# DESIGN CONTROL DOCUMENT FOR THE US-APWR

# Chapter 17
# Quality Assurance and Reliability Assurance

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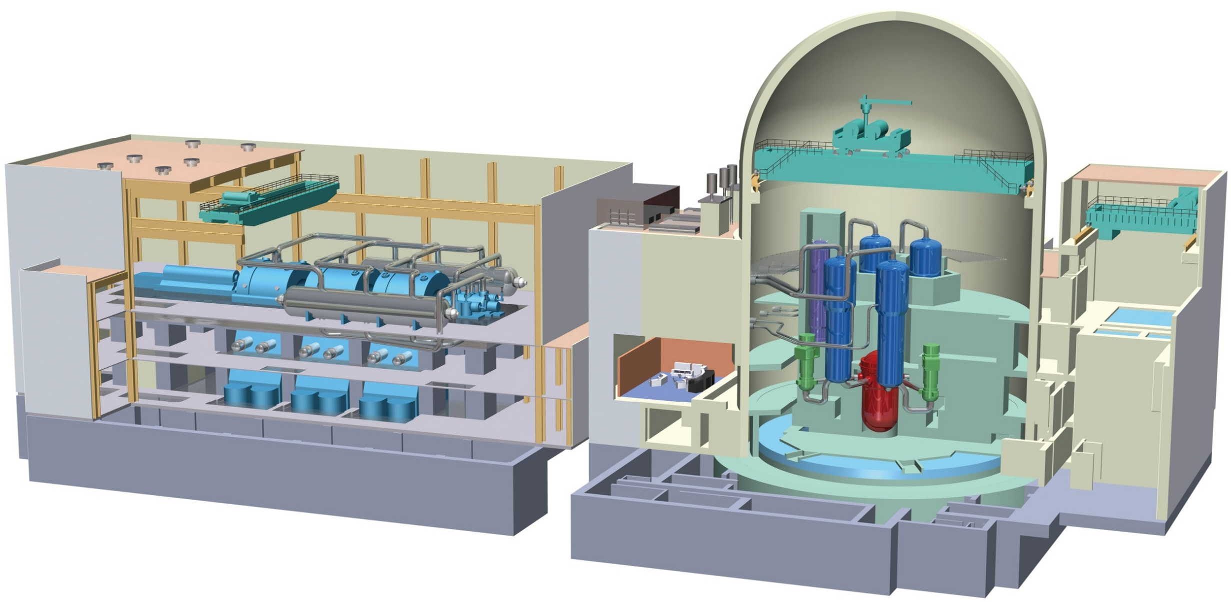

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AAC | alternative AC |
| ac | alternating current |
| CAP | corrective action program |
| CCF | common cause failure |
| CCW | component cooling water |
| CCWS | component cooling water system |
| CDF | core damage frequency |
| CFR | Code of Federal Regulations |
| COL | Combined License |
| COLA | Combined License Application |
| CS | containment spray |
| CSS | containment spray system |
| CVCS | chemical volume control system |
| DAS | diverse actuation system |
| dc | direct current |
| DCD | Design Control Document |
| D-RAP | design reliability assurance program |
| DVI | direct vessel injection |
| ECCS | emergency core cooling system |
| EFW | emergency feedwater |
| EFWP | emergency feedwater pit |
| EFWS | emergency feedwater system |
| EJ | engineering judge |
| EP | expert panel |
| EPS | emergency power source |
| ESF | engineered safety features |
| ESW | essential service water |
| ESWS | essential service water system |
| FIRE | FIRE event |
| FLOOD | FLOOD event |
| FSS | fire suppression systems |
| FV | Fussell Vesely |
| FVW | Fussell Vesely worth |
| HSIS | human-system interface system |
| HVAC | heating, ventilation, and air conditioning |

## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| I&C | instrumentation and control |
| ITAAC | inspection, test, analyses, and acceptance criteria |
| kV | kilovolt |
| LOCA | loss-of-coolant accident |
| LOOP | loss of offsite power |
| LPSD | low power and shut down operation |
| M/D | motor driven |
| MCC | motor control center |
| MFWS | main feedwater system |
| MHI | Mitsubishi Heavy Industries, Ltd. |
| MOV | motor operated valve |
| MSS | main steam supply system |
| NESH | Nuclear Energy Systems Headquarters |
| NRC | U.S. Nuclear Regulatory Commission |
| O-RAP | operational reliability assurance program |
| PAM | postaccident monitoring |
| PCMS | plant control and monitoring system |
| PRA | probabilistic risk assessment |
| QA | quality assurance |
| QAP | quality assurance program |
| QAPD | quality assurance program description |
| RAP | reliability assurance program |
| RAW | risk achievement worth |
| RCP | reactor coolant pump |
| RCS | reactor coolant system |
| RG | Regulatory Guide |
| RHR | residual heat removal |
| RHRS | residual heat removal system |
| RPS | reactor protection system |
| RRW | risk reduction worth |
| RTNSS | regulatory treatment of non-safety-related systems |
| RWAT | refueling water auxiliary tank |
| RWS | refueling water storage |
| RWSP | refueling water storage pit |
| RWSS | refueling water storage system |

## ACRONYMS AND ABBREVIATIONS (Continued)

| | |
|---|---|
| SBO | station blackout |
| SDV | safety depressurization valve |
| SFP | spent fuel pit |
| SFPCS | spent fuel pit cooling and purification system |
| SG | steam generator |
| SGTR | steam generator tube rupture |
| SIS | safety injection system |
| SRP | Standard Review Plan |
| SSC | structure, system, and component |
| T/D | turbine driven |
| VCT | volume control tank |
| VWS | chilled water system |
| WMS | waste management system |

## 17.0 QUALITY ASSURANCE AND RELIABILITY ASSURANCE

The Quality Assurance Program as described in Sections 17.1, 17.2, 17.3 and 17.5 of this chapter of DCD is applicable for Quality Assurance (QA) during the Design Certification phase for US-APWR standard plant design activities.

### 17.1 Quality Assurance During the Design Phase

For quality assurance during the Design Certification phase for US-APWR standard plant design activities, see Section 17.5.

The Combined License (COL) Applicant is responsible for the development of a Quality Assurance Program applicable to site-specific design activities.

## 17.2 Quality Assurance During the Construction and Operation Phases

The COL Applicant is responsible for development of the construction and operational phase Quality Assurance Program.

## 17.3 Quality Assurance Program

The General Manager of Nuclear Energy Systems Headquarters (NESH) is responsible for the Design Certification Activities of US-APWR. The design activities performed by the Nuclear Energy Systems Engineering Center for the US-APWR standard plant design are subjected to the QA Program controls specified in "Quality Assurance Program (QAP) Description For Design Certification of the US-APWR (PQD-HD-19005 Rev.1)" (Ref 17.5.5-4).

Subcontractors of the Nuclear Energy Systems Engineering Center performing design activities in support of the US-APWR are also required to follow QAPD (PQD-HD-19005 Rev.1).

For the Quality Assurance Program Description during the Design Certification phase for the US-APWR standard plant design, see Section 17.5.

The COL applicant is responsible for the development of a Quality Assurance Program Description applicable to site-specific design activities and for plant construction and operation phases.

## 17.4 Reliability Assurance Program

This section presents the US-APWR reliability assurance program (RAP).

### 17.4.1 New Section 17.4 in the Standard Review Plan

As noted in Item E of SECY 95-132 (Ref. 17.4-1), an applicant for design certification should establish the scope, purpose, objective, and essential elements of an effective D-RAP and would implement those portions of the D-RAP that apply to design certification. A COL Applicant is responsible for augmenting and completing the remainder of the D-RAP to include any site-specific design information and identify the risk-significant SSCs. Once the site-specific D-RAP is established and the risk-significant SSCs are identified, the procurement, fabrication, construction, and preoperational testing can be implemented in accordance with the COL holder's D-RAP or other programs and would be verified using the inspections, test, analyses and acceptance criteria (ITAAC) process.

### 17.4.2 Introduction

The purposes of the US-APWR RAP are to provide reasonable assurance that: 1) the US-APWR is designed, constructed, and operated in a manner that is consistent with the assumptions and risk insights for the SSCs, 2) the SSCs do not degrade to an unacceptable level during plant operations, 3) the frequency of transients that challenge SSCs is minimized, and 4) the SSCs function reliably when challenged. An additional goal is to facilitate communication between the probabilistic risk assessment (PRA), the design, and the ultimate COL activity.

