DESIGN CONTROL DOCUMENT FOR THE US-APWR

Chapter 17
Quality Assurance and Reliability Assurance

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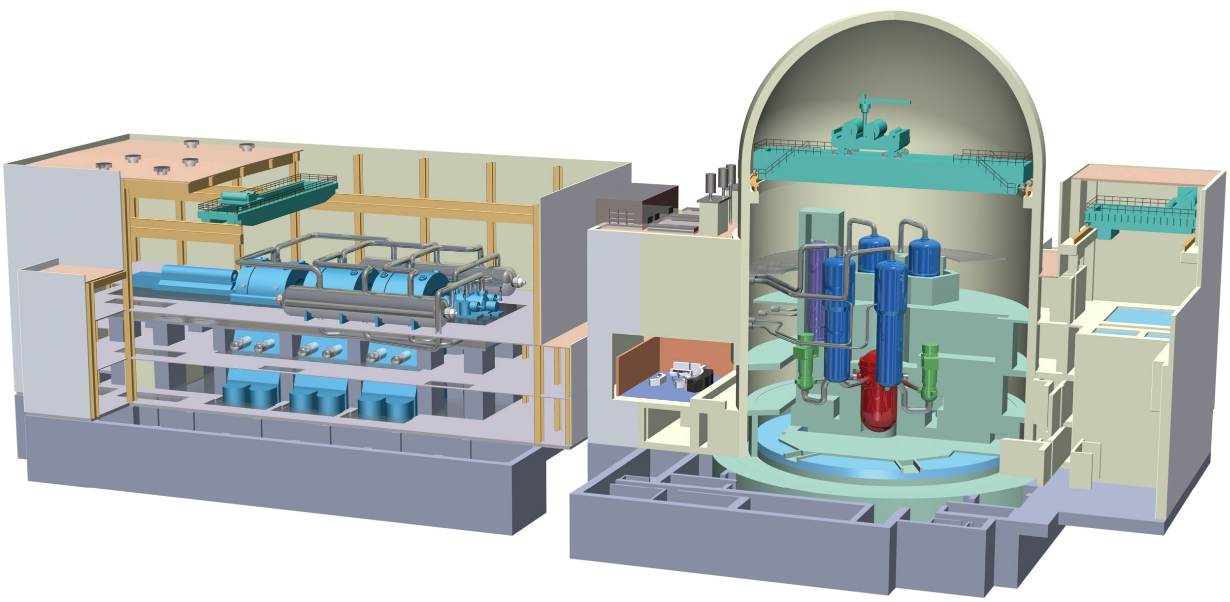

Mitsubishi Heavy Industries, Ltd.

16-5, Konan 2-chome, Minato-ku

Tokyo 108-8215 Japan

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TABLES

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 protection water supply system
FV	Fussell Vesely
FVW	Fussell Vesely worth
HSIS	human-system interface system
HVAC	heating, ventilation, and air conditioning
I&C	instrumentation and control
ITAAC	inspection, test, analyses, and acceptance criteria

ACRONYMS AND ABBREVIATIONS (CONTINUED)

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	reliability assurance program during the operations phase
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
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

ACRONYMS AND ABBREVIATIONS (CONTINUED)

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.3)” (Ref 17.5-4).

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.3).

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 DRAP 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 DRAP 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 risk-significant SSCs, 2) the risk-significant SSCs do not degrade to an unacceptable level during plant operations, 3) the frequency of transients that challenge risk-significant SSCs is minimized, and 4) the risk-significant 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. The risk-significant SSCs including both safety-related and non safety-related 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 sitespecific 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 designer, MHI, is responsible for Phase I of the D-RAP The site-specific list of SSCs is also provided as an input to reliability assurance program during the operations phase (O-RAP), which addresses the specific plant operation and maintenance activities. 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.

The non safety-related RAP SSCs would be subjected to the appropriate QA controls that are described in the Section 17.5 of the US-APWR DCD for the phase I of the D-RAP, and in Section 17.5 of the site specific COL for the phase II and III of 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 risksignificant 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 (Ref. 17.4-2) 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 is 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 10 CFR 50.65 (Ref. 17.4-3) 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. 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. The list of risk-significant SSCs identified during the design phase is updated when the plant-specific PRA is developed. In the expert panel's discussion, review of dominant failure modes are also considered in order to reflect industry operating experience.

a. Risk-Significant SSCs Identification

Importance Analysis based on the PRA Results

The PRA is used to identify risk-significant SSCs based on risk achievement worth (RAW) and Fussell-Vesely (FV) importance. Risk-significant SSCs are identified using importance criteria of FV importance greater than 0.005 and RAW greater than 2. In the US-APWR RAP, these criteria have been applied to both single failure basic events and common cause failure (CCF) basic events. Risk-significant SSCs identified by RAW greater than 2 cover sufficiently those identified by RAW greater than 20, which is the RAW criterion for common cause basic events per NEI-00-04 (Ref. 17.4-4). Component based FVs are also estimated and used to identify risksignificant SSCs. These RAW/FV criteria are applied to the results of each risk hazard model separately and not to the combined / integrated results. For seismic margin analysis(SMA), risk-significant SSCs are identified according to the approach provided by NEI 00-04, Revision 0 (Ref. 17.4-4).

Engineering Judge based on the PRA Assumption and Results

For SSCs

- for which RAW/FV values have not been quantified

  or

- whose RAW/FV results do not exceed the criteria,

risk significance are also identified by engineering judge from the following points of view:

- Attribution to required mitigation functions during the accident
- Similarity of the impact of failure with other risk-significant SSCs
- Impact on risk-significant human actions or signals

For LPSD, importance analysis was performed for the representative plant operation state (POS), which is mid-loop operation, for that PRA has been performed. For POSs RAW/FV values have not been quantified. SSCs that were not credited as mitigation function in the representative POS but can be used to mitigate accidents during other POSs were all included in the list of risk-significant SSCs.

For severe accident management SSCs, SSCs required to satisfy the requirement of 10 CFR are identified as risk-significant SSCs (e.g. igniter). And SSCs that are not modeled in the PRA but the loss of whose functions may directly result in large release, are identified as risk-significant SSCs (e.g. containment vessel).

Expert Panel's Discussions and Results

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. The EP also reviews the categorization of SSCs determined to be not risk-significant (NRS) from quantified PRA results (e.g., technical adequacy of the basis used in the categorization, review of defense-in-depth implications, review of safety margin implications). 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.

b. Dominant Failure Mode Identification

The PRA models failure modes of SSCs that can potentially degrade the operability of mitigation functions as basic events. Since the results of importance analysis are the RAW/FV importance of each basic event, dominant failure modes can be identified for each risk-significant SSCs. For risk-significant SSCs that are chosen based on engineering judge, dominant failure modes are supposed from the importance results of components that have similar impact on the system when a failure has occurred.

17.4.7.2 Expert Panel

An EP, consisting of at least one person with design engineering experience, at least one person with PRA experience, at least one person with operations and maintenance experience, and at least one person with quality assurance experience, is responsible for the final selection of the SSCs included in the D-RAP. Industry operating experience and use of the Expert Panel are used as the part of deterministic approach and other processes, and engineering judgment are employed in considering the addition of SSCs to the D-RAP. The level of education and experience of voting member of the RAP EP is defined in the Expert Panel Implementing Procedure for US-APWR Reliability Assurance Program as follows:

- For a person who has a science or technical/engineering degree, more than 10 years of experience in the specific area of Nuclear Power Plant, such as design, or identical experience, is required.
- For a person who does not have a science or technical/engineering degree, more than 15 years of experience in the specific area of Nuclear Power Plant, such as design, or identical experience, is required.

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. The boundary for the SSCs listed in the table can be identified as follows:

1. Boundary for the RAP SSCs is applicable to components and that for system or structure represents itself.
2. The boundary for the components modeled in the PRA is basically referred from US-APWR PRA technical report (Ref. 17.4-8), which is based on the general failure data.

Table 17.4-1 Risk-significant SSCs (Sheet 1 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
1	**Accumulator injection system**			
1	Discharge line secondary isolation check valves [SIS-VLV-102A (B, C, D)]	RAW(L1, L1-CC, L2-CC)	OD, EL, PR	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. 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 (Discharge line) [SIS-VLV-103A (B, C, D)]	RAW(L1, L1-CC, L2-CC)	OD, EL, PR	
3	Discharge line isolation motor operated valves [SIS-MOV-101A (B, C, D)]	RAW(L1)	EL, PR	
4	Discharge line orifices train A through D [SIS-SRO-006A (B, C, D)]	RAW(L1)	PR	
5	Piping train A through D (Accumulator injection line)	RAW(L1) SM	EL, SS	
6	Accumulators [SIS-MTK-001A (B, C, D)]	EJ SM	SR, SS	

Table 17.4-1 Risk-significant SSCs (Sheet 2 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
2	Chemical volume control system			
1	Charging line air operated valves [CVS-AOV-146] [CVS-FCV-048][CVS-AOV-159]	RAW(L1, L2, LP, FR1, FR2)	CM, EL, PR, FC	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. 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 protection water supply 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. 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. 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 [CVS-FCV-050] [CVS-AOV-165]	RAW(L1, L2, LP, FR1, FR2)	CM, EL, PR	
3	Auxiliary spray injection line air operated valve [CVS-AOV-155]	RAW(L1, L2, LP)	EL, IL	
4	Charging pumps [CVS-MPP-001A (B)]	FV(L1-CC, L2-SUM, LP, FL1, FL2) RAW(L1, L1-CC, L2, L2-CC, LP, FL1, FL1-CC, FR1-CC, FL2, FL2-CC, FR2-CC)	AD, BD, EL, YR	
5	Volume control tank discharge line check valve [CVS-VLV-125]	RAW(L1, L2, LP)	EL, PR	
6	Volume control tank discharge line motor operated valves [CVS-LCV-031 B(C)]	RAW(L1, L2, LP, LP-CC)	CD, CM, EL, PR	
7	Refueling water storage auxiliary tank discharge line change valves [CVS-LCV-031D (E, F, G)]	RAW(L1, L2, LP, LP-CC)	EL, OD, PR	
8	Refueling water storage auxiliary tank discharge line check valve [CVS-VLV-595]	RAW(L1, L2, LP, FR1, FR2)	EL, OD, PR	
9	Refueling water storage auxiliary tank discharge line manual valve [CVS-VLV-591]	RAW(LP)	EL, PR	

Table 17.4-1 Risk-significant SSCs (Sheet 3 of 51)

#	Systems, Structures and Components (SSCs)	Rationale[1]	Failure Mode[2]	Insights and Assumptions
10	Charging pump minimum flow line check valves [CVS-VLV-129A (B)]	RAW(L1, L2, LP)	EL, OD, PR	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 storage auxiliary tank, which is supplied by the refueling water storage pit. 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.
11	Charging pump discharge line check valves [CVS-VLV-131A (B)]	RAW(L1, L2, LP)	EL, OD, PR	
12	Charging line containment isolation check valve [CVS-VLV-153]	RAW(L1, L2, LP)	EL, PR	
13	Charging line isolation check valve [CVS-VLV-160]	RAW(L1, L2, LP)	EL, PR	
14	Charging line boundary isolation check valve [CVS-VLV-161]	RAW(L1, L2, LP)	EL, PR	
15	RCP seal water injection line boundary isolation check valves [CVS-VLV-182A (B, C, D)]	RAW(L1, L2, FR1, FR2)	EL, OD, PR	
16	RCP seal water injection line secondary isolation check valves [CVS-VLV-181A (B, C, D)]	RAW(L1, L2 ,FR1, FR2)	EL, OD, PR	
17	RCP seal water injection line third isolation check valves [CVS-VLV-179A (B, C ,D)]	RAW(L1, L2, FR1, FR2)	EL, OD, PR	
18	Charging line containment isolation motor operated valve [CVS-MOV-152]	RAW(L1, L2, LP)	CM, EL, PR	

