GE Hitachi Nuclear Energy

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Non-Proprietary Information

BWRX-300 Darlington New Nuclear Project (DNNP) Preliminary Fire Safe Shutdown Requirement and Analysis Document

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

REVISION SUMMARY

Revision #	Section Modified	Revision Summary
0	All	Originally Issued as Proprietary Version NEDC-33978P Rev 0
1	All	Initial Issue as Non-Proprietary Version

1.0 INTRODUCTION

1.1 Purpose

As part of its Power Operating Licence, the Darlington New Nuclear Project (DNNP) is required to have three documented fire safety assessments, with one of the required assessments a Fire Safe Shutdown Analysis (FSSA). The objective of the FSSA is to achieve compliance with the requirements of CSA N293-12, Fire Protection for Nuclear Power Plants (Reference 7-1) and Supplement No. 1 to CSA N293-12, Fire Protection for Nuclear Power Plants (Application to Small Modular Reactors) (Reference 7-2) as required by the stations Power Operating Licence and its amendments. The fire safety assessment reports also form part of the station fire protection program.

The station fire protection program has four main goals:

- To ensure that fires do not increase the risk of radiological release to the public
- To protect plant personnel
- To manage impact to the environment resulting from fire
- To minimize economic loss

The nuclear safety objectives include: (a) reactivity control, (b) decay heat removal, (c) maintaining fission product boundaries, and (d) limiting release of radioactive materials outside the reactor.

While the last two objectives are not specifically addressed in this document, maintaining the reactor coolant pressure boundary is considered in assessment of pressure and inventory control functions. Also, the Fire Hazard Assessment (Reference 7-3) assesses the radiological release for a fire in each fire area evaluated.

The fire safety assessments form a key element in the fire protection program. The fire safety assessments document a systematic review of the fire hazards at DNNP and the potential consequences of design basis fire events. These documents also identify the fire safety measures provided to meet the fire safety objectives. Documents forming part of the fire protection assessments shall be submitted to the AHJ for acceptance.

The station fire safety assessments are updated periodically to reflect changes in combustible loading and plant configuration. The objective of the fire safe shutdown document is to report the results of the fire safe shutdown assessments and demonstrate compliance to the related requirements of the CSA N293-12 standard.

The CCR, Fire Hazards Assessment (FHA), and FSSA are companion documents in demonstrating fire safety adequacy at station. The objectives for each are reported along with CSA N293-12 requirement reference. This report provides details on the FSSA, conducted in compliance with CSA N293-12. Scope of Fire Protection Assessments indicate where additional assessment to demonstrate nuclear safety objective for fire protection are covered in the FSSA or other analysis documents.

The process and assessments performed as part of this project are controlled by a quality program. This quality program described in Ontario Power Generation DNNP-1 Project Quality Plan (Reference 7-4), meets CSA N286-12 and CSA N286.7-12 standards, and subjects work to review by qualified persons independent of the work performed during the preliminary and detailed design phases of the project.

1.2 Scope

This document describes the impacts of a fire on the safe shutdown systems, based on the design maintaining the fire barrier between the three divisions for both mechanical and electrical components. The Safe Shutdown Circuit Analysis provides a documented review of the safety-related shutdown circuits in each fire area to confirm that the shutdown capability is not impacted by a fire in any single fire area.

The Safe Shutdown Circuit Analysis also considers the potential for hot shorts and spurious actuations and identifies those safe shutdown circuits that would require fire wrapping to maintain divisional separation. The manual actions, repairs, and emergency lighting required by the operators in the event of a fire are also addressed.

The methodology defined in NEI 00-01, Guidance for Post-Fire Safe Shutdown Circuit Analysis (Reference 7-5), is used to develop analysis where fire protection features used to protect Structures, Systems, and Components (SSCs) important to safe shutdown are capable of limiting damage so that:

- One train of systems necessary to achieve and maintain stable shutdown conditions from either the control room or emergency control station(s) is free of fire damage

The concept of alternative/dedicated shutdown systems, widely used in current reactors, is not required for BWRX-300 except for the main control room and containment. Alternate analysis as described in NUREG-0800, Section 9.5.1.1 (Reference 7-6) is normally identified for the control room where all trains of Safe Shutdown equipment are located. The DNNP BWRX-300 FSSA employs the fire containment approach and assumes fire areas are completely unavailable for safe shutdown. The containment and main control room will require assessment crediting alternate shutdown.

The BWRX-300 has three independent divisions of safety-related safe shutdown equipment, separated by fire barriers, and therefore, does not require an analysis for alternate shutdown capability for postulated fires outside the control room and containment.

The defense-in-depth principle is used to achieve a high degree of fire protection by providing redundancy, diversity, and balance in fire protection measures.

The Fire Safe Shutdown Requirements Report addresses fire safe shutdown from plant operational states, including startup, shutdown, and outages.

This conceptual BWRX-300 FSSA Report requires future updates to address additional design detail, uncertainties in the plant design, and to include additional fire safe shutdown tasks that are currently addressed only qualitatively, or which are not included in initial revisions of the BWRX-300 FSSA Report.

This conceptual BWRX-300 FSSA Report also requires future updates to address requirements from plant level requirements documents such as Life Safety and Fire Hazard Analysis (Reference 7-7) and BWRX-300 Plant Cable and Component Separation Requirements (Reference 7-8). Additional details, such as fire overlay drawings reflecting room number and fire area numbers and safe shutdown cable routing layout, are provided as design progresses.

The following action items are identified as limiting during preparation of this current document revision:

- Provide basis for fire-independent safe shutdown approach where, regardless of where the fire is located, safe shutdown is accomplished the same way.
- Demonstrate that each of the required functions (reactivity control, pressure control, inventory control, decay heat removal) are successful, regardless of the fire damage that can occur.

- Control cables, for a digital plant, cannot cause a spurious operation (except for hard-wired backup using copper cables).
- Spurious operation may still be possible at the power supply / motor control center (MCC).
- There is no possibility to disable a scram with any single fire barriered room to be completely burned out (and in many cases multiple rooms even across divisions).
- BWRX-300 specifies equivalent fire rated conduit.
    - The conduit (either fibre or wire) isn't as important since its loss also causes a scram (except for the Diverse Protection System (DPS) conduit).
- To validate this assumption, a fire-independent argument for each function, will require detailed circuit analysis on each of the cables credited SSCs.

The results of this conceptual study show that the BWRX-300 plant is inherently safe with respect to internal fire events. This is due in large part to the passive safety features of the BWRX-300 plant design which builds on prior Economic Simplified Boiling Water (ESBWR) and Boiling Water Reactor (BWR) Nuclear Power Plant (NPP) design insights.

1.3 Design Basis Evaluation

The purpose of this evaluation is to demonstrate the DNNP fire safe shutdown capability for postulated fires involving in situ and/or transient combustibles that could impact SSCs located in or adjacent to that area. For purposes of this evaluation, it is assumed that these fires may adversely affect those SSCs essential to safe shutdown in the fire area. The evaluation is performed conservatively assuming a loss of offsite power.

No concurrent or sequential design basis accidents are assumed to occur. Failures that may be a consequence of the fire are evaluated.

Limiting Safety Consequences

The limiting safety consequences used in the evaluation of fire safe shutdown are:

- No fuel clad damage
- No rupture of any primary coolant boundary
- No rupture of the containment boundary
- Reactor Coolant System (RCS) process variables will be within those predicted for a loss of normal AC power

The FSSA demonstrates that the nuclear safety performance criteria listed in sections 5.4.2 of CSA N293-12 is met for each fire scenario associated with safe shutdown SSC:

- Reactor shutdown
- Decay heat removal
- Barrier to fission product release
- Support services
- Monitoring of plant parameters

2.0 DESCRIPTION

2.1 Fire Safe Shutdown General Methodology Description

The FSSA described in this document follows the guidelines for a FSSA provided in CSA N293-12, Appendix B.4, Guidelines for a Safe Shutdown Analysis (FSSA) and illustrated in Figure 2-1.

CSA N293-12 references NEI 00-01, Guidance for Post-Fire Safe Shutdown Analysis, as basis for development of FSSA.

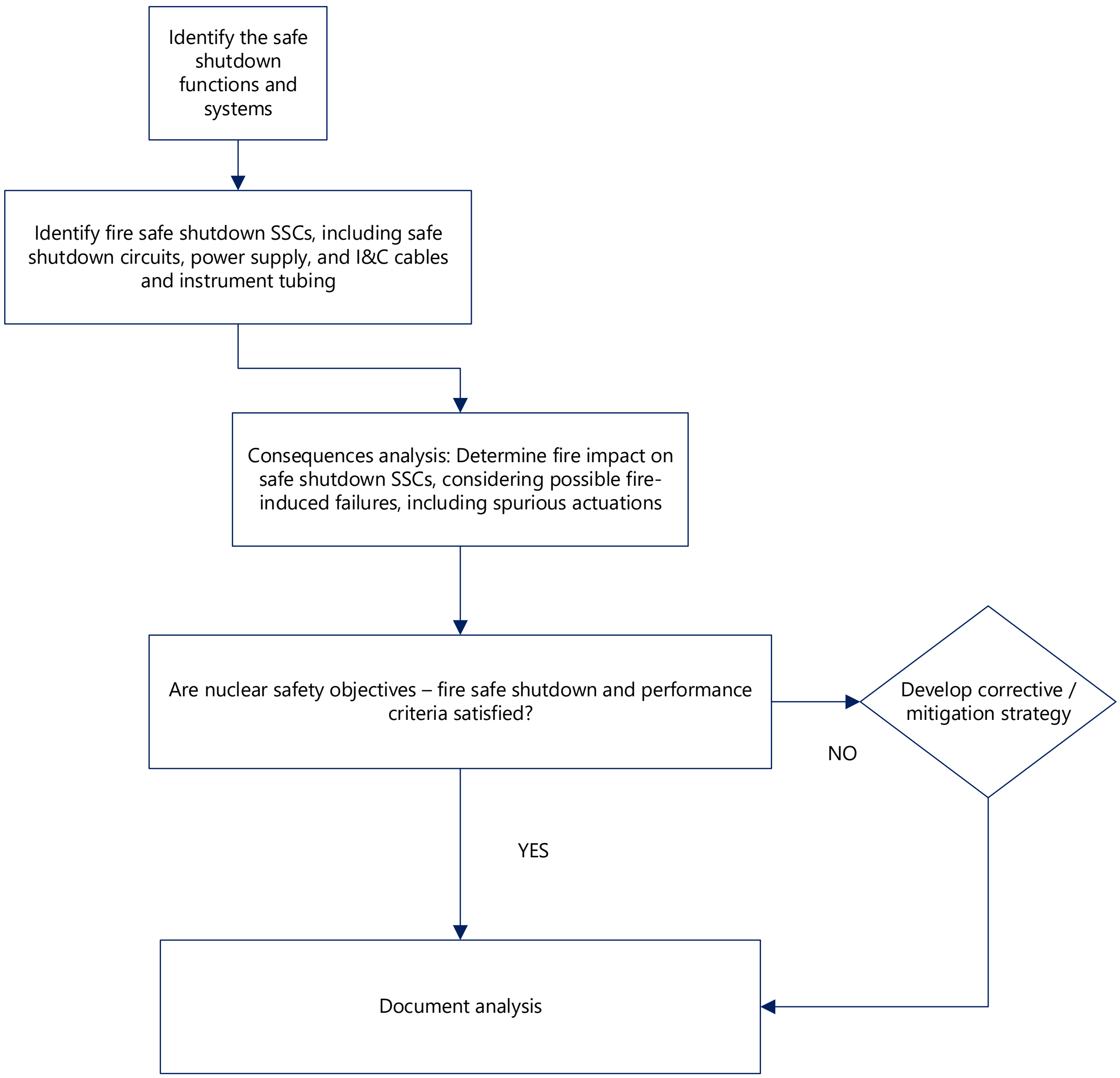

Figure 2-1: BWRX-300 Fire Safe Shutdown Analysis Methodology

The deterministic methodology described in this document is used to perform a post-FSSA (consequence analysis) to address the current regulatory requirements. The resolution methodology for Multiple Spurious Operations (MSO) evaluates the risk significance of potential failures or combinations of failures. This evaluation follows the method provided in NEI 00-01 Section 4, Appendix B, Appendix F and Appendices G-1 and G-2.