The PRA evaluates the US-APWR design response to a spectrum of initiating events to ensure that plant damage has a very low probability and that risk to the public is minimized. Risk significant SSCs for the US-APWR design control document (DCD) are identified and made available to the design organization.

The US-APWR D-RAP process is implemented in several phases. Phase I, the Design Certification phase, collects system information and develops a system model. This system information and model is used as input to the design phase PRA, an operating experience review, and a review for external events. The goal of the RAP during this stage is to ensure that the reactor design meets the purposes above, through the design, procurement, fabrication, construction and preoperational testing activities and programs. The results of each of these activities are provided to an expert panel (EP) which identifies risk significant items using probabilistic, deterministic, and other methods for inclusion in the program. Phase II, the site-specific phase, introduces the plant's site-specific information to the D-RAP process. During Phase II, the site-specific SSCs are combined with the US-APWR design SSCs into a list for the specific plant. Phase III, the last phase of the D-RAP, implements the procurement, fabrication, construction, and preoperational testing. The site-specific list of SSCs is also provided as an input to the operational phase of RAP (O-RAP) which addresses the specific plant operation and maintenance activities. The designer, MHI, is responsible for Phase I of the D-RAP. The objective during this stage is to ensure that the reliability for the SSCs within the scope of the RAP is maintained during plant operations. Phases II and III of the D-RAP and the O-RAP are the responsibility of the COL Applicant. The COL Applicant will specify the policy and implement procedures to address the specific plant operation and maintenance activities associated with the risk-significant SSCs identified by the D-RAP.

### 17.4.3 Scope

The US-APWR D-RAP identifies risk-significant SSCs and provides risk insights and reliability assumptions for aspects of plant operation, maintenance, and performance monitoring to be addressed to ensure safe, reliable plant operation or mitigate plant transients or other events that could present a risk to the public. The risk-significant SSCs are identified using PRA, deterministic, or other methods of analysis, including industry experience, and EPs.

### 17.4.4 Quality Controls

**a. Organization**

The MHI is responsible for Phase I of the D-RAP.

General Manager, US-APWR project: The General Manager, US-APWR project is overall responsible for the establishment of and implementation of the US-APWR D-RAP. In this regard, the General Manager or his designated representative is responsible to assure all affected organizations are aware of the D-RAP, its purpose, and the requirements herein.

General Manager, Reactor and Plant Safety: The General Manager, Reactor and Plant Safety, is responsible for the use of the PRA results and risk insights for the EP and for the conduct and coordination of the EP. The Reactor and Plant Safety organization includes the risk and reliability organization.

General Manager, QA: The General Manager, QA is responsible to assure proper implementation of QA program elements. This includes design control, procedures and instructions, records, corrective actions and audits pertaining to the D-RAP.

General Managers, Design Engineering: The General Managers, Design Engineering, are responsible to implement this D-RAP and specifically to assure that the US-APWR is designed consistent with the reliability assumptions and insights of the PRA for risk-significant SSCs.

The risk and reliability organization is responsible to ask the related design engineering sections to review key assumptions and to feed back their comments to ensure key assumptions are realistic and achievable.

The risk and reliability organization is responsible to provide the RAP related inputs in the design process by participating in the design change process.

The risk and reliability organization is also responsible to involve in the design review.

**b. Design Control**

The list of risk-significant SSCs for the D-RAP and its key assumptions shall be maintained by the risk and reliability organization. The list and changes thereof shall be approved by the EP and be provided to design engineering and QA staff working on the US-APWR project.

The risk and reliability organization shall ensure that the design engineers are provided the list of risk-significant SSCs for the D-RAP and its key assumption. The design engineers shall take into account the list of the risk-significant SSCs for the D-RAP and its key assumptions in their design activities and give some feedback to the risk and reliability organization in order to ensure that the key assumptions are realistic and achievable, if necessary.

**c. Procedures and Instructions**

General Manager, US-APWR project or his designated representative has prepared the procedures and instructions used in implementation of the D-RAP. General Manager, US-APWR project is responsible for development and verification of implementation of the D-RAP, and for assuring all affected MHI organizations are aware of the D-RAP.

**d. Records**

Records related to the D-RAP which are required to be maintained include the following:

- List of Risk-Significant SSCs
- EP meeting minutes/summaries
- Other quality assurance program records in accordance with the US-APWR QAPD for design certification.

**e. Corrective action**

Deficiencies identified where design documents address SSC reliability assumptions which are not compatible with the reliability assumptions of the PRA, or are not achievable or are unrealistic shall be entered into the corrective action program (CAP) system and addressed appropriately. The CAP utilized to support the QAPD can be used to implement the corrective actions related to the RAP.

**f. Audit**

Audit plans shall include for consideration, sampling the effectiveness of implementation of RAP implementation procedure. Audits shall consider several key aspects of the RAP including the identification of risk-significant SSCs, whether design and procurement information is consistent with the risk insights from the PRA, and whether assumed equipment reliability is determined to be practicable or achievable.

### 17.4.5 Integration into Existing Operational Programs

The US-APWR D-RAP is a source to other administrative and operational programs. Certain risk-significant SSCs identified in the D-RAP are included in existing operational programs such as the technical specifications surveillance requirements and provide assurance that the reliability values assumed in the PRA will be maintained throughout the plant life. The O-RAP implements the measures that yield the significant improvements in the PRA through the plant's existing programs for maintenance or QA. Implementation of the Maintenance Rule requirements contained in 10CFR50.65 (Ref. 17.4-2) is an example of how the plant could address the enhanced treatment of certain SSCs in the O-RAP. Per SECY 95-132, the COL Applicant may meet most of the objectives of the O-RAP via existing programs such as maintenance rule, in-service testing, and QA. The COL Applicant must address non-safety risk significant SSCs.

### 17.4.6 Operating Experience

Consideration and use of operating experience is vital to the overall objective of the D-RAP. Operating experience is considered along with various PRA analytical and importance measures when developing a comprehensive risk analysis. The EP considers component operating history and industry operating experience when it can be applied to assessing risk significance. For example, operating experience indicates that motor driven and turbine driven pumps may have different reliability.

The review of operating experience investigates situations where previous failures of components in similar design applications have led to functional failures of SSCs. The review of operating experiences is not limited to hardware failure but also extends to situations where human performance led to functional failures of SSCs of a similar system design. As an example, the US-APWR design improves reliability and eliminates required operator actions to switch over from injection to recirculation typical in conventional PWRs.

### 17.4.7 D-RAP

As discussed in Section 17.4.2, Phase I of the D-RAP includes the initial identification of SSCs to be included in the program, implementation of the aspects applicable to design efforts, and definition of the scope, requirements, and implementation options to be included in the later phases.

#### 17.4.7.1 SSCs Identification

During the US-APWR design phase, risk significant SSCs are identified for inclusion in the scope of the D-RAP. A list of risk significant SSCs is developed and controlled as a design input for consideration during the design phase. The list of risk significant SSCs is initially based on the results of the PRA and the EP. For further discussion on PRA, refer to Chapter 19, Section 19.1, of this DCD. The PRA is used to identify risk significant SSCs based on risk achievement worth (RAW) and Fussell-Vesely Worth (FVW). For further information, see Chapter 19, Section 19.1.7.4 of this DCD. The list of risk significant SSCs identified during the design phase is updated when the plant-specific PRA is developed. In addition to the PRA input, information from operating experience of Japanese design plants, as well as US industry experience is considered for identification of risk significant SSCs. A third source in the D-RAP process for identifying risk significant SSCs is the use of an EP consisting of representatives from Design Engineering, PRA, as well as other highly qualified individuals with operations, and maintenance experience who are independent of the PRA Section. As part of the

D-RAP process, the PRA analytical results, operating experience, and an EP process are combined to develop a comprehensive list of risk significant SSCs.

#### 17.4.7.2 Expert Panel

An EP, consisting of highly qualified representatives of Reliability and PRA Engineering, as well as representatives independent of the PRA process from Design and Plant Engineering is responsible for the final selection of the SSCs included in the D-RAP. Industry operating experience when it can be applied to assessing risk significance, and engineering judgment are employed in considering the addition of SSCs to the D-RAP. Each voting member of the RAP EP should have the level of education and experience defined by the RAP implementing procedure.

