ELECTRIC POWER RESEARCH INSTITUTE

Review of Current Practices for Configuration Risk Management at Nuclear Power Plants

EPRI Configuration Risk Management Forum—2007 Research Task

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REPORT SUMMARY

Background

A structured configuration risk management (CRM) process, using models based on the plant probabilistic risk assessment (PRA), is prevalent at U.S. nuclear power plants. CRM supports the planning and scheduling of equipment outages both during at-power operations and during plant outages. CRM enables the evaluation of equipment configurations from a safety risk standpoint and provides valuable information about possible risk management actions (RMAs) associated with the configurations. These models substantially improve both the safety and efficiency of plant maintenance activities.

In 2003, the EPRI configuration risk management forum (CRMF) performed a survey of the nuclear power industry concerning CRM practices and trends. That survey achieved a high degree of participation, and the results were published in EPRI Report 1007972, *Review of Current Practices for Establishing Configuration Risk Management Thresholds for Nuclear Power Plants: EPRI Configuration Risk Management Forum – 2003 Research Task.* Because many utilities found the survey results beneficial for their benchmarking efforts, and both the state of the art and the regulatory framework have advanced since this initial survey, the CRMF steering committee recommended that a new survey be performed to update the previous data and to explore additional areas of particular interest today.

Objectives

- To provide comparative information about CRM processes and model attributes that can be used by individual plants to improve the consistency and effectiveness of their CRM programs, including:
  - Categorization of at-power configuration-specific risk (including assessment of quantitative and qualitative CRM results), and communication of risk level information throughout the plant
  - Current practices regarding CRM administrative processes and technical features. In particular, identify and evaluate those that may be required to support the Risk-Informed Technical Specifications (RITS) Initiative 4B
  - Current and future approaches for assessing risk from external events, in light of a potential revision to NUMARC 93-01 and development of new fire PRAs to support the transition to NFPA-805, “Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants”
  - Non-quantified risk factors considered by plants as well as methods used to assess the impacts of these factors

– Current industry practices for evaluating the ability to close containment hatches in the event of an incident during refueling outages

Approach
An updated version of the 2003 questionnaire used to survey EPRI-member nuclear plant CRM programs was prepared and distributed under the auspices of the EPRI CRMF steering committee. In addition to follow-up to questions contained in the 2003 survey, this survey included two new topics: grid stability and containment closure during shutdown, as well as some new questions in the existing topic areas of risk categorization and evaluation of individual configurations. Results were compiled in tabular form that facilitates easy review and comparison.

Results
The survey was completed by 45 plant sites representing 71% of the U.S. nuclear units; the survey also was completed by one non-U.S. plant. Thus, a good cross-section of CRM methods is represented by the data. The results obtained continue to show a high level of consistency throughout the industry. The responsibility for performing routine CRM assessments continues to lie with the maintenance planning and scheduling personnel at a majority of plants. Instantaneous risk (core damage frequency) was the most prevalent measure. Thresholds for risk categories were quite consistent, even if developed using different methods. In addition to instantaneous measures, cumulative or accrued risk (in various forms) also is used at more than half the plants. Quantitative risk measures are universally used for internal events, and a majority also includes evaluations of internal flooding and large early release frequency (LERF).

EPRI Perspective
The use of CRM at nuclear plants is one of the greatest successes of risk-informed operations. Faced with the need to demonstrate effective safety risk management while moving to on-line maintenance and shorter refueling outages, nuclear utilities called upon EPRI to develop and demonstrate methods and models for CRM. This successful research and development was quickly adopted by utilities and supported by engineering service providers. In the United States, the regulator encourages the use of CRM, and it is even required for one aspect of the Maintenance Rule. As a result of its benefits and widespread use, the CRM process has matured to support even more beneficial risk-informed changes—for example, in the area of flexible Technical Specifications. To continue to achieve these benefits, the CRM methods must continue to provide accurate, consistent results to maintain the confidence of management and regulators. This project provides the data and insights to advance this level of confidence. Furthermore, the Configuration Risk Management Forum, which identified this work scope and oversaw its completion, provides an opportunity for continuing advances in CRM technology and implementation.

Keywords
Risk/safety management
Probabilistic risk assessment
Configuration risk management
Risk-informed regulations

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1 INTRODUCTION

Background

Configuration risk management (CRM) has evolved over the past decade as a powerful tool to assist nuclear power plant personnel in planning and executing day-to-day maintenance and operations activities. The use of CRM practices has reduced the risk of accidents and transients at nuclear power plants. Also, CRM tools and methods have enabled plant operations and maintenance personnel to use results from the plant's probabilistic risk assessment (PRA) model more directly in support of day-to-day decisions. This has also had the benefit of increasing the familiarity of plant staff with the risk insights from the PRA and has facilitated the use of the PRA in support of a wide range of plant issues.

In 2003, EPRI established the configuration risk management forum (CRMF) as an industry vehicle for discussing and disseminating information concerning CRM practices and issues. A key topic that was identified for research was the development of a survey of the nuclear power industry concerning CRM practices and trends. That survey achieved a high degree of participation, and the results were published in EPRI Report 1007972, *Review of Current Practices for Establishing Configuration Risk Management Thresholds for Nuclear Power Plants: EPRI Configuration Risk Management Forum – 2003 Research Task* [1] and several informal reports [2, 3]. As many utilities found these initial survey results beneficial for their benchmarking efforts, the CRMF steering committee in January 2007 recommended that a new survey be performed to update the previous data and to explore additional areas of particular interest today.

In this report, it is assumed that the reader is familiar with the concepts and terminology of CRM, the methods and tools used to perform CRM evaluations, the requirements of the Maintenance Rule, and the relevant industry and regulatory guidance documents. For more information about these topics, see the references listed in Section 5 of this report.

Project Approach

An updated version of the 2003 questionnaire used to survey EPRI-member nuclear plant CRM programs was prepared and distributed under the auspices of the EPRI CRMF steering committee. The survey included two new topic areas for 2007: grid stability and containment closure during shutdown. It also contained new questions in the topic areas of risk categorization and evaluation of individual configurations, which were addressed in the 2003 report.

Section 2 of this report summarizes the information obtained from the industry survey. Section 3 provides a detailed compilation of the survey results. Conclusions from this research project are presented in Section 4. Section 5 presents the references used in this project.

2
SURVEY OF INDUSTRY CRM PRACTICES

As a first step in the assessment of current industry CRM practices, a survey was prepared and distributed to all U.S. utilities (as well as the international CRMF utility members) to request information concerning current CRM practices. More than 70% of the operating U.S. nuclear power units are represented in the responses to this survey. This section presents an overall summary of the results. Section 3 provides a detailed compilation of the survey results.

A total of 24 surveys were completed by 21 utilities, representing a total of 44 U.S. plant sites (73 units, or 71% of the units in the United States) and one non-U.S. plant. In summarizing the survey results in terms of percent of plants responding, the results do not always total 100%, due to multiple approaches described by some plants or plants that did not provide answers for all questions. For survey topics that were also included in the 2003 survey, percentages from the 2003 CRMF survey are provided in brackets [] for comparison.