High/Low Pressure (LP) Interfaces have been addressed following NEI 00-01 Appendix C, High / Low Interfaces.

In an effort to clarify which fire-induced component impacts may be allowed to use operator manual actions, assessments are performed in accordance with NEI 00-01 Appendix H and Appendix E which provides additional guidance on operator manual actions.

NEI 00-01 Section 5 contains information useful for assessing the risk associated with fire-induced circuit failures.

2.2 Deterministic Method

When using the deterministic methodology described in NEI 00-01, a basic assumption is that there will be fire damage to systems and equipment located within a common fire area. The size and intensity of the fire required causing this type of system and equipment damage is not determined. Rather, fire damage is assumed to occur regardless of the level of combustibles in the area, the ignition temperatures of any combustible materials, the lack of an ignition source, or the presence of automatic or manual fire suppression and detection capability. Fire damage is also postulated for all cables and equipment in the fire area that may be used for safe shutdown, even though most plant fire areas do not contain sufficient fire hazards for this to occur.

It is with these basic and conservative assumptions regarding fire damage that use of the NEI 00-01 methodology begins. The methodology progresses by providing guidance on selecting systems and equipment needed for post-fire safe shutdown, on identifying the circuits of concern relative to these systems and equipment, and on mitigating each fire-induced effect to the systems, equipment, and circuits for the required safe shutdown path in each fire area. This methodology represents a comprehensive and safe approach for assuring that an operating plant can be safely shut down in the event of a single fire in any plant fire area.

To address the MSO issue, consideration is given to the MSO List in NEI 00-01 Appendix G and the circuit failure criteria contained in NEI 00-01 Appendix B. The circuit failure criteria are intended for use with the MSO List in Appendix G and the MSO resolution methodology described in Section 4 of NEI 00-01. Using the resolution methodology described in Section 4, a licensee can determine the potential fire-induced MSO impacts applicable to its facility. These potential fire-induced impacts can then be dispositioned using the deterministic methods described in Section 3 or by using the risk-informed method described in Section 5. Additionally, fire modelling, as described in Section 4, may be used to assess whether a particular MSO in a particular location presents a potential impact to post-fire safe shutdown. In addressing MSOs, the conservative assumptions discussed above for the Section 3 analysis are not necessarily applied, e.g., fire modelling or risk assessment may be an acceptable resolution approach. The mitigating techniques available for use with any MSO is a function of whether that MSO is classified as being comprised of required hot shutdown components or important to safe shutdown components. Refer to Appendix H for a description of the criteria to classify components as either required for hot shutdown or important to safe shutdown components. Additionally, the MSOs listed in Appendix G are to be evaluated separately. Other than the cases described in Section 4 involving an evaluation by the Expert Panel of the need to combine MSOs, there is no need to evaluate for the combined effect of multiple MSOs. The potential effect of each MSO on post-fire safe shutdown is to be evaluated individually.

In performing a deterministic post-FSSA, the analyst must be cautious not to improperly apply the conservative assumptions described above. For example, one cannot rule out fire damage to unprotected circuits in each fire area. This assumption is conservative only in terms of not being able to credit the systems and equipment associated with these circuits in support of post-fire safe shutdown. If the analyst, however, were to assume that these circuits damaged by the fire when this provided an analytical advantage, this would be non-conservative. For example, assuming that fire damage results in a loss of offsite power may be non-conservative in terms of heat load, assumptions used in an analysis to determine the need for room cooling systems for the 72-hour fire coping period.

2.2.1 Safe Shutdown System and Path Identification

Using the safe shutdown functions described above, the analyst identifies a system or combination of systems with the ability to perform each of these shutdown functions. The systems are combined to form safe shutdown paths

2.2.2 Safe Shutdown Equipment Identification

Using the Piping and Instrumentation Diagrams (P&IDs) for the mechanical systems comprising each safe shutdown path, the analyst identifies the mechanical equipment required for the operation of the system and the equipment whose spurious operation could affect the performance of the safe shutdown systems. Equipment that is required for the operation of a safe shutdown system for a particular safe shutdown path is related to that path (and is designated as a required hot shutdown component).

From a review of the associated P&IDs, the equipment that could spuriously operate and result in a flow blockage, a flow diversion (e.g., inventory makeup capability), loss of pressure control (due to overfeeding, excessive steam leakage, etc.), is identified. Similarly, this equipment is related to the safe shutdown path that it affects.

Using the criteria in NEI 00-01 Appendix H, the analyst classifies the components identified above either as required for hot shutdown component or as important to the SSD component.

The required safe shutdown path for any fire area is required for hot shutdown and important to SSD components. The classification for a particular component either required for hot shutdown or an important to SSD component can vary from fire area to fire area.

The analyst reviews the P&IDs for the systems physically connected to the reactor vessel to determine the equipment that can result in a loss of reactor inventory more than makeup capability. This includes a special class of valves known as high/LP. NEI 00-01 provides special requirements associated with high/LP interface valves. Equipment in this category is typically related to all safe shutdown paths since a loss of reactor vessel inventory or an interfacing system Loss of Coolant Accidents (LOCA) would be a concern for any safe shutdown path. The classification criteria contained in NEI 00-01 Appendix H also applies to high/LP interface components.

2.2.3 Safe Shutdown Cable Identification

Using the electrical schematic drawings for the BWRX-300 equipment identified above, the BWRX-300 SSA will identify all the cables required for the proper operation of the safe shutdown equipment, if required. This will include, in addition to the cables that are physically connected to the equipment, any cables interlocked to the primary electrical schematic through secondary schematics. The cables identified are related to the same safe shutdown path as the equipment supported.

While reviewing the electrical schematics for the equipment, the BWRX-300 SSA will identify the safe shutdown equipment from the Electrical Distribution System (EDS) (R Systems). The EDS equipment (bus) for the safe shutdown path is associated with the equipment that it powers. All upstream buses are identified and similarly related to the safe shutdown path. In addition, all power cables associated with each bus in the EDS are identified and related to the same safe shutdown path as the EDS equipment. This information is required to support the Breaker Coordination Analysis to be completed for detailed design.

2.2.4 Safe Shutdown Circuit Analysis

Using information on the physical routing of the required cables and the physical locations of all BWRX-300 safe shutdown equipment, the SSA will determine equipment and cable impacts for each safe shutdown path in each plant fire area. Based on the number and types of impacts to these paths, each fire area is assigned a required safe shutdown path(s). Initially, it is assumed that any cables related to a required safe shutdown component in each fire area will cause the component to fail in the worst-case position (i.e., if the safe shutdown position of a valve is closed, the valve is assumed to open if the required cable is routed in the fire area).

If necessary, a detailed analysis of the cable for the specific effect of the fire on that safe shutdown path is performed. This is accomplished by reviewing each conductor in each of these cables for the effects of a hot short, a short-to-ground or an open circuit. The impact on the required safe shutdown component is assessed. The impact is assessed in terms of the effect on the safe shutdown system, safe shutdown path, safe shutdown functions, and goal for post-fire safe shutdown. Due to the passive nature of BWRX-300 safety functions and extensive use of digital safe shutdown circuits, it is not expected that BWRX-300 will need to perform extensive Safe Shutdown Circuit Analysis.

2.2.5 Safe Shutdown Equipment Impacts

Using the process described above, the BWRX-300 SSA analyst will identify the potential impacts to safe shutdown equipment, systems, paths, and functions relied upon in each fire area, and verify that one train of safe shutdown equipment is free of fire damage. It is not expected that mitigating techniques will be required for BWRX 300 to meet the regulations. One of the mitigating tools available for an important to SSD circuit component is the use of an operator manual action. If an operator manual action is relied upon as the mitigating tool, then it must meet the regulatory acceptance criteria related to operator manual actions as discussed in NEI 00-01. BWRX-300 does not credit operator manual actions.

2.3 Risk Significance Methods

The resolution methodology for determining the plant specific list of MSOs is contained in Section 4 of NEI 00-01. The method details both the determination of applicable plant specific MSOs and the disposition/mitigation of the MSOs using either deterministic methods, Fire Modelling, or risk (e.g., Focused-Scope Fire Probabilistic Risk Assessment (PRA)) methods.

3.0 Fire Safe Shutdown Requirements

When specifying requirements, "shall" is used to denote actions that must be performed or requirements that must be met. "Should" is used to indicate recommended practices and guidance. Each requirement and guideline statement are accompanied by a basis which provides the justification for why the requirement or guideline exists, why it is specified in a particular manner, and why it has particular value.

3.1 Functional Requirements

State the functions required to be performed to accomplish its intended purpose in the facility. To the extent applicable to the system being described, the system's function statements should address the areas of safety (protection of onsite and offsite personnel from radiological and other types of hazards), environmental protection, programmatic mission, and general functions. Statements of safety function serve as the key link between the authorization basis documents and supporting documents. The essential elements of a safety function statement are: (1) the situations, and any general accidents types, during which the system may be called upon to perform its safety function; (2) The specific functional needs that prevent, detect, or mitigate undesirable occurrences; (3) those performance characteristics that have been specifically relied upon in the safety basis, including the hazards analysis and accident analysis.

3.1.1 Shutdown Function – Reactivity Control

[TBD] BWRX-300 shall include fail-safe means of negative reactivity insertion, without reliance on AC generated power or human intervention, to achieve and maintain shutdown with margin. Requirement or Guideline text with a unique identifier.

Basis: This requirement is necessary to ensure high reliability of the fundamental safety function to control reactivity. [[

]]

3.1.2 Shutdown Function - Pressure Control

[TBD] BWRX-300 Systems available to be credited for Reactor Pressure Control Functions:
- Main Steam Drains to Main Condenser (with Balance of Plant (BOP))
- Shutdown Cooling (SDC) Letdown Path
- Reactor Water Cleanup (CUW) Letdown Path
- Isolation Condenser System (ICS)

Basis: This requirement is necessary to ensure high reliability of the fundamental safety function to control reactivity. [[

]]

3.1.3 Shutdown Function – Inventory Control

[TBD] BWRX-300 Systems available to be credited for Reactor Coolant Inventory Control and Fuel Cooling Functions:
- BOP via Feedwater (FW) from the Condensate Storage Tank (CST) / Condenser
- High-Pressure Control Rod Drive (HPCRD) System

Any one of these methods is assumed to be capable of maintaining the function on its own.

Basis: Key Assumption supporting Event Tree Accident Sequence development [[
]]

The ICS provides initial reactor water make up.

3.1.4 Shutdown Function - Decay Heat Removal

[TBD] BWRX-300 Systems available to be credited for Decay Heat Removal Functions:
- BOP via FW-CST / Condenser
- ICS

Any one of these methods is assumed to be capable of maintaining the function on its own.

Basis: Key Assumption supporting Event Tree Accident Sequence development [[
]]

[[ ]]

[TBD] BWRX-300 shall include fail-safe passive decay heat rejection to an Ultimate Heat Sink for a minimum of seven (7) days, without reliance on AC generated power or human intervention.

Basis: This requirement is necessary to ensure high reliability of the fundamental safety function of passive decay heat removal. [[
]].

The ICS provides decay heat removal following a fire event.

3.1.5 Shutdown Function- Process Monitoring

[TBD] "Type D variables shall be those variables that provide primary information to the accident management personnel and are required in the plant's procedures and licensing basis documentation to:

a. Indicate the performance of those safety systems and auxiliary supporting features necessary for the mitigation of design basis events.

b. Indicate the performance of other systems and auxiliary supporting features necessary to achieve and maintain a safe shutdown condition.

c. Verify safety system status.

BWRX-300 shall include fail-safe means of negative reactivity insertion, without reliance on AC generated power or human intervention, to achieve and maintain shutdown with margin. Requirement or Guideline text with a unique identifier. The Type D variables shall be based upon the plant accident analysis licensing basis and those necessary to implement the following procedures (as applicable to the plant design): Event specific Emergency Program Guide (EPGs) or Emergency Operating Procedure (EOPs) (plant specific) Functional restoration EPGs or EOPs (plant specific) Plant Abnormal Operating Procedure (AOP)"

Basis: This requirement is consistent with IEC 63147:2017, Criteria for accident monitoring instrumentation for nuclear power generating stations and IEEE 497-2016, IEEE Standard Criteria for Accident Monitoring Instrumentation for Nuclear Generating Power Generation Stations.

