in the auxiliary building at an elevation of 47.5 m (156.0 ft). The locations of the class 1E switchgear rooms and associated access routes are shown in Figure 12.3-40.

g. Access areas outside the CS and SC pump rooms

The areas outside the CS and SC pump rooms are irregularly accessed, when the manual actuation is required after post-accident situations. The design dose for these areas shall not exceed TEDE of 50 mSv. These areas are located in the auxiliary building at an elevation of 16.8 m (55.0 ft). The locations of these areas and associated access routes are shown in Figure 12.3-20.

12.3.2 Shielding

The shielding design is based on the source terms, design dose rates, and established design criteria in Subsection 12.2.1 and is in accordance with the calculation method and guidance in NRC RG 1.69 (Reference 10) and NRC RG 8.8.

12.3.2.1 General Shielding Design Criteria

Shield walls are provided around components that contain and handle radioactive materials for worker safety and to maintain radiation doses ALARA. The wall thicknesses listed in Table 12.3-4 are based on the shielding basis source terms of the component, the design dose rate, and the shielding material. This approach is consistent with NRC RG 8.8.

The shielding design for the MCR and the primary shielding in the reactor containment building is safety related. The shielding for the MCR meets the requirements of 10 CFR Part 50, Appendix A, GDC 19.

Radiation protection of personnel, equipn
adequacy of the design of the plant s
protection function of radiation attenua

Pressurizer is separated from the operating floor with a minimum of 33-inch shield wall. Steam generators, reactor coolant pumps and associated RCS piping are also separated from the operating floor and the annulus area by the secondary shield wall with a minimum thickness of 48

Within the reactor containment building, the pressurizer is separated from the operating floor by a shield wall with a minimum thickness of 33 inches. The steam generators, reactor coolant pumps, and associated RCS piping are also separated from the operating floor and annulus area by the secondary shield wall which has a minimum concrete thickness of 48 inches.

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.

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

Limited access to the containment is allowed during power operation. Annulus areas outside the containment secondary shield walls are allowed with a limited occupancy.

Limited access to the annulus areas within the reactor containment building is allowed during power operation with a tightly controlled occupancy time. Access to these areas is restricted through administrative controls as well as a physical lock on the door.

to the hot machine shop is also provided from the truck bay for ease of equipment movement.

e. Staging areas

Large staging areas outside the equipment hatch and personnel airlocks allow for prestaging prior to the start of an outage, and provide space for efficient radiation controls for moving equipment in and out of reactor containment building.

f. Personnel decontamination and change areas

Personnel decontamination and change areas are adjacent to radiation control area access points. Storage space for protective clothing, respirators, shower and toilet facilities, lockers, and containers for contaminated clothing are provided in these areas.

g. Radiation control area

The scattered dose rate through the passageway and the transmitted dose rate through the shield wall from all contributing sources shall be below the upper limit of the radiation zone specified for each area.

The APR1400 design provides a single point of access into the radiation control areas; however, emergency egress is provided on all elevations. The access area to the radiation control area provides a flexible and adaptable layout to accommodate outage work crews and enhance the availability of immediate interaction with radiation protection personnel stationed at this point.

h. Accessways and entrances to high-radiation areas

Labyrinths are provided at the entrances to high-radiation areas to minimize exposure due to scattering and streaming of radiation through entrances and piping penetrations. This approach is consistent with NRC RG 8.8, Position 2.b(4).

The plant layout design can accommodate removable shields as necessary to provide shielding during normal operation for adjacent corridors. These shields can provide additional shielding during the removal of radioactive components, such as heat exchangers, for maintenance activities. This approach is consistent with NRC RG 8.8 Position 2.b (2).

The density of the removable shield wall (RSW) is required to be greater than the permanent concrete shield wall. The gap between the RSW and the concrete structure is designed to be less than 1/2” with an offset.

APR1400 DCD TIER 1

Table 2.2.1-1 (2 of 10)

Wall or Section Description	Column Lines	Floor Elevation or Elevation Range	Concrete Thickness (1)	Applicable Radiation Shielding Wall (Yes/No)
Containment Internal Structure				
Primary Shield Wall	Not Applicable	From 69'-0" to 94'-3 1/2"	12'-10 3/4"(East), 9'-8 5/8"(North/South)	Yes
		From 94'-3 1/2" to 114'-6"	9'-1"(East), 6'-9"(North/South)	
		From 114'-6" to 130'-0"	~~6'-0"~~	Yes
Secondary Shield Wall	Not Applicable	From 100'-0" to 156'-0"	4'-0"	Yes
Fill Slab	Not Applicable	From 66'-0" to 69'-0" From 78'-0 to 81'-0" From 78'-0 to 100'-0" From 76-0 to 80'-0"	3'-0" 3'-0" 22'-0" 4'-0"	No
IRWST Wall	Not Applicable	From 81'-0" to 97'-0"	3'-0"	No
IRWST Slab	Not Applicable	From 97'-0" to 100'-0"	3'-0"	No
Refueling Pool Wall	E-W direction	From 130'-0"to 156'-0"	6'-2"	Yes
	N-S direction	From 130'-0" to 156'-0"	5'-0"(West), 6'-0"(East)	Yes
Refueling Pool Slab	Not Applicable	From 126'-0" to 130'-0" From 107'-6" to 114'-6"	4'-0" 7'-0"	No No
Hold-up Volume Tank Wall	Not Applicable	From 80'-0" to 100'-0"	6'-2"(North/South)	No