
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.: 126-8012
SRP Section: 02.03.01 - Regional Climatology
Application Section: Regional Climatology
Date of RAI Issue: 08/04/2015

Question No. 02.03.01-3

The Staff considered the December 23, 2014 re-submittal, by Korea Hydro and Nuclear Power Co., Ltd. (KHNP), of Revision 0 of its application for Design Certification of the APR1400 Standard Design (ML15006A059) - in particular, Design Control Document (DCD) Tier 1, Table 2.1-1, DCD Tier 2, Table 2.0-1, DCD Tier 2 Section 2.3.1, and related information - along with KHNP's proposed responses, dated May 12, 2015, to requests for clarifications related to hydrology and meteorology (see ML15132A599 and ML15132A600).

DCD Tier 1, Table 2.1-1 and DCD Tier 2, Table 2.0-1 list design ambient temperature site parameter values applicable to the circulating water system (CWS) and essential service water system (ESWS) design, designated as:

- 5% Annual Exceedance Values for the CWS (i.e., maximum non-coincident wet-bulb, and presumably minimum dry-bulb temperatures); and
- 0% Annual Exceedance Values for the ESWS (i.e., maximum non-coincident wet-bulb, and presumably minimum dry-bulb temperatures).

DCD Tier 1, Table 2.1-1 and DCD Tier 2, Table 2.0-1 also list design ambient temperature site parameter values applicable to Heating, Ventilation, and Air Conditioning (HVAC) design, designated as:

- 5% and 1% Annual Exceedance Values (i.e., maximum dry-bulb and coincident wet-bulb, and presumably minimum dry-bulb temperatures); and
- 0% Annual Exceedance Values (i.e., maximum dry-bulb and coincident wet-bulb, and presumably minimum dry-bulb temperatures) as historical limits excluding peaks less than 2 hours duration.

Pursuant to 10 CFR 52.47(a)(1), a Design Certification (DC) applicant is required to provide site parameters postulated for its design and an evaluation of its design in terms of those site

parameters. In turn, NUREG-0800, SRP Section 2.3.1, Subsection IV (Evaluation Findings), Item 4(b), in part, calls for the NRC staff to reach a conclusion that “[t]he postulated site parameters are representative of a reasonable number of sites that have been or may be considered for a COL application”. In order to reach such a conclusion with respect to the design-basis dry- and/or wet-bulb ambient temperature site parameters, the Applicant should address the following technical issues:

- a) The 0% annual exceedance non-coincident wet-bulb temperature is listed in DCD Tier 1, Table 2.1-1 and DCD Tier 2, Table 2.0-1 as 27.2 °C (81 °F). Subsection 9.2.5.2.2.1 of the DCD Tier 2 FSAR identifies the Ultimate Heat Sink (UHS) cooling towers as mechanical draft type and designed to this site parameter value under accident conditions. The staff notes that although not cited in DCD Tier 1, Table 2.1-1 or DCD Tier 2, Table 2.0-1, the design ambient temperature site parameters and values for all percent exceedance levels are the same as those specified in earlier revisions of the Electric Power Research Institute (EPRI) Utility Requirements Document (URD) for Advanced Light Water Reactors.

The staff also notes that many of the previously reviewed DC applications for other new reactor designs initially referenced the EPRI URD for the same design ambient temperature site parameters, and in many cases subsequently revised several of these site parameter values, including the 0% exceedance non-coincident wet-bulb temperature. The staff further notes that almost all of the Combined License (COL) and Early Site Permit (ESP) applications that it has reviewed identify 0% exceedance non-coincident wet-bulb temperatures greater than the corresponding site parameter value listed in DCD Tier 1, Table 2.1-1 and DCD Tier 2, Table 2.0-1 of the APR1400 DC application. The table below summarizes many of these values:

Site	0% Exceedance NCWB (°F)
KNHP-APR1400	81
Bellefont	83.5
Callaway	81
Comanche Peak	86
Fermi	86.0
Grand Gulf	81
Levy County	85.5
Nine Mile Point	82.3
North Anna	88
River Bend	85.2
Shearon Harris	83.5
South Texas	88.3
Turkey Point	87.4
Victoria ESP	86.1
V.C. Summer	87.3
Vogtle	83.9
William States Lee	85
PSEG ESP	86.2

Note: NCWB = Non-Coincident Wet-Bulb Temperature

The geographical area covered by these site locations (under development and potential) is diverse not only in latitude and longitude, but in topographic setting (i.e., coastal and interior) as well.