CRM Software Tools Currently in Use

The first section of the survey requested information on the CRM software tools currently in use. Similar to 2003, all but one of the survey respondents is currently using a CRM software tool such as EOOS, Outage Risk Assessment Management (ORAM)-SENTINEL, PARAGON, Safety Monitor, or others for CRM during at-power conditions.

Although the primary focus of the survey was limited to at-power risk management, information was also collected on the use of CRM tools for transition and shutdown modes. In this case, 33% of plants responding do not currently use a CRM tool for transition modes (compared to 20% in 2003), and only 2% do not use a CRM tool for shutdown modes (compared to 8% in 2003). Note that some of the variation in response percentages (for these and other comparisons noted in this section) may be due to the fact that a subset of the utilities that responded to the 2003 survey did not respond to this new survey, and some utilities that responded to the current survey did not participate in 2003.

The CRM software tools in use are designed to evaluate risk for all modes, and 26 of the plants responding use the same, single software tool across all modes (compared to only 6 in 2003). The remaining plants either use DID or other plant status worksheets for transition and/or shutdown modes, or use a combination of software tools. For example, a plant may use Safety Monitor at-power and ORAM for shutdown.

Configuration Risk Management Program Characteristics

The second section of the survey collected information on how the plant CRM program is implemented, including such topics as responsible personnel, risk characterization criteria and communication processes, and CRM model scope.

Figure 2-1 illustrates which plant groups are responsible for performing Maintenance Rule (a)(4) assessments. The responsibility for performing routine CRM assessments in accordance with (a)(4) primarily belongs to the maintenance planning and scheduling personnel (at 89% of the plants responding). More than one-third (36%) of the respondents also rely on control room staff, while at 16% of the plants the responsibility lies entirely or partially with PRA personnel, and 7% of the responding plants have a dedicated CRM coordinator.

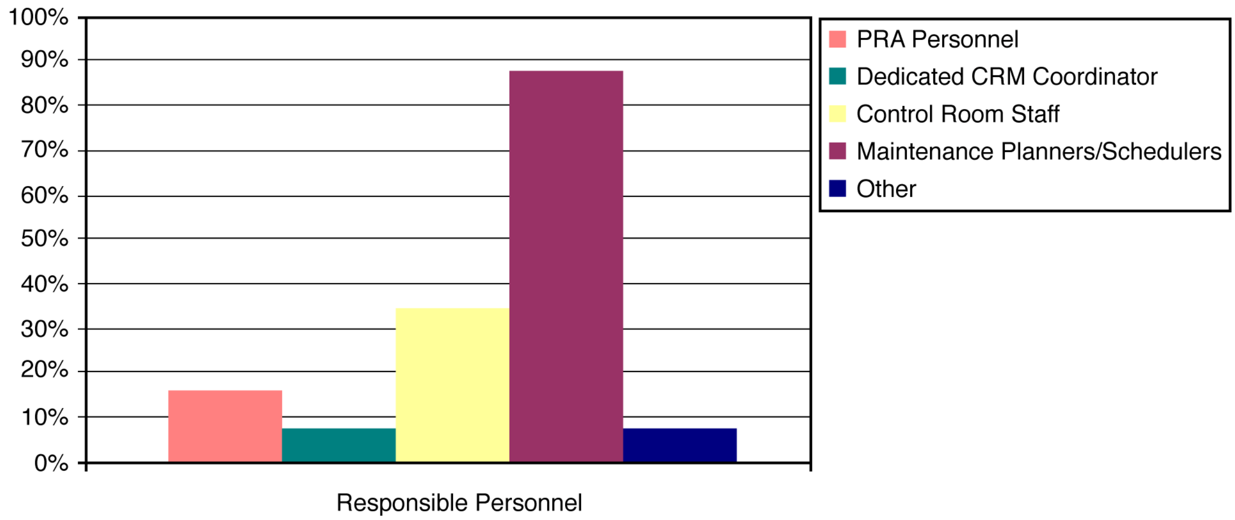

Figure 2-1
Plant Assignments of Responsibility for (a)(4) Assessments

Quantitative Risk Thresholds

All of the plants responding to the survey currently use risk zones (typically represented by colors) to communicate risk. The majority (93%) uses a four zone/color classification (typically green, yellow, orange, and red), while the remaining plants use a three zone/color classification (for example, green, yellow, and red).

The 2007 survey results indicate that 64% of the plants use a blend of quantitative and qualitative risk criteria, down from the 83% that reported a use of blended criteria in 2003. The blended approaches described represent a range of methods and applications, such as the following methods used in addition to a quantitative CRM model:

- Use of safety function assessment trees (SFATs) and/or plant transient assessment trees (PTATs) to assess the defense-in-depth (DID) for plant safety functions and mitigation of transients, respectively. The approach (qualitative or quantitative) providing the highest risk result is used to specify the overall risk.
- Consideration of qualitative criteria (based on industry operating experience, personnel judgment, and so on) for external event impacts, weather, grid conditions, switchyard work, actuation system testing, and so on.

As described in the 2003 report [1], the use of multiple risk metrics can provide additional insights for plant personnel. A risk metric based only on instantaneous risk will highlight the importance of a configuration where risk exceeds the green zone, but this metric may not cause a plant to examine the duration of a longer configuration with risk within the green zone. Figure 2-2 illustrates the quantitative risk metrics currently in use at the surveyed plants.

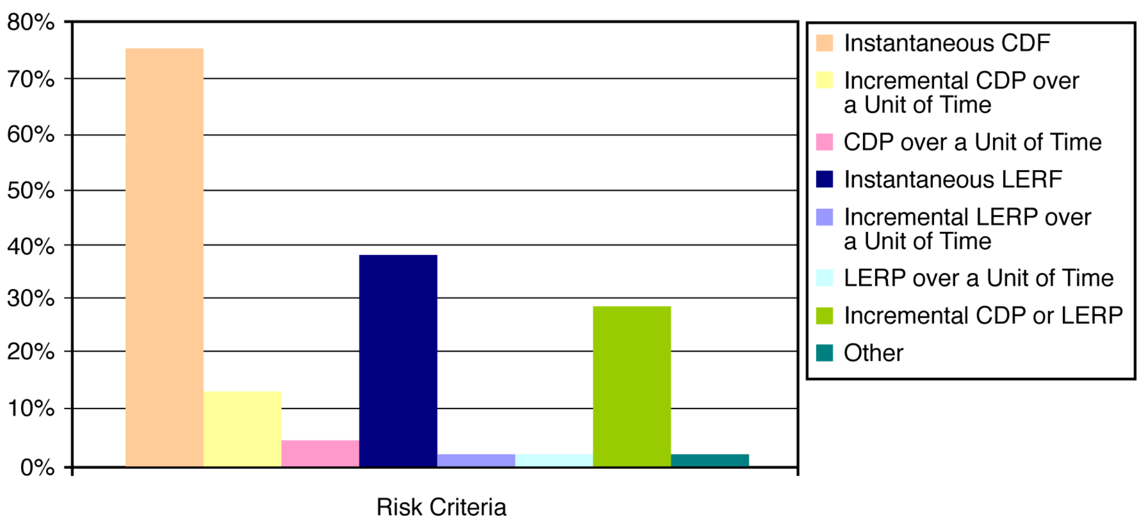

Figure 2-2
Plants Using Specific Quantitative Risk Metrics

The survey shows that most of the responding plants use at least one instantaneous risk measurement metric, with 76% of the plant sites using instantaneous core damage frequency (CDF). Nearly half of the plants (44%) use only a single risk metric, while the remaining 56% use two or more risk measurement metrics.