[TBD] Control Room instrumentation and equipment shall include all controls and displays needed for bringing the plant to a safe shutdown condition.

Basis: NUREG-0700, Rev. 3, 12.1.1.2-4 Arranged to Facilitate Coverage; [[
]].

3.1.6 Shutdown Function Support Systems

[TBD] The design of SC1 systems and the safety support systems shall address support system functional dependencies (power supply, cooling supply, instrumentation and control, fire protection zone) of the SC1 system by providing adequate physical segregation and separation of the necessary support systems essential to the SC1 function.

Basis: Mechanical Equipment Separation for Safety Class 1 Systems [[
]].

3.2 Design Requirements

This section identifies both requirements and the bases for those requirements. This section also present the classification of those requirements regarding importance, thereby differentiating whether or not each requirement applies to a safety function. The bases should refer to source documents from which the requirements and bases were obtained. If requirements of an applicable standard were tailored, a justification that explains the adequacy of the design with the tailored requirements should be included in the basis.

Requirements and bases statements should be appropriate, concise, and meaningful. System requirements statements should be clear and specific and should not include basis information. In addition, the bases statements should be informative and add value instead of merely re-stating the requirement in different words.

Format and instruction for requirements and bases are shown as examples in Subsection 3.1. Categorizing requirements by type is useful for identifying information that may be sought quickly for making decisions concerning system operability and compliance with the safety basis.

3.2.1 Process Requirement-Safe Shutdown Design Basis Analysis

[TBD] A Safe Shutdown Design Basis Analysis shall be performed, as described in Reference 7-10.

Basis: Process definition. [[
]]

[TBD] The scope of the Safe Shutdown Design Basis Analysis shall include the scenarios included in the Baseline Design Basis Analysis and Conservative Design Basis Analysis.

Basis: Scope definition in BWRX-300 Safety Strategy [[ ]]

[TBD] The results of the Safe Shutdown Design Basis Analysis shall meet the derived quantitative acceptance criteria.

Basis: Define acceptance criteria for this analysis. This shows the capability of transitioning the plant to cold shutdown after an event if necessary. The Extended Deterministic Safety Analysis scenarios are analyzed to the point of achieving safe shutdown conditions as described in BWRX-300 Safety Strategy [[
]]

[TBD] SSCs that support the minimum system functions required for safe shutdown in a Postulated Accident shall be separated from, or have protection against, the hazards of that Postulated Accident.

Basis: Exception to the preceding requirement is allowed only if it can be demonstrated that supporting SSCs are not required to assure safe plant shutdown for the PA under consideration [[
]]

[TBD] At least one means of reactor shutdown and core cooling shall be provided in the event of extreme BDBT.

Basis: For more severe BDBTs, a sufficient structural integrity shall be ensured to protect important safety systems that provide safe shutdown path. A limited degradation of the containment barrier may be acceptable if the response includes onsite and offsite emergency measures [[
]]

[TBD] Protection for the SC1 systems shall be incorporated such that the effects of any applicable postulated event will not cause the loss of an SC1 function and plant safe shutdown is assured.

Basis: For each postulated piping failure event or event class, the plant SC1 systems and support systems that are required to function to achieve safe plant shutdown are identified.

For each identified hazard resulting from the postulated piping failure event or event class, determine the separation required or equivalent protection measures that will protect the identified safe-shutdown functions. Refer to Mechanical Equipment Separation for Safety Class 1 Systems [[ ]]

[TBD] Active mechanical equipment whose function is required to ensure the safe operation or safe shutdown of the nuclear plant shall be qualified per the requirements in ASME QME-1.

Basis: According to REGDOC-2.5.2, Version 1, paragraph 7.13, Seismic Qualification and Design: "The seismic qualification of all SSCs shall meet the requirements of Canadian national or equivalent standards."

Qualification of seismic class equipment shall satisfy the requirements of Regulatory Guide 1.100, which invokes ASME QME-1-2017, Qualification of Active Mechanical Equipment Used in Nuclear Facilities for qualification of active mechanical equipment whose function is required to ensure the safe operation or safe shutdown of the nuclear plant.

Recommendations on seismic qualification for nuclear power plants are provided in IAEA SSG-67, Seismic Design for Nuclear Installations [[
]]

[TBD] Portions of System U43 credited to support safe shutdown of the plant shall be analyzed to withstand the effects of Safe Shutdown Earthquake (SSE) and remain functional.

Basis: The plant must be designed to achieve and maintain safe shutdown following an SSE [[ ]]

[TBD] The BWRX-300 DL3/SC1 DCIS shall supervise Safety Class 1 instruments in all plant locations and trip the affected logic if they fail supervision checks.

Basis: [[ ]], safe shutdown of the reactor must be possible considering failure of the safety class instruments for BOP and Turbine Systems [[ ]]

[TBD] [[ ]], safe shutdown of the reactor must be possible considering failure of the safety class instruments for BOP and Turbine Systems [[ ]]

Basis: REGDOC 2.5.2, Version 1, Section 7.6.2 (Reference 7-16) describes single failure criterion. The design must consider the potential failure of safety class instrumentation that extends to the nonseismic BOP scope of the plant to ensure its failure does not adversely affect plant safety.

[TBD] The BWRX-300 design shall include a MCR as well as a SCR that is physically and electrically separate from the MCR and provides the capability to achieve and maintain a safe shutdown state if MCR functionality is lost [[ ]].

Basis: REGDOC 2.5.2, Version 1, Section 8.10 (Reference 7-16). Redundant and physically separate control room functionality reduces the risk of a single event that compromises operation of both facilities [[ ]].

[TBD] Protection for the SC1 systems shall be incorporated such that the effects of any applicable postulated event will not cause the loss of an SC1 function and plant safe shutdown is assured.

Basis: For each postulated piping failure event or event class, the plant SC1 systems and support systems that are required to function to achieve safe plant shutdown are identified.

For each identified hazard resulting from the postulated piping failure event or event class, determine the separation required or equivalent protection measures that will protect the identified safe-shutdown functions [[ ]].

3.2.2 Fire Safe Shutdown Analysis Assumption Requirements

Certain aspects of the FSSA cannot be developed until the detailed design phase such as layout of Fire Safe Shutdown (FSS) cables and success paths. Therefore, FSSA requirements are managed until the design progresses to allow the physical configuration to replace these assumption requirements.

[TBD] Reactivity Control - Analysis shall be performed to ensure rod insertion using the hydraulic control units (HCUs) would not be prevented by a fire.

Basis: Fire damage to the control rod drive (CRD) pumps would not prevent the control rods from inserting, and any loss of signal should result in a reactor trip; assuming a “fail-safe design” of the reactor protection system (RPS). The impact of a fire affecting the HCUs is assessed directly deterministically; but the other areas can be handled similar to the Fire PRA . The following PRA components are assumed to fail in a safe manner and to be train separated: isolation condenser system (ICS) actuation logic, CRD system actuation logic for control rod insertion, CRD HCUs, and RPS actuation logic. Therefore, cable routes are not required for these components since any cable impacts from a postulated fire will actuate the component in its safe shutdown position. Note that cable routes are required for the CRD pumps and associated components as used for the injection logic model which is separate from the scram model logic in the internal events PRA model. Also note that cables routes are required for the ICS valves which are separate from the actuation software events in the internal events PRA model. Additionally, note that the current internal events PRA model represents the CRD HCUs by a single common cause event and that train-specific HCU failures are not possible in that configuration [[ ]].

[TBD] Pressure Control - Analysis shall be performed to ensure reactor pressure control using the ICS would not be prevented by any fire postulated.

Basis: To be developed as design progresses.

[TBD] Inventory Control - Analysis shall be performed to ensure the reactor inventory control function is maintained for each of the lines connected to the vessel under any fire event postulated.

Basis: To be developed as design progresses.

[TBD] Decay Heat Removal - Analysis shall be performed to ensure the decay heat removal function using the ICS would not be prevented by any fire postulated.

Basis: To be developed as design progresses.

4.0 DETERMINISTIC METHODOLOGY

4.1 Safe Shutdown Systems and Path Development

4.1.1 Criteria/Assumptions

A single, postulated fire is assumed to occur in any area of the plant containing equipment or electrical circuits that are necessary for safe shutdown except for primary containment, which is inerted with nitrogen during power operations.

The FHA postulates design basis fires in each fire zone within the protected area and external to protected area for SSC that directly support the plant with assessment of damage including impact on safe shutdown equipment. The fire containment approach described in CSA N293 will be used to the maximum extent practical Areas expected to include transient equipment / materials will consider transient combustible loading in margin development.

The evaluation of secondary effects such as smoke spread and impact to structural supports is considered in the FHA. The spread of fire from a nonsafety-related room to a safety-related room is prevented by the appropriate design of fire barriers.

Design basis fires are assumed not to occur concurrently with non-fire related failures in systems, other accidents, or the most severe natural phenomena.

The plant is assumed to be in a standard lineup governed by operating procedures, operating modes or administrative controls at the onset of the fire. All components, including manual valves, are assumed to be in their normal position as shown on the applicable P&ID's (e.g., mechanical flow diagrams) or as described in applicable plant operating procedures.

Piping, check valves, strainers, tanks, manual valves, heat exchangers, safety relief valves, and pressure vessels are assumed to remain functional during and after a fire. For valves, the fire damage is limited to power-assisted operators such as motors, air operators, hydraulic and/or solenoid operators.

Fire damage to substantial passive components, such as, piping, heat exchangers, and tanks, is assumed to have no adverse impact on the ability to function as pressure boundaries or as safe shutdown components.

Spurious operation of control circuits is considered improbable for circuits in fibre optic cable.

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4.1.2 Shutdown Functions

4.1.2.1 Reactivity Control

Reactivity control systems are capable of inserting negative reactivity to achieve and maintain subcritical conditions. Negative reactivity insertion will occur rapidly enough such that fuel design limits are not exceeded.

Reactivity control credits the RTS and CRD HCU to insert the control rods and provide positive assurance that the reactor will be shut down and remain subcritical.

BWRX-300 assumes fail-safe design for the RTS or CRD actuation or the CRD HCU function as these systems are based on fail-safe designs in current power plants and expected to remain as such in the BWRX-300 design. Rod insertion using the HCUs would not be prevented by a fire. Fire damage to the CRD pumps would not prevent the control rods from inserting, and any loss of signal should result in a reactor trip; assuming a “fail-safe design” of the RTS.

4.1.2.2 Pressure Control Systems

With fuel in the reactor vessel, the head on and tensioned, functional systems remain capable of maintaining reactor pressure below the design pressure of the reactor vessel.

The Isolation Condenser System (ICS) will provide pressure control following a fire event.

4.1.2.3 Inventory Control

With fuel in the reactor vessel, the head on and tensioned, functional systems remain capable of maintaining reactor water level above Top of Active Fuel (TAF) such that fuel clad damage (because of a fire) is prevented.

The ICS will provide initial reactor water make up. The RPV isolation valves isolate large breaks. Small breaks are compensated with inventory in the RPV to keep the core cooled for seven days. BWRX-300 is designed to eliminate any breaks below 4 m above TAF and includes a flow orifice to limit the size of the small break. ICS removes decay heat and depressurizes the plant without losing inventory.

4.1.2.4 Decay Heat Removal

Decay heat removal "systems" are capable of removing sufficient heat such that fuel is maintained in a safe-and-stable condition.

The ICS will provide decay heat removal following a fire event.

The ICS removes decay heat after any reactor isolation and shutdown event during power operations. The ICS decay heat removal limits increases in steam pressure and maintains the RPV pressure at an acceptable level. [[

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Thermal energy removal condenses steam on the tube side and transfers heat by heating/evaporating water in the ICS (IC) pools which are vented to the atmosphere. Only one of the three are needed to mitigate anticipated operational occurrences. Two of three are required for LOCA mitigation, and all three are required for beyond design basis events. The ICS is initiated automatically and will also be initiated if a loss of direct current power occurs (fail-safe). [[

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The ICS can also be initiated manually by the operator from the MCR [[
]]. The heat rejection process can be continued beyond seven days by replenishing the IC pool inventory. The ICS Pool Cooling and Cleanup System (G20) provides ICS pool water continuous cleanup to meet water quality standards and to maintain the pool water temperature and provide normal makeup water from Water, Gas, and Chemical Pads (Y53) to maintain pool water levels. The ICS pools are located at ground level and are not pressurized, so replenishment can be accomplished using readily available transportable sources such as a fire truck.