Given the preceding, either update the DC application where applicable by justifying the selection of the 0% annual exceedance non-coincident wet-bulb temperature as listed in DCD Tier 1, Table 2.1-1 and DCD Tier 2, Table 2.0-1 (i.e., 27.2 °C (81 °F)) such that the staff can reach its conclusion as stated in the SRP 2.3.1 guidance, or revise the indicated site parameter value and any other related site parameter value(s), text, and associated current or new table(s).

- b) Evaluate whether any other design ambient temperature site parameters and values listed in DCD Tier 1, Table 2.1-1 and DCD Tier 2, Table 2.0-1, should be similarly revised based on the lessons learned from previous DC, COL, and ESP application submittals to the staff for review. If so, revise the affected site parameter value(s), text, and associated current or new table(s).
- c) NUREG-0800, SRP Section 2.3.1, Subsection I (Areas of Review), Item 6, states, with respect to meteorological conditions identified as - (1) site characteristics for ESP applications, (2) design and operating bases for Construction Permit, Operating License, and COL applications, and (3) site parameters for DC applications – including, among others “ambient temperature and humidity statistics....for use in establishing heat loads for the design of normal plant heat sink systems, post-accident containment heat removal systems, and plant heating, ventilating, and air conditioning systems” that “[a]ll references to FSAR sections in which these conditions are used should be identified by the applicant”.

As indicated previously, DCD Tier 1, Table 2.1-1 and DCD Tier 2, Table 2.0-1 list design ambient temperature site parameter values applicable to the following systems:

- 5% Annual Exceedance Values for the CWS (i.e., maximum non-coincident wet-bulb, and presumably minimum dry-bulb temperatures);
- 0% Annual Exceedance Values for the ESWS (i.e., maximum non-coincident wet-bulb, and presumably minimum dry-bulb temperatures);
- 5% and 1% Annual Exceedance Values for HVAC systems (i.e., maximum dry-bulb and coincident wet-bulb, and presumably minimum dry-bulb temperatures); and
- 0% Annual Exceedance Values for HVAC systems (i.e., maximum dry-bulb and coincident wet-bulb, and presumably minimum dry-bulb temperatures) as historical limits excluding peaks less than 2 hours duration.

Subsection 9.2.5.2.2.1 of the DCD Tier 2 FSAR and related Table 9.2.5-3 identify the percent annual exceedance levels that apply to the UHS cooling towers under normal operating and accident conditions. In contrast, the introduction to DCD Tier 2 FSAR Section 9.4 merely states that “[t]he HVAC outdoor air design temperature conditions are shown in Table 2.0-1” while there are three distinct annual percent exceedance levels associated with various (presumably safety- and non-safety-related) HVAC systems. In order for subsequent ESP and COL applicants to properly associate site

characteristic values with the corresponding design ambient temperature site parameter values listed in DCD Tier 1, Table 2.1-1 and DCD Tier 2, Table 2.0-1, and consistent with the guidance in SRP Section 2.3.1 for applicants to identify the “FSAR sections in which these conditions are used” (i.e., linked to specific structures, systems, and components (SSCs)), the applicant should either confirm where the DCD FSAR already clearly identifies these associations or:

- revise the appropriate sections of the DCD FSAR and current or new tables and/or figures, as appropriate, where such conditions are applicable to the design or operation of an SSC;
 - delete design ambient temperature site parameters and values where no such association exists with the design or operation of an SSC; and
 - confirm that associations are clearly identified in the DCD FSAR for the other climate-related site parameters and values listed in DCD Tier 1, Table 2.1-1 and DCD Tier 2, Table 2.0-1 (i.e., precipitation and structural loads, extreme wind, tornado and hurricane parameters) or revise the related sections of the DCD FSAR and current or new tables and/or figures, as appropriate.
- d) Confirm whether the minimum temperature values listed among the design ambient temperature site parameters in DCD Tier 1, Table 2.1-1 and DCD Tier 2, Table 2.0-1 represent dry-bulb temperature values (as appears to be the case). If so, clarify the respective table entries by annotating accordingly.
- e) Confirm whether the 0% Annual Exceedance Values for the ESWS (i.e., maximum non-coincident wet-bulb, and presumably minimum dry-bulb temperatures) listed in DCD Tier 1, Table 2.1-1 and DCD Tier 2, Table 2.0-1 represent an historical limit or limits excluding peaks less than two hours as shown for the 0% Annual Exceedance Values for HVAC systems (i.e., maximum dry-bulb and coincident wet-bulb, and presumably minimum dry-bulb temperatures). The staff notes that the minimum (presumably dry-bulb) temperature values are the same in both cases (i.e., -40.0 °C (-40 °F)).

