

REQUEST FOR ADDITIONAL INFORMATION 343 2208 REVISION 0

4/23/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

SRP Section: 09.02.02 - Reactor Auxiliary Cooling Water Systems
Application Section: 9.2.7

QUESTIONS for Balance of Plant Branch 1 (AP1000/EPR Projects) (SBPA)

09.02.02-3

Based on a review of the information provided in Tier 2 of the Design Control Document (DCD), Section 9.2.7, "Chilled Water System," the staff found that the description of the essential chilled water system (ECWS) and non-essential chilled water system (non-ECWS) is generally incomplete and does not adequately explain how the applicable regulatory requirements and design bases are satisfied by the proposed design, what limiting assumptions apply, how much excess margin is available, what operating experience insights are relevant and how they were addressed, and so forth. Consequently, Tier 1 and Tier 2 of the Design Control Document (DCD) needs to be revised to include information that is sufficient to demonstrate that the chilled water systems meet all applicable regulatory requirements and are capable of performing its design-bases functions, that applicable design considerations are satisfied by the proposed design, and that reasonable assurance exists that the availability and design-bases capability will be maintained over the life of the plant. Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)," provides guidance on the specific information that should be included in the application for evaluation by the staff.

09.02.02-4

Standard Review Plan (SRP) Section 9.2.2, which is being utilized as guidance for the review of the chilled water system, specifies in Section III confirmation of the overall arrangement of the system. The staff noted that Tier 1 Design Control Document (DCD), Figure 2.7.3.5-1 (sheets 1 and 2) and Tier 2, DCD Figure 9.2.7-1 (sheets 1 and 2) have inaccurate and incomplete information related to safety-related to non-safety piping interfaces.

- Essential chilled water system equipment classification breaks were not found on the Tier 1 or Tier 2 system diagrams. This needs to be clarified in the DCD to the exact location of the safety-related to non-safety-related class break and seismic classifications. For example, the class breaks are shown at the support systems for the compression tank (water and nitrogen) and relief valve on top of the compression tank.
- Non-essential chilled water system diagrams in Tier 1 and Tier 2 are missing. All the system loads need to appear on the flow diagram. Equipment classification breaks are needed at the containment valves and penetrations.

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- For Tier 1, DCD Figure 2.7.3.5-1, there is a “3” inside the box at four locations; this needs to be explained.
- For Tier 1, DCD Figure 2.7.3.5-1, there is no cooling water flow shown for the chiller unit (four locations missing). There are no support systems shown for the compression tank.

09.02.02-5

The chilled water system must be able to withstand natural phenomena without the loss of function in accordance with General Design Criteria (GDC) 2 requirements. The staff noted that the system description in Design Control Document (DCD) Section 9.2.7 does not explain the functioning of safety-related boundary to non-safety-related boundary to ensure essential chilled water system integrity and operability during seismic events and other natural phenomena. Consequently, additional information needs to be included in DCD Section 9.2.7 to fully describe:

- How essential chilled water system integrity and operability is assured by the safety-related boundary isolation so that common-cause simultaneous failure of all non-safety-related chilled water system piping will not compromise the chilled water system safety functions during seismic events.
- Any other performance assumptions that pertain to the boundary isolation or other parts of the system that are necessary to assure the capability of the essential chilled water system to perform its safety functions during natural phenomena.
- That GDC 2 is satisfied.

09.02.02-6

Standard Review Plan (SRP) 9.2.2 Section III, which is being utilized as guidance for the review of the chilled water system, specifies in Section III confirmation of the overall arrangement of the system. The chilled water system description and flow diagrams in Tier 2, Design Control Document (DCD), Figure 9.2.7-1, were reviewed to assess the design adequacy of the chilled water system for performing its heat removal functions. While the flow diagrams show the essential chilled water system (ECWS) components, some of the information is incomplete, inaccurate, or inconsistent. Consequently, the applicant needs to revise the DCD to address the following considerations in this regard:

Note: Many of these items may also be applicable to the non-essential chilled water flow diagram when it is added to the DCD.

- Pipe sizes need to be shown on the Tier 2, DCD Figure 9.2.7-1, and the system description needs to explain the criteria that were used in establishing the appropriate pipe sizes (such as limiting flow velocities).
- The system description needs to provide design details such as system operating temperatures, pressures, and flow rates for all operating modes and alignments.