Table 17.4-1 Risk-significant SSCs (Sheet 4 of 51)

#	Systems, Structures and Components (SSCs)	Rationale[1]	Failure Mode[2]	Insights and Assumptions
19	Charging line containment isolation motor operated valve [CVS-MOV-151]	RAW(L1, L2, LP)	CM, EL, PR	The "Insights and Assumptions" for these SSCs are described on the previous page.
20	RCP seal water injection line containment isolation motor operated valves [CVS-MOV-178A (B, C, D)]	RAW(L1, L2)	CM, EL, PR	
21	Charging line orifice [CVS-FE-048]	RAW(LP, FR1, FR2)	PR	
22	Charging flow control orifice [CVS-SRO-003]	RAW(LP)	PR	
23	RCP seal water injection line orifices [CVS-FE-060 (070, 080, 090)]	RAW(L1, L2, LP, FR1, FR2)	PR	
24	Regenerative heat exchanger [CVS-MHX-001]	RAW(L1, L2, LP)	EL	
25	Charging pump minimum flow line manual valves [CVS-VLV-130A (B)]	RAW(L1, L2, LP)	EL, PR	
26	Charging pump discharge line manual valves [CVS-VLV-132A (B)]	RAW(L1, L2, LP)	EL, PR	
27	Charging pump discharge line cross tie- line manual valve [CVS-VLV-133]	RAW(L1, L2, LP)	EL, PR	
28	Charging pump suction line manual valves [CVS-VLV-126A (B)]	RAW(L1, L2, LP)	EL, PR	
29	Charging line manual valves [CVS-VLV-145] [CVS-VLV-147]	RAW(L1, L2, LP)	EL, PR	
30	Charging line by-pass line manual valve [CVS-VLV-144]	RAW(L1, L2, LP)	EL	

Table 17.4-1 Risk-significant SSCs (Sheet 5 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
31	RCP seal water injection line manual valves [CVS-VLV-164] [CVS-VLV-166] [CVS-VLV-168] [CVS-VLV-170A(B)] [CVS-VLV-171A(B)] [CVS-VLV-173]	RAW(L1, L2, LP)	EL, PR	The "Insights and Assumptions" for these SSCs are described on the previous page.
32	RCP seal water injection line filters [CVS-MFT-003A(B)]	RAW(L1, L2) EJ*2	PR	
33	RCP seal water injection by-pass line manual valve [CVS-VLV-163]	RAW(L1, L2, LP)	EL	
34	RCP seal water injection line manual valves [CVS-VLV-180A (B, C, D)]	RAW(L1, L2)	EL, PR	
35	RCP seal water injection line needle valves [CVS-VLV-177A (B, C, D)]	RAW(L1, L2)	EL, PR	
36	Low-pressure letdown line air operated valve [CVS-HCV-012]	RAW(LP)	EL, CD	
37	Charging pump minimum flow orifice [CVS-SRO-002A (B)]	RAW(LP)	PR	
38	Seal water line manual valve [CVS-VLV-167]	RAW(L1, L2, LP)	EL	
39	RWSAT outlet check valve [CVS-VLV-592]	RAW(LP)	EL, PR, OD	
40	SFP outlet check valve [CVS-VLV-594]	RAW(LP)	EL	
41	Volume control tank [CVS-MTK-001]	RAW(L1, L2)	EL	
42	Piping (CVS charging injection line piping between RWSAT and CVS-VLV-595)	RAW(L1, L2, LP)	EL	

Table 17.4-1 Risk-significant SSCs (Sheet 6 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
3	Component cooling water system (CCWS)			
1	CCW pump discharge line check valves [NCS-VLV-016A (B, C, D)]	RAW(L1, L1-CC, L2, L2-CC, LP, LP-CC, FL1, FL1-CC, FL2, FR1, FR1-CC, FR2)	EL, PR, OD	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. 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. SSCs that have either of the following characteristics are risk significant. - 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. - 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	Component cooling water pumps [NCS-MPP-001A (B, C, D)]	FV(L1-CC, L2-CC, LP- CC, FL1, FL2, RF2-SUM) RAW(L1, L1-CC, L2, L2-CC, LP, LP-CC, FL1, FL1-CC, FL2-CC, FL2, FR1, FR1-CC, FR2, FR2-CC,) SM	BD, YR, EL, SS, FS	
3	Component cooling water heat exchangers [NCS-MHX-001A (B, C, D)]	RAW(L1, L1-CC, L2, L2-CC, LP, LP-CC, FL1, FL1-CC, FL2, FL2-CC, FR1-CC, FR2, FR2-CC) SM	PR, EL, SS	
4	CCW pump discharge cross tie-line motor operated valves [NCS-MOV-020A (B, C, D)]	RAW(L1- CC, L2, L2-CC, LP, FL1, FL1-CC, FL2, FL2-CC, FR1-CC, FR2-CC)	CD, EL, OD	
5	CCW pump suction line cross tie-line motor operated valves [NCS-MOV-007A (B, C, D)]	RAW(L1-CC, L2, L2-CC, LP, FL1, FL1-CC, FL2, FL2-CC, FR1-CC, FR2-CC)	CD, EL, OD	
6	CCW surge tank outlet manual valves [NCS-VLV-005A (B, C, D)]	EJ RAW(L1,L2, LP, FL1,FL2, FR1, FR2)	PR, EL	
7	CCW pump inlet manual valves [NCS-VLV-008 A (B, C, D)]	RAW(L1, L2, LP, FL1, FL2, FR1, FR2)	PR, EL	
8	CCW heat exchanger outlet manual valves [NCS-VLV-018 A (B, C D)]	RAW(L1, L2, LP, FL1, FL2, FR1, FR2)	PR, EL	

Table 17.4-1 Risk-significant SSCs (Sheet 7 of 51)

#	Systems, Structures and Components (SSCs)	Rationale[1]	Failure Mode[2]	Insights and Assumptions
9	CCW pump motor inlet manual valves [NCS-VLV-101 A (B, C, D)]	RAW(L1,L2, LP FL1,FL2, FR1, FR2)	PR, EL	These valves are used (opened) to provide alternative CCW from the fire protection water supply 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.
10	CCW pump motor outlet manual valves [NCS-VLV-104 A (B, C, D)]	RAW(L1, L2, LP FL1, FL2, FR1, FR2)	PR, EL	
11	A-A(B-B,C-C,D-D) supply header flow meter orifices [NCS-FE-034 (035, 037, 038)]	RAW(L1, L2, LP, FL1, FL2, FR1, FR2)	PR	
12	A-A(B-B,C-C,D-D) CCW pump cooling line flow meter orifice [NCS-FE-040 (041, 042, 043)]	RAW(L1, L2, LP, FL1, FL2, FR1, FR2)	PR	
13	Safety injection pump motor outlet manual valves [NCS-VLV-114A (B, C, D)]	RAW(L1, L2, LP, FR1, FL1)	PR, EL	
14	Safety injection oil cooler outlet manual valves [NCS-VLV-115A (B, C, D)]	RAW(L1, L2, LP, FR1, FL1)	PR, EL	
15	Safety injection pump outlet manual valves [NCS-VLV-116A (B, C, D)]	RAW(L1, L2, LP, FR1, FL1)	PR, EL	
16	Safety injection pump outlet manual valves [NCS-VLV-119A (B, C, D)]	RAW(L1, L2, LP, FR1, FL1)	PR, EL	
17	Safety injection pump outlet flow meter orifices [NCS-FE-080 (081, 082, 083)]	RAW(FR1, FL1)	PR	
18	Safety injection pump motor outlet flow meter orifices [NCS-FE-084 (085, 086, 087)]	RAW(FR1, FL1)	PR	
19	Safety injection pump inlet manual valves [NCS-VLV-111 A (B, C, D)]	RAW(L1, L2, LP, FR1, FL1)	PR, EL	

Table 17.4-1 Risk-significant SSCs (Sheet 8 of 51)

#	Systems, Structures and Components (SSCs)	Rationale[(1)]	Failure Mode[(2)]	Insights and Assumptions
20	CS/RHR heat exchanger discharge line motor operated valves [NCS-MOV-145A (B, C, D)]	FV(L1-CC, L2-CC, FL1, FL1-CC, FL2, FL2-CC, FR1-CC, FR2, FR2-CC) RAW(L1-CC, L2, L2-CC, LP, LP-CC, FL1, FL1-CC, FR1-CC, FL2, FL2-CC, FR1, FR2, FR2-CC) LP / SM	EL, CD, CM, OD, OM, PR, FS	The "Insights and Assumptions" for these SSCs are described on the previous page.
21	CS/RHR pump outlet manual valves [NCS-VLV-131A (B, C, D)]	RAW(L2, LP, FL1, FL2, FR1, FR2)	EL, PR	
22	CS/RHR pump motor outlet manual valves [NCS-VLV-128A (B, C, D)]	RAW(L2, LP, FL1, FL2, FR1, FR2)	EL, PR	
23	CS/RHR pump outlet flow meter orifices [NCS-FE-056 (057, 058, 059)]	RAW(L2, LP , FL1, FL2, FR1, FR2)	PR	
24	CS/RHR pump motor outlet flow meter orifices [NCS-FE-060 (061, 062, 063)]	RAW(L2, LP , FL1, FL2, FR1, FR2)	PR	
25	CS/RHR pump inlet manual valves [NCS-VLV-125A (B, C, D)]	RAW(L2, LP, FL1, FL2, FR1, FR2)	EL, PR	
26	CS/RHR heat exchanger inlet manual valves [NCS-VLV-141A (B, C ,D)]	RAW(L2, LP , FL1, FL2, FR1, FR2)	EL, PR	
27	CS/RHR heat exchanger outlet flow meter orifices [NCS-FE-052 (053, 054, 055)]	RAW(L2, LP, FL1, FL2, FR1, FR2)	PR	
28	CS/RHR heat exchanger outlet manual valves [NCS-VLV-144A (B, C, D)]	RAW(L2, LP, FL1, FL2, FR1, FR2)	EL, PR	
29	Charging injection pump cooling line check valves [NCS-VLV-306A (B)]	RAW(L1, L1-CC, L2, L2-CC, LP, FR1-CC, FR2-CC)	CD, EL, IL, PR, OD	
30	Charging injection pump cooling line motor operated valves [NCS-MOV-316A (B)]	FV(LP) RAW(L1, L1-CC, L2, L2-CC, LP)	CD, CM, EL, PR, IL, OM	