#### 17.4.7.3 Phase I D-RAP Implementation and SSCs included

The implementation of the Phase I D-RAP is the responsibility of MHI as it applies to the reactor design process. The SSCs included in this phase are listed in Table 17.4-1.

**Table 17.4-1 Risk significant SSCs (sheet 1 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale(1) | Insights and Assumptions |
|---|---|---|---|
| 1 | Accumulator injection system | | |
| 1 | Discharge line secondary isolation check valves train A through D [VLV-102A (B,C,D)] | RAW/CCF | The accumulator provides safety injection function for refill and re-flooding of the reactor vessel following a loss of coolant accident (LOCA). Also provides negative reactivity to shutdown the reactor.<br><br>Single failure of any SSCs listed here has potential to cause failure of its dedicated train to inject coolant to RCS. |
| 2 | Boundary check valves train A through D (Discharge line) [VLV-103A (B,C,D)] | RAW/CCF | |
| 3 | Discharge line isolation motor operated valves train A through D [VLV-101A (B,C,D)] | RAW | |
| 4 | Discharge line orifices train A through D [R006A (B,C,D)] | RAW | |
| 5 | Piping of discharge lines train A through D [TBD] | RAW | |
| 6 | A～D-Accumulators [SIS-CTK-001A (B,C,D)] | EJ | |

**Table 17.4-1 Risk significant SSCs (sheet 2 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale(1) | Insights and Assumptions |
|---|---|---|---|
| 2 | Charging injection system | | |
| 1 | Charging line air operated valves<br>[AOV-146]<br>[FCV-138]<br>[AOV-159] | RAW/LPSD | The chemical volume control system (CVCS) maintains appropriate volume and quality of reactor coolant for the primary reactor coolant system, adjusts boron concentration for the chemical shim control, and supplies seal water to the reactor coolant pump seals, and disposes borated water discharged from the primary reactor coolant system.<br><br>RCP seal water injection provided by the CVCS is an essential function to prevent RCP seal LOCA under loss of CCW conditions. When loss of CCW occurs, either the fire suppression system or the non-essential chilled water system is connected to the charging pump cooling line. Thus, the RCP seal water injection is maintained under loss of CCW conditions.<br><br>Since CVCS is not completely separated in trains, large external leak from SSCs that result in loss of inventory is assumed to result in degradation or failure of the system. Accordingly, SSCs that has the potential of large leak are risk significant.<br><br>SSCs that have potential to cause common cause failures among multiple trains are also important. Such common cause failure results in loss of redundant SSCs. |
| 2 | RCP seal cooling injection line air operated valves<br>[FCV-140]<br>[AOV-165] | RAW | |
| 3 | Auxiliary spray injection line air operated valve<br>[AOV-155] | RAW/LPSD | |
| 4 | A,B-Charging pumps<br>[CVS-RPP-001A (B)] | RAW/CCF/LPSD | |
| 5 | Volume control tank discharge line check valve<br>[VLV-125] | RAW/LPSD | |
| 6 | Volume control tank discharge line motor operated valves<br>[LCV-121B]<br>[LCV-121C] | RAW/LPSD | |
| 7 | RWS refueling water auxiliary tank discharge line check valve<br>[VLV-595] | RAW/LPSD | |
| 8 | RWS refueling water auxiliary tank discharge line manual valve<br>[VLV-591] | RAW/LPSD | |

**Table 17.4-1 Risk significant SSCs (sheet 3 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale(1) | Insights and Assumptions |
|---|---|---|---|
| 9 | Charging pump minimum flow line check valves [VLV-129A (B)] | RAW/LPSD | During low power and shutdown operation, CVCS provides RCS make up function. On low VCT level, suction is switched from the VCT to the refueling water auxiliary tank, which is supplied by the refueling water storage pit.<br><br>Low-pressure letdown line isolation valves are automatically closed and the CVCS is isolated from the RHRS with receiving the RCS loop low-level signal to prevent loss of RCS inventory at mid-loop operation. When these valves are not closed, loss of a RCS inventory is prevented by manually closing the air-operated valve at the downstream of these valves. |
| 10 | Charging pump discharge line check valves [VLV-131A (B)] | RAW/LPSD | |
| 11 | Charging line containment isolation check valve [VLV-153] | RAW/LPSD | |
| 12 | Charging line isolation check valve [VLV-160] | RAW/LPSD | |
| 13 | Charging line boundary isolation check valve [VLV-161] | RAW/LPSD | |
| 14 | RCP seal water injection line boundary isolation check valves [VLV-182A (B,C,D)] | RAW | |
| 15 | RCP seal water injection line secondary isolation check valves [VLV-181A (B,C,D)] | RAW | |
| 16 | RCP seal water injection line third isolation check valves [VLV-179A (B,C,D)] | RAW | |
| 17 | Charging line containment isolation motor operated valve [MOV-152] | RAW/LPSD | |

**Table 17.4-1 Risk significant SSCs (sheet 4 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale[(1)] | Insights and Assumptions |
|---|---|---|---|
| 18 | Charging line containment isolation motor operated valve [MOV-151] | RAW/LPSD | The "Insights and Assumptions" for these SSCs are described on the previous page. |
| 19 | RCP seal water injection line containment isolation motor operated valves [MOV-178A (B,C,D)] | RAW | |
| 20 | Charging line orifice [FE-138] | RAW/LPSD | |
| 21 | Charging flow control orifice [TBD] | RAW/LPSD | |
| 22 | RCP seal water injection line orifices [FE-160A (B,C,D)] | RAW | |
| 23 | Regenerative heat exchanger [CHX-001] | RAW/LPSD | |
| 24 | Charging pump minimum flow line manual valves [VLV-130A (B)] | RAW/LPSD | |
| 25 | Charging pump discharge line manual valves [VLV-132A (B)] | RAW/LPSD | |
| 26 | Charging pump discharge line cross tie-line manual valve [VLV-133] | RAW/LPSD | |
| 27 | Charging pump suction line manual valves [VLV-126A (B)] | RAW/LPSD | |

**Table 17.4-1 Risk significant SSCs (sheet 5 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale[1] | Insights and Assumptions |
|---|---|---|---|
| 28 | Charging line manual valves<br>[VLV-145]<br>[VLV-147] | RAW/LPSD | The "Insights and Assumptions" for these SSCs are described on the previous page. |
| 29 | Charging line by-pass line manual valve<br>[VLV-144] | RAW/LPSD | |
| 30 | RCP seal water injection line manual valves<br>[VLV-164]<br>[VLV-166]<br>[VLV-168]<br>[VLV-170B]<br>[VLV-171B]<br>[VLV-173] | RAW | |
| 31 | RCP seal water injection by-pass line manual valve<br>[VLV-163] | RAW | |
| 32 | RCP seal water injection line manual valves<br>[VLV-180A (B,C,D)] | RAW | |
| 33 | RCP seal water injection line needle valves<br>[VLV-177A (B,C,D)] | RAW | |
| 34 | Low-pressure letdown line air operated valve<br>[HCV-102] | LPSD | |

**Table 17.4-1 Risk significant SSCs (sheet 6 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale(1) | Insights and Assumptions |
|---|---|---|---|
| 3 | Component cooling water system (CCWS) | | |
| 1 | CCW pump discharge line check valves<br>[VLV-016A (B,C,D)) | RAW/CCF/LPSD | The component cooling water system (CCWS) transfer heat from plant safety-related components to the essential service water system (ESWS). This system supports various safety and non-safety mitigation systems. Accordingly, reliability of CCWS emergency feedwater system (EFWS) has significant impact on risk.<br><br>CCWS has four trains, each having a component cooling water pump and a component cooling water heat exchanger. Two trains compose a subsystem, which shares a supply / return header and a surge tank.<br><br>SSCs that have either of the following characteristics are risk significant.<br>- SSCs that have potential to cause common cause failures among multiple trains. Common cause failure of such system will result in loss of multiple trains.<br>- SSCs that have potential to cause large external leak are risk significant. Since the two trains that compose a subsystem are not physically isolated, large external leak from SSCs that result in loss of inventory is assumed to result in degradation or failure of two trains. |
| 2 | A~D-Component cooling water pumps<br>[NCS-RPP-001A (B,C,D)] | FV/RAW/CCF<br>/LPSD | |
| 3 | A~D-Component cooling water heat exchangers<br>[NCS-RHX-001A (B,C,D)] | RAW/CCF/LPSD | |
| 4 | CCW pump discharge cross tie-line motor operated valves<br>[MOV-020A (B,C,D)] | RAW/CCF/LPSD | |
| 5 | CCW pump suction line cross tie-line motor operated valves<br>[MOV-007A (B,C,D)] | RAW/CCF/LPSD | |
| 6 | SSCs that compose CCW boundary | RAW/EJ/LPSD | |
| 7 | CS/RHR heat exchanger discharge line motor operated valves<br>[MOV-145A (B,C,D)] | FV/RAW/CCF<br>/LPSD | |