BWRX-300 also has three 100% redundant Isolation Condenser System (ICS) trains, each of which is equipped with two 100% redundant valve pathways. Each of the two valves on each ICS train is mechanically diverse, such that there is no common cause failure assumed between the two valve types. These valves do not require offsite or continual onsite AC power to operate (open). This feature allows a safe-and-stable end state to be achieved in Station Blackout (SBO) scenarios without the need for a tertiary power source or significant operator action over the mission time. Once ICS is initiated and the RPV is isolated, achievement of a safe-and-stable state is met passively. This also precludes the need to continually provide active makeup, and/or depressurize to initiate Shutdown Cooling (SDC) that is required at existing BWRs.

4.1.2.5 Process Monitoring

Process monitoring is capable of providing the necessary indication to assure the criteria addressed in the safe shutdown functions have been achieved and are being maintained.

Monitoring for the BWRX-300 will be limited based on the simplified response for safe shutdown systems. Basic functions such as temperature, pressure, flux/power are required.

Limited separation of monitoring functions will be validated based on fail-safe rod insertion from HCUs, closure of the Main Steam Isolation Valves (MSIVs) and other connection points, and fail-safe ICS actuation. This will allow limited separation requirements for cables supporting ICS, and Containment Isolation Valves (CIVs). Monitoring can also be fail-safe with fire separated instrumentation used for the monitoring functions identified.

4.1.2.6 Support Systems

4.1.2.6.1 Electrical Systems

Electrical systems that support any safe shutdown functions will be identified. Specific equipment determination is in progress.

4.1.2.6.2 Cooling Systems

Cooling Water systems that support any safe shutdown functions will be identified. Specific equipment determination is in progress.

4.1.2.6.3 Heating, Ventilation and Air Conditioning Systems

Heating and Ventilation systems that support any safe shutdown functions will be identified. Specific equipment determination is in progress.

4.1.3 Methodology for Shutdown System Selection

BWRX-300 safe shutdown systems evaluated under conceptual design are listed in Table 4-1, Safe Shutdown Systems.

BWRX-300 safety-related SSC (monitoring devices) outside the Reactor Building (RB) are listed in Table 4-2, Turbine Building Safety-Related Monitoring Devices.

BWRX-300 safe shutdown equipment evaluated under conceptual design are listed in Table 4-3, Safe Shutdown Equipment. Table 4-3 provided safe shutdown equipment associated with safe shutdown systems listed in Table 4-1, Safe Shutdown Systems. The preliminary fire safe shutdown assessment lists support systems such as U41 Heating Ventilating and Cooling System for completeness at this stage of design.

4.1.4 Methodology for Shutdown Equipment Selection

Using draft P&IDs, identify those mechanical systems credited for satisfying the safe shutdown function and the specific mechanical equipment required for the operation of those systems. A safe shutdown system performs one or more of the required safe shutdown functions and is, therefore, a part of the required safe shutdown path for a particular fire area. Safe Shutdown Components are defined as equipment that is required to either function or not malfunction so that the required safe shutdown path will be capable of achieving and maintaining safe shutdown in a particular fire area and meet the established regulatory criteria. The attributes below are considered when determining which pieces of equipment are required:

Components that operate by electrical, pneumatic, or hydraulic means.

Components that need to "actively" operate to achieve the system function (e.g., pump motors, level indicators).

Power supplies for active components are identified and listed as separate equipment.

Components in the flow paths that require operation or repositioning to allow the system to function, and components that could spuriously operate and impair safe shutdown.

Process monitoring instrumentation required to verify proper system operation and control system operation.

Equipment that could spuriously operate and result in a flow blockage, a flow diversion (e.g., inventory makeup capability) or loss of pressure control (due to overfeeding, excessive steam leakage, etc.) are also identified.

4.1.5 Criteria/Assumptions

Safety-related SSC associated with safe shutdown is located in the RB. Safety-related devices within the Turbine Building (TB) is limited to the instrumentation listed in Table 4-2, Turbine Building Safety-Related Monitoring Devices.

The safety-related RTS input devices listed in the table provide a monitoring function of the measured parameter. The devices listed in Table 4-2 are provided for Analysis of Anticipated Operating Occurrences and Analysis of Infrequent Events, and do not perform a safe shutdown function in the event of a fire.

The cables associated with these devices are routed in individual raceways specific to their associated division and are separated in accordance with Canadian and IEEE 384 criteria. Since these devices and associated cables do not perform a safe shutdown function, complete burnout of all these devices and associated cables does not affect the ability to achieve and maintain post-fire safe shutdown, as shown in Table 4-2.

4.1.6 Methodology for Equipment Selection

NOTE: Equipment designation from draft P&IDs if available.

Table 4-1: Safe Shutdown Systems

System	Safety-Related Divisional Equipment & Cabling	Non-Safety Redundant Trains or Equipment	Fire Area	Room Number	Function (see footnote)	Reactor Condition	Division	Backup System	Remarks
E52 ICS-A	A				Inventory Control, Pressure control, Decay Heat Removal	RPV Isolation	Any one of three divisions	E52 ICS divisions B and C	Fail-safe, no support functions from electrical or I&C need separation
E52 ICS-B	B				Inventory Control, Pressure control, Decay Heat Removal	RPV Isolation	Any one of three divisions	E52 ICS divisions A and C	Fail-safe, no support functions from electrical or I&C need separation
E52 ICS-C	C				Inventory Control, Pressure control, Decay Heat Removal	RPV Isolation	Any one of three divisions	E52 ICS divisions A and B	Fail-safe, no support functions from electrical or I&C need separation
B21 Reactor Vessel Isolation Valves	Multiple				Inventory Control, Pressure control,	RPV Isolation	N/A	N/A	Fail-safe, no support functions from electrical or I&C need separation
G12 CRD	A				Reactivity Control	Scram	N/A	N/A	Fail-safe, no support functions from electrical or I&C need separation
G12 CRD	B				Reactivity Control	Scram	N/A	N/A	Fail-safe, no support functions from electrical or I&C need separation
G12 CRD	C				Reactivity Control	Scram	N/A	N/A	Fail-safe, no support functions from electrical or I&C need separation
C10 I&C Division 1	A				Monitoring of process parameters (power, pressure, reactor vessel level, ICS Pool level)	Monitoring	Any one of three divisions	C10 I&C Division 2 or 3	[[ ]]
C10 I&C Division 2	B				Monitoring of process parameters (power, pressure, reactor vessel level, ICS Pool level)	Monitoring	Any one of three divisions	C10 I&C Division 1 or 3	[[ ]]

Table 4-1: Safe Shutdown Systems

System	Safety-Related Divisional Equipment & Cabling	Non-Safety Redundant Trains or Equipment	Fire Area	Room Number	Function (see footnote)	Reactor Condition	Division	Backup System	Remarks
C10 I&C Division 3	C				Monitoring of process parameters (power, pressure, reactor vessel level, ICS Pool level)	Monitoring	Any one of three divisions	C10 I&C Division 2 or 3	[[ ]]
R10 Safety Class 1 EDS Div 1	1				Support of required equipment	Support	Support HVAC and HPI		
R10 Safety Class 1 EDS Div 2	2				Support of required equipment	Support	Support HVAC and HPI		
R10 Safety Class 1 EDS Div 3	3				Support of required equipment	Support	Support HVAC and HPI		
Instrumentation	A				process monitoring	Support	TBD	TBD	Variables to be monitored: [[ ]]
Instrumentation	B				process monitoring	Support	TBD	TBD	Variables to be monitored:
Instrumentation	C				process monitoring	Support	TBD	TBD	Variables to be monitored:
HVAC -Safety Control Room	A/B/C				Support of required equipment/personnel	Support			
HVAC -Safety Control Room	A				Support of required equipment/personnel	Support			
HVAC -Safety Control Room	B				Support of required equipment/personnel	Support			
HVAC -Safety Control Room	C				Support of required equipment/personnel	Support			

Table 4-1: Safe Shutdown Systems

System	Safety-Related Divisional Equipment & Cabling	Non-Safety Redundant Trains or Equipment	Fire Area	Room Number	Function (see footnote)	Reactor Condition	Division	Backup System	Remarks
HVAC - EDS Div 1	A				Support of required equipment	Support			Assumed that the HVAC will be need. Calculation maybe able to demonstrate that temperature rise in compartment would be limited under passive cooling or local direct expansion units can be used for electrical cabinet and equipment cooling to minimize systems credited (chilled water system, plant cooling water system) .
HVAC - I&C Div 1	A				Support of required equipment	Support			Assumed that the HVAC will be need. Calculation maybe able to demonstrate that temperature rise in compartment would be limited under passive cooling or local direct expansion units can be used for electrical cabinet and equipment cooling to minimize systems credited (chilled water system, plant cooling water system) .
HVAC - EDS Div 2	B				Support of required equipment	Support			Assumed that the HVAC will be need. Calculation maybe able to demonstrate that temperature rise in compartment would be limited under passive cooling or local direct expansion units can be used for electrical cabinet and equipment cooling to minimize systems credited (chilled water system, plant cooling water system) .
HVAC - I&C Div 2	B				Support of required equipment	Support			Assumed that the HVAC will be need. Calculation maybe able to demonstrate that temperature rise in compartment would be limited under passive cooling or local direct expansion units can be used for electrical cabinet and equipment cooling to minimize systems credited (chilled water system, plant cooling water system) .
HVAC - EDS Div 3	C				Support of required equipment	Support			Assumed that the HVAC will be need. Calculation maybe able to demonstrate that temperature rise in compartment would be limited under passive cooling or local direct expansion units can be used for electrical cabinet and equipment cooling to minimize systems credited (chilled water system, plant cooling water system) .

Table 4-1: Safe Shutdown Systems

System	Safety-Related Divisional Equipment & Cabling	Non-Safety Redundant Trains or Equipment	Fire Area	Room Number	Function (see footnote)	Reactor Condition	Division	Backup System	Remarks
HVAC - I&C Div 3	C				Support of required equipment	Support			Assumed that the HVAC will be need. Calculation maybe able to demonstrate that temperature rise in compartment would be limited under passive cooling or local direct expansion units can be used for electrical cabinet and equipment cooling to minimize systems credited (chilled water system, plant cooling water system) .
P25 Chilled Water System -A	A				Support of HVAC	Support			Supports RB HVAC
P25 Chilled Water System -B	B				Support of HVAC	Support			Supports RB HVAC

Table 4-2: Turbine Building Safety-Related Monitoring Devices

Parameter Description	RTS Input or Output	Building	Room	Divisions	Total Burnout Impact with No Hot Short	Total Burnout Impact with Hot Short
To be developed as design progresses.	To be developed as design progresses.	To be developed as design progresses.	To be developed as design progresses.	To be developed as design progresses.	To be developed as design progresses.	To be developed as design progresses.