Table 17.4-1 Risk-significant SSCs (Sheet 9 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
31	Charging injection seal water heat exchanger inlet manual valves [NCS-VLV-311A (B)]	RAW(LP)	EL, PR	The "Insights and Assumptions" for these SSCs are described on the previous page.
32	Charging injection oil cooler inlet manual valves [NCS-VLV-312A (B)]	RAW(LP)	EL, PR	
33	Charging injection pump motor inlet manual valves [NCS-VLV-301A (B)]	RAW(LP)	EL, PR	
34	Charging injection pump motor line manual valves [NCS-VLV-315A (B)]	RAW(LP)	EL, PR	
35	Charging injection pump motor line flow meter orifices [NCS-FE-076 (077)]	RAW(LP) EJ*2	PR	
36	Charging injection oil cooler line flow meter orifices [NCS-FE-070 (071)]	RAW(LP) EJ*2	PR	
37	CCWS - RWSP line boundary check valves [NCS-VLV-065A (B)]	RAW(L1, L2, LP, FL1, FR1, FR2)	EL	
38	CCWS - RWSP line boundary manual valves [NCS-VLV-066A (B)]	RAW/(L1, L2, LP, FL1, FR1, FR2)	EL	
39	AB(CD) Supply header flow meter orifices [NCS-FE-036 (039)]	RAW(LP)	PR	
40	A2(C2) Supply header line manual valves [NCS-VLV-033A (B)]	RAW(LP)	EL, PR	
41	A2(C2) Return header line manual valves [NCS-VLV-034A (B)]	RAW(LP)	EL, PR	
42	B-CCW Surge tank nitrogen supply line stop valve [NCS-PCV-022]	FV(L2) RAW/(L2)	CM, EL, OD, PR	

Table 17.4-1 Risk-significant SSCs (Sheet 10 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
43	B-CCW Surge tank vent valves [NCS-RCV-056B]	RAW/(L2)	EL, IL, OM	The "Insights and Assumptions" for these SSCs are described on the previous page.
44	B-Component cooling water surge tank [NCS-MTK-001B]	RAW/(L2) SM	EL, SS, IL, OM	
45	B-CCW Surge tank safety valve [NCS-SRV-003B]	RAW/(L2)	OM	
46	B-CCW Surge tank nitrogen supply stop bypass valve [NCS-VLV-045B]	RAW/(L2)	EL	
47	Charging pump alternate CCW supply line valves [NCS-MOV-322A (B)]	FV(LP) RAW/(L1, L1-CC, L2, L2-CC, LP)	EL, OD, CM, PR	
48	Charging pump alternate CCW return line valves [NCS-MOV-324A (B)]	FV(LP) RAW/(L1, L1-CC, L2, L2-CC, LP)	CM, EL, OD, PR	
49	Piping (Fire service water tank line Piping, Alternate charging pump cooling suction line piping, Alternate charging pump cooling discharge line piping, CCW surge tank line piping, CCWS train piping, CCWS heater piping)	RAW(L1, L2, LP, FL1) SM	EL, IL	
50	FSS - CCWS boundary motor operated valves [NCS-MOV-321A (B)] [NCS-MOV-325A (B)]	FV(LP) RAW(L1, L1-CC, L2, LP)	CM, EL, OD, PR	Large external leak from these valves result in loss of alternative component cooling water from both non-essential chilled water system and fire protection water supply system. On the other hand, external leak from other SSCs degrade the fire protection water supply 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.
51	CCWS - non-essential chilled water system boundary motor operated valves [NCS-MOV-323A (B)] [NCS-MOV-326A (B)]	RAW(L1, L2, LP)	EL, IL	

Table 17.4-1 Risk-significant SSCs (Sheet 11 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
4	**Containment system**			
1	Containment vessel(PCCV)	EJ SM	SS	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. Hydrogen ignition system are provided for protection against possible detonation following a core damage accident to meet the requirement of 10 CFR 50.34(f) and 10 CFR 50.44(c).
2	Hydrogen igniters	EJ	SR	
3	Interior containment structure	SM	SS	
4	Equipment hatches	SM	SS	
5	**Containment isolation system**			
1	Instrument air system motor operated and check valves [IAS-MOV-002], [IAS-VLV-003]	RAW(L2,FR2), SM	CD, IL, FS	In the case of core damage accident, the containment isolation valve is important to prevent radionuclide releases to the environment.
2	RCP seal water return line : C/V isolation valves [CVS-MOV-203], [CVS-MOV-204]	RAW(L2-CC, FL2-CC, FR2-CC) SM	CD, FS	
3	RCP seal water return line C/V isolation system piping	SM	SS	
4	C/V sump pump outlet pipe line C/V isolation system piping	SM	SS	
5	Instrument air pipe C/V isolation system piping	SM	SS	
6	C/V clean up pipe line C/V isolation system piping	SM	SS	

Table 17.4-1 Risk-significant SSCs (Sheet 12 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
6	Emergency feedwater system (EFWS)			
1	EFW pit discharge line check valves [EFS-VLV-008A (B)]	FV(FR2-CC) RAW(L1, L1-CC, L2, L2-CC, FL1, FL1-CC, FR1, FR1-CC, FL2, FL2-CC, FR2, FR2-CC) LP	EL, OD, PR	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. 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. SSCs that have either of the following characteristics are risk significant. - 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. - 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	Turbine driven emergency feedwater pump actuation valves [EFS-MOV-103A (D)]	FV(FR2) RAW(L1, L1-CC, L2, L2-CC FL1, FL1-CC, FR1, FR1-CC, FL2, FL2-CC, FR2, FR2-CC LP	CM, EL, OD, PR	
3	Motor driven emergency feedwater pumps [EFS-MPP-001B (C)]	FV(FL2) RAW(L1-CC, L2-CC, FL1, FL1-CC, FR1, FR1-CC, FL2, FL2-CC, FR2, FR2-CC) LP SM	AD, EL, LR, SR, FS	
4	Turbine driven emergency feedwater pumps [EFS-MPP-001A (D)]	FV(L1, L1-CC, L2, L2- CC, L2-SUM, FL1, FR1, FR1-SUM, FL2 ,FR2, FR2-CC) RAW(L1, L1-CC, L2, L2-CC, FL1, FL1-CC, FR1, FR1-CC, FL2, FR2, FR2-CC) LP SM	AD, EL, LR, SR, FS	
5	Feedwater line check valves [EFS-VLV-018A (B, C, D)]	FV(FR2-CC) RAW(L1, L1-CC, L2, L2-CC, FL1, FL1-CC, FR1, FR1-CC, FL2, FL2-CC, FR2, FR2-CC) LP	EL, OD, PR	

Table 17.4-1 Risk-significant SSCs (Sheet 13 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
6	EFW pump discharge line check valves [EFS-VLV-012A (B, C, D)]	FV(FR2-CC) RAW(L1, L1-CC, L2, L2-CC, FL1, FL1-CC, FR1, FR1-CC, FL2, FL2-CC, FR2, FR2-CC) LP	EL, OD, PR	The "Insights and Assumptions" for these SSCs are described on the previous page.
7	Minimum/Full flow line check valves [EFS-VLV-020A (B, C D)] [EFS-VLV-022A (B, C, D)]	RAW(L1, L2, FL1) LP	EL	
8	Minimum/Full flow line manual valves [EFS-VLV-021A (B, C, D)] [EFS-VLV-023A (B, C, D)]	RAW(L1, L2 , FL1, FR1, FR2) LP	EL, IL	
9	Emergency feedwater control valves [EFS-MOV-017A (B, C, D))	FV(FL1-SUM, FR1-SUM, FR2-SUM) RAW(L1, L1-CC, L2, L2- CC, FL1, FL1-CC, FR1, FR1-CC, FL2, FR2, FR2-CC) LP	CM, IL, PR. EL, FC	
10	Emergency feedwater isolation valves [EFS-MOV-019A (B, C, D)]	RAW(L1, L2, FL1, FR1, FL2, FR2)	CM, PR, EL	
11	Emergency feedwater line orifices [EFS-FE-016 (026, 036, 046)]	RAW (FL1, FR1, FL2, FR2)	PR	
12	Emergency feedwater line tie-line valves [EFS-MOV-014A (B, C, D)]	RAW(L1, L2, L2-CC, FL1, FL2, FR1, FR1-CC, FR2, FR2-CC)	OD, EL	
13	EFW system pipng (EFW pit discharge line piping, EFW pit discharge line tie-line piping, A~D-emergency feedwater line piping, Minimum/Full flow line piping)	RAW(L1, L2, LP, FL1) SM	EL, SS	
14	T/D EFW pump steam supply line piping	RAW(L1,L2, FL1)/LP/SM	EL, SS	

Table 17.4-1 Risk-significant SSCs (Sheet 14 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
15	Emergency feedwater pits [EFS-MPT-001A (B)]	RAW(L1, L2, FL1, FR1, FR2) LP / SM	EL, SS	The "Insights and Assumptions" for these SSCs are described on the previous page.
16	Minimum/Full flow line manual valves [EFS-VLV-026A (B)]	RAW(L1, L2, FL1, FR1, FR2) LP	EL	
17	EFW pump suction line manual valves [EFS-VLV-009A (B, C, D)]	RAW(L1, L2, FL1, FR1, FR2) LP	EL, PR	
18	EFW pump discharge line manual valves [EFS-VLV-013A (B, C, D)]	RAW(L1, L2, FL1, FR1, FR2) LP	EL, PR	
19	EFW pit discharge line manual valves [EFS-VLV-007A (B)]	FV(FL1, FL2, FR2-SUM) RAW(L1, L2, FL1, FL2, FR1, FR2)	CD, EL, PR	
20	Secondary demineralizer water tank discharge line manual valves [EFS-VLV-006A (B)]	FV(FL1, FL2, FR2-SUM) RAW(L1, L2, FL1, FL2, FR1, FR2) LP	EL, OD,PR	
21	Secondary demineralizer water tank discharge line check valve [EFS-VLV-005]	RAW(L1, L2, FL1)	EL, OD,PR	
22	Secondary demineralizer water tank discharge line manual valve [EFS-VLV-004]	FV(FL1) RAW(FL1, FL2)	EL, OD,PR	
23	Turbine driven pump steam supply line check valves [EFS-VLV-102A (B, C, D)]	SM	FS	
24	Emergency feedwater pump actuation cabinets	SM	FS	
25	Turbine driven EFW pump steam supply line motor-operated valves [EFS-MOV-101A (B, C, D,)]	EJ	CM, EL, PR	

Table 17.4-1 Risk-significant SSCs (Sheet 15 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
7	Emergency power source (EPS)			
1	Class 1E 480V motor control centers (MCC) [MCC-A (B, C, D)], [MCC-A1 (D1)]	RAW(L1, L2, LP, FL1, FR1, FL2, FR2) LP SM	FF,SS	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. 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	Class 1E 480V load centers [LC-A (B, C, D)], [LC-A1 (D1)]	RAW(L1, L2, LP, FL1, FR1, FL2, FR2) LP SM	FF,SS	
3	Class 1E 6.9kV switchgears [MC-A (B, C, D)]	RAW(L1, L2, LP, FL1, FR1, FL2, FR2) EJ / LP / SM	FF, SS	
4	Class 1E DC switchboards [DCC-A (B, C, D)], [DCC-A1 (D1)]	RAW (L1, L2, LP, FL1, FR1, FL2, FR2)	FF	
5	Class 1E AC 120V panelboards [IBD-A (B, C, D)]	RAW(L1, L2, FL1, FR1, FL2, FR2) SM	FF, FS	
6	Circuit breakers between Class 1E 480V load centers A, B (C, D) and A1(D1) [52/LLAA, LLBB, LLDA, LLBA] [52/LLBC, LLAD, LLBD, LLDD]	RAW(L1-CC, L2, L2-CC, LP-CC, FL1, FL1-CC, FR1, FR1-CC, FL2, FL2-CC, FR2, FR2-CC)	SO	
7	Class 1E Batteries [BAT-A (B, C, D)]	RAW(L1-CC, L2-CC, LP-CC ,FL1, FL1-CC, FR1, FR1-CC, FL2, FL2-CC, FR2, FR2-CC) LP	FF, SO	
8	Class 1E Battery chargers [BCP-A (B, C, D)]	RAW(FL1) SM	FF, WR, SS	