**Table 17.4-1 Risk significant SSCs (sheet 7 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale[(1)] | Insights and Assumptions |
|---|---|---|---|
| 8 | Charging injection Pump Cooling Line Check Valves [TBD] | RAW/CCF/LPSD | These valves are used (opened) to provide alternative CCW from the fire suppression system or the non-essential chilled water system to the charging pump cooling line under loss of CCW events. These are important SSCs at loss of CCW events to prevent RCP seal LOCA. |
| 9 | Charging injection pump cooling discharge line motor operated valves [TBD] | RAW/CCF/LPSD | |
| 10 | CCWS - fire suppression system boundary motor operated valves [TBD] | RAW/CCF/LPSD | |
| 11 | CCWS - RWSP line boundary check valves [VLV-065A (B)] | RAW/LPSD | |
| 12 | CCWS - RWSP line boundary manual valves [VLV-066A (B)] | RAW/LPSD | |

**Table 17.4-1 Risk significant SSCs (sheet 8 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale[1] | Insights and Assumptions |
|---|---|---|---|
| 4 | Containment system | | |
| 1 | Containment vessel<br>[TBD] | EJ | The containment vessel is designed to completely enclose the reactor and reactor coolant system and to ensure that essentially no leakage of radioactive materials to the environment would result even if a major failure of the reactor coolant system were to occur. |
| 2 | Hydrogen ignition system<br>[TBD] | EJ | Hydrogen ignition system are provided for protection against possible detonation following a core damage accident to meet the requirement of 10CFR50.34(f) and 10CFR50.44(c). |
| 5 | Containment isolation system | | |
| 1 | Instrument air system check valve<br>[VLV-003] | RAW(L2) | In the case of core damage accident, the containment isolation valve is important to prevent radionuclide releases to the environment. |

**Table 17.4-1 Risk significant SSCs (sheet 9 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale(1) | Insights and Assumptions |
|---|---|---|---|
| 6 | Emergency feedwater system (EFWS) | | |
| 1 | EFW pit discharge line check valves [VLV-008A (B)] | RAW/CCF/LPSD | The emergency feedwater system (EFWS) supplies feedwater to the steam generators in order to remove reactor decay heat and RCS residual. This system is required after all initiating events exceeding large and medium LOCA. Accordingly, reliability of EFW system has significant impact on risk.<br>Two trains share one emergency feedwater pit, which has 50% capacity to perform cold shutdown. Large leak from SSCs or failure that result in degradation of water supply from EFW pit will lead to lack of EFW. In this case manual action to supply feedwater from Secondary Demineralizer Water Tank is required.<br>SSCs that have either of the following characteristics are risk significant.<br>- SSCs that have potential to cause common cause failures among multiple trains. Common cause failure of such system will result in loss of multiple trains.<br>- SSCs that have potential to cause large leak or failure that result in degradation of water supply from EFW pit will lead are risk important. If such failure occurs, manual action to supply feedwater from secondary demineralizer water tank will be required. |
| 2 | A(D)-emergency feedwater pump actuation valves [EFS-MOV-103A(D) ] | RAW/LPSD | |
| 3 | B,C-Emergency feedwater pumps [EFS-RPP-001B (C)] | RAW/CCF/LPSD | |
| 4 | A,D-Emergency feedwater pumps [EFS-RPP-001A (D)] | FV/RAW/CCF/LPSD | |
| 5 | Feedwater line check valves [VLV-018A (B,C,D)] | RAW/CCF/LPSD | |
| 6 | EFW pump discharge line check valves [VLV-012A (B,C,D)] | RAW/CCF/LPSD | |
| 7 | Minimum/Full flow line check valves [VLV-020A (B,C,D)] [VLV-022A (B,C,D)] | RAW/LPSD | |
| 8 | Minimum/Full flow line manual valves [VLV-021A (B,C,D)] [VLV-023A (B,C,D)] | RAW/LPSD | |
| 9 | A~D-emergency feedwater control valves [EFS-MOV-017A (B,C,D)) | RAW/LPSD | |
| 10 | A~D-emergency feedwater isolation valves [EFS-MOV-019A (B,C,D)] | RAW | |

**Table 17.4-1 Risk significant SSCs (sheet 10 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale(1) | Insights and Assumptions |
|---|---|---|---|
| 11 | A~D-emergency feedwater line orifices [FE3716,3726,3736,3746] | RAW (FLOOD) | The "Insights and Assumptions" for these SSCs are described on the previous page. |
| 12 | A~D-emergency feedwater line tie-line valves [EFS-MOV-014A (B,C,D)] | RAW/CCF(FLOOD) | |
| 13 | EFW pit discharge line piping [TBD] | RAW/LPSD | |
| 14 | EFW pit discharge line tie-line piping [TBD] | RAW(FLOOD) | |
| 15 | A~D-emergency feedwater line A(B,C,D) piping [TBD] | RAW(FLOOD) | |
| 16 | T/D pump steam supply line piping [TBD] | RAW/LPSD | |
| 17 | Minimum/Full flow line piping [TBD] | RAW/LPSD | |
| 18 | A,B-Emergency feedwater pits [EFS-RPT-001A(B)] | RAW/LPSD | |
| 19 | Minimum/Full flow line manual valves [VLV-026A (B)] | RAW/LPSD | |
| 20 | EFW pump suction line manual valves [VLV-009A (B,C,D)] | RAW/LPSD | |
| 21 | EFW pump discharge line manual valves [VLV-013A (B,C,D)] | RAW/LPSD | |

**Table 17.4-1 Risk significant SSCs (sheet 11 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale(1) | Insights and Assumptions |
|---|---|---|---|
| 22 | EFW pit discharge line manual valves [VLV-007A (B)] | RAW/LPSD | The “Insights and Assumptions” for these SSCs are described on the previous page. |
| 23 | Secondary demineralizer water tank discharge line manual valves [VLV-006A (B)] | RAW/LPSD | |
| 24 | Secondary demineralizer water tank discharge line check valve [VLV-005] | RAW(FLOOD) | |

**Table 17.4-1 Risk significant SSCs (sheet 12 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale(1) | Insights and Assumptions |
|---|---|---|---|
| 7 | Emergency power source (EPS) | | |
| 1 | 480V AC motor control center (MCC) buses<br>[TBD] | RAW/LPSD | The EPS consists of four separate trains. Each safety train consists of one 6.9kV AC medium voltage bus and 480V AC low voltage buses (Load Centers, Motor Control Centers). Each AC medium voltage bus connects to class 1E gas turbine generator. This system supports various safety mitigation systems and therefore, reliability of the EPS system has significant impact on risk.<br><br>Since the EPS consists of four separate trains, single failure in trains not significantly impact risk. However, failure of multiple trains is have significant impact on risk. Accordingly, SSCs that have potential to cause common cause failures among multiple trains are risk significant |
| 2 | 480V AC load center buses<br>[TBD] | | |
| 3 | 6.9kV buses<br>[TBD] | RAW/EJ/LPSD | |
| 4 | 125V DC buses train A and D<br>[TBD] | RAW/LPSD | |
| 5 | 125V DC buses train B and C<br>[TBD] | RAW(L2) | |
| 6 | 120V buses train A-D<br>[TBD] | RAW(L2/ FIRE) | |
| 7 | Swing MCC incomer circuit breakers<br>[TBD] | RAW/CCF/LPSD | |
| 8 | Batteries<br>[TBD] | RAW/CCF/LPSD | |
| 9 | 6.9kV AC bus incomer circuit breakers<br>[TBD] | FV/RAW/CCF/LPSD | |
| 10 | Gas turbine discharge circuit breakers<br>[TBD] | RAW/CCF/LPSD<br>FV/CCF(FIRE) | |