In order for subsequent ESP and COL applicants to properly develop site characteristic values for comparison to corresponding design ambient temperature site parameter values and, therefore, facilitate the staff’s eventual review, the applicant should either:

- annotate the 0% Annual Exceedance Values for the ESWS accordingly, if one or both of those values represent an historical limit or limits excluding peaks less than two hours, or
- if not the case, add footnotes to DCD Tier 1, Table 2.1-1 and DCD Tier 2, Table 2.0-1 to indicate how the respective 0% Annual Exceedance site parameter values were determined because they represent two different statistics.

Response

- a) The NRC certified the U.S. ABWR design in May 1997. This design certification application included sections that defined and enveloped site-related parameter which

the ABWR standard plant design could accommodate. The site related parameters were identified as being able to envelope most potential sites in the US. These ABWR site parameters included a 0% exceedance value of 27.2 oC (81 oF) wet bulb for non-coincident ambient design temperature.

The NRC recently performed a detailed review of the US EPR design. This design uses a site parameter of 81 oF for wet bulb temperature in its DCD. In SER for EPR Chapter 2 it concludes that site parameters meet the requirements of 10 CFR 52.47 (a) (1). The staff agreed that the site parameters are representative of a reasonable number of sites that have been or may be considered for a COL application. In this particular case the staff reviewed the ASHRAE Weather Data and found that 33 percent of the weather stations were within the 0% exceedance non-coincident wet bulb temperature of 27.2 oC (81 oF).

The APR1400 wet bulb temperature is identical to the one used by the ABWR and the EPR.

Also, as mentioned in the subject RAI, APR1400 design ambient temperature site parameters and values for all percent exceedance levels are the same as those specified in the Electric Power Research Institute (EPRI) Utility Requirements Document (URD) for Advanced Light Water Reactors. Therefore, the 0% exceedance wet bulb temperature of 27.2 oC (81 oF) used in the APR1400 is reasonable and valid for use today.

KHNP believes that a wet bulb temperature of 27.2 oC (81 oF) is sufficient for building a plant in a reasonable amount of locations across the US. We further believe that the intent of applicable guidance and 10 CFR 52.47 (a) (1) has been met.

- b) Design ambient temperatures listed in DCD Tier 1, Table 2.1-1 and DCD Tier 2, Table 2.0-1 are also identical to the values used by the ABWR and the US-EPR. In SER for EPR Chapter 2 it concludes that site parameters meet the requirements of 10 CFR 52.47 (a) (1). The staff agreed that the site parameters are representative of a reasonable number of sites that have been or may be considered for a COL application.

KHNP believes that other design ambient temperature site parameters and values listed in DCD Tier 1, Table 2.1-1 and DCD Tier 2, Table 2.0-1 are sufficient for building a plant in a reasonable amount of locations across the US based on the lessons learned from SER for EPR. We further believe that the intent of applicable guidance and 10 CFR 52.47 (a) (1) has been met.

- c) DCD Tier 2, Subsection 9.4 will be revised to identify the percent annual exceedance values that are applied to the safety-related and non-safety-related HVAC systems.

The probable maximum precipitation (PMP) is provided to determine the probable maximum flood (PMF) on streams and rivers and PMF due to potential dam failures as described in DCD Tier 2 Section 2.4.3 and Section 2.4.4. Based on site-specific PMF information, the probable maximum flood loads (Hs) are determined for structural design as described in DCD Tier 2 Section 3.8.4.3.4.c.

Extreme wind, tornado and hurricane parameters are described in DCD Tier 2 Section 3.3 and applied to wind loads (W) and tornado or hurricane load (Wt) for structural design as described in DCD Tier 2 Section 3.8.4.3.3.a and Section 3.8.4.4.b, respectively.

Therefore, the associations for precipitation and structural loads, extreme wind, tornado and hurricane parameters are identified in the DCD FSAR Section 2.4, 3.3 and 3.8.4.