Table 17.4-1 Risk-significant SSCs (Sheet 16 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
9	Class 1E 6.9kV bus incoming circuit breakers from reserve auxiliary transformer [52/RATA (B, C, D)]	FV(L1-CC, L2-CC, LP-CC, LP-SUM, FL2, FR1-SUM) RAW(L1, L1-CC, L2, L2-CC,LP, LP-CC, FL1, FL1-CC, FR1-CC, FL2, FL2-CC, FR2-CC)	SC, FO	The "Insights and Assumptions" for these SSCs are described on the previous page.
10	Class 1E Gas turbine discharge circuit breakers [52/EPSA (B, C, D)]	FV(L1-SUM,FR) RAW(L1-CC, L2, L2-CC, LP, LP-CC, FL1-CC, FR1-CC, FL2-CC, FR2-CC)	FC, FO, SC, SO	
11	Circuit breakers between Class 1E 6.9kV switchgear and Class 1E station service transformer [52/STHA (B, C, D)]	FV(L2-CC) RAW(L1, L1-CC, L2, L2-CC, LP, LP-CC, FL1, FL1-CC, FR1, FR1-CC, FL2, FL2-CC, FR2, FR2-CC)	SO	
12	Circuit breakers between Class 1E 480V load center and MCC [52/LCA (B, C, D), LCA1 (LCD1)]	FV(L2-CC) RAW(L1, L1-CC,L2, L2-CC, LP, LP-CC, FL1, FL1-CC, FR1, FR1-CC, FL2, FL2-CC, FR2, FR2-CC)	SO	
13	Circuit breakers between DC switchboard and MOV Inverter [72/DUA1 (DUB, DUC, DUD1)]	RAW(L2-CC, FR2) LP	SO	
14	Circuit breakers between Class 1E 480V MCC and battery charger [52/DCA (B, C, D)]	RAW(FL1)	WR	

Table 17.4-1 Risk-significant SSCs (Sheet 17 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
15	Class 1E gas turbine generators [A (B, C, D)-EGTG]	FV(L1,L1-CC,L1-SUM, L2, L2-CC, L2-SUM, LP, LP-CC, FL1, FL1-SUM, FR1, FR1-CC, FL2, FL2-CC, FR2, FR2-CC,) RAW(L1-CC, L2-CC, LP-CC, FL1-CC, FR1-CC, FL2, FL2-CC, FR2-CC) LP	AD, LR, SR	The “Insights and Assumptions” for these SSCs are described on the previous page.

Table 17.4-1 Risk-significant SSCs (Sheet 18 of 51)

#	Systems, Structures and Components (SSCs)	Rationale[1]	Failure Mode[2]	Insights and Assumptions
16	Class 1E gas turbines generator sequencers [EPBA (B, C, D)]	FV(L1-CC, L2-CC, L2-SUM, FL2-SUM, FR1, FR1-CC) RAW(L1-CC, L2-CC, LP-CC, FL1-CC, FR1, FR1-CC, FL2, FL2-CC, FR2-CC) LP	FF	The "Insights and Assumptions" for these SSCs are described on the previous page.
17	MOV Inverters [MVIA1, MVIA2, MVIB, MVIC, MVID1, MVID2]	RAW(L1-CC, L2-CC, FL1, FL1-CC, FL2, FL2-CC, FR1-CC, FR2, FR2-CC)/ LP / SM	FF	
18	Main transformers [MT]	RAW(L2, FL1, FL2)	FF	
19	Reserve auxiliary transformer 3 and 4 [RAT3(4)]	RAW(L2, FL1, FL2, PL)	FF	
20	Class 1E station service transformers [STA (B, C, D)]	RAW(L1, L2, PL, FL1, FR1, FL2, FR2) / LP	FF	
21	Circuit breakers between AAC and Class 1E 6.9kV switchgear [52/AACA (B, C, D)]	RAW(L1, L1-CC, L2, L2-CC, LP, LP-CC, FR1-CC, FR2-CC)	FC, SO	
22	Circuit breakers between Class 1E 480V load center A1 (D1) and MCC A1 (D1) [52/LCA1 (D1)]	RAW(L1, L1-CC, L2, L2-CC, LP-CC, FL1, FL1-CC, FL2, FL2-CC, FR1, FR1-CC, FR2, FR2-CC)	SO	
23	Circuit breakers between Class 1E 480V load center and Class 1E station service transformer [52/STLA (B, C, D)]	FV(L2-CC) RAW(L1, L1-CC, L2, L2-CC,LP, LP-CC, FL1, FL1-CC, FL2, FL2-CC, FR1, FR1-CC, FR2, FR2-CC)	SO	
24	Circuit breakers between Class 1E UPS unit and Class 1E AC 120V panelboard [52/UAA (B, C,D)]	RAW(L1-CC, L2-CC, LP-CC, FR1-CC)	SO	

Table 17.4-1 Risk-significant SSCs (Sheet 19 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
25	Circuit breakers between unit auxiliary transformer and Class 1E 6.9 kV switchgear [52/UATA (B, C, D)]	FV(L1-CC, L2-CC, LP-CC, LP-SUM, FL2, FR1-SUM) RAW(L1, L1-CC, L2, L2-CC,LP, LP-CC, FL1, FL1-CC, FR1-CC, FL2, FL2-CC, FR2-CC)	FO,SC	The "Insights and Assumptions" for these SSCs are described on the previous page.
26	Circuit breakers between Class 1E DC switchboard and Class 1E UPS unit [72/AUA (B, C, D)]	RAW(L1-CC, L2-CC, LP-CC, FR1-CC)	SO	
27	Circuit breakers between Class 1E battery and Class 1E DC switchboard [72/DBA (B, C, D)]	RAW(L1-CC, L2-CC, LP-CC, FL1, FR1, FR1-CC, FL2, FR2, FR2-CC)	SO	
28	Circuit breakers between Class 1E DC switchboard and DC Switchboard A1 (D1) [72/DDAA (DDBB, DDBC, DDAD)] [72/DDDA (DDBA, DDBD, DDDD)]	RAW(L1-CC, L2, L2-CC, LP, LP-CC, FL1, FL1-CC, FR2)	SO	
29	Class 1E UPS Units [IBC-A (B, C, D)]	RAW(L1-CC, L2-CC, LP-CC, FL2-CC, FR1-CC, FR2-CC) SM	FF	
30	Class 1E Gas turbine generators control centers	SM	FS, SS	
31	Class 1E I&C power transformers [IBB-A (B, C, D)]	SM	SS, FF	
32	Cable trays (safety related SSCs)	SM	FS	
33	Switches between Class 1E MOV 480V MCC and MOV inverter	RAW(L2-CC)	FF	
34	Breakers between Class 1E 480V MCC and switch	RAW(L2-CC)	SO	
35	Class 1E MOV 480V MCC [MVCA1, MVCA2, MVCB, MVCC, MVCD1, MVCD2]	Raw(L1, L2, FL1, FL2, FR1, FR2)	FF	

Table 17.4-1 Risk-significant SSCs (Sheet 20 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
36	Breakers between Class 1E DC switchboard and MOV inverters [DUA1, DUD1]	RAW(L2-CC)	SO	

Table 17.4-1 Risk-significant SSCs (Sheet 21 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
8	Alternative AC power sources (Permanent bus)			
1	Non-Class 1E gas turbine generators (AAC) [ACC-A(B)]	FV(L1, L1-CC, L2, L2-CC, LP, LP-CC, FL1-SUM, FR1, FR1-CC, FR1-SUM, FR2, FR2-CC, FL2) RAW(L1-CC, L2, L2-CC, LP, LP-CC, FR1-CC, FR2-CC, FL2, FL2-CC) LP	AD, SR, LR	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. SSCs that have potential to cause failures that degrade the availability to supply AAC power to safety medium voltage are risk significant. Systems for the mitigation of core damage accident are connected to permanent bus.
2	P1, P2 Non-Class 1E 480V load center [LC-P1 (P2)]	RAW(L2)	FF	
3	P1, P2 Non-Class 1E 6.9kV switchgears [MC-P1 (P2)]	RAW(L2)	FF	
4	Circuit breakers between P1 (P2) Non-Class 1E 6.9kV switchgear and station service transformer [52/STHP1 (2)]	RAW(L2, L2-CC, FL1, FR1, FR2)	SO, WR	
5	N1, N2 Non-Class 1E batteries [BAT-N1(N2)]	RAW(FR1-CC) LP	FF,	
6	Circuit breakers between Non-class 1E gas turbine generator (AAC) and P1 (P2) Non-Class 1E 6.9kV switchgear [52/AACP1 (2)]	RAW(FR1-CC, FR2-CC) LP	TD	
7	Circuit breakers between Non-Class 1E gas turbine generator (AAC) and selector switch [52/AACAP (52/AACBP)]	RAW(L1-CC, L2, L2-CC, LP, LP-CC, FR1-CC,FR2-CC) LP	FC, SO	
8	Non-Class 1E gas turbine generators (AAC) sequencers [AAS-A (B)]	FV(L2, LP) RAW(L1-CC, L2, L2-CC, LP, LP-CC, FL2, FR1-CC, FR2-CC)	FF	
9	P1, P2 Non-Class 1E station service transformers [STP1 (2)]	RAW(L2, L2-CC) LP	FF, SO	

Table 17.4-1 Risk-significant SSCs (Sheet 22 of 51)

#	Systems, Structures and Components (SSCs)	Rationale[1]	Failure Mode[2]	Insights and Assumptions
10	P11, P12, P21, P22 Non-Class 1E 480V MCC [MCC-P11 (P12, P21, P22)]	RAW(L2)	FF	The "Insights and Assumptions" for these SSCs are described on the previous page.
11	Circuit breakers between P1(P2) Non-Class 1E 480V load center and MCC [52/LCP11 (LCP12, LCP21, LCP22)]	RAW(L2, L2-CC)	SO	
12	Circuit breakers between P1(P2) Non-Class 1E 480V load center and Non-Class 1E station service transformer [52/STLP1 (LP2)]	RAW(L2, L2-CC)	SO	
13	AAC selector switches [89/AACA (B, C, D)]	RAW(L1, L1-CC, L2, L2-CC, LP, LP-CC, FR1-CC, FR2-CC)	FC, SO	