**Table 17.4-1 Risk significant SSCs (sheet 13 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale[1] | Insights and Assumptions |
|---|---|---|---|
| 11 | Circuit breakers between 6.9kV bus and 6.9kV/480V safety power transformers [TBD] | RAW/CCF/LPSD | The “Insights and Assumptions” for these SSCs are described on the previous page. |
| 12 | MCC bus incomer circuit breakers [TBD] | RAW/CCF/LPSD | |
| 13 | Circuit breakers between 125V DC bus and Inverter [TBD] | RAW/CCF/LPSD | |
| 14 | Class 1E gas turbine generators [TBD] | FV/RAW/CCF /LPSD) | |
| 15 | Gas turbines generator sequencers [TBD] | RAW/CCF/LPSD FV(FIRE) | |
| 16 | Inverters [TBD] | RAW/CCF/LPSD | |
| 17 | Main transformers [TBD] | RAW(L2) | |
| 18 | 6.9kV/480V safety power transformers [TBD] | RAW/LPSD | |

**Table 17.4-1 Risk significant SSCs (sheet 14 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale(1) | Insights and Assumptions |
|---|---|---|---|
| 8 | Alternative AC power sources (Permanent bus) | | |
| 1 | Non-class 1E gas turbine generators [TBD] | FV/RAW/CCF /LPSD | Two non-safety buses called “Permanent bus”, which is connected to Alternative AC (AAC), which consists of non-class 1E gas turbine generators respectively. Each non-class 1E gas turbine generators is manually connected to two safety medium voltage buses via selector circuit under the occurrence of loss of safety AC power. The AAC is a countermeasure against station blackout events.<br><br>SSCs that have potential to cause failures that degrade the availability to supply AAC power to safety medium voltage are risk significant.<br><br>Systems for the mitigation of core damage accident are connected to permanent bus. |
| 2 | 480V permanent buses [TBD] | RAW(L2) | |
| 3 | 6.9kV permanent buses [TBD] | RAW(L2) | |
| 4 | Circuit breakers between 6.9kV bus and 6.9kV/480V power transformer [TBD] | RAW(L2) | |
| 5 | Batteries [TBD] | RAW/CFF/LPSD | |
| 6 | Gas turbine generator discharge circuit breakers [TBD] | RAW/CCF/LPSD | |
| 7 | AAC selector circuit breakers [TBD] | RAW/CCF/LPSD | |
| 8 | Circuit breakers between 125V DC bus and Inverter [TBD] | RAW/CCF/LPSD | |
| 9 | Inverters [TBD] | RAW/CCF/LPSD | |
| 10 | Gas turbine generator sequencers | RAW/CCF/LPSD | |
| 11 | 6.9kV/480V power transformers [TBD] | RAW/LPSD | |

**Table 17.4-1 Risk significant SSCs (sheet 15 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale[1] | Insights and Assumptions |
|---|---|---|---|
| 9 | Non-essential chilled water system | | |
| 1 | Non-essential chilled water system - CCWS boundary motor operated valves [TBD] | RAW/LPSD | In the case of loss of component cooling water events, non-essential chilled water system or fire suppression system provides alternative component cooling water to charging pumps in order maintain RCP seal water injection.<br><br>These SSCs are risk significant because large external leak from these valves result in loss of alternative component cooling water from both non-essential chilled water system and fire suppression system. On the other hand, failure of other SSCs of this system affects only the non-essential chilled water system itself. |

**Table 17.4-1 Risk significant SSCs (sheet 16 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale[1] | Insights and Assumptions |
|---|---|---|---|
| 10 | Fire suppression systems (FSS) | | |
| 1 | FSS pump discharge motor operated valve<br>[TBD] | FV(L2)/RAW(L2) | In the case of core damage accident, Fire Suppression Systems (FSS) injects water from Raw Water Tank into the reactor cavity via the direct injection line by the fire water pumps.<br><br>The containment spray system and/or safety injection system perform the reactor cavity flooding through the drain line at loop compartment to prevent core-concrete interaction when the reactor vessel is failed. The Fire suppression system performs as alternative function for the reactor cavity flooding.<br><br>In the case of loss of component cooling water events, fire suppression system or non-essential chilled water system provides alternative component cooling water to charging pumps in order maintain RCP seal water injection. |
| 2 | FSS pump discharge flow meter<br>[TBD] | RAW(L2) | |
| 3 | Reactor cavity injection line orifice<br>[TBD] | RAW(L2) | |
| 4 | FSS piping (from tank to tie line piping)<br>[TBD] | RAW(L2) | |
| 5 | Raw water tank<br>[TBD] | RAW(L2) | |
| 6 | FSS pump discharge manual valve<br>[TBD] | RAW(L2) | |
| 7 | FSS - CCWS Boundary motor operated valves<br>[TBD] | RAW/LPSD | Large external leak from these valves result in loss of alternative component cooling water from both non-essential chilled water system and fire suppression system. On the other hand, external leak from other SSCs degrade the fire suppression system but the non-essential chilled water system is still available for alternative component cooling. Therefore these valves are risk significant SSCs in preventing core damage. |

**Table 17.4-1 Risk significant SSCs (sheet 17 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale[1] | Insights and Assumptions |
|---|---|---|---|
| 11 | High head safety injection system | | |
| 1 | Safety injection pump discharge check valves [VLV-004A (B,C,D)] | FV/RAW/CCF/LPSD | In the case of LOCA, high head safety injection system injects coolant from refueling water storage pit (RWSP) into the reactor vessel via the Direct Vessel Injection (DVI) line by the safety injection pumps. This system is also essential for bleed and feed operation.<br><br>Since this system consists of four independent trains, failure of one train does not have significant impact on risk. However, failures of SSCs that impact multiple trains are risk significant.<br><br>SSCs that have either of the following characteristics are risk significant.<br>- SSCs that have potential to cause common cause failures among multiple trains. Common cause failure of such system will result in loss of multiple trains.<br>- SSCs that have potential to cause loss of RWSP inventory out side the containment due to large external leaks. Loss of RWSP inventory impacts not only all four trains of high head safety injection system but also other systems that use RWSP as water source. |
| 2 | Safety injection pump outlet orifices 1A(B,C,D) [FE962(963,964,965)] | RAW(FLOOD) | |
| 3 | Minimum flow line orifices 3 C(D) [FE972(973,974,975)] | RAW(FLOOD) | |
| 4 | Containment isolation check valves [VLV-010A (B,C,D)] | RAW/CCF/LPSD | |
| 5 | Containment isolation motor operated valves [MOV-011 A(B,C,D)] | RAW(FLOOD)<br>FV(FLOOD) | |
| 6 | RV injection line orifices (between VLV-012 A(B,C,D) and MOV-0011 A(B,C,D)) | RAW(FLOOD) | |
| 7 | Injection line secondary isolation check valves [VLV-012A (B,C,D)] | RAW/CCF/LPSD | |
| 8 | Injection line boundary check valves [VLV-013A (B,C,D)] | RAW/CCF/LPSD | |
| 9 | A～D-Safety injection pumps [SIS-RPP-001A (B,C,D)] | FV/RAW/CCF/LPSD | |
| 10 | Containment isolation motor operated valves [MOV-009A (B,C,D)] | RAW<br>FV(FLOOD) | |

**Table 17.4-1 Risk significant SSCs (sheet 18 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale[1] | Insights and Assumptions |
|---|---|---|---|
| 11 | Containment isolation motor operated valves [MOV-001A (B,C,D)] | RAW/LPSD FV(FLOOD) | The “Insights and Assumptions” for these SSCs are described on the previous page. |
| 12 | Piping | RAW/LPSD | |
| 13 | Minimum flow line orifices (next to VLV-L023 A(B,C,D)) | RAW(FLOOD) | |
| 14 | Minimum flow line manual valves [VLV-024 A(B,C,D)] | RAW(FLOOD) | |
| 15 | Minimum flow line manual valves [VLV-023 A(B,C,D)] | RAW(FLOOD) | |