The percentage of responding plants that use core damage probability (CDP), incremental CDP/ large early release probability (LERP), or incremental CDP over a unit of time (in addition to or instead of instantaneous risk criteria) has increased from 25% in the 2003 survey to 46%. The use of CDP is an extension of the instantaneous risk approach (that is, CDP is the combination of instantaneous risk and duration). In addition, 42% of the plants responding currently use instantaneous large early release frequency (LERF), LERP, or incremental LERP.

For the plants responding that use quantitative instantaneous risk measures, 56% use multiples of the baseline risk value (for example, 2x or 10x) to establish risk thresholds, while 36% use fixed-risk values based on the EPRI *Probabilistic Safety Assessment (PSA) Applications Guide* [4], or NUMARC 93-01 [5]. The remaining plants use a combination of the methods mentioned previously. As noted by one responding utility, a lack of standardization in risk color thresholds across the industry makes it difficult for the U.S. Nuclear Regulatory Commission (NRC) to compare the relative risk of different plants. All 45 plants responding to the survey indicated that *baseline risk* is defined as the no-maintenance risk level. This approach is consistent with the guidance noted in NUMARC 93-01.

Although more than 75% of plants use instantaneous CDF as a risk measure, 60% of the plants responding do not establish risk zone thresholds for CRM actions based on cumulative, time-averaged, or duration measures (although many of these plants do consider duration or cumulative risk measures either directly or indirectly when making risk management decisions, as described below). By considering duration for configurations with a low level of instantaneous risk, these plants may find that some such configurations can be more significant contributors to cumulative risk than previously thought.

Of those plants using duration or cumulative measures, 27% base their risk zone thresholds on the expected cumulative risk accrual during each planned configuration change, and 9% base them on cumulative risk accrued over a moving time period.

The survey results indicate that slightly more than one-quarter of the plants responding (27%) have some sort of cumulative risk target. These targets take a variety of forms, including:

- Cumulative risk is tracked weekly and compared to the expected yearly CDF with average maintenance.
- Monthly accumulated CDP is tracked to ensure that it remains below 25% of the baseline CDP.
- 12-month rolling cumulative risk must be less than 110% of PRA annual CDF with average maintenance.
- Risk is monitored to verify that CDP limit of 1E-6 and LERP limit of 1E-7 are not exceeded.

Although plants typically do not establish risk zone thresholds based on cumulative, time-averaged, or duration measures, more than half of the plants consider the expected or actual duration of a configuration when making risk management decisions. Here is how respondents answered this question:

- Respondents calculating an allowable duration for the configuration based on a CDP or LERP limit: 33% (more than double the 15% reported in 2003)
- Respondents maintaining cumulative risk below a fixed limit for a specified time period: 7% (roughly half the 13% reported previously)
- Respondents using a cumulative risk metric in conjunction with peak instantaneous risk: 13% (18% reported in 2003)

About 22% of the plants also indicated that they employed some form of rolling average measure of accumulated risk over time to limit the total accrued risk (for example, over a weekly period). This type of risk measure is actually a cumulative risk measure, where the duration of each individual configuration change would directly impact the outcome of such a risk measure. The use of a rolling average smoothes the data, making trends more readily apparent, but it does not measure total accrued risk.

Only 13% of the plants responding indicated they had not made any significant changes in risk zone definitions or thresholds since they began CRM (compared to 30% in the 2003 survey). This decrease in the percentage of plants that have made changes is due to differences in the plants that responded to the 2007 survey versus the 2003 survey (that is, eight of the plants who indicated in 2003 that they had not had any risk threshold changes did not respond to the 2007 survey). In the majority of cases, those changes were not due to enhancements to the CRM model, tool, or data. Rather, 47% of responding plants made changes in risk thresholds because of refinements in management CRM philosophy, 40% made changes after benchmarking with other sites, and 42% made changes for other reasons, such as a desire for fleet consistency or input from the NRC or the World Association of Nuclear Operators (WANO).

Quantitative Model Scope and Validation

The scope of the quantitative CRM model has an impact on the calculated baseline risk values as well as any risk threshold values that are based in part on baseline risk. Model scope also influences the degree to which a blended (qualitative and quantitative) approach is needed to accurately assess risk. Figure 2-3 illustrates the scope of the CRM model in use at the surveyed plants.

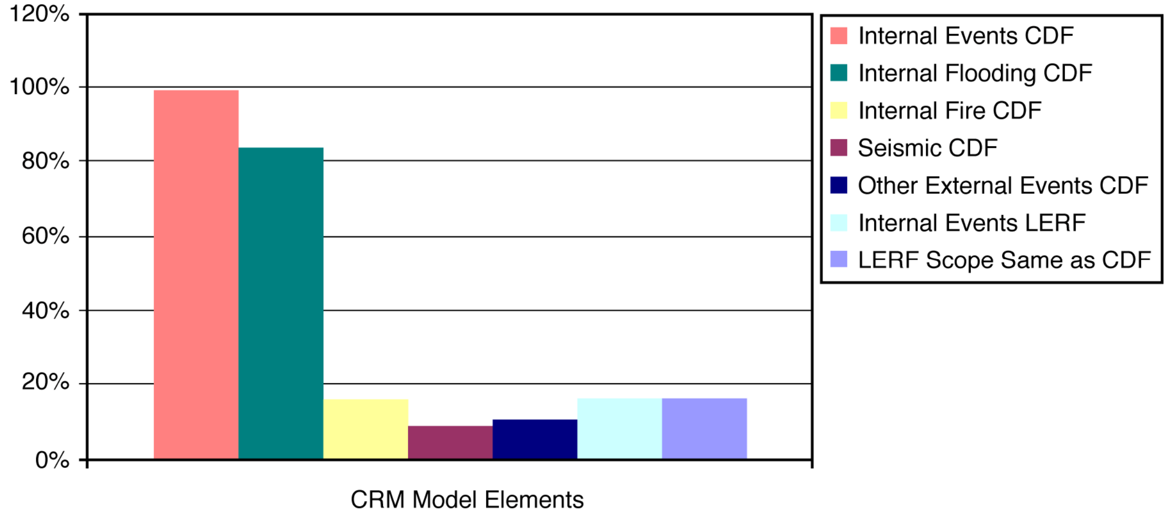

Figure 2-3
Elements Included in Plant CRM Models Scope

As expected, all of the plants responding include the internal events model for CDF in the scope of their at-power quantitative CRM model. In addition, a strong majority (84%, an increase from 55% in the 2003 survey) of plants include internal flooding but not fire (only 16%) or seismic (9%) in the CRM quantitative model.