Table 17.4-1 Risk-significant SSCs (Sheet 23 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
9	**Non-essential chilled water system**			
1	Non-essential chilled water system -CCWS boundary motor operated valves [VWS-MOV-424] [VWS-MOV-425]	FV(L2) RAW(L2) LP	CM, EL, OD, PR	In the case of loss of component cooling water events, non-essential chilled water system or fire protection water supply system provides alternative component cooling water to charging pumps in order maintain RCP seal water injection. 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 protection water supply system. On the other hand, failure of other SSCs of this system affects only the non-essential chilled water system itself.
2	Containment fan cooler unit supply line changeover valve [VWS-MOV-401] [VWS-MOV-409]	RAW(L2)	EL	
3	Containment fan cooler unit containment isolation valves [VWS-MOV-403] [VWS-MOV-407] [VWS-MOV-422]	FV(L2) RAW(L2)	CM,EL,OD,PR	
4	Containment fan cooler unit cooling coil inlet valve [VWS-MOV-411A (B,C,D)]	FV(L2) RAW(L2, L2-CC)	CM, EL, OD, PR	
5	CRDM cooling unit cooling coil inlet valve [VWS-MOV-414]	FV(L2) RAW(L2)	CD, EL, IL, OM	
6	Containment fan cooler unit line piping	RAW(L2)	EL	
7	Containment fan cooler unit outlet air operated valves [VWS-TCV-041A (B), 042A (B)]	RAW(L2)	CM, EL, PR	
8	Containment fan cooler unit outlet manual valves [VWS-VLV-412A (B,C,D)]	RAW(L2)	EL, PR	

Table 17.4-1 Risk-significant SSCs (Sheet 24 of 51)

#	Systems, Structures and Components (SSCs)	Rationale[1]	Failure Mode[2]	Insights and Assumptions
9	Containment fan cooler unit bypass line valves [VWS-VLV-413A (B,C,D)]	RAW(L2)	EL	The "Insights and Assumptions" for these SSCs are described on the previous page.
10	CRDM cooling unit outlet valve [VWS-VLV-415]	RAW(L2)	EL	
11	Containment fan cooler unit supply line check valve [VWS-VLV-421]	RAW(L2)	EL, OD, PR	
12	Containment fan cooler unit return line check valve [VWS-VLV-423]	RAW(L2)	EL	

Table 17.4-1 Risk-significant SSCs (Sheet 25 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
10	**Fire protection water supply system (FSS)**			
1	FSS pump discharge motor operated valve	FV(L2) RAW(L2)	EL, OD, PR	In the case of core damage accident, fire protection water supply system (FSS) injects water from Raw Water Tank into the reactor cavity via the direct injection line by the fire water pumps. 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 FSS performs as alternative function for the reactor cavity flooding. In the case of loss of component cooling water events, FSS 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	RAW(L2)	FF, PR	
3	Reactor cavity injection line orifice	RAW(L2)	PR	
4	FSS piping (from tank to tie line piping, from tie line to CSS-VLV-012 piping, from FWT to tie line)	RAW(L2)	EL	
5	Fire suppression water tank	RAW(L1, L2)	EL	
6	FSS pump discharge manual valve	RAW(L2, LP)	EL,PR	
7	Motor driven fire suppression pump	EP	BD, YR, EL	
8	Diesel driven fire suppression pump	EP	BD, YR, EL	
9	Reactor cavity injection line motor operated valve [FSS-MOV-004]	EJ	EL, OD, PR	
10	Reactor cavity injection line check valve [FSS-VLV-006]	EJ	EL, OD, PR	
11	Reactor cavity injection line orifice	EJ	PR	

Table 17.4-1 Risk-significant SSCs (Sheet 26 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
11	**High head safety injection system**			
1	Safety injection pump discharge check valves [SIS-VLV-004A (B, C, D)]	RAW(L1, L1-CC, L2, L2-CC, LP, LP-CC, FL1, FL1-CC, FR1, FR1-CC, FL2, FL2-CC, FR2, FR2-CC) SM	EL, OD, PR, FS	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. 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. SSCs that have either of the following characteristics are risk significant. - 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. - 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 [SIS-FE-062 (063, 064, 065)]	RAW(FL1, FR1)	PR	
3	Minimum flow line orifices [SIS-FE-072 (073, 074, 075)]	RAW(FL1, FR1)	PR	
4	Containment isolation check valves [SIS-VLV-010A (B, C, D)]	RAW(L1-CC, L2-CC, LP-CC, FL1, FL1-CC, FR1, FR1-CC, FL2-CC, FR2-CC) SM	OD, EL, PR, FS	
5	Containment isolation motor operated valves [SIS-MOV-011 A(B, C, D)]	RAW(L2, FL1, FR1) FV(FL1)	FF, CM, EL, PR	
6	RV injection line orifices [SIS-SRO-001A (B, C, D)]	RAW(FL1, FR1)	PR	
7	Injection line secondary isolation check valves [SIS-VLV-012A (B,C,D)]	RAW(L1-CC, L2-CC, LP-CC, FL1, FL1-CC, FR1, FR1-CC, FL2-CC, FR2-CC)	OD,EL,PR	
8	Injection line boundary check valves [SIS-VLV-013A (B,C,D)]	RAW(L1-CC, L2-CC, LP-CC, FL1, FL1-CC, FR1, FR1-CC, FL2-CC, FR2-CC)	OD, EL, PR	
9	Safety injection pumps [SIS-MPP-001A (B,C,D)]	FV(L1-CC, FL1, FL1-CC, FR1-CC) RAW(L1, L1-CC, L2, L2-CC, LP, LP-CC, FL1, FL1-CC, FR1, FR1-CC, FL2, FL2-CC, FR2, FR2-CC) SM	AD, EL, LR, SR, FS, SS	

Table 17.4-1 Risk-significant SSCs (Sheet 27 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
10	Containment isolation motor operated valves [SIS-MOV-009A (B,C,D)]	FV(FL1) RAW (L1, L2, LP, LP-CC, FL1, FR1, FR2)	CM, EL, FF, PR	The "Insights and Assumptions" for these SSCs are described on the previous page.
11	Safety injection pump suction Isolation valves [SIS-MOV-001A (B,C,D)]	FV(FL1) RAW(L1, L2, LP-CC, FL1, FR1, FR2, LP)	CM, EL, FF, PR	
12	Piping train A through D Between safety injection pump and SIS-MOV-001A (B, C, D), Safety injection pump discharge Line out of CV, between RWSP and SIS-MOV-001A (B, C, D)	RAW(L1, L2 ,LP, LP-CC, FL1, FR1) SM	EL, SS	
13	Minimum flow line orifices [SIS-SRO-003A (B, C, D)]	RAW(FL1, FR1)	PR	
14	Minimum flow line motor operated valves [SIS-MOV-024 A(B,C,D)]	RAW(FL1)	EL, IL	
15	Minimum flow line manual valves [SIS-VLV-023 A(B,C,D)]	RAW(FL1, FR1)	EL, PR	
16	Hot leg recirculation line isolation valves [SIS-MOV-014 A(B,C,D)]	RAW(FL1)	EL, IL, OM	

Table 17.4-1 Risk-significant SSCs (Sheet 28 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
12	**Heating, ventilation, and air conditioning (HVAC) system**			
1	B,C-Emergency feedwater pump room fans [VRS-MFN-401B, C]	FV(FL1, FR2) RAW(FL1, FL1-CC, FR1, FR1-CC, FR2, FR2- CC), LP	AD, LR, SR	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. HVAC systems of other rooms are considered not to be risk significant for the following reasons. - HVAC of emergency gas turbine room 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. - HVAC of ESF room (RHR/CSS pump, SI pump) According to room temperature analysis, room temperature will not exceeds limit of the system during the mission time regardless of availability of HVAC. - HVAC of class1E electric power room (Class 1E I&C, switch gear, battery, battery charger) 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. - HVAC of EFW T/D pump room 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.
2	B,C-Emergency feedwater pump air handling unit [VRS-MAH-401B, C]	FV(FR1-SUM, FR2) RAW(L1-CC, L2-CC, FL1, FL1-CC, FR1, FR1-CC, FR2, FR2-CC)	AD, LR, SR	

Table 17.4-1 Risk-significant SSCs (Sheet 29 of 51)

#	Systems, Structures and Components (SSCs)	Rationale[1]	Failure Mode[2]	Insights and Assumptions
3	ESW pump room exhaust fans	EJ	LR	Based on the assumption that the ESW pump motors are air-cooled, the ESW pump room ventilation system is included in this table. The ESW pump room ventilation system provides convection air cooling to ESW pump motors in the ESW room.

Table 17.4-1 Risk-significant SSCs (Sheet 30 of 51)

#	Systems, Structures and Components (SSCs)	Rationale[1]	Failure Mode[2]	Insights and Assumptions
13	**Containment fan cooler system**			
1	Containment fan cooler units [VCS-MAH-001A (B,C,D)]	EP RAW(L2)	EL, PR	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 units [VRS-MAH-101A (B,C,D)]	EP	FC	Temperature control of main control room atmosphere is judged important by experts from the viewpoint of operator habitability during an accident.
2	Air conditioner ducts	SM	SS	

Table 17.4-1 Risk-significant SSCs (Sheet 31 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
15	**Instrumentation and control (I&C) system**			
1	Permanent bus low voltage signal software	RAW/CC	FF	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. 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. 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. Reliability of signals other than "S signal" is assumed to have same reliability with "P signal".
2	Black out signal software	RAW(FR1-CC, FR2-CC)	FF	
3	Containment pressure sensors (Safety related) [CSS-PT-010 (011, 012, 013)]	FV(LP, FL2-SUM, FR1, FR2) RAW(L1-CC, L2-CC, FL1-CC, FL2-CC, FR1, FR1-CC, FR2, FR2-CC)	FF	
4	Steam generator water level sensors (Narrow range) [FWS-LT-510 (511, 512, 513, 520, 521, 522, 523, 530, 531, 532, 533, 540, 541, 542, 543)]	EJ*3 FV(L2, FR1) RAW(L1, L1-CC, L2, L2-CC, FL1-CC, FL2-CC, FR1-CC, FR2-CC)	FF	
5	CCW pump breaker position sensing device	EJ*3	FF	
6	Reactor protection system	EJ*3 FV(FL1-CC, FL2-CC, LP, LP-CC) RAW(FL1-CC, FL2-CC, LP-CC) SM	FF, SF, HF, FS	
7	Engineered Safety Features Actuation System	EJ*3 FV(FL1-CC, FL2-CC, LP, LP-CC) RAW(FL1-CC, FL2-CC, LP-CC) SM	FF, SF, HF, FS	
8	Safety Logic System	EJ*3 FV(FL1-CC, FL2-CC, LP, LP-CC) RAW(FL1-CC, FL2-CC, LP-CC) SM	FF, SF, HF, FS	
9	CCW supply header pressure sensor [NCS-PT-030 (031, 032, 033)]	RAW(LP-CC)	FF	

Table 17.4-1 Risk-significant SSCs (Sheet 32 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
10	Pressurizer pressure sensor [RCS-PT-061 (062, 063, 064)]	RAW(L1-CC, L2-CC)	FF	The “Insights and Assumptions” for these SSCs are described on the previous page.
11	CS/RHR header pressure sensor [RHS-PT-011 (021, 031, 041)]	RAW(LP-CC)	FF	
12	Volume control tank water level sensor [CVS-LT-030 (031)]	RAW(LP-CC)	FF	
13	RWSP water level sensor [RWS-LT-010 (011, 012, 013)]	RAW(LP-CC)	FF	
14	RWSAT water level sensor [RWS-LT-020]	RAW(LP. LP-CC)	FF	
15	RCS mid-loop water level sensor (Narrow range) [RCS-LT-014 (015)]	RAW(LP-CC)	FF	
16	RCS mid-loop water level sensor (Middle range) [RCS-LT-012]	RAW(LP, LP-CC)	FF	
17	Containment pressure sensor (non-safety related) [CSS-PT-014]	RAW(L1,L2, FL1, FL2, FR1, FR2)	FF	
18	B-CCW surge tank water pressure transmitter [NCS-PT-022 (023)]	RAW(L2)	FF	
19	EFW pit water level transmitters [EFS-LT-060 (061, 070, 071)]	EJ*2	FF	
20	Ventilation chiller control cabinets	SM	FS	
21	Diverse actuation system	EJ FV(L1, L2, FL1, FL2, FR1, FR2) RAW(L1, L2, FL1, FL2, FR1, FR2)	FF	The unreliability of this system is assumed to be 0.01.