**Table 17.4-1 Risk significant SSCs (sheet 19 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale(1) | Insights and Assumptions |
|---|---|---|---|
| 12 | Heating, ventilation, and air conditioning (HVAC) system | | |
| 1 | B,C-Emergency feedwater pump room fans<br>[VRS-RFN-401B,C] | RAW/CCF/LPSD<br>FV(FLOOD) | EFW M/D pump room fans maintain room temperature when pumps are running. EFW M/D pumps are assumed to be unavailable within the mission time without room cooling due to high room temperature.<br><br>HVAC systems of other rooms are considered not to be risk significant for the following reasons.<br>- HVAC of emergency gas turbine room<br>Gas turbine units itself has function to intake outer air to remove heat out to atmosphere. Accordingly, HVAC is considered not essential to maintain gas turbine function.<br>- HVAC of ESF room (RHR/CSS pump, SI pump)<br>According to room temperature analysis, room temperature will not exceeds limit of the system during the mission time regardless of availability of HVAC.<br>- HVAC of class1E electric power room (Class 1E I&C, switch gear, battery, battery charger)<br>This system is running during normal operation and continues to run after initiating events. Reliability of normally operating HVAC systems are considered to be high and failure of this system is unlikely to occur during the mission time.<br>- HVAC of EFW T/D pump room<br>Since T/D driven EFW pump room can operate under high room temperature conditions, they are assumed to be available regardless of room cooling during the mission time. |

**Table 17.4-1 Risk significant SSCs (sheet 20 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale(1) | Insights and Assumptions |
|---|---|---|---|
| 13 | Containment fan cooler system | | |
| 1 | Containment fan cooler [VCS-CAH-001A (B,C,D)] | EP | Temperature control of Containment Vessel atmosphere is judged important by experts from a point of view of keeping function of safety components in Containment Vessel. |
| 14 | Main control room HVAC system | | |
| 1 | Main control room air handling unit [VRS-RAH-101A (B,C,D)] | EP | Temperature control of main control room atmosphere is judged important by experts from the viewpoint of operator habitability during an accident. |

**Table 17.4-1 Risk significant SSCs (sheet 21 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale[1] | Insights and Assumptions |
|---|---|---|---|
| 15 | Instrumentation and control (I&C) system | | |
| 1 | Permanent bus low voltage signal software | RAW/CCF | This software provides start signal to non-class 1E gas turbine generator. Under SBO, This software must operate in order to backup of the safety bus by AAC power source. |
| 2 | Component cooling water system train isolation signal software | RAW/CCF | SSCs that have potential to cause common cause failure of signals are risk significant since such failure may result in loss of total system function.<br><br>EFW T/D pump start signals are risk significant since such failure results in loss of one of two available EFW pumps under, SBO and loss of EFW room cooling conditions.<br><br>Reliability of signals other than “S signal” is assumed to have same reliability with “P signal”. |
| 3 | SG isolation signal software | RAW/CCF | |
| 4 | Engineered safety features actuation signal software (P,S) | RAW/CCF | |
| 5 | SG(EFW) isolation signals | RAW/CCF | |
| 6 | Main steam line isolation signal software | RAW/CCF | |
| 7 | Black out signal software | RAW/CCF | |
| 8 | CCW start signals | RAW(L2,FLOOD) | |
| 9 | Containment pressure sensors [TBD] | RAW(L2)/CCF(L2) | |
| 10 | A~D-Emergency feed water pump start signals | RAW | |
| 11 | EFW pump start signal software | RAW/CCF | |
| 12 | Diverse actuation system | EJ | The unreliability of this system is assumed to be 0.01. |

**Table 17.4-1 Risk significant SSCs (sheet 22 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale[1] | Insights and Assumptions |
|---|---|---|---|
| 16 | Waste management system (WMS) | | |
| 1 | Refueling water storage (RWS) system – WMS line boundary check valve [VLV-037] | RAW | Large External leak of the boundary check valve results in loss of inventory from the RWS system. Systems that relies on the RWS as water source is affected by this failure mode. |
| 17 | Main feedwater system (MFWS) | | |
| 1 | Main feedwater system | RAW | The Main feedwater system is credited as a function to secondary side cooling during general transients, which does not involve loss of main feedwater. |

**Table 17.4-1 Risk significant SSCs (sheet 23 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale(1) | Insights and Assumptions |
|---|---|---|---|
| 18 | Main steam supply system (MSS) | | |
| 1 | A~D-Main steam isolation valves [NMS-AOV-515A (B,C,D)] | RAW/CCF FV/CCF(FIRE) | Main steam isolation valve isolates the ruptured Steam Generator (SG) at the Steam Generator Tube Rupture (SGTR). In case of secondary line break, main steam isolation is required to prevent unlimited steam release.<br>Main steam line piping is required to be intact to isolate the ruptured SG at SGTR events. |
| 2 | A~D-Main steam bypass isolation valves [NMS-HCV-3615,3625,3635,3645] | RAW(L2) | |
| 3 | Main steam line piping | RAW | |
| 4 | Main steam line isolation check valve s A(B,C and D) [VLV-516A(B,C and D)] | RAW(FIRE) | |
| 5 | A1~A2-Main steam safety valves<br>B1~B2-Main steam safety valves<br>C1~C2-Main steam safety valves<br>D1~D2-Main steam safety valves<br>[NMS-VLV-509A (B,C,D) ]<br>[NMS-VLV-510A (B,C,D) ] | RAW(L2) | |
| 6 | A,B,C,D,E,F,G,H,J,K,L,M,N,P,Q-Turbine bypass valves<br>[NMS-TCV-500A(B,C,D,E,F,G,H,J,K,L,M,N,P,Q) ] | RAW(L2) | |

**Table 17.4-1 Risk significant SSCs (sheet 24 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale(1) | Insights and Assumptions |
|---|---|---|---|
| 19 | Pressurizer pressure control system part of emergency core cooling system (ECCS) | | |
| 1 | A(B)--Safety depressurization valves [RCS-MOV-117A(B)] | RAW/CCF FV/CCF(FLOOD,FIRE) | Safety Depressurization Valves (SDVs) are required to open during bleed and feed operation.<br><br>Pressurizer safety valves releases RCS pressure in case of high RCS pressure. Failure of safety valves to re-close results in loss of primary coolant. |
| 2 | A(B) -Safety depressurization valves [RCS-MOV-116 A(B) ] | RAW(FLOOD,FIRE) | |
| 3 | A～D-Pressurizer safety valves<br>[RCS-VLV-120]<br>[RCS-VLV-121]<br>[RCS-VLV-122]<br>[RCS-VLV-123] | RAW | |
| 20 | Depressurization system for severe accident | | |
| 1 | Depressurization valves<br>[RCS-MOV-118 ]<br>[RCS-MOV-119 ] | FV(L2) | In the case of core damage accident, depressurization of the reactor coolant system is required to prevent high pressure melt ejection and direct containment heating. |

**Table 17.4-1 Risk significant SSCs (sheet 25 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale(1) | Insights and Assumptions |
|---|---|---|---|
| 21 | Containment spray / residual heat removal (CS/RHR) system | | |
| 1 | Heat exchanger bypass valves<br>[FCV-604]<br>[FCV-636] | RAW/LPSD | The Containment Spray / Residual Heat Removal (CS/RHR) System consists of four independent trains. The CS/RHR System has the following four functions.<br>a. Containment Spray<br>b. Alternative Core Cooling<br>c. RHR Operation during operating modes 4 , 5 and 6..<br><br>Since CS/RHR system consists of four independent trains, failure of one train does not have significant impact on risk. However, failures of SSCs that impact multiple trains are risk significant.<br><br>SSCs that have either of the following characteristics are risk significant.<br>- SSCs that have potential to cause common cause failures among multiple trains. Common cause failure of such system will result in loss of multiple trains.<br>- SSCs that have potential to cause loss of RWSP inventory out side the containment due to large external leaks. Loss of RWSP inventory impacts not only all four trains of CS/RHR system but also other systems that use RWSP as water source. |
| 2 | RHR line heat exchanger discharge air operated valves<br>[FCV-603]<br>[FCV-633] | RAW/LPSD | |
| 3 | Pump suction line check valves<br>[VLV-004A (B,C,D)] | RAW/CCF/LPSD | |
| 4 | RHR line containment isolation check valves<br>[VLV-022A (B,C,D)] | RAW/CCF/LPSD | |
| 5 | RHR line containment isolation motor operated valves<br>[MOV-021A (B,C,D)] | RAW/CCF/LPSD | |
| 6 | A~D-Containment spray/residual heat removal pumps<br>[RHS-RPP-001A (B,C,D)] | RAW/CCF/LPSD<br>FV(FLOOD) | |
| 7 | A~D-Containment spray/residual heat removal heat exchangers<br>[RHS-RHX-001A (B,C,D)] | RAW/CCF/LPSD | |
| 8 | RHR line boundary check valves<br>[VLV-028A (B,C,D)] | RAW/LPSD | |
| 9 | RWSP discharge line isolation valves<br>[TBD] | RAW | |