Nearly two-thirds (64%) of the plants responding now include LERF in the at-power CRM quantitative model (compared to fewer than half, 45%, in 2003). For those plants, the scope of the LERF model is either internal events only (16%) or the same as the scope of the CDF model (48%).

For fewer than half (42%) of the plants surveyed, the approved plant PRA model is used directly to evaluate risk in the plant CRM program. However, more than one-third (36%) of responding plants perform and document a formal validation process for each released version of the CRM model. The remaining respondents have performed an informal validation or no validation at all. More than half (58%) of the plants responding to the survey have not performed truncation sensitivities on their quantitative CRM model.

Qualitative CRM Models

The portion of the survey regarding qualitative models for CRM was intended to capture information regarding at-power CRM models; however, many plants also included information regarding their qualitative CRM models for shutdown and/or transition modes.

A total of 38% of the plants responding do not use any qualitative models (either exclusively or in conjunction with quantitative models) for CRM at power. However, the remaining plants (approximately 60%) use qualitative CRM models, which include the safety functions specified in the recommendations of NUMARC 93-01 (decay heat removal, inventory control, status of key support systems, containment integrity, and reactivity control). Only 16% of these plants with qualitative models also include color representation of their quantitative results (based on the defined color zones) as part of the qualitative analysis.

For the approximately 60% of plants responding to the survey that use some sort of qualitative tool for at-power or shutdown CRM or both qualitative and quantitative measures, the majority (90%) establish the configuration color associated with each safety function based on the number of systems or trains available to perform the function (N+2, N+1, N, N-1, and so on). (Note that due to wording ambiguities in the survey, many plants included information regarding their qualitative CRM models for shutdown and/or transition modes.)

Finally, of the plants that use both qualitative and quantitative risk measures at power, almost none has truly correlated the qualitative and quantitative thresholds or results. One utility noted that although some of its plants have calibrated the DID model to the PRA model, the preference is not to do this in order to preserve the diversity inherent in the two different approaches. Note that a direct correlation between qualitative and quantitative risk results would be difficult to achieve, given that the two approaches typically model different items, and in many cases the qualitative approach tends to be more conservative. However, the results from the two approaches should corroborate each other and follow similar trends, rather than providing results that are diametrically opposed and lead to different conclusions. Generally, qualitative measures based on DID (for example, using SFATs) do not have a direct correlation to quantitative risk measures, but qualitative measures based on defense against high-risk events (for example, using PTATs) could be correlated to PRA quantitative risk measures.

Industry Definitions of Configuration Changes

Figures 2-4 through 2-6 illustrate the survey responses regarding the explicit evaluation of various component configurations, plant activities, and conditions. These responses are discussed later in this report.

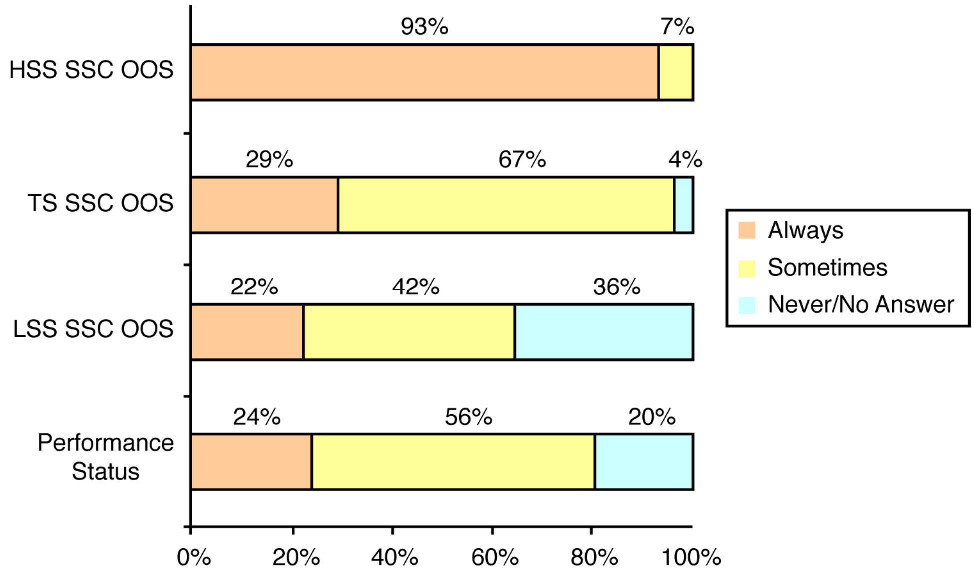

Figure 2-4
Frequency with Which Plants Evaluate Component Configurations

As in 2003, all (100%) of the plants responding to the 2007 survey consider removal or return to service (for planned or unplanned maintenance) of high safety significance (HSS) systems, structures, or components (SSCs), or SSCs explicitly modeled in the Level 1–2 PSA a configuration change. In addition, 93% of those plants indicated that this type of configuration change is always explicitly evaluated, while 7% sometimes evaluate this type of change.

Fewer responding plants (87%) consider removal or return to service (for planned or unplanned maintenance) of SSCs included in the Technical Specification (TS) limiting conditions for operation (LCOs) a configuration change. Only 29% of the respondents (down from 49% in 2003) always evaluate such a configuration change, while two-thirds (67%) sometimes evaluate this type of change. It should be noted that much of the TS equipment is not highly risk-significant. As high risk-significant SSCs are evaluated (whether TS or not), the response here most likely refers to the remaining TS equipment.

Nearly three-quarters (73%) of the plants responding consider removal or return to service (for planned or unplanned maintenance) of low safety significance (LSS) SSCs, or SSCs not modeled in the Level 1–2 PSA, as a configuration change. Fewer than half (42%) of the plants sometimes evaluate out-of-service LSS SSCs, and fewer than one-quarter (22%) always evaluate LSS SSCs.

Approximately two-thirds of the plants (67%) consider a change in performance status of redundant, in-service SSCs (for example, degradation) a configuration change (an increase from 44% in 2003). More than half (56%) of the plants evaluate the performance status of redundant, in-service SSCs sometimes (presumably only when there is known degradation), and 24% always evaluate such conditions.