- d) DCD Tier 1, Table 2.1-1 and DCD Tier 2, Table 2.0-1 will be revised to identify that the minimum temperature values are dry-bulb temperature values.
- e) DCD Tier 1, Table 2.1-1 and DCD Tier 2, Table 2.0-1 will be revised to identify that the 0% annual exceedance values for the ESWS represent historical limit excluding peaks less than two hours.

Impact on DCD

DCD Tier 2, Subsection 9.4, DCD Tier 1, Table 2.1-1 and DCD Tier 2, Table 2.0-1 will be revised as indicated in the 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 Environmental Reports.

APR1400 DCD TIER 29.4 Heating, Ventilation and Air Conditioning Systems

The HVAC systems are provided as required throughout all areas for personal comfort, personnel safety protection, and equipment functional protection.

The reference subsections of HVAC systems and related systems are as follows:

- a. Chilled water system (Subsection 9.2.7)
- b. Control room HVAC system (Subsection 9.4.1)
- c. Fuel handling area HVAC system (Subsection 9.4.2)
- d. Auxiliary building clean area HVAC system (Subsection 9.4.3)
- e. Turbine generator building HVAC system (Subsection 9.4.4)
- f. Engineered safety feature (ESF) ventilation system (Subsection 9.4.5)
- g. Reactor containment building HVAC system and purge system (Subsection 9.4.6)
- h. Compound building HVAC system (Subsection 9.4.7)

The design conditions for the systems are given in the design bases of each system.

The flow diagrams for HVAC systems are shown on Figures 9.4.1-1 through 9.4.7-1. The HVAC outdoor air design temperature conditions are shown in Table 2.0-1.

The HVAC systems are designed such that fire or smoke in the area containing safety-related equipment does not migrate through the ventilation ducts to the other areas containing safety-related equipment. Fire dampers are installed in the ductwork that penetrates fire-rated barriers and have the same fire-resistance rating as a fire barrier. Further information regarding fire dampers is provided in Section 9.5.

The zero percent exceedance values listed in Table 2.0-1 are applied to the safety-related HVAC systems and the one percent exceedance values are applied to non-safety-related HVAC systems. The five percent exceedance values are applied to the turbine generator building HVAC system.

APR1400 DCD TIER 1

Table 2.1-1 (1 of 3)

Site Parameters





Ground Water	
Maximum Elevation of Groundwater	0.61 m (2 feet) below plant grade ⁽¹⁾ in the vicinity of the SSCs important to safety
Flood (or Tsunami) Level	
Maximum Flood Elevation	0.3 m (1 foot) below plant grade in the vicinity of the SSCs important to safety
Precipitation	
Maximum Precipitation Rate [1 mi ²]	- 492.7 mm (19.4 in) over 1-hour - 157 mm (6.2 in) in 5 minutes
100-Year Snowpack Roof Load	- 2.873 kPa (60 lbf/ft ²)
Extreme Winter Precipitation Roof Load	- 5.985 kPa (125 lbf/ft ²)
Depth of 48-Hour Probable Maximum Winter Precipitation (PMWP)	- 914.4 mm (36 in)
Design Ambient Temperatures	
HVAC Outdoor Design Temperature - 5 % exceedance values · Maximum · Minimum	35 °C (95 °F) dry bulb and 25 °C (77 °F) coincident wet bulb -20.6 °C (-5 °F) ← dry bulb
- 1 % Exceedance Values · Maximum · Minimum	43.3 °C (100 °F) dry bulb and 25 °C (77 °F) coincident wet bulb -23.3 °C (-10 °F) ← dry bulb
- 0 % Exceedance Values (historical limit excluding peaks < 2 hours)	
· Maximum · Minimum	46.1 °C (115 °F) dry bulb and 26.7 °C (80 °F) coincident wet bulb -40.0 °C (-40 °F) ← dry bulb
Ambient Design Temperature for Cooling Tower - Ambient 5 % Exceedance Values for CWS · Maximum · Minimum	26.1 °C (79 °F) non-concurrent wet bulb -20.6 °C (-5 °F) ← dry bulb
- Ambient 0 % Exceedance Values for ESWS · Maximum · Minimum	27.2 °C (81 °F) non-concurrent wet bulb -40.0 °C (-40 °F) ← dry bulb
Extreme Wind	
50-Year 3-Second Wind Gust Speed	64.8 m/s (145 mph)
Importance Factors	1.15 ⁽²⁾