Table 4-3: Safe Shutdown Equipment

MPL System	Equipment Designation	Description (will need to verify component descriptions)	Normal Position	Non-Power OPS	Hot Shutdown Position	Failed Air Position	Failed Power Position	High / Low Pressure Interface
E52 ISOLATION CONDENSER SYSTEM	[[	ICS Condensate Return Isolation Valves	[[					
E52 ISOLATION CONDENSER SYSTEM		ICS Condensate Return Isolation Valves						
E52 ISOLATION CONDENSER SYSTEM		ICS Condensate Return Isolation Valves						
E52 ISOLATION CONDENSER SYSTEM		ICS Condensate Return Isolation Valves						
E52 ISOLATION CONDENSER SYSTEM		ICS Condensate Return Isolation Valves						
E52 ISOLATION CONDENSER SYSTEM		ICS Condensate Return Isolation Valves						
B21 NUCLEAR BOILER SYSTEM		Reactor Water Level Indicators Div A						
B21 NUCLEAR BOILER SYSTEMB21		Reactor Water Level Indicators Div B						
B21 NUCLEAR BOILER SYSTEMB21		Reactor Water Level Indicators Div C						
B21 NUCLEAR BOILER SYSTEMB21		Reactor Pressure Indicators Div A						
B21 NUCLEAR BOILER SYSTEMB21		Reactor Pressure Indicators Div B						

Table 4-3: Safe Shutdown Equipment

MPL System	Equipment Designation	Description (will need to verify component descriptions)	Normal Position	Non-Power OPS	Hot Shutdown Position	Failed Air Position	Failed Power Position	High / Low Pressure Interface
B21 NUCLEAR BOILER SYSTEMB21		Reactor Pressure Indicators Div C						
B21 NUCLEAR BOILER SYSTEMB21		Main Steam RPV Isolation Valves – DIV A						
B21 NUCLEAR BOILER SYSTEMB21		Main Steam RPV Isolation Valves – DIV B						
B21 NUCLEAR BOILER SYSTEMB21		ICS Steam Supply RPV Isolation Valves – Div A						
B21 NUCLEAR BOILER SYSTEMB21		ICS Steam Supply RPV Isolation Valves – Div B						
B21 NUCLEAR BOILER SYSTEMB21		ICS Steam Supply RPV Isolation Valves – Div C						
B21 NUCLEAR BOILER SYSTEMB21		Feedwater RPV Isolation Valves – Div A						
B21 NUCLEAR BOILER SYSTEMB21		Feedwater RPV Isolation Valves – Div B						
B21 NUCLEAR BOILER SYSTEMB21		Feedwater RPV Isolation Valves – Div C						
B21 NUCLEAR BOILER SYSTEMB21		ICS Condensate Return RPV Isolation Valves – Div A						
B21 NUCLEAR BOILER SYSTEMB21		ICS Condensate Return RPV Isolation Valves – Div B						
B21 NUCLEAR BOILER SYSTEMB21		ICS Condensate Return RPV Isolation Valves – Div C						

Table 4-3: Safe Shutdown Equipment

MPL System	Equipment Designation	Description (will need to verify component descriptions)	Normal Position	Non-Power OPS	Hot Shutdown Position	Failed Air Position	Failed Power Position	High / Low Pressure Interface
B21 NUCLEAR BOILER SYSTEMB21		CUW Bottom Head Discharge RPV Isolation Valves – Div A						
B21 NUCLEAR BOILER SYSTEMB21		CUW Bottom Head Discharge RPV Isolation Valves – Div B						
G31 REACTOR WATER CLEANUP SYSTEM		CUW Containment Isolation Valve						
U41 HEATING VENTILATION AND COOLING SYSTEM		Reactor Building Air Handling unit						
U41 HEATING VENTILATION AND COOLING SYSTEM		Reactor Building Air Handling unit						
U41 HEATING VENTILATION AND COOLING SYSTEM		Safety Control Room Inlet Damper						
U41 HEATING VENTILATION AND COOLING SYSTEM		Safety Control Room Outlet Damper						
U41 HEATING VENTILATION AND COOLING SYSTEM		Div 1 Battery Room Exhaust Fan						
U41 HEATING VENTILATION AND COOLING SYSTEM		Div 1 Battery Room Exhaust Fan						
U41 HEATING VENTILATION AND COOLING SYSTEM		Div 2 Battery Room Exhaust Fan						
U41 HEATING VENTILATION AND COOLING SYSTEM		Div 2 Battery Room Exhaust Fan						

Table 4-3: Safe Shutdown Equipment

MPL System	Equipment Designation	Description (will need to verify component descriptions)	Normal Position	Non-Power OPS	Hot Shutdown Position	Failed Air Position	Failed Power Position	High / Low Pressure Interface
U41 HEATING VENTILATION AND COOLING SYSTEM		Div 3 Battery Room Exhaust Fan						
U41 HEATING VENTILATION AND COOLING SYSTEM		Div 3 Battery Room Exhaust Fan						
P25 CHILLED WATER EQUIPMENT		Chilled Water Pump 1						
P25 CHILLED WATER EQUIPMENT		Chilled Water Pump 2						
P25 CHILLED WATER EQUIPMENT		Chilled Water Pump 3						
P25 CHILLED WATER EQUIPMENT		Chiller 1						
P25 CHILLED WATER EQUIPMENT		Chiller 2						
P25 CHILLED WATER EQUIPMENT		Chiller 3						
P25 CHILLED WATER EQUIPMENT		Chiller 4						
R20 SAFETY CLASS 2 and 3 ELECTRICAL DISTRIBUTION SYSTEM		Switchgear/MCC A Load Group						
R20 SAFETY CLASS 2 and 3 ELECTRICALISTRIBUTION SYSTEM 0		Switchgear/MCC B Load Group						
C10 SAFETY CLASS 1 INSTRUMENTATION AND CONTROL SYSTEM		Switchgear/MCC Div1						

Table 4-3: Safe Shutdown Equipment

MPL System	Equipment Designation	Description (will need to verify component descriptions)	Normal Position	Non-Power OPS	Hot Shutdown Position	Failed Air Position	Failed Power Position	High / Low Pressure Interface
C20 SAFETY CLASS 2 AND 3 INSTRUMENTATION AND CONTROL SYSTEM		Battery Charger Div 1 Battery Charger Div 1						
C20 SAFETY CLASS 2 AND 3 INSTRUMENTATION AND CONTROL SYSTEM		Battery Charger Div 2 Battery Charger Div 2						
C20 SAFETY CLASS 2 AND 3 INSTRUMENTATION AND CONTROL SYSTEM	]]	Battery Charger Div 3 Battery Charger Div 3						]]

4.2 Safe Shutdown Cable Selection and Location

4.2.1 Criteria / Assumptions

The cable routing is assumed with the currently designed plant general arrangement drawings BWRX-300 General Arrangement Drawing [[ ]]as listed in BWRX-300 Internal Fire Scoping Evaluation [[ ]]with divisional separation where possible. The power, instrumentation, and control cable routes are all assumed based on the preliminary plant design. To model cable failure impacts, the worst-case failure mode for a SSC is used, except where documented assumptions from BWRX-300 Internal Fire Scoping Evaluation [[ ]].

Some preliminary cable tray locations are shown on the general arrangement drawings, but no details of which cables or which divisions are included in the trays is yet defined. Some route information is simple to discern such as cable which support the TB and RB switchgear room divisions being contained within the respective divisional rooms. Other route information is not obvious at the current design stage of the BWRX-300 plant. Preliminary design information assumes that cable entries between buildings will be at or above grade level (+0.0 meters), that is, no cables are expected to be buried or to enter buildings at elevations below grade level. Major routes include:

A. The postulated BWRX-300 cable routing assumptions are provided for separation criteria.
    1. C20 SC3 Distributed Control and Information System (DCIS) cables will originate from the C20 DL2 Rooms A and B in the Control Building and pass through its own duct bank, then connect to its load groupl cable chase in the reactor building.
    2. C30 SCN Nonsafety-related DCIS cables will originate from the C30 Room in the Control Building and pass through the C30 SCN cable tunnels, and connect to rooms in the reactor building, or turbine building.
        a. {If the C30 SCN cable has to pass through the divisional rooms in reactor building, it is assumed that C10 SC1 Div 1 and 3 rooms can be used for C30 SCN Load Group A and Div 2 used for Load Group B B.} Note: This routing rule is defined under [[ ]]

B. Cables routed from the Control Building (CB) into the RB for division I and II (train A and B) are assumed to come from the two divisional rooms in the [[ ]]then across the Radiologically Controlled Area Entrance [[ ]]or across the MCR [[ ]]respectively and into the Rad Waste Building [[ ]] and RB [[ ]]. This includes DL2 and DL4a cables.

C. Cables routed from the CB into the RB for division III (train C) are assumed to come from the two divisional rooms in the CB [[ ]]then across the Control Room Storage [[ ]]and into the Truck Space [[ ]] and into the RB [[ ]]. This includes DL2 cables.

D. Cables routed from the TB into the RB are assumed to come from the two divisional rooms in the TB [[ ]]then into the general open area of the second [[ ]]and ground level elevations [[ ]]of the TB and into the Rad Waste Building [[ ]]and down to lower elevations of the Rad Waste Building where the cable trays join the trays coming from the CB and the RB [[ ]]. This includes DL2 cables from the CB to the TB as well as the Bus A2 and B2 cables feeding from the TB switchgear into the CB divisional electrical rooms [[

]] as well as feeding into the RB divisions I and II rooms [[
]]

E. Cables routed from the TB into the RB are assumed to come from the two divisional rooms in the TB [[ ]] then into the general open area of the second [[ ]] and ground level elevations [[ ]] of the TB and then onto the Annex Building Roof [[ ]] then into the Truck Space [[ ]] and then into the Reactor Building [[ ]]. This includes the division III cables [[ ]].

F. Diesel generator cables are assumed to route from the Diesel Generator Room [[ ]] then into the general open area of the second [[ ]] and ground level elevations [[ ]] of the TB and then into the two divisional rooms in the TB [[ ]].

G. Cables associated with RB division I, II, and III are assumed to route vertically from [[ ]] into the Battery Rooms [[ ]]. This includes divisional power as well as DL3 cables. Cables are also assumed to penetrate the Primary Containment [[ ]] from the divisional rooms without going through additional PAUs.

H. Cables associated with display or visualization of component status or function which may be routed between a component or instrumentation location and the MCR or SCR are assumed to not impact any automatic function of the component.

I. The only scram related equipment in either control room are the manual scram switches, opening these circuits will cause a scram.

4.2.2 Methodology for Cable Selection and Location

The list of cables whose failure could impact the operation of a piece of safe shutdown equipment includes more than those cables connected to the equipment. Detailed information on cable routes, cable types, and design of circuits is not available yet for the BWRX-300 plant design. As such, no screening of cable or circuit designs which will not impact the safe shutdown component the cable or circuit supports is possible.

Cable routes from the BWRX-300 Fire PRA, as documented in Reference 7-17, are used and it is assumed that if the cable is impacted that the safe shutdown equipment function supported by that cable is failed.

4.2.3 Cable Selection and Location Assessments

The following list of safe shutdown cables is taken from the [[ ]] which bases the cable routes primarily on assumed locations. [[ ]]

Detailed spurious interaction analysis will not be completed for the draft FSSA. For control cables in a digital design power plant, the control cables cannot cause a spurious operation. Exceptions to this in the final design are possible if a hard-wired backup using copper cables is used rather than fibre cables.

Table 4-4: Safe Shutdown Cable Routes

MPL	Equipment Designation	Description (will need to verify component descriptions)	PRA Component	Cable Route Currently Assumed	Notes
[[					

Table 4-4: Safe Shutdown Cable Routes

MPL	Equipment Designation	Description (will need to verify component descriptions)	PRA Component	Cable Route Currently Assumed	Notes

Table 4-4: Safe Shutdown Cable Routes

MPL	Equipment Designation	Description (will need to verify component descriptions)	PRA Component	Cable Route Currently Assumed	Notes
					]]

4.3 Circuit Analysis and Evaluation

4.3.1 Criteria/Assumptions

- BWRX-300 utilizes digital I&C systems to minimize the adverse effect on safe shutdown from fire-induced spurious actuations. A spurious signal cannot be induced by fire damage in a fibre optic cable. The hard wires are minimized to limit the consequences of a postulated fire. The communication links between the MCR and the DCIS rooms do not include any copper or other wire conductors that could potentially cause fire-induced spurious actuations that could adversely affect safe shutdown. From the DCIS rooms to the components, fibre optics will also be used up to the RMUs in the plant. Hard wires then are used to control the subject components. The exposure of the DCIS equipment to heat and smoke caused by a fire in a single fire area does not cause spurious actuations that could adversely affect safe shutdown. Based on the ESBWR FPSA, Spurious Operation (SO) from fire damage to fibre optic cable is considered incredible and not analyzed in the FPSA.
- Based on NUREG/CR-7150, Volume 3, Section 2.1.1.3 (Reference 7-19), the following is assumed regarding proper polarity shorts:
  - AC and DC solenoids used in double break circuits are assumed “polarity insensitive,” which means the coil will operate regardless of the orientation of the applied positive and negative voltage to the coil.
  - AC Solenoids and relays are assumed capable of being operated by a DC source. Note: This assumes a UPS is used for the AC solenoids.
  - DC Solenoids and relays are assumed capable of being operated by an AC source. Note: This assumes a DC power supply for DC solenoids
  - A loss of a fibre optic cable will not cause inadvertent actuations, nor will it lead directly to failure of the automatic actuations associated with safety or non-safety equipment. Fibre optic cable deterioration leads to a loss of signal and should be treated as an open circuit in the case of fire. For example, in the case of a logic voting system; if one of the 1-out-of-2 signals is lost (downscaling), the logic becomes 1-out-of-1; similarly, for loss of one signal in 2-out-of-4 logic the logic then becomes 2-out-of-3.
  - Fire-induced fibre optic cable damage need not be considered as a primary cable failure mode of concern when conducting the detailed circuit failure analysis. The effects of a loss of signal should be considered in determining the functional impact on the affected equipment only.
  - A loss of a fibre optic cable in the MCR will not cause inadvertent actuations, nor will it affect the automatic actuations associated with safety or non-safety equipment. Fibre optic cable deterioration leads to a loss of signal and will be treated as an open circuit in the case of fire. For fibre optic cable deterioration due to fire, only the effects of a loss of signal are considered for the functional impact / cable selection, not the effects of a spurious signal. Spurious actuations may occur from fires in the MCR due to damage to copper conductors and cable connections.
  - Operator consoles are digital workstations, with limited potential for fire-induced spurious operations and low electrical load within the consoles. Operator consoles are connected to, or interface with the RTS and ESF through fibre optic cables.