**Table 17.4-1 Risk significant SSCs (sheet 26 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale[1] | Insights and Assumptions |
|---|---|---|---|
| 10 | CS line containment isolation motor operated valves [MOV-004A (B,C,D)] | RAW<br>FV(FLOOD) | The "Insights and Assumptions" for these SSCs are described on the previous page. |
| 11 | A~D-CS line check valves [VLV-005A(B,C,D)] | RAW/CCF(FLOOD) | |
| 12 | Piping [TBD] | RAW | |
| 13 | CS line heat exchanger discharge manual valves [VLV-002A (B,C,D)] | RAW | |
| 14 | Minimum flow line manual valves [VLV-13A (B,C,D)] | RAW | |
| 15 | CS/RHR - spent fuel pit boundary manual valves (discharge line) [VLV-031A (D)) | RAW | |
| 16 | From FSS to CSS tie line check valve [VLV-012] | RAW(L2) | These valves are required to open to perform firewater injection from FSS to the spray header. |
| 17 | From FSS to CSS tie line motor operated valve [CSS-MOV-011] | FV(L2)/RAW(L2) | |
| 18 | CS/RHR - spent fuel pit boundary manual valves (suction line) [VLV-034A (D)] | RAW/LPSD | These valves are required to open to perform gravitational injection from the spent fuel pit to the RCS when RCS is atmospheric pressure at LPSD operation. |
| 19 | CS/RHR - spent fuel pit boundary manual valves (suction line) [VLV-33A(D)] | LPSD | |

**Table 17.4-1 Risk significant SSCs (sheet 27 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale[1] | Insights and Assumptions |
|---|---|---|---|
| 20 | CS/RHR pump hot leg suction isolation valves [MOV-001A(B,C,D)] [MOV-002A(B,C,D)] | LPSD | Failure of these valves result in loss of RHR during LPSD |
| 21 | RCS cold leg injection line motor operated valves [MOV-026A(B,C,D)] | LPSD | |
| 22 | RCS cold leg injection line check valves [VLV-027A(B,C,D)] [VLV-028A(B,C,D)] | LPSD | |

**Table 17.4-1 Risk significant SSCs (sheet 28 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale(1) | Insights and Assumptions |
|---|---|---|---|
| 22 | Refueling water storage system (RWS) | | |
| 1 | Refueling water storage pit (RWSP) sump strainers<br>[TBD] | FV/RAW/CCF | The RWSP is the source of borated water for containment spray and safety injection. During LPSD operation, RWSS has the following functions.<br>a. Refill refueling water auxiliary tank (RWAT) for RCS injection via charging pumps.<br>b. Refill SFP for gravitational injection to RCS.<br><br>SSCs that have either of the following characteristics are risk significant.<br>- SSCs that have potential to cause common cause failures among multiple trains. Sump strainers have potential of sump screen, which may occur in multiple trains.<br>- SSCs that have potential to cause resulting loss of RWSP inventory out side the containment due to large external leaks are risk significant, since such failure impacts all systems that use RWSP as water source.<br><br>SSCs that have potential to cause failure to supply RWSP water to RWAT or SFP during LPSD operation are also considered risk significant. |
| 2 | Refueling water storage pit<br>[RWS-CPT-001] | RAW | |
| 3 | Refueling water recirculation pump suction line manual valves<br>[VLV-006A (B)] | RAW/LPSD | |
| 4 | Refueling water recirculation pump discharge line check valves<br>[VLV-012A (B)] | RAW/LPSD | |
| 5 | Refueling water recirculation pump discharge line manual valves<br>[VLV-013A (B)] | RAW/LPSD | |
| 6 | RWSP discharge line containment isolation motor operated valves<br>[MOV-002]<br>[MOV-004] | RAW/LPSD | |
| 7 | A,B-Refueling water recirculation pumps<br>[RWS-RPP-001A (B)] | RAW/LPSD | |
| 8 | RWSP discharge line manual valve<br>[VLV-001] | RAW/LPSD | |
| 9 | Refueling water recirculation pump suction cross tie line manual valve<br>[VLV-005] | RAW/LPSD | |

**Table 17.4-1 Risk significant SSCs (sheet 29 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale(1) | Insights and Assumptions |
|---|---|---|---|
| 10 | Refueling water recirculation pump discharge cross tie line manual valve [VLV-014] | RAW/LPSD | The "Insights and Assumptions" for these SSCs are described on the previous page. |
| 11 | Refueling water auxiliary tank inlet line manual valve [VLV-052] | RAW/LPSD | |
| 12 | Refueling water auxiliary tank discharge line manual valve [VLV-101] | RAW/LPSD | |
| 13 | Refueling water auxiliary tank suction line manual valves [VLV-021] [VLV-051] | LPSD | |
| 14 | RWSP suction line containment isolation air operated valve [AOV-022] | LPSD | |

**Table 17.4-1 Risk significant SSCs (sheet 30 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale(1) | Insights and Assumptions |
|---|---|---|---|
| 23 | Reactor protection system (RPS) | | |
| 1 | Reactor trip breakers<br>[TBD] | RAW/CCF | These systems are necessary to provide negative reactivity for plan t trip. |
| 2 | Control rod (rod injection)<br>[TBD] | FV/RAW/CCF | |
| 24 | Chilled water system (VWS) | | |
| 1 | Chiller units train B and C<br>[TBD] | FV/RAW/CCF/LPSD | The safety related water system supplies chilled water to safety related HVAC systems.<br>SSCs that have potential to cause common cause failures among trains B and C are risk significant since such failures results in loss room cooling in M/D EWF pump area.<br>SSCs that compose train A and D are not risk significant because the PRA assumes only the M/D EFW pumps to be dependent on room cooling during the mission time. |
| 2 | Pumps train B and C<br>[TBD] | RAW/CCF/LPSD | |

## Table 17.4-1 Risk significant SSCs (sheet 31 of 34)

| # | Systems, Structures and Components (SSCs) | Rationale[1] | Insights and Assumptions |
|---|---|---|---|
| 25 | Essential service water system (ESWS) | | |
| 1 | Pump discharge line check valves<br>[VLV-502A (B,C,D)] | RAW/CCF/LPSD | The essential service water system (ESWS) transfers heat from the CCW system as Ultimate Heat Sink (UHS). This system supports the CCW system, which supports various safety and non-safety mitigation systems. Accordingly, reliability of CCWS EFW system has significant impact on risk.<br><br>Since ESWS consists of four independent trains, failure of one train does not have significant impact on risk. However, failures of SSCs that impact multiple trains have risk significant impact on risk. Accordingly, SSCs that have potential to cause common cause failures among multiple trains are risk significant. |
| 2 | Essential service water pump motor cooling line check valves<br>[VLV-602A (B,C,D)] | RAW/CCF/LPSD | |
| 3 | A~D-Essential service water pump<br>[EWS-OPP-001A (B,C,D)] | FV/RAW/CCF/LPSD | |
| 4 | A1,B1-Essential service water pump outlet strainers<br>[EWS-OSR-001A (B)] | RAW/LPSD | |
| 5 | A1~D1-Essential service water pump outlet strainers<br>A2~D2-Essential service water pump outlet strainers<br>[EWS-OSR-001A (B,C,D)]<br>[EWS-OSR-002A (B,C,D)] | RAW/LPSD | |
| 6 | Valves located in essential service water pump motor cooling line of train B & C<br>[VLV-601B (C)] | RAW/LPSD | |
| 7 | ESW pump motor cooling line valves of train A & D<br>[VLV-601A (D)] | RAW(L2) | |