Table 17.4-1 Risk-significant SSCs (Sheet 33 of 51)

#	Systems, Structures and Components (SSCs)	Rationale[(1)]	Failure Mode[(2)]	Insights and Assumptions
22	Reactor coolant hot leg temperature sensor (Wide range) [RCS-TE-020 (030, 040, 050)]	EJ	FF	These sensors are necessary to perform operator action.
23	Reactor coolant cold leg temperature sensor (Wide range) [RCS-TE-025 (035, 045, 055)]	EJ	FF	
24	Reactor coolant pressure sensor [RCS-PT-020 (030, 040, 050)]	EJ	FF	
25	Pressurizer water level sensor [RCS-LT-061 (062, 063, 064, 065)]	EJ	FF	
26	RCS mid-loop water level sensor (Wide range) [RCS-LT-011]	EJ	FF	
27	Boric acid transfer tank water level transmitter [CVS-LT-116, 118]	EJ	FF	
28	Core exit thermocouples	EJ	FF	
16	**Waste management system (WMS)**			
1	Refueling water storage (RWS) system - WMS line boundary check valve [LMS-VLV-037]	RAW(L1, L2, PL, FL1, FR1, FR2)	EL	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	FV(L1)	SR	The Main feedwater system is credited as a function to secondary side cooling during general transients, which does not involve loss of main feedwater.
2	Main feedwater isolation check valves [FWS-VLV-511A (B, C, D)]	SM	FS	
3	Main feedwater isolation valves [FWS-SMV-512A (B, C, D)]	SM	FS	

Table 17.4-1 Risk-significant SSCs (Sheet 34 of 51)

#	Systems, Structures and Components (SSCs)	Rationale[1]	Failure Mode[2]	Insights and Assumptions
18	**Main steam supply system (MSS)**			
1	Main steam isolation valves [MSS-SMV-515A (B,C,D)]	FV(L1-SUM ,FR1, FR1-CC, FR2-CC) RAW(L1-CC, L2, L2-CC, FL1, FL1-CC, FR1, FR1-CC, FR2, FR2-CC)	CD, IL, OM	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. Main steam line piping is required to be intact to isolate the ruptured SG at SGTR events.
2	Main steam bypass isolation valves [MSS-HCV-565 (575, 585,595)]	FV(FR2) RAW(L2, FR1, FR2)	IL, OM	
3	Main steam line piping	RAW(L1, L2) SM	EL, SS	
4	Main steam line isolation check valves [MSS-VLV-516A(B, C, D)]	RAW(L1, FL1)	CD, IL	
5	-Main steam safety valves [MSS-SRV-509A (B, C, D)] [MSS-SRV-510A (B, C, D)] [MSS-SRV-511A (B, C, D)] [MSS-SRV-512A (B, C, D)] [MSS-SRV-513A (B, C, D)] [MSS-SRV-514A (B, C, D)]	RAW(L1, L2)	CD, OM	Main steam safety valves are designed to have different actuation pressure and relieving capacity.
6	A,B,C,D,E,F,G,H,J,K,L,M,N,P,Q-Turbine bypass valves [MSS -TCV-550A(B,C,D,E,F,G,H,J,K, L,M,N, P,Q)]	FV(L1, L2-SUM) RAW(L2)	CD	
7	Main steam relief valve isolation valves [MSS -MOV-507A (B,C,D)]	RAW(L2)	CD	
8	Main steam depressurization valves [MSS -MOV-508A (B,C,D)]	RAW(L2-CC) LP	OD, CD	
9	Main steam relief valves [MSS -PCV-515 (525, 535, 545)]	RAW(L2, L2-CC)	OD, CD	

Table 17.4-1 Risk-significant SSCs (Sheet 35 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
19	**Pressurizer pressure control system part of emergency core cooling system (ECCS)**			
1	Safety depressurization valves [RCS-MOV-117A(B)]	FV(FL1, FL1-CC, FR1, FR1-CC, FL2, FL2-CC, FR2, FR2-CC) RAW(L1-CC, L2-CC, FL1, FL1-CC, FR1, FR1-CC, FL2, FL2-CC, FR2, FR2-CC,)	CM, OD, PR	Safety Depressurization Valves (SDVs) are required to open during bleed and feed operation. 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	Safety depressurization valves [RCS-MOV-116 A(B)]	RAW(FL1, FL2, FR1, FR2)	CM, PR	
3	Pressurizer safety valves [RCS-SRV-120] [RCS-SRV-121] [RCS-SRV-122] [RCS-SRV-123]	RAW(L1, L2, FL1, FL2, FR1, FR2) SM	CD, FS	
4	Pressurizer [RCS-MTK-002]	SM	SS	
5	Pressurizer piping (Pressurizer safety valve piping, Pressurizer safety depressurization valve piping, Pressurizer spray piping)	RAW(L2) SM	SS, EL	
6	Pressurizer spray line vent valve [RCS-VLV-153]	EJ	FC, IL, EL	
20	**Depressurization system for severe accident**			
1	Depressurization valves [RCS-MOV-118] [RCS-MOV-119]	FV(L2)	FC	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 36 of 51)

#	Systems, Structures and Components (SSCs)	Rationale[1]	Failure Mode[2]	Insights and Assumptions
21	**Containment spray / residual heat removal (CS/RHR) system**			
1	Heat exchanger bypass valves [RHS-FCV-021] [RHS-FCV-031]	RAW(L1, L2, LP, FL1, FR1, FR2)	EL, OM	The Containment Spray / Residual Heat Removal (CS/RHR) System consists of four independent trains. The CS/RHR System has the following three functions. a. Containment Spray b. Alternative Core Cooling c. RHR Operation during operating modes 4 , 5 and 6.. 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. SSCs that have either of the following characteristics are risk significant. - 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. - SSCs that have potential to cause loss of RWSP inventory outside 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 [RHS-HCV-023] [RHS-HCV-033]	RAW(L1, L2, LP, FL1, FR1, FR2)	EL, CM, PR	
3	Pump suction line check valves [RHS-VLV-004A (B, C, D)]	RAW(L1, L1-CC, L2, L2-CC, LP, LP-CC, FL1, FL1-CC, FR1, FR1-CC, FL2, FL2-CC, FR2,FR2-CC)	EL,OD,PR	
4	RHR line containment isolation check valves [RHS-VLV-022A (B, C, D)]	RAW(LP, LP-CC)	OD,PR	
5	RHR line containment isolation motor operated valves [RHS-MOV-021A (B, C, D)]	RAW(L1, L2, LP, LP-CC, FL1, FR1, FR2)	CM, PR, OD, EL	

Table 17.4-1 Risk-significant SSCs (Sheet 37 of 51)

#	Systems, Structures and Components (SSCs)	Rationale[1]	Failure Mode[2]	Insights and Assumptions
6	Containment spray/residual heat removal pumps [RHS-MPP-001A (B,C,D)]	FV(L2-CC, FL1, FR1, FL2, FL2-CC, FL2-SUM, FR2, FR2-CC) RAW(L1, L1-CC, L2, L2-CC, LP, LP-CC, FL1, FL1-CC, FR1, FR1- CC, FL2, FL2-CC, FR2, FR2- CC) / SM	AD, LR, SR, EL, SS, FS, YR, BD	
7	CS/RHR pump outlet orifices [RHS-FE-011 (021, 031, 041)]	RAW(L2, LP, FL1, FR1, FL2, FR2)	PR	
8	Containment spray/residual heat removal heat exchangers [RHS-MHX-001A (B, C, D)]	FV(L2-CC, FL) RAW(L1, L1-CC, L2, L2-CC, LP, LP-CC, FL1, FL1-CC, FR1, FR1-CC, FL2, FL2-CC, FR2, FR2-CC) SM	PR, EL, SS	
9	RHR line boundary check valves [RHS-VLV-028A (B, C, D)]	RAW(L1, LP, LP-CC)	OD, PR	
10	RWSP discharge line isolation valves [CSS-MOV-001A (B, C, D)]	RAW(L1, L2, LP, LP-CC, FL1, FR1, FL2, FR2)	EL, CM, PR, CD	

Table 17.4-1 Risk-significant SSCs (Sheet 38 of 51)

#	Systems, Structures and Components (SSCs)	Rationale[(1)]	Failure Mode[(2)]	Insights and Assumptions
11	CS line containment isolation motor operated valves [CSS-MOV-004A (B, C, D)]	FV(L2-SUM, FR1-CC, FL1, FL1-CC, FL2, FL2-CC, FR2, FR2- CC,) RAW(L1,L1-CC,L2,L2- CC,LP, FL1, FL1-CC, FR1, FR1-CC, FL2, FL2-CC, FR2, FR2-CC)	OD, CM, EL, FC, PR	The "Insights and Assumptions" for these SSCs are described on the previous page.
12	CS line check valves [CSS-VLV-005A (B, C, D)]	RAW(L1,L1-CC, L2, L2-CC, FL1, FL1-CC, FR1, FR1- CC, FL2, FL2-CC, FR2, FR2-CC)	EL, OD, PR	
13	Piping (between RWST and CSS-MOV-001A (B, C, D), between RHS-MOV-034A (D) and CS/RHR Pump, between RHS-VLV-031A (D) and alternate core cooling, RHS-FCV-021 (031) line, between CSS-MOV-001A (B, C, D) and A (B, C, D)- CS/RHR pump, A (B, C, D)--CS/RHR pump line, CS/RHR pump line, alternate core cooling line A (B, C, D) (outside C/V) piping, Containment spray nozzles)	RAW(L1, L2, LP) SM	EL, SS	
14	CS line heat exchanger discharge manual valves [CSS-VLV-002A (B, C, D)]	RAW(L1, L2, LP, FL1, FR1, FL2, FR2)	EL, PR	
15	Minimum flow line manual valves [RHS-VLV-013A (B, C, D)]	RAW(L1, L2, LP, FL1, FR1, FL2, FR2)	EL, PR	
16	Minimum flow line orifices [RHS-SRO-001A (B, C, D)]	RAW(LP, FL1, FR1, FL2, FR2)	PR	
17	Minimum flow line orifices [RHS-FE-014 (024, 034, 044)]	RAW(LP, FL1, FR1, FL2, FR2)	PR	
18	CS/RHR - spent fuel pit boundary manual valves (discharge line) [RHS-VLV-031A (D))	RAW(L1, L2, LP, FL1, FR1, FL2, FR2)	EL	

Table 17.4-1 Risk-significant SSCs (Sheet 39 of 51)