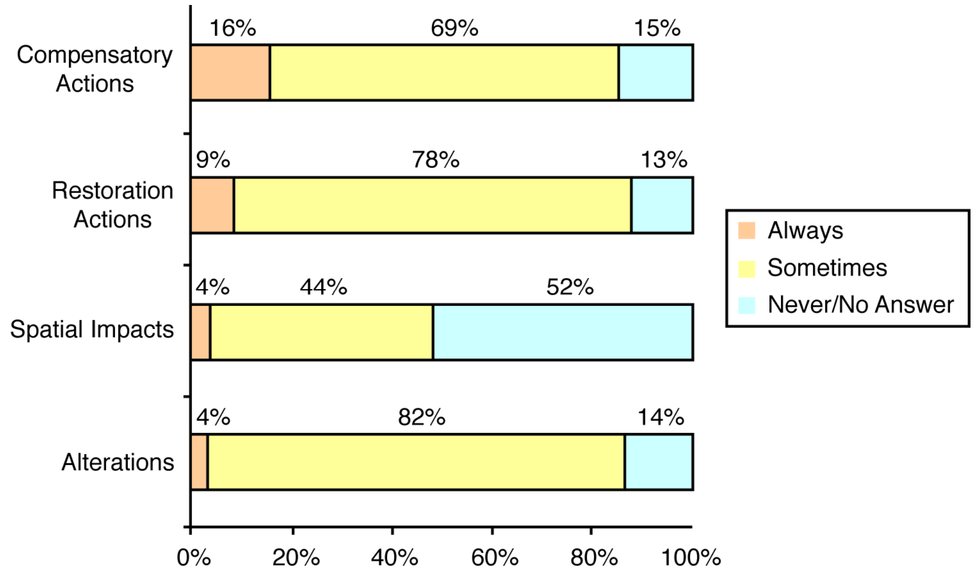

Figure 2-5
Frequency with Which Plants Evaluate Plant Activities

The use of compensatory actions for maintenance activities (for example, temporary equipment, cross-ties, and so on) is considered a configuration change by 84% of the plants responding. Compensatory actions are always evaluated by 16% of the plants, while 69% of plants sometimes evaluate these actions.

Potential prompt restoration actions for SSCs removed from service are considered a configuration change by 84% of the plants responding (a large increase from 54% in 2003). Potential prompt restoration actions are always evaluated by 9% of the plants, while 78% sometimes evaluate these actions.

More than half (58%) of the survey respondents consider maintenance activities that may lead to a spatial impact (for example, opening a fluid pressure boundary, use of heat or flame, and so on) a configuration change. Only 4% of the plants always evaluate maintenance spatial impacts, while 44% sometimes evaluate these impacts, and 49% never do.

More than 80% of the plants responding consider maintenance-related alterations (for example, erecting scaffolding, installing shielding, and so on) a configuration change (compared to only 49% in 2003). Only 4% of the plants always evaluate maintenance-related alterations, while 82% sometimes evaluate these impacts.

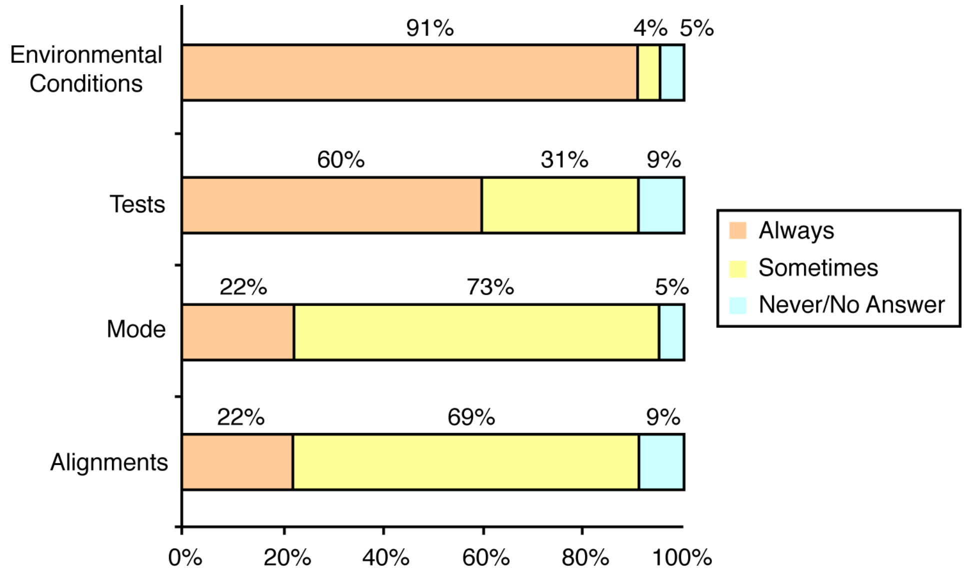

Figure 2-6
Frequency with Which Plants Evaluate Plant Conditions

A similar number of plants (82%) consider a change in environmental conditions (for example, severe weather, grid instability, and so on) a configuration change, and more than 90% of the plants responding always explicitly evaluate environmental conditions (compared to 72% in 2003).

Eighty-two percent (82%) of the plants responding also consider a plant mode change a configuration change, with more than half (60%) of the plants always explicitly evaluating plant mode changes.

Similarly, 82% of plants consider the start or end of tests on equipment or systems a configuration change, and again the majority of plants (73%) sometimes evaluate this type of change, while 22% always do.

A change in equipment or system alignments (for example, pumps running or on standby, valves open or closed, and so on) is considered a configuration change by a majority (80%) of the plants responding. However, less than one-quarter (22%) of the plants always evaluate equipment alignment changes. This is probably because a CRM model typically does not include operating alignments for all equipment, but only for those systems or components where alignment can have a noticeable impact on plant risk. For some plants, equipment and system operational states have an insignificant impact on risk level.

Other configuration changes identified include activities that heighten the potential for a plant trip or loss of off-site power (by 11% of plants).

Unplanned Versus Planned Plant Activities

The plant activities and conditions discussed previously as potential configuration changes may occur as planned or unplanned conditions (some conditions are strictly unplanned, such as degradation of SSCs or environmental conditions). The industry survey also attempted to determine if the fact that an activity was unplanned affected whether it was considered a change in the plant configuration.

More than three-quarters (76%, compared to 41% in 2003) of the plants surveyed consider an unplanned change in any of the activities or conditions described previously as a configuration change. The remaining plants do not appear to distinguish a configuration change based on whether an activity is planned or unplanned. Instead, the determination of a configuration change may depend on the equipment affected, the reason for the change in plant conditions, or other factors. When an unplanned change in plant maintenance configuration occurs, all of the plants responding typically perform a reassessment to determine new risk values.

If a plant is currently in a configuration with planned maintenance or other activities and an additional configuration change occurs, such as an unplanned event or emergent plant work, there are several possible approaches to integrate the risk impact from this new change with the existing non-baseline configuration risk. The majority (73%) of the plants responding uses the risk color or zone that results from a reassessment of the combined activities as the primary factor for managing the new configuration risk. Most of the remaining plants (22%) use a new allowed configuration time, calculated for the combined activities as the primary factor to manage risk. Of these plants using the new allowed configuration time, three-quarters do not consider the cumulative risk already accrued from the initial non-baseline configuration.