4.3.2 Types of Circuit Failures

NEI-00-01 also contains guidelines on addressing other associated circuit concerns, including common power and common enclosure concerns. These will be included in future revisions of this FSSA.

4.4 Fire Area Assessment and Compliance Strategies

4.4.1 Criteria/Assumptions

The following assumptions apply to the Fire Area assessment:

- The RTS is a fail-safe design.
- Rated fire barriers can withstand impacts and prevent propagation from potential fire scenarios for at least the full duration of the rating.
- Only one fire in any single fire area at a time.
- The postulated fire will affect all unprotected cables and equipment within the fire area (full area failures) for all potential ignition sources within the fire area.
- No credit for automatic or manual fire suppression, consistent with [[ ]]. Further, fire protection design features are provided to prevent damage from inadvertent operation, as well as rupture of the fire suppression system as described in [[ ]].
- No credit for potential protection or separation of cables when more than one train or more than one system are assumed to be in the same fire area.
- No credit for post-fire equipment recovery.

4.4.2 Methodology for Fire Area Assessment

The following steps are undertaken for the draft FSSA with the safe shutdown equipment defined in Section 4.2 and the safe shutdown cables defined in Section 4.3:

Note: changes to the room layouts/designations from that listed here is subject to change as the design matures.

- Determine the cables and equipment impacted in each individual fire area.
- Determine the shutdown path least impacted by the fire in each fire area.

4.4.3 Fire Area Assessments

Note: The fire area assessment is based on preliminary unverified information. The equipment identification and cable routing is not complete.

The following shutdown functions are noted as failed by equipment and cable-related failures within the fire area. Table 4-5, Fire Area Safe Shutdown Assessments, includes functions noted as being failed on a per-train (i.e., ICS-A) or per-divisional (i.e., AC-1) basis as well as the overall system functional failure (i.e., CV). A field is provided to identify the resolutions for each fire scenario that results in failed safe shutdown functions, as required.

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
RX-34.0	[[	Entry -34.0	All walls are expected to be fire rated steel-plate composite (SC) structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.	[[	
RX-34.0		FMCRD Group 3 Controls	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-34.0		Service -34.0	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-34.0		FMCRD Group 4 Controls	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-34.0		FMCRD Group 1 Controls	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-34.0		FMCRD Group 2 Controls	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-34.0		Stair A	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
RX-34.0		Elevator A	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-34.0		Chase B	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-34.0		Stair B	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-34.0		Chase A	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
RX-34.0		Primary Containment	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated. Containment atmosphere is inerted during operation to preclude the initiation or propagation of a fire.		Damage from a fire in containment is limited to one train of safe shutdown components because of the separation of redundant components, low combustible loading, and primary containment inerting during power operation. During shutdown modes of operation, while containment is un-inerted, redundant components are spatially separated and while fire damage may result to both Control Rod Drive (CRD) system and Hydraulic Control Unit (HCU) components from a postulated fire within containment during an outage, there would be no effect to plant safe shutdown because all control rods would already have been inserted into the reactor vessel at the onset of the outage and prior to removing the inerting environment. Further backup of reactor scram capability and maintenance of safe shutdown can be provided by other systems (such as Boron Injection System) that are located in other fire areas of the plant.

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
RX-29.0		Entry -29.0	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-29.0		HCU Group 3	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-29.0		Service -29.0	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-29.0		HCU Group 4	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-29.0		HCU Group 1	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-29.0		HCU Group 2	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-29.0		Equipment Hatch	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
RX-21.0		Entry -21.0	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-21.0		Div. 2 DCIS and SWGR	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-21.0		Div. 3 DCIS and SWGR	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-21.0		SDC Pump B	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-21.0		SDC Pump A	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-21.0		Div. 1 DCIS and SWGR	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-14.5		Entry -14.5	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
RX-14.5		Div. 2 Battery	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-14.5		Service -14.5	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-14.5		Div. 3 Battery	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-14.5		HPI CRD Pump B	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-14.5		HPI CRD Pump A	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-14.5		Div. 1 Battery	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-8.0		Entry -8.0	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
RX-8.0		Corridor	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-8.0		FP Equipment	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-8.0		Boron Injection	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-8.0		Secondary Control Room	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		The MCR and SCR are in different fire areas. A fire anywhere in the plant could not disable plant control and monitoring from both control rooms.
RX-8.0		SDC Instrument A	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-8.0		SDC Instrument B	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
RX-8.0		SDC-A	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-8.0		SDC B	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX-8.0		Service Hatch	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated		
RX0.0		Truck Bay	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX0.0		Cask Pit	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated		
RX0.0		Fuel Pool	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated		
RX0.0		Service +0 A	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
RX0.0		Service +0 B	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX0.0		MS and FW Piping	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX0.0		ICC Cooling	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX4.9		Skimmer Drain Tank	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
RX4.9		ICS Pool C	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated		
RX4.9		ICS Pool B	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated		
RX4.9		ICS-C	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
RX4.9		ICS-B	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated		
RX4.9		ICS Common Pool	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated		
RX4.9		ICS Pool A	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated		
RX4.9		ICS-A	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated		
RX4.9		Reactor Well	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated		
RX13.0		Operating Deck	All walls are expected to be fire rated SC structure with steel plates exposed to fire. Any door(s) or HVAC dampers are expected to be fire rated.		
AN0.0		Facility Annex	Design details for wall construction and door/damper ratings are not known, most areas are smaller rooms.		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
AN0.0		Office	Design details for wall construction and door/damper ratings are not known, most areas are smaller rooms.		
AN0.0		Clean Tool Room	Design details for wall construction and door/damper ratings are not known, most areas are smaller rooms.		
AN0.0		Calibration Room	Design details for wall construction and door/damper ratings are not known, most areas are smaller rooms.		
AN0.0		Contaminated Storage	Design details for wall construction and door/damper ratings are not known, most areas are smaller rooms.		
AN0.0		Decontamination Area	Design details for wall construction and door/damper ratings are not known, most areas are smaller rooms.		
AN0.0		Hot Machine Shop	Design details for wall construction and door/damper ratings are not known, most areas are smaller rooms.		
AN0.0		Includes Truck Space and Storage Area Rooms	Design details for wall construction and door/damper ratings are not known, most areas are smaller rooms		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
AN0.0		Area Between Truck Space and Entry Areas	Design details for wall construction and door/damper ratings are not known, most areas are smaller rooms		
AN6.1		Hot Machine Shop Roof	Outdoors		
TB0.0		First Floor Area - Main	Design details for wall construction and door/damper ratings are not known, there will likely be large areas open to each other within the overall building. Some areas such as the electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
TB0.0		Freight Elevator	Design details for wall construction and door/damper ratings are not known, there will likely be large areas open to each other within the overall building. Some areas such as the electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
TB0.0		Stair B	Design details for wall construction and door/damper ratings are not known, there will likely be large areas open to each other within the overall building. Some areas such as the electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
TB0.0		Diesel Generator Room	Design details for wall construction and door/damper ratings are not known, there will likely be large areas open to each other within the overall building. Some areas such as the electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
TB0.0		First Floor Area - Condenser	Design details for wall construction and door/damper ratings are not known, there will likely be large areas open to each other within the overall building. Some areas such as the electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
TB0.0		CUW HX Room	Design details for wall construction and door/damper ratings are not known, there will likely be large areas open to each other within the overall building. Some areas such as the electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
TB0.0		Offgas Absorber Vessel Room	Design details for wall construction and door/damper ratings are not known, there will likely be large areas open to each other within the overall building. Some areas such as the electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
TB0.0		Stair A	Design details for wall construction and door/damper ratings are not known, there will likely be large areas open to each other within the overall building. Some areas such as the electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
TB6.1		Second Floor Area - Main	Design details for wall construction and door/damper ratings are not known, there will likely be large areas open to each other within the overall building. Some areas such as the electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
TB6.1		Turbine Building SWGR A	Design details for wall construction and door/damper ratings are not known, there will likely be large areas open to each other within the overall building. Some areas such as the electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
TB6.1		Turbine Building SWGR B	Design details for wall construction and door/damper ratings are not known, there will likely be large areas open to each other within the overall building. Some areas such as the electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
TB5.1		Second Floor Area - Condenser	Design details for wall construction and door/damper ratings are not known, there will likely be large areas open to each other within the overall building. Some areas such as the electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
TB12.2		Operating Deck	Design details for wall construction and door/damper ratings are not known, there will likely be large areas open to each other within the overall building. Some areas such as the electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
TB24.4		Turbine Building Roof	Outdoors		
RW0.0		Refuelling Water Storage Tank Crawl Space	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated		
RW0.0		Sample Tank 1 Crawl Space	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated		
RW0.0		Sample Tank 2 Crawl Space	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated		
RW0.0		Collection Tank 1 Crawl Space	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated		
RW0.0		Collection Tank 2 Crawl Space	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
RW0.0		Elevator	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW0.0		Stair A	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW0.0		Dress Out Area	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW0.0		Filtering Skid Area	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW0.0		Sludge Tank 1	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW0.0		Sludge Tank 2	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW0.0		Spent Resin Tank	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
RW0.0		Drum Evaporator	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW0.0		Dewatering Pump Room	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW0.0		HIC 1	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW0.0		HIC 2	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW0.0		HIC 3	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW0.0		Stair B	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW6.1		Refuelling Water Storage Tank	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
RW6.1		Sample Tank 1	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW6.1		Sample Tank 2	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW6.1		Collection Tank 1	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW6.1		Collection Tank 2	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW6.1		Hallway	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated		
RW6.1		Condensate Pre-Filter 1	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW6.1		Condensate Pre-Filter 2	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
RW6.1		Condensate Pre-Filter 3	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW6.1		Condensate Polisher 1	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW6.1		Condensate Polisher 2	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW6.1		Condensate Polisher 3	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW6.1		Second Floor Area	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW6.1		Laboratory	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW13.0		Chiller Equipment Area	All walls are expected to be fire rated poured concrete. Any door(s) or HVAC dampers are expected to be fire rated.		
RW24.4		Radwaste Building Roof	Outdoors		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
CB0.0		JC (JANITOR CLOSET)	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
CB0.0		Hallway	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
CB0.0		OPERATIONS SUPPORT CENTER (OSC) & Technical Support Centre (TSC)	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
CB0.0		LGB Electrical Equipment Room	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
CB0.0		MCC B	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
CB0.0		BATTERY ROOM LOAD GRP B	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
CB0.0		C20 DL 2 ROOM B	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
CB0.0		DL 4a ROOM	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
CB0.0		Main Control Room	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		The MCR and SCR are in different fire areas. A fire anywhere in the plant could not disable plant control and monitoring from both control rooms.
CB0.0		SHIFT TECHNICAL ASSISTANT DESK	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
CB0.0		SHIFT SUPERVISOR ROOM	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
CB0.0		TOILET	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
CB0.0		DCIS MAINTENANCE AND CYBER SECURITY ROOM	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
CB0.0		C30 RM	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
CB0.0		COMMUNICATIONS ROOM	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
CB0.0		LGA Electrical Equipment Room	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
CB0.0		MCC A	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
CB0.0		BATTERY ROOM LOAD GRP A	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
CB0.0		C20 DL 2 ROOM A	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
CB0.0		BREAK ROOM KITCHENNETTE	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
CB0.0		ACCESS ROOM	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
CB0.0		HP RCA Entrance	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
CB0.0		CONFERENCE RM	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
CB0.0		WOMENS ROOM	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
CB0.0		MEN'S ROOM	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		