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- Tier 2, DCD Figure 9.2.7-1 needs to show where indications are displayed (e.g., local, remote panel, control room), and what instruments provide input to a process computer and/or have alarm and automatic actuation functions.
- Tier 2, DCD Figure 9.2.7-1 needs to show what the normal valve positions are, what valves are locked in position, and what valves have automatic functions. Also, these design features need to be described in the system description. For example, the valve downstream of the nitrogen supply is shown as normally closed.
- Tier 2, DCD Figure 9.2.7-1 needs to show specific set point for system alarms (including compression head tank) and relief. Also, the bases for these set points need to be explained in the system description.
- All isolation valves for taking components out of service for maintenance need to be shown on the Tier 2, DCD Figure 9.2.7-1.
- Describe in Section 9.2.7 why filters are not necessary in the design of the chilled water system.
- Non-essential chilled water system diagrams in Tier 1 and Tier 2 are missing and should include the containment penetration with isolation valves.
- Building location and/or building transitions need to be shown on the flow diagrams.
- The relief valve for the compression tank should be shown venting to a safety location since this is nitrogen. This also applies to the non-essential chilled water system.
- State in Tier 2, DCD Section 9.2.7 that GDC 4 and 44 are satisfied.
- Discuss in Tier 2, DCD Section 9.2.7 if any chemical are to be added to the chilled water system and if design features such as chemical addition tanks are needed.
- Discuss in Tier 2, DCD Section 9.2.7 the seismic source of makeup to the compression tank or the capacity in days if a seismic source for tank makeup is not available.
- Discuss in Tier 2, DCD Section 9.2.7 if environmental safe refrigerants are being utilized in the chilled water system chillers.
- Discuss in Tier 2, DCD Section 9.2.7 the non-safety related heating, ventilation, air conditioning (HVAC) systems in which the ECWS provides cooling.

09.02.02-7

The essential chilled water system (ECWS) must be capable of removing heat from structures, system and components (SSCs) important to safety during normal operating and accident conditions over the life of the plant in accordance with General Design Criteria (GDC) 44 requirements. In order for the staff to confirm that the ECWS has been adequately sized, the applicant needs to include additional information in Tier 2 of the Design Control Document (DCD), Section 9.2.7, to fully describe and explain what the minimum system heat transfer and flow requirements are for normal operating, refueling, and accident conditions, the bases for these requirements including limiting assumptions that apply (such as temperature considerations), how much excess margin is available and how this was determined, and what limiting system temperatures and pressures are assumed with supporting basis.

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09.02.02-8

General Design Criteria (GDC) 44 requires the transfer of heat from systems, structures and components (SSC) important to safety to a heat sink during both normal and accident conditions assuming a single active component failure coincident with the loss of offsite power. The Design Control Document (DCD) indicates that the essential chilled water system (ECWS) chillers are rated at 3.6×10^6 Btu/hr (300 tons) but does not provide a basis for these capacities. Provide information in Tier 2, DCD Section 9.2.7 on the major heat loads in the various ECWS divisions for which the chillers have been sized. Information should include both normal operations and postulated accident conditions.

09.02.02-9

General Design Criteria (GDC) 44 requires the essential chilled water system (ECWS) must be capable of removing heat from structures, system and components (SSCs) important to safety during normal operation. The system description (Tier 2, Design Control Document (DCD) Section 9.2.7.2.) indicates that the ECWS consists of four independent trains and each train consists of one 50% capacity system. However, the staff has determined that fluctuation in the supplied electrical frequency, increased pipe roughness due to aging and fouling, and maximum pressure drop through the system heat exchangers, the actual amount of excess margin that is provided by the ECWS pump design and the basis for this determination was not explained. The information should be provided in the Tier 2, DCD Section 9.2.7.

09.02.02-10

The essential chilled water system (ECWS) must be capable of removing heat from structures, systems and components (SSCs) important to safety during normal operating and accident conditions over the life of the plant in accordance with General Design Criteria (GDC) 44 requirements. In order to satisfy system flow requirements, the ECWS design must assure that the required minimum net positive suction head (NPSH) for the ECWS pumps will be met for all postulated conditions, including consideration of vortex formation. The staff found that the minimum required NPSH for the ECWS pumps was not specified in the DCD. Also, the staff found that Tier 2, Design Control Document (DCD) Section 9.2.7 did not describe how the ECWS design will assure that the minimum required NPSH for the ECWS pumps is satisfied (including consideration of vortex formation) and how much excess margin is provided by the ECWS design for the most limiting assumptions. Consequently, the applicant needs to provide additional information in Tier 2, DCD Section 9.2.7 to specify the minimum required net positive suction head (NPSH) is for the ECWS pumps and to fully explain how this required minimum NPSH is satisfied by the system design when taking vortex formation into consideration, and how much excess margin is available for the most limiting case. Sufficient information is needed to enable the staff to independently confirm that the design is adequate in this regard, including limiting assumptions that were used along with supporting justification.