There is also some variation for the timeframe in which a reassessment must be performed. Nearly half (44%) of the plants responding indicated a reassessment of an unplanned configuration change is performed as soon as possible after stabilizing the situation and ensuring that the plant remains in a safe condition. (This is consistent with NUMARC 93-01 guidance.) In addition, one-quarter (24%) of plants specify a timeframe of 24 hours in the procedure, although reassessments typically take much less time. Less than one-fifth (15%) of the plants have no specific time in which a reassessment must be performed; presumably these plants also perform any required reassessments as soon as practical. Three plants re-evaluate emergency conditions within 2 hours, and one plant must perform the reassessment within one shift (12 hours).

For emergent conditions that cannot be explicitly evaluated by the plant CRM tool, nearly one-half (44%, compared to two-thirds in 2003) of the plants responding indicate that a qualitative assessment will be performed (independent of the CRM tool) by operations personnel using procedural guidance, expert judgment, and other resources to support decision making. The operations personnel at one-third of the plants may contact the PSA group for support in this situation, in addition to or instead of performing a qualitative assessment (compared to 20% in 2003). Four plants will restore the known high risk significance equipment first.

Finally, for emergent conditions that result in an unacceptably high risk level, all of the plants responding consider and implement appropriate risk management actions (RMAs). A total of 49% of the plants responding indicate they implement compensatory measures; another 47% of plants restore the plant to an acceptable risk level as soon as possible and establish risk management actions (42%). Nearly one-third (28%) of plants noted that management notification or approvals are required. A few plants (21%) will restore out-of-service equipment (presumably that equipment that is contributing to the high-risk condition), or perform work around the clock (14%). Most plants will perform a combination of the actions described previously.

Configuration Risk Management Attributes to Support Risk-Informed Technical Specifications

In the near-term, there is at least one pilot application of Risk-Informed Technical Specifications (RITS) Initiative 4B. Based on the success of pilot applications, other plants may choose to also adopt this initiative (as of this writing, two plants have notified NRC of intent to do so). The implementation of such a program may require some additional technical features and administrative programs; however, many of the items (or portions of them) applicable to CRM, as specified in the implementation guidance provided in NEI 06-09, may already be in place at nuclear power plants.

In June of 2005, the EPRI CRMF supported the RITS Initiative 4B regulatory approval process by identifying a set of CRM program attributes in response to NRC questions about the fidelity and traceability of the CRM models and tools. The survey collected information about the current practices for many of these attributes. It should be noted that compliance with these program attributes, while required for RITS, is not required to support Maintenance Rule CRM activities. However, these attributes represent good practices that should be considered for incorporation into all CRM programs.

The proper mapping of plant components to the actual CRM model is one of the most important elements of the CRM evaluation process. Without properly developed mapping data, an accurate risk model might provide an incorrect CRM evaluation. Of the plants surveyed, two-thirds (66%) consider a significant number of individual plant components (several hundred) for basic event component mapping in the CRM model. Another 22% consider a very large number of individual plant components (a few thousand), while 18% consider only major components or perform mapping at the system or train level.

In addition, more than half (56%) of the plants responding perform and document a formal validation process for the basic event to component mapping, while another one-third (36%) perform an informal validation. Only three plants do not perform such a validation. Figure 2-7 illustrates the portion of plants surveyed that perform a validation of basic event mapping. Finally, at all of the plants surveyed, only PRA modeling personnel have authority to make changes to the basic event mapping.

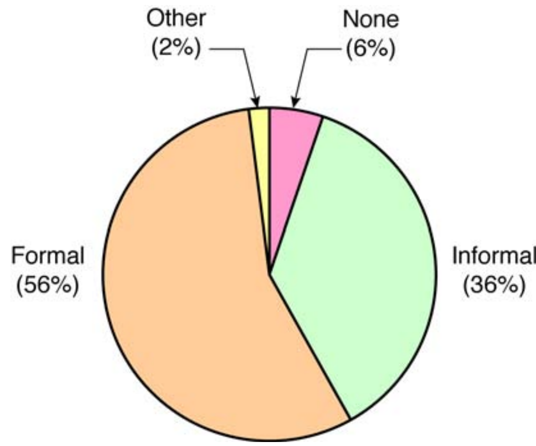

Figure 2-7
Plants Performing Validation of CRM Model Basic Event Mapping

CRM applications tools and associated software must be verified to reflect the as-built, as-operated plant and must be maintained and updated in accordance with approved station procedures on a periodic basis following PRA model updates. Of the plants responding to the survey, 62% indicated that they have procedures in place for updating the CRM model/tool and the associated PRA model.

Along with procedures for updating the CRM tool, more than three-quarters (77%) of plants have procedures in place for the at-power work control/risk management process, and 36% indicate similar procedures are in place for shutdown. Nearly one-quarter (22%) of plants also noted they have procedures for risk management training, and 7% noted procedures for qualifying CRM personnel.

Also related to performance of CRM processes, more than 90% of the plants responding provide CRM-specific training to various plant personnel. Figure 2-8 provides an illustration of the plant groups that receive CRM-specific training. At 80% of plants, training is provided to operations personnel, with 64% providing training to maintenance planning/scheduling personnel, and 44% training PRA modeling personnel. There are also a few plants that provide CRM training to a dedicated CRM coordinator (11%) or the Maintenance Rule coordinator (7%).