**Table 17.4-1 Risk significant SSCs (sheet 32 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale[1] | Insights and Assumptions |
|---|---|---|---|
| 8 | Orifices located in essential service water pump motor cooling line of train B & C<br>[FT-2061 (2)] | RAW/LPSD | The “Insights and Assumptions” for these SSCs are described on the previous page. |
| 9 | Main piping orifices of train B and D<br>[FE2025 , FE2026] | RAW/LPSD | |
| 10 | Main piping orifices of train A and D<br>[FE2024 , FE2027] | RAW(L2) | |
| 11 | Main piping valves of train B and C<br>[MOV-503B (C)]<br>[VLV-506B (C)]<br>[VLV-507B (C)]<br>[VLV508B (C)]<br>[VLV-509B (C)]<br>[VLV-511B (C)]<br>[VLV-514B (C)]<br>[VLV-517B (C)]<br>[VLV-520B (C)] | RAW/LPSD | |
| 12 | Main piping valves of train A and D<br>[MOV-503A (D)]<br>[VLV506A (D)]<br>[VLV-507A (D)]<br>[VLV508A (D)]<br>[VLV-509A (D)]<br>[VLV-511A (D)]<br>[VLV-514A (D)]<br>[VLV-517A (D)]<br>[VLV-520A (D)] | RAW(L2) | |
| 13 | Piping of train B and C<br>[TBD] | RAW/LPSD | |
| 14 | Piping of train A and D<br>[TBD] | RAW(L2) | |

**Table 17.4-1 Risk significant SSCs (sheet 33 of 34)**

| # | Systems, Structures and Components (SSCs) | Rationale(1) | Insights and Assumptions |
|---|---|---|---|
| 26 | Spent fuel pit cooling and purification system (SFPCS) | | |
| 1 | RWS – SFP inlet line boundary check valves [VLV-027] | RAW/LPSD | Large External leak of valves that form boundary between RWS result in loss of inventory of the RWS system. Accordingly, systems that relies on the RWS as water source is affected by failure of these valves.<br><br>During RCS is atmospheric pressure at LPSD operation, the spent fuel pit is used as water source of gravitational injection in case loss of decay heat removal function occurs. SSCs associated with gravitational injection line are considered to be risk significant. |
| 2 | RWS – SFP inlet line manual valve [VLV-028] | RAW/LPSD | |
| 3 | RWS – SFP demineralizer line boundary manual valves [VLV-103A (B)] | RAW | |
| 4 | RWS – SFP inlet line manual valves [VLV-029] [VLV-015] [VLV-017] | LPSD | |
| 5 | Spent fuel pit [RPT-001] | LPSD | |
| 6 | A~D-Spent fuel pit strainers [SFS-RSR-001A (B,C,D)] | LPSD | |
| 7 | Spent fuel pit discharge line manual valves [VLV-021A(D)] | LPSD | |
| 8 | Spent fuel pit discharge cross tie-line manual valve [VLV-022] | LPSD | |

**Table 17.4-1 Risk significant SSCs (sheet 34 of 34)**

Notes:

1. Definition of Rationale Terms:
   CCF = Common Cause Failure
   FV = Fussell-Vesely
   RAW = Risk Achievement Worth
   FV(L2) = Fussell-Vesely for L2
   RAW(L2) = Risk Achievement Worth for L2
   CCF(L2) = Common Cause Failure for L2
   LPSD =Low Power and Shut Down Operation
   EJ = Engineering Judge
   FLOOD = FLOOD Event
   FIRE = FIRE Event
   EP = Expert Panel

### 17.4.8 ITAAC for the D-RAP

Tier 1 ITAAC are proposed to verify that the D-RAP provides reasonable assurance that the design of SSCs within the scope of the RAP is consistent with their assumed design reliability. The list of risk-significant SSCs for ITAAC will be prepared by introducing the plant's site-specific information to the list shown in Table 17.4-1 in the Phase II of the D-RAP. The ITAAC acceptance criteria are established to ensure that the estimated reliability of each as-built SSC is at least equal to the assumed design reliability and that industry experience including operations, maintenance, and monitoring activities were assessed in estimating the reliability of these SSCs.

### 17.4.9 Combined License Information

*COL 17.4(1)* *The COL Applicant shall be responsible for the development and implementation of the Phases II and III of the D-RAP. In the Phase II, the plant's site-specific information should be introduced to the D-RAP process and the site-specific SSCs should be combined with the US-APWR design SSCs into a list for the specific plant. In the Phase III, procurement, fabrication, construction, and test specifications for the SSCs within the scope of the RAP should ensure that significant assumptions, such as equipment reliability, are realistic and achievable. The QA requirements should be implemented during the procurement, fabrication, construction, and pre-operation testing of the SSCs within the scope of the RAP.*

*COL 17.4(2)* *The COL Applicant shall be responsible for the development and implementation of the O-RAP, in which the RAP activities should be integrated into the existing operational program (i.e., Maintenance Rule, surveillance testing, in-service inspection, in-service testing, and QA). The O-RAP should also include the process for providing corrective actions for design and operational errors that degrade non-safety-related SSCs within the scope of the RAP.*

### 17.4.10 References

17.4-1 "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems (RTNSS) in Passive Plant Design," SECY 95-132, U.S. Nuclear Regulatory Commission, Washington, DC, May 1995.

17.4-2 'Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants,' "Domestic Licensing of Production and Utilization Facilities," Energy. Title 10, Code of Federal Regulations, Part 50.65, U.S. Nuclear Regulatory Commission, Washington, DC.

## 17.5 Quality Assurance Program Description

During the Design Certification phase for US-APWR standard plant design, the MHI-NESH US-APWR Project Quality Assurance Program (QAP) is the top-level policy that establishes the quality assurance policy and assigns major functional responsibilities. The QAP provides for the methods and establishes the QAP and administrative control requirements described in “Quality Assurance Program (QAP) Description For Design Certification of the US-APWR (PQD-HD-19005 Rev.1)” (MHI QAPD)(Ref 17.5.5-4), that meet 10 CFR Part 50, Appendix B and 10 CFR Part 52. The MHI QAPD is based on the requirements of ASME NQA–1-1994, “Quality Assurance Requirements for Nuclear Facility Applications,” Parts I and II, as specified in Ref.17.5.5-4.

The MHI QAPD for the Design Certification Phase has been prepared on the basis of the NRC approved QAP template (NEI, 06-14A Rev.4 and earlier revisions) (Ref 17.5.5-3) prepared by the Nuclear Energy Institute and has been evaluated against the SRP. The MHI QAPD provides the controls that implement the QAP. MHI performed a comparison of the MHI QAPD against the SRP (Mar. 2007) (Ref 17.5.5-2) and the draft SRP (Sept. 2006) (Ref 17.5.5-1) which was used as a reference for the MHI QAPD and determined that the MHI QAPD is satisfactory.

Business policies of MHI-NESH establish high level responsibilities and authority for carrying out administrative functions which are outside the scope of the QAP.

Procedures establish practices for certain activities which are common to all MHI-NESH organizations performing those activities such that the activity is controlled and carried out in a manner that meets QAP requirements. Organization specific procedures establish detailed implementation requirements and methods, and may be used to implement the business policies of MHI-NESH or be unique to particular functions or work activities.

The COL applicant is responsible for the development of a Quality Assurance Program Description for site-specific design activities and for plant construction and operation.

### 17.5.1 Combined License Information

*COL 17.5(1)* *The COL applicant shall develop and implement a Quality Assurance Program Description for site-specific design activities and for plant construction and operation.*

### 17.5.2 References

17.5.5-1 “Draft Standard Review Plan (SRP) 17.5 dated September 22, 2006”

17.5.5-2 “Standard Review Plan (SRP) 17.5 March 2007”

17.5.5-3 “Quality Assurance Program Description (NEI 06-14A Rev.4 and earlier versions)”

17.5.5-4 “Quality Assurance Program (QAP) Description For Design Certification of the US-APWR (PQD-HD-19005 Rev.1)”

## 17.6 Description of the Applicant's Program for Implementation of 10 CFR 50.65, the Maintenance Rule

The COL Applicant is responsible for development of the program for implementation of 10 CFR 50.65, the Maintenance Rule.

### 17.6.1 Combined License Information

*COL 17.6(1)* *The COL applicant develops and implements the program for implementation of 10 CFR 50.65, the Maintenance Rule.*