(historical limit excluding peaks < 2 hours)

APR1400 DCD TIER 2

Table 2.0-1 (1 of 4)

Site Parameters

Parameter Description	Parameter Value
Maximum Elevation of Groundwater	0.61 m (2 ft) below plant grade ⁽¹⁾ in the vicinity of the SSCs important to safety
Maximum Flood Elevation	0.30 m (1 ft) below plant grade in the vicinity of the SSCs important to safety
Precipitation - Maximum precipitation rate (1 mi ²) - 100-year snowpack roof load - Extreme winter precipitation roof load - Depth of 48-hour probable maximum winter precipitation (PMWP)	492.7 mm (19.4 in) over 1 hour 157 mm (6.2 in) in 5 minutes 2.873 kPa (60 lbf/ft ²) 5.985 kPa (125 lbf/ft ²) 914.4 mm (36 in)
HVAC Outdoor Design Temperature - 5 % exceedance values · Maximum · Minimum - 1 % exceedance values · Maximum · Minimum - 0 % exceedance values (historical limit excluding peaks < 2 hours) · Maximum · Minimum	35 °C (95 °F) dry bulb and 25 °C (77 °F) coincident wet bulb -20.6 °C (-5 °F)  dry bulb 43.3 °C (100 °F) dry bulb and 25 °C (77 °F) coincident wet bulb -23.3 °C (-10 °F)  dry bulb 46.1 °C (115 °F) dry bulb and 26.7 °C (80 °F) coincident wet bulb -40 °C (-40 °F)  dry bulb
Ambient Design Temperature for Cooling Tower - Ambient 5 % exceedance values for circulating water system (CWS) · Maximum · Minimum	.1 °C (79 °F) non-concurrent wet bulb -20.6 °C (-5 °F) 26.1 °C (79 °F) non-concurrent wet bulb -20.6 °C (-5 °F)  dry bulb 27.2 °C (81 °F) non-co dry bulb ulb

APR1400 DCD TIER 2

(historical limit excluding peaks < 2 hours)

Table 2.0-1 (2 of 4)

Parameter Description	Parameter Value
- Ambient 0 % exceedance values for essential service water system (ESWS) · Maximum · Minimum	-40.0 °C (-40 °F)
Extreme Wind - 50-year 3-second wind gust speed - Importance factor	64.8 m/s (145 mph) 1.15 ⁽²⁾
Tornado Parameters - Maximum horizontal wind speed - Translational speed - Rotational speed - Radius of maximum rotational speed - Maximum pressure differential - Rate of pressure drop - Missile spectra	102.8 m/s (230 mph) 20.6 m/s (46 mph) 82.2 m/s (184 mph) 45.7 m (150 ft) 8.274 kPa (1.2 psi) 3.447 kPa/s (0.5 psi/s) Table 2 (Region I) of NRC RG 1.76 (Reference 1)
Hurricane Parameters - Maximum 3-second wind gust speed - Missile spectra	116 m/s (260 mph) Table 1 of NRC RG 1.221 (Reference 2)
Accident Release χ/Q Values at exclusion area boundary (EAB) · 0-2 hr	$1.00 \times 10^{-3} \text{ s/m}^3$
Accident Release χ/Q Values at low-population zone (LPZ) · 0-8 hr · 8-24 hr · 24-96 hr · 96-720 hr	$2.20 \times 10^{-4} \text{ s/m}^3$ $1.60 \times 10^{-4} \text{ s/m}^3$ $1.00 \times 10^{-4} \text{ s/m}^3$ $8.00 \times 10^{-5} \text{ s/m}^3$
Annual Average χ/Q Values at Site Boundary · Undepleted/no decay · Undepleted/2.26-day decay · Depleted/8.00-day decay · Relative deposition factor (D/Q)	$2.00 \times 10^{-5} \text{ s/m}^3$ $1.99 \times 10^{-5} \text{ s/m}^3$ $1.84 \times 10^{-5} \text{ s/m}^3$ $2.00 \times 10^{-7} \text{ 1/m}^2$
Inventory of radionuclides that could seep into the groundwater	See Table 11.2-9
Safe Shutdown Earthquake (SSE)	0.3 g peak ground acceleration