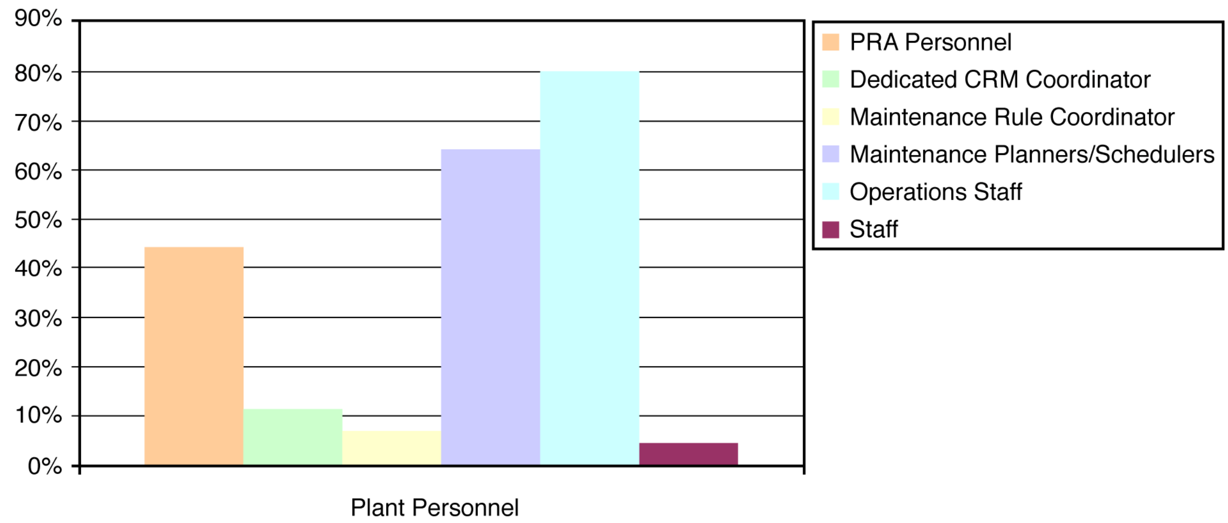

Figure 2-8
Plants Providing CRM Training to Specific Personnel

Unlike a time-averaged traditional PRA model, the CRM model may also need to address any plant-specific features that may vary as a result of the time of year or the current portion of the fuel cycle. Time-of-year examples may include changes in success criteria based on seasons (for example, fewer cooling water pumps needed during cold weather conditions, additional HVAC capacity needed for temperature-sensitive conditions during hot weather conditions, and so on). Time in fuel cycle could have a risk impact for some initiating events, particularly for anticipated transients without scram (ATWS) responses. At some plants, such an event at the beginning of the fuel cycle may have more severe mitigation requirements than an ATWS that could occur near the end of the fuel cycle. While these impacts could be treated conservatively (for example, develop the CRM model assuming the worst-case conditions that would be expected), it may be advantageous for a plant to enhance the CRM model to address variations. Figure 2-9 provides an illustration of plants considering these types of factors.

Nearly half (44%) of the plants surveyed do not consider these factors in the CRM model. Those plants that address time-of-year factors (24%) include consideration of summer/winter service for ultimate heat sink, HVAC, and grid stress. The plants that do address time-of-cycle factors (9%) consider the impact of fuel burnup on the boron, charging, and power-operated relief valve (PORV) challenges and requirements. Of the respondents, 11% indicated that time-dependent risk factors did not have a significant risk impact at their plants, and hence these factors are not considered in the model.

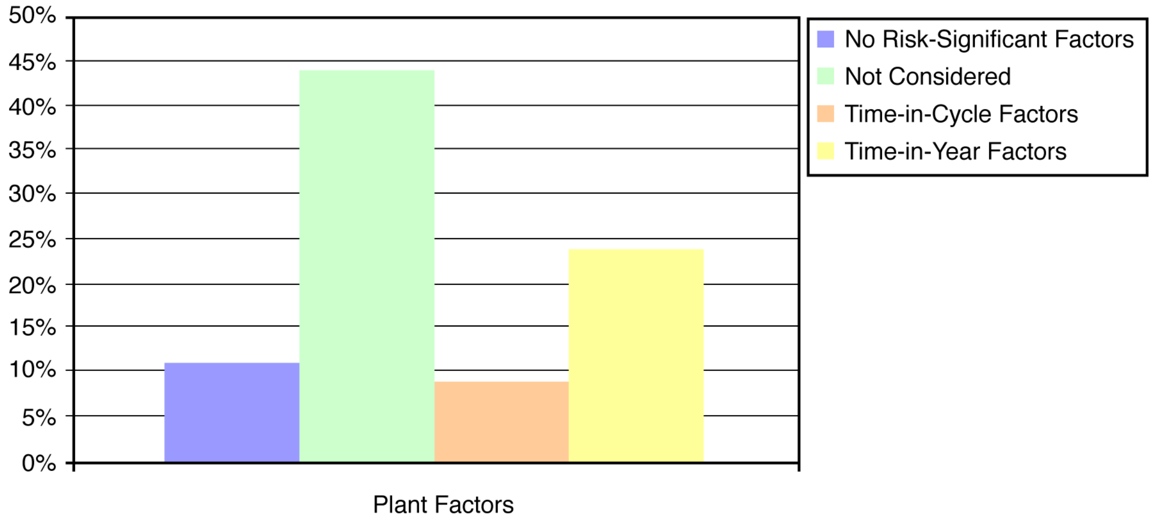

Figure 2-9
Plants That Consider Time-in-Cycle and Time-in-Year Factors

CRM calculations should appropriately account for, and quantify, the impacts of human action dependence relative to plant configurations and conditions analyzed. CRM models also should consider human interactions that are dependent on certain equipment or instrumentation and account for conditions where the required equipment or instrumentation is out of service. Figure 2-10 provides an illustration of how the surveyed plants currently account for human interaction (HI) dependencies in their CRM models. The survey results show that more than three-quarters (78%) of the plants responding treat the dependencies between human actions and/or recovery actions in the same manner as the base PRA. The other one-quarter (22%) do adjust human action and recovery events on a configuration-specific basis as key equipment is removed/returned to service.

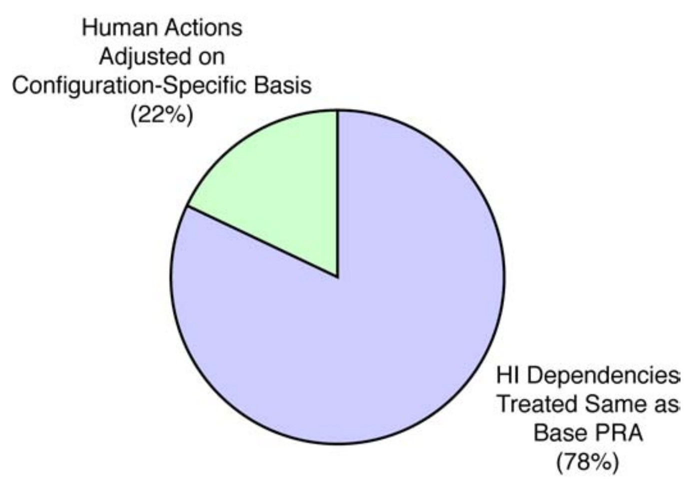

Figure 2-10
Plants Treating HI Dependencies in the CRM Model

Any new key uncertainties contained in the CRM model (that are identified via PRA model to CRM tool benchmarking) should be identified and evaluated prior to use of the CRM tool for RITS applications. Model elements included in the CRM tool that are not in the PRA must be evaluated for uncertainty according to the same criteria as the PRA. Configurations that introduce high uncertainty must also be identified and that uncertainty evaluated or appropriate RMAs considered. A majority (91%) of the plants responding to the survey indicated that they have not identified and evaluated risk-important uncertainties specific to the CRM model. For those plants that indicated they have evaluated CRM model uncertainties, it appears that the uncertainty evaluations performed were in most cases actually done for the underlying PRA model (see Figure 2-11).

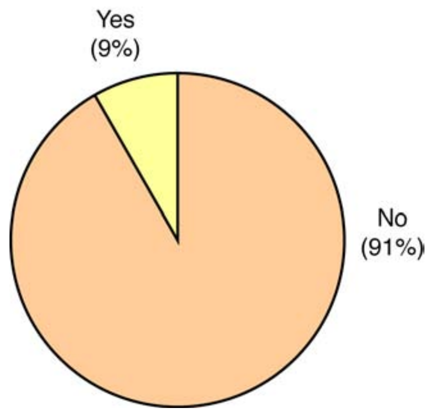

Figure 2-11
Plants Addressing CRM Model Uncertainties

Corrective actions should be identified and implemented as soon as practicable to address any identified modeling errors that could significantly impact the CRM calculations. Roughly ninety-five percent (96%) of the plants reported a process in place for addressing errors in the CRM model or tool. Nearly half (44%) of the plants rely on the plant corrective action process, while one-third (33%) identified specific procedural guidance with criteria for determining the need for an interim/unscheduled model change, and 15% use a specific PRA configuration control procedure and/or database.