Table 4-4: Fire Area Safe Shutdown Assessments

Building / Elevation	Fire Area ID	Description	Fire Area Assessment	Functions Failed	Resolutions Required For Failed Safe Shutdown Functions
CB0.0		VESTIBULE	Design details for wall construction and door/damper ratings are not known. Some areas such as the MCR and electrical equipment rooms would be expected to have higher fire ratings than other support areas of the building.		
TY0.0		Transformer Yard	Outdoors		
YD0.0		General Yard Area	Outdoors		
IN0.0	]]	Intake Structure	All walls are expected to be fire rated poured concrete, may be constructed as one large open building. Any door(s) or HVAC dampers are expected to be fire rated	]]	

5.0 IDENTIFICATION AND TREATMENT OF MULTIPLE SPURIOUS OPERATIONS

5.1 Introduction

Development of the list of potential MSO concerns is addressed using the methodology provided in NEI 00-01. The main process involves selecting an MSO Expert Panel to assess the risk associated with various MSOs. The MSO Expert Panel Review is performed via a four-phase process as described in NEI 00- 01.

The MSO list will be adjusted based on any protection and likelihood considerations mentioned in the previous sections including the limitation discussed on the use of fibre optic cables. If, for example, the use of fibre optic cable or other cable protections discussed above are in place for specific control circuits, then the MSO can be dispositioned based on this protection.

The phases are summarized as follows:

A. Phase I: Pre-Review of Fire-Induced MSO’s
   1. Review of the Generic MSO List for Applicability
   2. Perform PRA Runs per Appendix F (the internal events PRA insights were used; the Fire PRA was not yet available.)
B. Phase II: Preparation for the Expert Panel Meeting
   1. Select Expert Panel
   2. Schedule Expert Panel
   3. Training
C. Phase III: Performance of the Expert Panel Meetings
   1. Review MSO’s on the Generic List for Applicability
   2. Review Generic MSO List for Similar or Additional MSO’s
   3. Review P&ID’s and Electrical Diagrams for New Scenarios
   4. Review of SSA and MSO Combinations
   5. Review of RIS 2004-03 Assessment
   6. Review PRA Results (the internal events PRA insights were used; the Fire PRA was not yet)
D. Phase IV: Develop Comprehensive Plant Specific MSO List
   1. Develop the comprehensive Plant Specific MSO List
   2. MSO Categorization
   3. Document Expert Panel Review and Post-Review
   4. Fire Area Assessment of MSO’s
   5. Expert Panel Review of Fire Modelling & Focused-Scope Fire PRA Dispositions
   6. Overview of the MSO Identification and Treatment Process
E. Phase I Activities
   1. Activity 1: Review of the Generic MSO List for Applicability. After the initial training, the panel members performed a review of the BWROG Generic MSO list and provided comments before the MSO Expert Panel Meeting convened.

2. Activity 2: Perform PRA Runs per Appendix F

   Phase 1 of NEI 00-01 Revision 3 (Section 4.4.1.2) includes, as a prudent measure, performing PRA runs of the internal events model to identify scenarios that may not be in the SSA internal events PRA model quantification risk insights and documentation were utilized during the MSO Expert Panel process. The scenarios and systems that were not included in the Nuclear Safety and Control Act (NSCA) but were included in the PRA were also analyzed by the Expert Panel. PRA staff participate in the panel to provide insights into risk significant systems and equipment and to obtain a broad perspective for identifying MSO scenarios. In addition, the PRA group was also engaged in reviewing fire scenarios and the associated Fire PRA (FPRA) quantification cutsets after the initial MSO Expert Panel development meetings. Insights gained from these reviews were factored back into the overall fire assessment process and updates to the MSO Expert Panel Report.

F. Phase II Activities

1. Activity 1: Select Expert Panel

   In accordance with NEI 00-01, the Expert Panel members are selected to provide plant specific input in the following areas:

   - Fire Protection
   - FSSA
   - PRA
   - Operations
   - System Engineering
   - Electrical Circuits

   Resumes for the members of the Expert Panel should be documented to show that all required disciplines are included.

2. Activity 2: Schedule Expert Panel

   To be developed as design progresses.

3. Activity 3: Training

   Document training of Expert Panel members.

G. Phase III Activities

1. Activity 1: Review MSOs on the Generic List for Applicability

   The MSO Expert Review Panel utilized the BWROG MSO list from Appendix G of NEI 00-01 as a starting baseline. This list was divided into the safety functions listed in Table 1 of NEI 00-01. The Generic MSOs in each safety function are listed in Appendix 1 of NEI 00-01. By using the BWROG Generic MSO list as guidance, a step-by-step discussion held, including use of reference documents (e.g., flow diagrams, control diagrams, and simplified training diagrams), postulating scenarios, discussion of potential consequences, discussing of operator response, and recommendations of additional courses of action.

2. Activity 2: Review Generic MSO List for Similar or Additional MSO's

   After performing Activity 1 for a safety function, the Generic MSOs were considered for additional MSO's.

3. Activity 3: Review P&ID's and Electrical Diagrams for New Scenarios

   For each safety function, the SSA MSO's and the RIS 2004-03 MSOs for that safety function were evaluated. New plant specific MSOs were developed using plant documentation including plant drawings and the Fire Protection Report, ideas from the previous MSOs, and plant specific expert knowledge. These new MSOs were numbered with a "PS" designator for "Plant Specific."

   The following guidelines were used in the MSO determination process:

   - All plant specific potential MSO scenarios identified by the BFN MSO Expert Panel are dispositioned
   - A flow diversion path for a system protected by one or more passive/mechanical devices (e.g., check valves) not affected by a fire may be eliminated from further analysis and that equipment is not added to the component list.
   - Automatic actuation systems were not credited when determining MSO's unless they created an undesired effect.
   - Locations of components or cables involved in potential MSO's were not considered.
   - MSO's involving the bypassing of torque and limit switches allowing a valve to fail due to over-thrust were considered.
   - No presupposed limits on the number of fire-induced spurious operations are assumed.
   - Any number of hot shorts (inter-cable or intra-cable) was considered when assuming spurious operation of equipment.

4. Activity 4: Review of MSO Combinations

   After all the safety functions were reviewed, the panel looked for combinations of MSO's that could have more serious implications than the individual MSO's.

5. Activity 5: Review PRA Results

   PRA insights were considered as part of the MSO Expert Panel review. MSOs of concern only to Fire PRA systems (i.e., not credited by the Nuclear Safety Capability Assessment) were also included on the MSO list.

H. Phase IV Activities

1. Activity 1: Develop the Plant Specific MSO List

   The Plant Specific List of MSO's was developed and is included in Appendix 1. New MSOs are forwarded to NEI and the responsible owner's group for consideration when revising the Generic list of MSOs in NEI 00-01.

2. Activity 2: MSO Categorization

   The MSO's will be categorized as required or important to safe shutdown.

3. Activity 3: Document Expert Panel Review and Post-Review

   The results of the Expert Panel Review are documented in a Plant Specific List of MSO's. The rationale and approval for exclusion of any identified MSOs is also documented.

4. Activity 4: Fire Area Assessment of MSOs

Fire Area Assessments of MSOs are included in the Nuclear Safety Capability Analysis.

5. Activity 5: Expert Panel Review of Fire Modelling & Focused-Scope Fire PRA Dispositions The rationale for exclusion of any identified MSOs from the PRA is documented. All other MSOs are modelled in the Fire PRA and included in the Fire Risk Evaluations.

Note: While CSA N293-17 references NEI 00-01 Rev 3, with Appendix G -1 and G-2 referenced for MSO methodology, this risk based methodology was not accepted by the USNRC and the methodology has been revised in NEI-00-01 Revision 4. Future revisions of this FSSA will address changes provided in NEI 00-01 with respect to applying the risk based method for resolution of MSOs.

BWRX-300 applies strategy and generic rules rather than detailed spurious interaction analysis. See REGDOC 2.10.2 Clause 6.5, Appendix A and C for guidance. Based on preliminary design maturity for the OPG BWRX-300 fire protection system and program, detailed spurious interaction analysis will not be complete and available for 3rd party review. But a case can be made that control cables, for a digital plant, cannot cause a spurious operation (except if a hard-wired backup is chosen using copper cables).

The MCR consoles are connected to the equipment in the safety-related DCIS rooms via optical fibre. The remote multiplier units in the field contain the logic/"intelligence" that responds to the controllers and operates the switches. The DCIS equipment rooms are in separate fire areas from each other and from the MCR and the failsafe hard wired scram, isolation and initiation controls. The video display units require at least two distinct operator actions be performed for any actuation to satisfy GEH human factors requirements. Additionally, each of the messages associated with those two operator actions are authenticated by sending/receiving addresses, sequence numbering, cyclic redundancy checks, and hash functions. At least two distinct actions are required to be performed for any actuation. It is essentially impossible for a smoke or fire-impaired video display unit or its controller to inadvertently emit the required commands/authentication once and then again representing the operator actions

Note that there are also three divisions of redundant power going to each control room,–six power panels in all. These are used to power the video display units and provide lighting and, if necessary, power for the filtered HVAC in the CB control room. These power cables are protected at the (SC 1) source such that fires, floods and shorts will not adversely affect the R10 (SC1) power system.

The MSIV and RTS load drivers open circuits to actuate; these are fail-safe in that inadvertent actuation causes safe shutdown. The switches that operate the various emergency core cooling system solenoids or squib igniters (if used) are either a series circuit of two (solenoid) or three (squib) switches (if used); the switches (even within the same division) are in separate cabinets that are in separate fire areas. A single fire could only affect one of the cabinets and therefore not "hot short" and cause an inadvertent actuation. The logic/"intelligence" in the switches will not close the output contacts on either the loss of communication or incompetent communication from the DCIS equipment room controllers

For SC 1 (C10) only note that the distances within the RB are so short or the cables so few (TB) that there will be no remote multiplier units used in SC 1.

NOTE 1: The cables most sensitive to hot shorts are the scram solenoids and these are to be run in four groups of grounded conduit (any three groups shuts the reactor down). No possibility of a hot short.

NOTE 2: Various solenoids for isolation and IC initiation are in the inerted drywell outside containment with the wires are in separate rooms/penetrations.

The fire protection program considers multiple hot shorts for any equipment that has hard wires for its power or control circuits that could cause equipment to either actuate or not actuate which could result in not being able to be place equipment in its safe shutdown position. For AC circuits, hard wires that are in conduit do not have to consider hot shorts from conductors/cables that are outside of the conduit. Hard wires in cabinets/panels that are in wire bundles are considered for hot shorts. CSA N293 separation criteria such as three-hour fire barrier separation between redundant success paths is considered in the Safe Shutdown Circuit Analysis. The fire protection program can use a deterministic analysis approach for the Safe Shutdown Circuit Analysis and, therefore, does not use any performance-based approach like fire modelling that considers the location of cables and equipment. This deterministic approach would assume that if a hot short could adversely affect safe shutdown, then the cable that could cause that hot short would be present or nearby. The fire protection program could take an exception to the above, but this cable routing/arrangement including cabinet bundles would then be controlled by procedure to prevent the SSA from being invalidated

5.2 List of MSOs

Cable fire testing performed by the NRC and industry has demonstrated that multiple cable faults occur when cables are exposed to fire. All spurious actuations that could affect the operation of systems and equipment that are required to achieve and maintain hot shutdown conditions are required to be protected.