#	Systems, Structures and Components (SSCs)	Rationale[(1)]	Failure Mode[(2)]	Insights and Assumptions
19	From FSS to CSS tie line check valve [CSS-VLV-012]	RAW(L1,L2,LP, FL1, FR1, FR2)	EL,OD, PR	These valves are required to open to perform firewater injection from FSS to the spray header.
20	From FSS to CSS tie line motor operated valve [CSS-MOV-011]	RAW(L2)	EL, OD, PR	
21	CS/RHR - spent fuel pit boundary manual valves (suction line) [RHS-VLV-034A (D)]	RAW(L1, L2, LP, FL1, FR1, FL2, FR2)	EL, OD	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.
22	CS/RHR - spent fuel pit boundary manual valves (suction line) [RHS-VLV-033A (D)]	RAW(LP, FL1, FR1, FR2)	EL, OD	
23	CS/RHR pump hot leg suction isolation valves [RHS-MOV-001A (B, C, D)] [RHS-MOV-002A (B, C, D)]	RAW(L1, LP, LP-CC)	CM, OD, PR	
24	RCS cold leg injection line motor operated valves [RHS-MOV-026A (B, C, D)]	RAW(LP, LP-CC)	CM, OD, PR	
25	RCS cold leg injection line check valves [RHS-VLV-027A (B, C, D)]	RAW(LP,LP-CC)	OD, PR	
26	Low-pressure letdown line isolation valves [RHS-AOV-024B (C)]	FV(LP) RAW(LP)	CD, OM	
27	CS/RHR pump full-flow test line stop valves [RHS-MOV-025A (B, C, D)]	RAW(LP)	OM	
28	RHR line safety valves [RHS-SRV-003A (B, C, D)]	RAW(LP)	OM	

Table 17.4-1 Risk-significant SSCs (Sheet 40 of 51)

#	Systems, Structures and Components (SSCs)	Rationale[1]	Failure Mode[2]	Insights and Assumptions
22	Refueling water storage system (RWS)			
1	Refueling water storage pit (RWSP) sump strainers [SIS-SST-001A (B, C, D)]	FV(L1-CC, L2-CC, LP- CC, FL1-SUM, FL2-CC, FL2, FR2-SUM) RAW (L1, L1-CC, L2, L2-CC, LP-CC, FL1, FL1-CC, FR1, FR1-CC, FL2, FL2-CC, FR2, FR2-CC) SM	PR, SS	The RWSP is the source of borated water for containment spray and safety injection. During LPSD operation, RWSS has the following functions. a. Refill refueling water strage auxiliary tank (RWAT) for RCS injection via charging pumps. b. Refill SFP for gravitational injection to RCS. SSCs that have either of the following characteristics are risk significant. - 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. - 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. 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 [RWS-MCP-001]	RAW(L1, L2, LP, FL1, FR1, FL2, FR2)	EL	
3	Refueling water recirculation pump suction line manual valves [RWS-VLV-006A (B)]	RAW(L1, L2, LP, FL1, FR1, FR2)	EL	
4	Refueling water recirculation pump discharge line check valves [RWS-VLV-012A (B)]	RAW(L1, L2, LP, FL1, FR1, FR2)	EL	
5	Refueling water recirculation pump discharge line manual valves [RWS-VLV-013A (B)]	RAW(L1, L2, LP, FL1, FR1, FR2)	EL	
6	RWSP discharge line containment isolation motor operated valves [RWS-MOV-002] [RWS-MOV-004]	RAW(L1, L2, LP, FL1, FR1, FR2)	EL, CM, PR	
7	Refueling water recirculation pumps [RWS-MPP-001A (B)]	RAW(L1, L2 ,LP, LP-CC, FL1, FL2, FR1, FR2)	EL, AD, LR, SR	
8	RWSP discharge line manual valve [RWS-VLV-001]	RAW(L1, L2, LP, FL1, FL2, FR1, FR2)	EL, PR	
9	Refueling water recirculation pump suction cross tie line manual valve [RWS-VLV-005]	RAW(L1, L2, LP, FL1, FR1, FR2)	EL	

Table 17.4-1 Risk-significant SSCs (Sheet 41 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
10	Refueling water recirculation pump discharge cross tie line manual valve [RWS-VLV-014]	RAW(L1, L2, LP, FL1, FR1, FR2)	EL	The "Insights and Assumptions" for these SSCs are described on the previous page.
11	Refueling water storage auxiliary tank [RWS-MTK-002]	RAW(L1, L2, LP)	EL	
12	Refueling water storage auxiliary tank inlet line manual valve [RWS-VLV-052]	RAW(LP)	EL, OD, PR	
13	Refueling water storage auxiliary tank discharge line manual valve [RWS-VLV-101]	RAW(L1, L2, LP, FL1, FR1, FR2)	EL	
14	Refueling water storage auxiliary tank suction line manual valves [RWS-VLV-021], [RWS-VLV-051]	RAW(L1, L2, LP, FL1, FR1, FR2)	EL,OD,PR	
15	Refueling water storage auxiliary tank line orifice	RAW(LP)	EL	
16	RWSP suction line containment isolation air operated valve [RWS-AOV-022]	LP	EL, CD, OM	
17	RWSP return line check valve [RWS-VLV-023]	RAW(L1, L2, LP, FL1, FR1, FL2, FR2)	EL	
18	RWSP Return Line Manual Valve [RWS-VLV-024]	RAW(L1, L2, LP, FL1, FR1, FL2, FR2)	EL	
19	Piping (between RWSP and RWS-VLV-023 ,between RWSP and RWS-MOV -002, between RWS-MOV-002 and RWS-MOV -004 ,between RWS-MOV -004 and RWSAT ,between RWS-VLV-021 and RWSAT)	RAW(L1, L2, LP, FL1, FR1)	EL	

Table 17.4-1 Risk-significant SSCs (Sheet 42 of 51)

#	Systems, Structures and Components (SSCs)	Rationale[1]	Failure Mode[2]	Insights and Assumptions
23	**Reactor trip system (RTS)**			
1	Reactor trip breakers	RAW(L1-CC, L2-CC)	FF	These systems are necessary to provide negative reactivity for plan t trip.
2	Control rods	FV(L1) RAW(L1,L2, L1-CC, L2-CC)	FS, FR	
3	Control rod drive mechanism	RAW(L1, L2) SM	FS	
4	Fuel assembly (Reactor internals and core assembly)	SM	FS	
24	**Chilled water system (VWS)**			
1	Essential chiller units [VWS-MEQ-001B (C)]	FV(L1, FL1, FR1, FR2, FR2-SUM) RAW(L1-CC, L2-CC, FL1, FL1-CC, FR1, FR1-CC, FR2, FR2-CC) LP SM	YR, BD, SS, FS	The safety related water system supplies chilled water to safety related HVAC systems. 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. 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	Essential chilled water pumps [VWS-MPP-001B (C)]	RAW(L1-CC, FL1, FL1-CC, FR1, FR1-CC, FR2, FR2-CC) LP	BD, YR	
3	Essential chilled water compression tanks [VWS-MTK-001B (C)]	RAW(FL1) SM	FS, EL	
4	HVAC chiller system piping	RAW(FL1) SM	FS, EL	
5	Essential chilled water pump discharge line check valves [VWS-VLV-005B (C)]	RAW(FL1, FR2) EJ	OD, EL, PR	
6	Essential chilled water system orifice [VWS-FE-051, 101]	RAW(FL1, FR2)	PR	
7	Essential chilled water system three way valve [VMS-TMV-412 and 422]	RAW(FL1)	CM, EL, PR	

Table 17.4-1 Risk-significant SSCs (Sheet 43 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
8	Essential chilled water inlet manual valve [VWS-VLV-001B, C]	RAW(FL1)	EL, PR	
9	Essential chilled water system manual valve [VWS-VLV-006B, C]	RAW(FL1)	EL, PR	
10	Emergency Feedwater pump air handling unit manual valve [VWS-VLV-101B, C]	RAW(FL1)	EL, PR	
11	Emergency Feedwater pump air handling bypass line valve [VWS-VLV-102B, C]	RAW(FL1)	EL	
12	Emergency Feedwater pump air handling unit manual valve [VWS-VLV-105B, C)	RAW(FL1)	EL, PR	

Table 17.4-1 Risk-significant SSCs (Sheet 44 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
25	**Essential service water system (ESWS)**			
1	EWS pump discharge line check valves [EWS-VLV-502A (B,C,D)]	RAW(L1, L1-CC, L2,L2-CC, LP ,LP-CC, FL1, FL1-CC, FR1, FR1-CC, FL2, FR2, FR2-CC,)	EL,PR,OD	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. 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 pumps [EWS-MPP-001A (B,C,D)]	FV(L1-CC, L2-CC, LP-CC, FL1, FR1-CC, FR1-SUM, FL2, FR2, FR2-CC) RAW(L1, L1-CC, L2, L2-CC, LP, LP-CC, FL1, FL1-CC, FR1, FR1-CC, FL2, FL2-CC,FR2, FR2-CC) SM	BD, YR, EL, SS, FS	
3	CCW heat exchanger inlet strainers [EWS-SST-003A (B, C, D)]	FV(FL2) RAW(L1, L2, LP, FL1, FR1, FL2, FR2) LP	PR	
4	Essential service water pump outlet strainers [EWS-SST-001A (B,C,D)] [EWS-SST-002A(B,C,D)]	FV(FL2) RAW(L1, L2, LP, FL1, FR1, FR2, FL2)	PR	
5	Main piping orifices [EWS-FE-034(035, 036, 037)]	RAW(L1, L2, LP, FL1, FR1, FL2, FR2) / SM	PR, SS	

Table 17.4-1 Risk-significant SSCs (Sheet 45 of 51)

#	Systems, Structures and Components (SSCs)	Rationale[1]	Failure Mode[2]	Insights and Assumptions
6	ESW pump discharge line motor operated valves [EWS-MOV-503 A(B,C,D)]	FV(FL2, FR2) RAW(L1, L2, LP, LP-CC, FL1, FR1, FL2, FR2)	CM, EL, OD, PR,	The "Insights and Assumptions" for these SSCs are described on the previous page.
7	Manual valves in main piping [EWS-VLV-506 A(B,C,D)] [EWS-VLV-507 A(B,C,D)] [EWS-VLV508 A(B,C,D)] [EWS-VLV-509 A(B,C,D)] [EWS-VLV-511 A(B,C,D)] [EWS-VLV-514 A(B,C,D)] [EWS-VLV-517 A(B,C,D)] [EWS-VLV-520 A(B,C,D)]	RAW(L1, L2, LP, FL1, FR1, FL2, FR2)	EL, PR	
8	Piping [ESW pump discharge line, ESW pump cooling line, CCW Hx cooling line A(B,C,D)]	RAW(L1, L2, LP, FL1) SM	EL, SS	
9	Orifices (between EWS-FE-034 (035, 036, 037) and EWS-VLV-520A (B, C, D)	RAW(L1, L2, LP, FL1, FR1, FL2, FR2)	PR	