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09.02.02-11

The essential safety chilled water system (ECWS) must be capable of removing heat from structures, systems and components (SSCs) important to safety during normal operating and accident conditions over the life of the plant in accordance with General Design Criteria (GDC) 44 requirements. Based on Tier 2, Design Control Document (DCD), Section 9.2.7 a compression tank is utilized with a nitrogen fill connection with relief valve protection for each division. Piping voids are precluded by the constant pressure from the divisionalized nitrogen-charged compression tank; however, in the DCD, there is no detailed description of water hammer consideration in the design. Discuss in DCD Section 9.2.7 the design features of the ECWS which minimize water hammer. Section 9.2.7 should discuss if there are protective features to the chilled water pumps, such as pump trips, automatic start permissives (due to emergency core cooling system actuation), or pump lockouts, based on low pressure for the compression tanks.

09.02.02-12

The essential chilled water system (ECWS) must be capable of removing heat from structures, systems and components (SSCs) important to safety during normal operating and accident conditions over the life of the plant in accordance with General Design Criteria (GDC) 44 requirements. Under seismic or post-accident conditions where the demineralized water system (DWS) or the primary make-up system (PWS) water may be unavailable for ECWS makeup, the compression tanks should contain sufficient water volume to assure reliable system operation without makeup for at least seven days (see SRP 9.2.2, section III.3.C). Makeup water to the compression tank is shown in Tier 2, DCD Figure 9.2.7-1; however, Tier 2, DCD Section 9.2.7 does not discuss compression tank capabilities in the event of a makeup source interruption.

- Describe in Section 9.2.7 the sources of water makeup to the compression tanks.
- Describe in Section 9.2.7 the most limiting system leak rate that is assumed during normal operating and accident conditions, the bases for these assumptions, and how many days of operation the expansion tank is sized for should the makeup source be unavailable.
- Describe in Section 9.2.7 how are these lines are treated with regard to compression tank capabilities, and how are nitrogen relief valves routed to safe areas for discharge.

09.02.02-13

The essential chilled water system (ECWS) must be capable of removing heat from structures, systems and components (SSCs) important to safety during normal operating and accident conditions over the life of the plant in accordance with General Design Criteria (GDC) 44 requirements. The Design Control Document (DCD) does not adequately describe the various operating modes and operator actions that are required and how the ECWS control system functions. These considerations need to be fully described in Tier 2, DCD Tier 2 Section 9.2.7, including (for example):

- Schematics showing all circuit process components with associated signal inputs and control signal outputs. This should include the temperature controls

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for control valves at each air handling unit and nitrogen control valve and associated level alarms to the compression tank.

- Failure positions for the flow control valves.
- Operations of the thirty-four 3-way temperature control valves are not described in detail of their control functions in Tier 2, DCD Section 9.2.7.
- Instrumentation and controls (I&C) related to ECWS automatic operation such as pump and chiller starts signals, trip signals, lock-outs, and permissives. This should include loss of offsite power (LOOP) signals and emergency core cooling system (ECCS) actuation signals.
- Discuss all operator controls and instruments in Tier 2, DCD Section 9.2.7 that are available in the main control room and remote shutdown panel. (Tier 1, DCD Table 2.7.3.5-4 data should be included in Tier 2, DCD Section 9.2.7).

09.02.02-14

The essential chilled water system (ECWS) must be capable of removing heat from SSCs important to safety during normal operating and accident conditions over the life of the plant in accordance with General Design Criteria (GDC 44) requirements. Also, 10 CFR 52.47(a)(22) requires that information demonstrating how operating experience insights have been incorporated into the plant design be included in the Design Control Document (DCD). During a recent review of industry operating experience, the staff found that some licensees were experiencing significant wall thinning of pipe downstream of butterfly valves that were being used to throttle service water flow. In order to assure that this will not occur in the ECWS for the US Advanced Pressurized-Water Reactor (US-APWR) design, the applicant needs to provide additional information in Tier 2, DCD Section 9.2.7 to describe to what extent butterfly valves may be used to throttle ECWS flow and design provisions that will be implemented to prevent consequential pipe wall thinning from occurring.