The approach outlined in Chapter 4 of NEI 00-01, which relies on the Expert Panel Process and the Generic List of MSOs contained in Appendix G to that document, will be used for the identification of multiple spurious actuations that may affect safe shutdown success path SSCs for the BWRX-300. Spurious actuations, either single or multiple, with the potential to affect safe shutdown success path components will be mitigated under detailed design. Tools such as fire modelling and manual actions will not be used.

The methodology described in Section 4.0 of this document will be applied during preliminary and detailed design as details on cable routing and BWRX-300 plant specific MSO lists are generated.

5.3 High/Low Interfaces

Detailed HI/LP system interface analysis will not be complete. The BWRX-300 plant has a passive design that the safety systems do not have active components such as the high-pressure injection pumps in the traditional plant designs

For the high/LP interfaces, multiple check valves are included which prevent the opening of the path even if a spurious actuation should occur after a fire

The BWRX-300 design focuses on the mitigation of LOCAs by reducing the number and size of RPV nozzles as compared to previous designs and limiting nozzle penetrations to the upper regions of the vessel. There are no fluid system nozzles located below approximately four metres above the TAF.

The RPV is equipped with RPV isolation valves attached directly to the vessel for large and medium piping. The design for these valves is two valves in series that are independently able to isolate the line. The isolation valves work together with an ICS, an RTS, and a slower pressurization rate vessel design to eliminate the need for relief and safety valves and to limit loss of coolant inventory from the Reactor Coolant Pressure Boundary (RCPB).

Fire SSA must evaluate the potential for spurious operations that may adversely affect the ability to achieve and maintain safe shutdown. A subset of components considered for spurious operation involves RCPB components whose spurious operation can lead to an unacceptable loss of RPV/RCS inventory via an interfacing system ISLOCA. Because an ISLOCA is a significant transient, it may be beyond the capability of a given safe shutdown path to mitigate. As a result of this concern, selected RCPB valves are defined as high/LP interface valve components that require special consideration and criteria.

An ISLOCA is postulated to occur when a series of failures or inadvertent actions occur that allow the high-pressure from one system to be applied to the low design pressure of another system, which could potentially rupture the pipe and release coolant from the reactor system pressure boundary. This may also occur within the high and low pressure portions of a single system. The design of the BWRX-300 reduces the possibility of a LOCA outside the containment by designing piping systems, major system components (pumps and valves), and subsystems connected to the RCPB to an ultimate rupture strength at least equal to the full RCPB pressure, to the extent practicable.

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This initial scoping of areas of intersystem leakage points was developed through review of NEI 00-01 Appendix C, high / Low Pressure Interfaces and Table G-1, BWR Generic MSO List.

The BWRX-300 strategy related to mitigation of intersystem leakage at high/LP interfaces includes the following:

- To the extent practicable, low pressure piping systems that interface with the RCPB be designed to withstand reactor pressure.
- Isolation of the high/LP pressure systems is maintained under the condition of an inadvertent opening of a valve due to an electrical failure.

Systems that have not been designed to withstand full reactor pressure should provide:

- The capability for leak testing the pressure isolation valves,
- Valve position indication that is available in the control room when isolation valve operators are de-energized,
- High-pressure alarms to warn MCR operators when rising reactor pressure approaches the design pressure of attached LP systems or when both isolation valves are not closed.

Table 5-1: High / Low Pressure Interfaces

Nozzle	QTY(1)	Pipe (Nom.)	System	RPV Isolation Valve IDs(1,6,7)	Flow Path and Additional Safeguards	High/Low Interface Considerations (list of required for SSD or important for SSD)
[[						

(1)
(2)
(3)
(4)
(5)
(6)
(7)
(8)
(9)
(10)
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6.0 ACRONYMS, DEFINITIONS, AND SYMBOLS

6.1 Acronyms

Acronym	Explanation
AC	Alternating Current
BDBT	Beyond Design Basis Threat
BL-DBA	Baseline Design Basis Analysis
BWR	Boiling Water Reactor
BWROG	BWROG
CB	Control Building
CCF	Common Cause Failure
CN-DBA	Conservative Design Basis Analysis
CRD	Control Rod Drive
CIV CUW	Containment Isolation Valve Reactor Water Cleanup System
CWE	Chilled Water Equipment
DCIS	Distributed Control and Information System
DNNP	Darlington New Nuclear Project
ECCS	Emergency Core Cooling System
EDS	Electrical Distribution System
ESBWR	Economic Simplified Boiling Water Reactor
FMCRD	Fine Motion Control Rod Drive
FPRA	Fire Probabilistic Risk Assessment Analysis
FSS	Fire Safe Shutdown
FSSA	Fire Safe Shutdown Analysis
FW	Feedwater
GEH	GE-Hitachi Nuclear Energy
HVAC	Heating, Ventilation and Air Conditioning
HX	Heat Exchanger
I&C	Instrumentation and Controls
IC	Isolation Condenser
ISLOCA	Intersystem Loss of Coolant Accident
LP	Low Pressure
LWR	Light Water Reactor
MCR	Main Control Room
MSIV	Main Steam Isolation Valve
NEI	Nuclear Energy Institute

Acronym	Explanation
NPP	Nuclear Power Plant
NRC	Nuclear Regulatory Commission
NSCA	Nuclear Safety and Control Act
PA	Postulated Accident
P&ID	Piping and Instrumentation Diagram
PCW	Plant Cooling Water System
PRA	Probabilistic Risk Assessment Analysis
PS	
RB	Reactor Building
RC	Reinforced Concrete
RCS	Reactor Coolant System
RIV	Reactor Isolation Valve
RP	Radiation Protection
RTS	Reactor Trip System
RPV	Reactor Pressure Vessel
RX	Reactor
SC	Steel-plate composite
SBO	Station Black Out
SCR	Secondary Control Room
SDC	Shutdown Cooling
SSA	Safe Shutdown Analysis
SSC	Structures, Systems or Components
SSD	Important to Safe Shutdown
SS	Safe Shutdown
TB	Turbine Building
T-H	Thermal Hydraulic

6.2 Definitions

Term	Definition
Cable	IEEE Standard 100-1984 – A conductor with insulation, or a stranded conductor with or without insulation and other coverings (single-conductor cable) or a combination of conductors insulated from one another (multiple-conductor cable).
Circuit	IEEE Standard 100-1984 – A conductor or system of conductors through which an electric current is intended to flow.

Term	Definition
Circuit failure modes	The following are the circuit failure modes that are postulated in the post-fire safe shutdown analysis because of a fire: Hot Short A fire-induced insulation breakdown between conductors of the same cable, a different cable or from some other external source resulting in a compatible but undesired impressed voltage or signal on a specific conductor. Open Circuit A fire-induced break in a conductor resulting in a loss of circuit continuity. Short-to-Ground A fire-induced breakdown of a cable's insulation system resulting in the potential on the conductor being applied to ground/neutral.
Design Basis Fire	A postulated event used in the post-fire safe shutdown analysis. See Exposure Fire.
Exposure Fire	SRP Section 9.5.1 – An exposure fire is a fire in each area that involves either in situ or transient combustibles and is external to any structures, systems, or components located in or adjacent to that same area. The effects of such fire (e.g., smoke, heat, or ignition) can adversely affect those structures, systems, or components important to safety. Thus, a fire involving one train of safe shutdown equipment may constitute an exposure fire for the redundant train located in the same area, and a fire involving combustibles other than either redundant train may constitute an exposure fire to both redundant trains located in the same area.
Fire Area	Generic Letter 86-10 – The term "fire area" as used in Appendix R means an area sufficiently bounded to withstand the hazards associated with the fire area and, as necessary, to protect important equipment within the fire area from a fire outside the area. In order to meet the regulation, fire area boundaries need not be completely sealed with floor to ceiling and/or wall-to-wall boundaries. Where fire area boundaries were not approved under the Appendix A process, or where such boundaries are not wall-to-wall or floor to ceiling boundaries with all penetrations sealed to the fire rating required of the boundaries, licensees must perform an evaluation to assess the adequacy of fire area boundaries in their plants to determine if the boundaries will withstand the hazards associated with the area and protect important equipment within the area from a fire outside the area.
Fire Barrier	SRP Section 9.5. – those components of construction (walls, floors, and their supports), including beams, joists, columns, penetration seals or closures, fire doors, and fire dampers that are rated by approving laboratories in hours of resistance to fire and are used to prevent the spread of fire.
Fire Zone	The subdivision of fire area(s) for analysis purposes that is not necessarily bound by fire rated barriers.

Term	Definition
Free of Fire Damage	It is expected that the term "free of fire damage" will be further clarified in a forthcoming Regulatory Issue Summary. Until this occurs, NRC recommends using the following guidance in Regulatory Guide 1.189: "The structure, system, or component under consideration is capable of performing its intended function during and after the postulated fire, as needed, without repair."
High Impedance Fault	Generic Letter 86-10 – electrical fault below the trip point for a breaker on an individual circuit.
Important to Safe Shutdown (SSD)	10 CFR 50, Appendix R, Section III.G.1 describes SSC important to safe shutdown for which fire protection features apply. Components classified as important to SSD in accordance with Appendix H may apply different mitigation tools than components classified as required for hot shutdown.
Isolation Device	IEEE Standard 380-1975 – A device in a circuit that prevents malfunctions in one section of a circuit from causing unacceptable influences in other sections of the circuit or other circuits.
Local Operation	Operation of safe shutdown equipment by an operator outside the Main Control Room when automatic, remote manual, or manual operation are no longer available (e.g., opening of a motor operated valve using the hand wheel).
Operator Manual Action	Action performed by operators to manipulate components and equipment from outside the Main Control Room to achieve and maintain post-fire hot shutdown, not including "repairs."
Performance Barriers	FPA fire zone boundaries within the plant that are credited to mitigate the effects of fire from one zone to another. Note: Performance barriers are not always credited for life safety and thus are not required to be fire rated.
Remote Control	Plant design features that allow the operation of equipment through a combination of electrically powered control switches and relays. Remote control can typically be performed from the control room or from local control stations, including the remote shutdown panel and other locations with control capability outside the control room.
Remote Manual Operation	Operation of safe shutdown equipment on the required safe shutdown path using remote controls (e.g., control switches) specifically designed for this purpose from a location other than the main.
Required Hot Shutdown Component	Equipment that is required to either function or not malfunction so that the required safe shutdown path will be capable of achieving and maintaining hot shutdown in a particular fire area and meet the established regulatory criteria.
Required Safe Shutdown System	A system that performs one or more of the required safe shutdown functions and is, therefore, a part of the required safe shutdown path for a particular fire area.
Required Hot Shutdown Cable/Circuit	Cable/circuit required to support the operation or prevent the mal-operation of required hot shutdown component in a particular fire area.

Term	Definition
Required Safe Shutdown Path	The safe shutdown path selected for achieving and maintaining safe shutdown in a particular fire area. This safe shutdown path must be capable of performing all the required safe shutdown functions described in this document.
Safe Shutdown	A shutdown with (1) the reactivity of the reactor kept to a margin below criticality consistent with technical specifications, (2) the core decay heat being removed at a controlled rate sufficient to prevent core or reactor coolant system thermal design limits from being exceeded, (3) components and systems necessary to maintain these conditions operating within their design limits, and (4) components and systems necessary to keep doses within prescribed limits operating properly. For fire events, those plant conditions specified in the plant Technical Specifications as Hot Standby, Hot Shutdown, or Cold Shutdown.
Safe Shutdown Capability	Redundant Any combination of equipment and systems with the capability to perform the shutdown functions of reactivity control, inventory control, decay heat removal, process monitoring and associated support functions when used within the capabilities of its design. Alternative For a given fire area/zone where none of the redundant safe shutdown capability are “free of fire damage” and dedicated equipment is not provided, the shutdown strategy used is classified as alternative. Dedicated A system or set of equipment specifically installed to provide one or more of the post-fire safe shutdown functions of inventory control, reactivity control, decay heat removal, process monitoring, and support as a separate train or path.
Safe Shutdown Equipment/Component	Equipment that performs a function that is required for safe shutdown either by operating or by not mal-operating.
Spurious Operation	The possible inadvertent operation or repositioning of a piece of equipment.

6.3 Symbols

None

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