Table 17.4-1 Risk-significant SSCs (Sheet 46 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
10	Essential chiller unit cooling line manual valves [EWS-VLV-701A (B-D)] [EWS-VLV-704A (B-D)]	RAW(L1, L2, FL1) EJ*1	EL, PR	
11	Essential service water intake structure	SM	FS	
12	Essential service water pipe tunnel	SM	FS	
13	Essential chiller unit cooling line orifice [EWS-SRO-003B, C]	RAW(FL1, FR2)	PR	
14	Essential chiller unit cooling line flow mater [EWS-FE-055, 056]	RAW(FL1, FR2)	PR	

Table 17.4-1 Risk-significant SSCs (Sheet 47 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
26	**Spent fuel pit cooling and purification system (SFPCS)**			
1	RWS - SFP inlet line boundary check valves [SFS-VLV-027]	RAW(L1, L2, LP, FL1, FR1, FR2)	EL	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. 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 [SFS-VLV-028]	RAW(L1, L2, LP, FL1, FR1, FR2)	EL	
3	RWS - SFP demineralizer line boundary manual valves [SFS-VLV-103A (B)]	RAW(L1, L2, LP, FL1, FR1, FR2)	EL	
4	RWS - SFP inlet line manual valves [SFS-VLV-029] [SFS-VLV-015] [SFS-VLV-017]	LP	EL	
5	Spent fuel pit [SFS-MPT-001]	LP / SM	EL, SS	
6	Spent fuel pit strainers	LP	EL	
7	Spent fuel pit discharge line manual valves [SFS-VLV-021A(D)]	LP	EL	
8	Spent fuel pit discharge cross tie-line manual valve [SFS-VLV-022]	LP	EL	
9	Spent fuel pit heat exchangers [SFS-MHX-001A(B)]	SM	FS	
10	Spent fuel pit pumps [SFS-MPP-001A(B)]	SM	SS, FS	
11	Spent fuel pit water cooling system piping	SM	SS	
27	**Remote Shutdown Panel (RSP)**			
1	Remote shutdown console	EJ	FF	In case of Fire event at power some operations are required to be carried out in remote shutdown panel therefore remote shut down panel are considered risk significant.
2	Transfer switches	EJ	FF	The switch can transfer the plant control system from the MCR to remote shutdown console.

Table 17.4-1 Risk-significant SSCs (Sheet 48 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
28	**Buildings**			
1	Reactor building	SM	FS	Considering the secondary effect to Reactor building and Safety power source buildings, Turbine building, Auxiliary building are risk significant.
2	Safety power source	SM	FS	
3	Turbine building	SM	FS	
4	Auxiliary building	SM	FS	
29	**Reactor Coolant System**			
1	Steam generators (including Steam generator tubes) [RCS-MHX-001A (B,C,D)]	SM	FS	SSCs that compose boundary with primary system are risk significant.
2	RCS piping	SM	FS	
3	DVI piping	SM	FS	
4	Reactor coolant pumps [RCS-MPP-001A (B,C,D)]	SM	FS	
5	Reactor vessel [RCS-MTK-001]	SM	FS	
6	RCS instrumentation piping	SM	FS	
7	In-core instrumentation tube	SM	FS	
8	Emergency letdown piping	SM	FS	
30	**Other Equipments**			
1	Flood barriers	SM	FS	The flood barriers that separate the reactor building between east side and west side and between restricted area and non-restricted area are important to safety for the operation of the facility.

Table 17.4-1 Risk-significant SSCs (Sheet 49 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
31	**Boric Acid Transfer**			
1	Boric injection line air-operated valves [CVS-FCV-130A (B)]	EJ	CM, EL, OD, PR	Boric acid transfer is effective to prevent core damage in the ATWS event. Operators start boric acid transfer pumps and open injection line air-operated valves to inject boric water into the RCS.
2	Boric acid tank return line air-operated valves [CVS-AOV-549A (B)]	EJ	EL, IL, OM	
3	Boric acid transfer pumps [CVS-MPP-002A (B)]	EJ	BD, SR, YR, EL	
4	Boric acid transfer pump discharge check valves [CVS-VLV-532A (B)]	EJ	EL, OD, PR	
5	Boric acid transfer line check valve [CVS-VLV-556]	EJ	EL, OD, PR	
6	Boric acid tank outlet manual valves [CVS-VLV-515A (B)]	EJ	EL, PR	
7	Boric injection line isolation manual valves [CVS-VLV-527A (B)]	EJ	EL	
8	Boric acid transfer pump suction manual valves [CVS-VLV-528A (B)]	EJ	EL. PR	
9	Boric acid transfer pump discharge manual valves [CVS-VLV-533A (B)]	EJ	EL, PR	
10	Boric acid filter inlet manual valve 1 [CVS-VLV-535]	EJ	EL	

Table 17.4-1 Risk-significant SSCs (Sheet 50 of 51)

#	Systems, Structures and Components (SSCs)	Rationale(1)	Failure Mode(2)	Insights and Assumptions
11	Boric acid filter inlet manual valve 2 [CVS-VLV-536]	EJ	EL, PR	
12	Boric acid filter outlet manual valve [CVS-VLV-539]	EJ	EL, PR	
13	Boric injection line manual valve [CVS-VLV-555]	EJ	EL, PR	
14	Boric acid filter [CVS-MFT-004]	EJ	PR	
15	Boric acid tank [CVS-MTK-002A (B)]	EJ	EL	
16	Piping [Boric acid transfer pump discharge line, A (B) boric acid transfer pump suction line]	EJ	EL	

Table 17.4-1 Risk-significant SSCs (sheet 51 of 51)

Notes:

1. Definition of Rationale Terms:

FV = Fussell-Vesely
RAW = Risk Achievement Worth

EJ = Engineering Judge
EP = Expert Panel

L1/2 = Level1/2 Internal Event
LP = Low Power and Shut Down Operation

FL1/2 = Level1/2 Flood Event
FR1/2 = Leve1/2 Fire Event
SM = SEISMIC Event

CC = Common Cause Failure
SUM = Sum of specific SSCs' FV

*1 = Based on the equality and similarity in function and failure behavior to other SSCs, which are risk significant

*2 = Based on the risk-significant human error concerning the SSCs

*3 = Based on the risk-significant signal error concerning the SSCs

2. Definition of Failure Mode Terms:

AD = Fail to start [Pump, Chiller, GTG]
BD = Fail to start [Pump, Chiller, Fan]
CD = Fail to Close [Valve]
CM = Spurious Operation (Mis-Close) [Valve]
EL = External Leak [Valve, Pipe, Tube, Pump, Tank, Heat Exchanger(Shell/Tube)]
FC = Fail to Control [M/V, Optical Switch]
FS = Functional Failure by Seismic Hazard
FF = Fail to Operate [Indicator, Buttery Charger, Bus, Sequencer, Transformer, Switch, Breaker, Ignitor]
FO = Fail to Open [Circuit Breaker]
HF = Hardware Failure
LR = Fail to Run [Pump, Gas Turbine Generator, Fan]
IL = Internal Leak [Valve]

OD = Fail to Open [Valve]
OM = Spurious Operation (Mis-open) [Valve]
PR = Plug [Valve, Orifice, Strainer, Heat Exchanger, Nozzle, Sump]
SC = Spurious Close [Circuit Breaker]
SF = Software Failure
SO = Spurious Open [Circuit Breaker]
SR = Fail to Run [Pump, Gas Turbine Generator, Fan]
SS = Structural Failure by Seismic Hazard
TD = Fail to Close [Breaker]
WR = Fail to Operate [Breaker]
YR = Fail to Run [Pump, Chiller, Compressor]
FR = Functional Failure of Control Rod

17.4.8 ITAAC for the D-RAP

Tier 1 ITAAC are proposed to verify that the D-RAP provides reasonable assurance that the plant is designed and constructed in a manner that is consistent with the key assumptions and risk insights for risk-significant SSCs. 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 following three (3) major elements are taken into consideration:

- Identification of all as-built SSCs in the scope of the D-RAP
- Description of the methodology used to identify the as-built SSCs in scope of the D-RAP
- For the as-built SSCs in scope of D-RAP, identify and describe the reliability assurance activities that are accomplished prior to the initial fuel load, which provide reasonable assurance that the plant is designed and constructed in a manner that is consistent with the key assumptions (including reliability and availability assumptions in PRA, when applicable) and risk insights for the risk-significant 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, including QA requirements. In the Phase II, the plant's site-specific information should be introduced to the D-RAP process and the site-specific risk-significant SSCs should be combined with the US-APWR design risk-significant SSCs into a list for the specific plant. Phase II is performed during the COL application phase and updated/maintained during the COL license holder phase. 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. Phase III is performed during the COL license holder phase and prior to initial fuel loading. The COL Applicant will propose a method by which it will incorporate the objectives of the reliability assurance program into other programs for design or operational errors that degrade nonsafety-related, risk-significant SSCs.*

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 (e.g., 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. A description*

of the proposed method for developing/integrating the operational RAP into operating plant programs (e.g., maintenance rule, quality assurance) is performed during the COL application phase. The development/integration of the operational RAP is performed during the COL license holder phase and prior to initial fuel loading. All SSCs identified as risk-significant within the scope of the D-RAP should be categorized as high-safety-significant (HSS) within the scope of initial Maintenance Rule. The integration of reliability assurance activities into existing operational programs will also address establishment of:

1) *Reliability performance goals for risk-significant SSCs consistent with the existing maintenance and quality assurance processes on the basis of information from the DRAP (for example, implementation of the maintenance rule following the guidance contained in RG 1.160 is one acceptable method for establishing performance goals provided that SSCs are categorized as HSS within the scope of the Maintenance Rule program), and*

2) *Performance and condition monitoring requirements to provide reasonable assurance that risk-significant SSCs do not degrade to an unacceptable level during plant operations.*

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 “Quality Assurance Program (QAP) Description For Design Certification of the US-APWR (PQD-HD-19005 Rev.3)”

17.4-3 ‘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.

17.4-4 10 CFR 50.69 SSC Categorization Guideline ,NEI 00-04 Rev 0 Draft, Nuclear Energy Institute, July 2005.

17.4-5 Industry-Average Performance for Components and Initiating Events at U.S. Commercial Nuclear Power Plants, NUREG/CR-6928, U.S. Nuclear Regulatory Commission, Washington, DC, February 2007.

17.4-6 Guide to the Collection And Presentation of Electrical, Electronic, Sensing Component, And Mechanical Equipment Reliability Data For Nuclear Power Generating Stations, IEEE Std. 500, Appendix D, Institute of Electrical and Electronics Engineers, New York, NY, 1984.

17.4-7 Analysis of Core Damage Frequency: Internal Events Methodology, NUREG/CR-4550 Volume 1, Rev. 1, U.S. Nuclear Regulatory Commission, Washington, DC, January 1990.

17.4-8 US-APWR Probabilistic Risk Assessment, MUAP-07030-P Rev. 2 (Proprietary), Mitsubishi Heavy Industries, December 2009.

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.3)” (MHI QAPD)(Ref 17.5-4), 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.17.5-4.

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 17.5-3) 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 17.5-2) and the draft SRP (Sept. 2006) (Ref 17.5-1) 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

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

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

17.5-3 “Quality Assurance Program Description (NEI 06-14A Rev.4 and earlier versions)”

17.5-4 “Quality Assurance Program (QAP) Description For Design Certification of the US-APWR (PQD-HD-19005 Rev.3)”

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 must provide in its FSAR a description of the maintenance rule program , and its for implementation , for monitoring the effectiveness of maintenance necessary to meet the requirements of 10 CFR 50.65.*