09.02.02-15

The essential chilled water system (ECWS) and non-essential chilled water system (non-ECWS) must be designed so that periodic inspections of piping and components can be performed to assure that the integrity and capability of the system will be maintained over time in accordance with General Design Criteria (GDC 45) requirements. The staff finds the design to be acceptable if the Design Control Document (DCD) describes inspection program requirements that will be implemented and are considered to be adequate for this purpose. While Tier 2, DCD Section 9.2.7.4 indicates that periodic inspections will be performed, the extent and nature of these inspections and procedural controls that will be implemented to assure that the ECWS is adequately maintained over time were not described. Consequently, the applicant needs to provide additional information in the DCD to describe the extent and nature of inspections that will be performed and procedural controls that will be implemented commensurate with this requirement. Also, state that GDC 45 is satisfied in Tier 2, DCD Section 9.2.7.

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09.02.02-16

The essential chilled water system (ECWS) and non-essential chilled water system (non-ECWS) must be designed so that periodic pressure and functional testing of components can be performed in accordance with General Design Criteria (GDC) 46 requirements to assure the structural and leak tight integrity of system components, the operability and performance of active components, and the operability of the system as a whole and performance of the full operational sequences that are necessary for accomplishing the ECWS safety functions. The staff finds the design to be acceptable if the Design Control Document (DCD) describes pressure and functional test program requirements that will be implemented and are considered to be adequate for this purpose. While Tier 2, FSAR Section 9.2.7.4 indicates that periodic testing will be performed, the extent and nature of these tests and procedural controls that will be implemented to assure continued chilled water system structural and leak tight integrity and system operability over time were not described. Consequently, the applicant needs to provide additional information in the DCD to describe the extent and nature of testing that will be performed and procedural controls that will be implemented commensurate with this requirement. Also, state that GDC 46 is satisfied in Tier 2, DCD Section 9.2.7.

09.02.02-17

Means must be provided for monitoring effluent discharge paths and the plant environs for radioactivity that may be released in accordance with General Design Criteria GDC 64 requirements. Also, 10 CFR 52.47(a)(6) and 10 CFR 20.1406 require applicants for standard plant design certifications to describe how facility design and procedures for operation will minimize contamination of the facility and the environment. The staff's review criteria (Standard Review Plan Section 9.2.1, Paragraph III.3.D) specify that provisions should be provided to detect and control leakage of radioactive contamination into and out of the essential service water system (ESWS) which is the heat sink for the essential chilled water system (ECWS). The design is considered to be acceptable by the staff if the ECWS flow diagrams show that radiation monitors are located at components that are susceptible to leakage, and if the components that are susceptible to leakage can be isolated. However, the staff noted that Tier 2, Design Control Document (DCD) Section 9.2.7 and the ECWS flow diagrams do not include radiation monitors in the system design and the NRC regulations in this regard have not been addressed. Additional information needs to be provided in DCD, Tier 2 Section 9.2.7 to address the NRC requirements referred to above.

09.02.02-18

Standard Review Plan (SRP) Section 9.2.2, which is being utilized as guidance for review of the essential chilled water system (ECWS), specifies in Section III confirmation of the overall arrangement of the component cooling system (CCWS). 10CFR52.47(a)(2), contents of applications; technical information states that, "The description shall be sufficient to permit understanding of the system designs and their relationship to the safety evaluations." Technical Specification (TS) Bases (B3.7.10) states, "Two trains of MCRATCS (main control room air temperature control system) will provide the required temperature control to maintain the control room between 73°F and 78°F." This is one example of important design bases information, such as the

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MCRATCS/ECWS system, which is missing from Tier 2, Design Control Document (DCD), Section 9.2.7. The design bases (room and area temperature limits) for all the safety related area should be listed in Tier 2, DCD Section 9.2.7.

The US-APWR DCD states that the identification of the structures, systems and components, and parameters for which Limiting Conditions for Operation (LCOs) have been included in the US-APWR Technical Specification was based on the screening criteria of 10 CFR 50.36 (d)(2)(ii). Discuss application of the screening criteria to the component cooling system (CCWS), and justify why the CCWS did not meet the criteria for inclusion as an LCO.

09.02.02-19

Standard Review Plan (SRP) 9.2.2, which is being utilized as guidance for the review of the essential chilled water system (ECWS), Section III specifies review procedures to confirm the overall arrangement of the component cooling system (CCWS). SRP 14.3, Appendix C, Item 1B.ix states that Tier 1 figures for safety-related system should include most of the valves on the Design Control Document (DCD) Tier 2 drawings. The staff found that the Tier 1 and Tier 2 information is incomplete, inconsistent, inaccurate, or that clarification is needed and requests the applicant to revise the information in DCD, Tier 1 Section 2.7.3.5 and applicable Tier 2 Sections (as appropriate) to address the following considerations in this regard:

- Although the Introduction Section in Chapter 1 (page 1-2) of the Tier 1 DCD states that, "Information contained in the Tier 1 document was derived from the Tier 2 document," the staff found that much of the information provided in DCD Tier 1 is not described in Tier 2 DCD Section 9.2.7 (e.g., active safety function, loss of motive power position, harsh environment considerations, MCR alarm and display, control function, and RCS display). This information needs to be added to Tier 2.
- The specifications need to stipulate that the ECWS is accessible for performing periodic inspections as required by GDC 45.
- Figure 2.7.3.5-1, "Essential Chilled Water System," needs to show nominal pipe sizes, which are necessary for design certification.
- Figure 2.7.3.5-1 needs to show the safety related class break at the compression tank for the water fill, relief valve and nitrogen system.
- Figure 2.7.3.5-1 needs to show essential service water cooling the chiller.
- Figure 2.7.3.5-1 shows a "3" with a box in at four locations; provide clarification.
- Figure 2.7.3.5-1 needs to show system check valves.
- Table 2.7.3.5-2, "Essential Chilled Water System Equipment Characteristics," indicates dashes (-/-) for the essential chiller water compression tanks, under class 1E and harsh envirn; provide clarification.
- Table 2.7.3.5-2 needs to show power classification (IEEE class) for each component.
- Table 2.7.3.5-2 needs to show compression tank relief valve. Verify all required valves have been listed.
- Table 2.7.3.5-1, "Essential Chilled Water System Location of Equipment," needs to show location of all system components which includes all valves.

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- Table 2.7.3.5-4, “Essential Chilled Water System Equipment Displays and Control Functions,” needs to indicate the chilled water pumps have main control room alarms.

09.02.02-20

Standard Review Plan (SRP) Section 9.2.2, which is being utilized as guidance for the review of the essential chilled water system (ECWS), Section III specifies review procedures to confirm the overall arrangement of the component cooling system (CCWS). The staff found that the proposed inspections, tests, analyses, and acceptance criteria (ITAAC) in Design Control Document (DCD) Tier 1, Section 2.7.3, Table 2.7.3.5-5, are incomplete, inconsistent, inaccurate, or that clarification is needed. Consequently, the Tier 1 information needs to be revised to address the following:

- Item 1a only refers to functional arrangement, but it should refer to functional arrangement and design details since nominal pipe size is an important consideration that needs to be verified.
- Need to specify that ECWS pump testing to demonstrate adequate net positive suction head will be completed at the lowest allowed compression tank level. The acceptance criteria for an acceptable test need to be specified.
- Quantitative acceptance criteria need to be established for all ITAAC as applicable (flow rates, heat transfer rates, completion times, etc.).
- Need to provide a test item to demonstrate that water hammer will not occur in the as built system upon manual or automatic start of a previously idle train, and during loss-of-power scenarios.
- Need to provide a test item for nitrogen makeup and relief valve to the compression tank.
- Need to provide a test item for casing of the chiller refrigerant compressor and the chilled water pumps to withstand penetration from internally generated missiles (from Tier 2, DCD Section 9.2.7.3.1).
- Need to provide a test item to maintain compression tank in its required pressure and level band.
- Need to provide a test item related to the system maintaining chilled water supply temperature within band.
- Need to provide a test item for the testing of chiller alarms and malfunctions.
- Need to describe in detail operations of the thirty-four 3-way temperature control valves control functions.
- Need to provide an inspection item for verification of equipment by location; that is valves, pumps, chillers, etc.
- Need to provide a test item for testing of system check valves.

09.02.02-21

Standard Review Plan (SRP) 9.2.2, which is being utilized as guidance for the review of the non-essential chilled water system (non-ECWS), Section III specifies review procedures to confirm the overall arrangement of the component cooling system (CCWS). Section 10CFR52.47(a)(2), contents of applications; technical information

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states that, “The description shall be sufficient to permit understanding of the system designs and their relationship to the safety evaluations.” The staff found that the Tier 1 and Tier 2 information is incomplete, inconsistent, inaccurate, or that clarification is needed and requests the applicant to revise the information in Design Control Document (DCD), Tier 1 Section 2.7.3.6 and applicable Tier 2 Sections (as appropriate) to address the following considerations in this regard:

- A functional arrangement drawing needs to be provided in Tier 1 for the non-essential chilled water system. Without this drawing, the as-built cannot be performed.
- Locations of components need to be listed in a Tier 1 table.
- Describe any design features in Tier 1 and Tier 2 of the DCD that will trip the non-essential chilled water system chillers or pumps if the containment isolation valves are closed on an actuation signal from the protection and safety monitoring system (PSMS).