In addition to a process for correcting errors identified in the CRM tool or model, a process for evaluation and disposition of proposed facility changes is needed for items impacting the CRM tool with criteria established to require CRM updates (within a reasonable amount of time) of the facility changes that have the potential to significantly impact CRM evaluations. Facility changes likely require PRA updates as well as CRM updates, and adequate time is required to plan and execute these updates. Roughly ninety-five percent (96%) of the plants reported a process in place for evaluating the impact of plant changes on the CRM model or tool and determining the need for an update. A majority (87%) of the plants have a process or procedure in place to identify changes and determine whether a change to the CRM model is needed immediately, as an interim update, or during the next scheduled update. A few plants (9%) review plant and/or procedure changes during the scheduled model update, and one plant reported that no plant changes had occurred that affected the CRM model.

Treatment of External Events

In the near future, NUMARC 93-01 may be revised to require explicit consideration of the impacts of configuration changes on the risk of accidents due to some external events. Also, many plants are performing new fire PRAs as part of ongoing programs to implement NFPA-805. In light of these activities, the survey gathered information concerning current and future approaches for assessing risk from external events. Figure 2-12 illustrates how the survey respondents are currently considering external events.

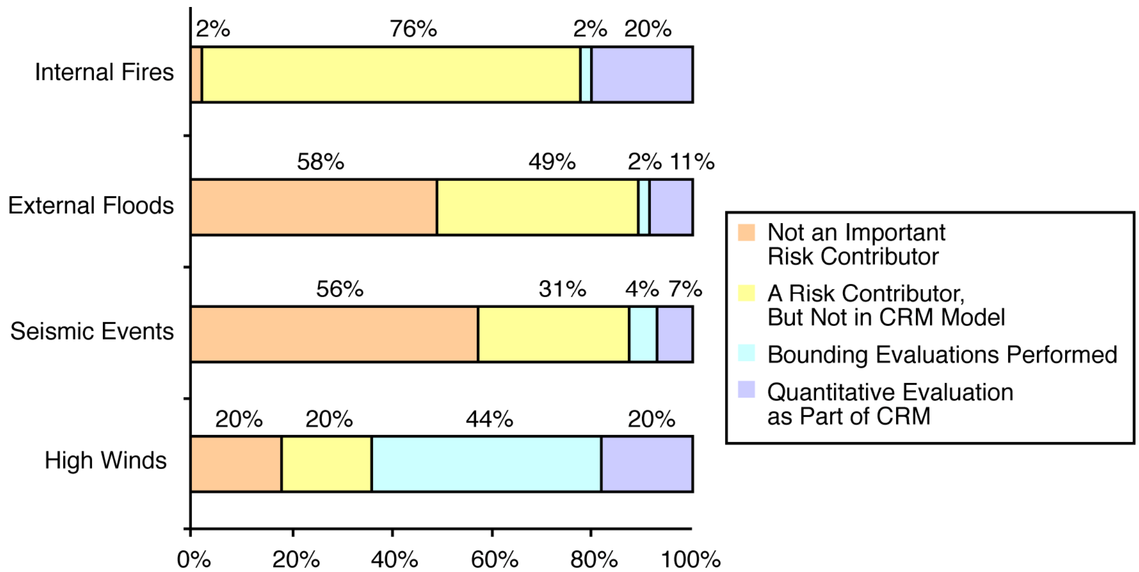

Figure 2-12
Plants Considering External Events in CRM Evaluations

Internal fire is considered to be a risk contributor at 76% of the plants responding but is not currently addressed in the CRM evaluations. Of the plants responding, one-fifth (20%) does include a quantitative evaluation of internal fire risk as part of the CRM evaluations. One plant uses bounding risk evaluations to address internal fire, and one plant has shown fire to not be an important risk contributor.

More than half (58%) of the plants surveyed have shown that external floods are not an important risk contributor; another one-fourth (27%) consider external floods to be a risk contributor but do not address them in the CRM evaluations. Five plants (11%) do include external floods in their CRM evaluations, and one plant uses a bounding risk evaluation.

Similarly, more than half (56%) of the plants surveyed have shown that seismic events are not an important risk contributor; another one-third (31%) consider seismic events to be a risk contributor but do not address them in the CRM evaluations. Three plants (7%) do include seismic events in their CRM evaluations, and two plants use a bounding risk evaluation.

Finally, high winds are evaluated using bounding evaluations by nearly half (44%) of the plants responding. Twenty percent (20%) of the plants consider high winds to be a risk contributor, but do not consider these events in the CRM model. High winds are included in the CRM evaluations for 20% of the plants, and the remaining 20% have shown high winds are not an important risk contributor.

Given the current industry interest and regulatory attention regarding risk due to internal fires, it is not surprising that 80% of the plants surveyed either currently have an internal fire PRA underway or are planning to do so in the near term. For the other external events, however, the vast majority of plants (80% or more) have no plans to perform PRAs in the near term for external floods, seismic events, or high winds.

For the plants performing external-events PRAs, 40% have yet to determine how the new PRA models will be incorporated into the CRM evaluation process. Slightly more than one-quarter will incorporate the external event models directly into the CRM quantitative model, while nearly one-tenth will develop a simplified version of the new external events PRA to incorporate into the CRM quantitative model.

While nearly half the plants surveyed (47%) have indicated that they use bounding evaluations for external events, fewer than half of those plants (18% of total) have validated the bounding evaluation results for the CRM evaluations. That validation has either been informal or based on the individual plant examination external event (IPEEE) or other specific analyses for external events, such as for the regulatory approval process. The bounding evaluations are typically integrated into the CRM evaluation process by the use of high-risk evolutions for external conditions considered risk significant (29% of plants) or by using a blended approach to combine quantitative and qualitative results (13%).

Treatment of Non-Quantified Risk Factors

CRM models can be quite sophisticated in their consideration of the various factors that can influence plant risk. However, not all models consider all applicable factors; additionally, some factors can be difficult to quantify regardless of model sophistication. The industry surveys conducted in 2003 and 2007 both included a section to gather information about what types of risk factors are considered and what methods (quantitative or non-quantitative) are used to assess the impacts of these factors.

A total of six potentially non-quantified risk factors were addressed in the 2007 survey, and plants were asked to identify any other risk factors that might be considered. For each of the risk factors, two distinct questions were asked: the first was how often such factors are considered as part of the CRM evaluation; the second question concerned the methods by which these factors are evaluated. The results for the six factors that were specifically questioned are presented in Figure 2-13 and discussed next.

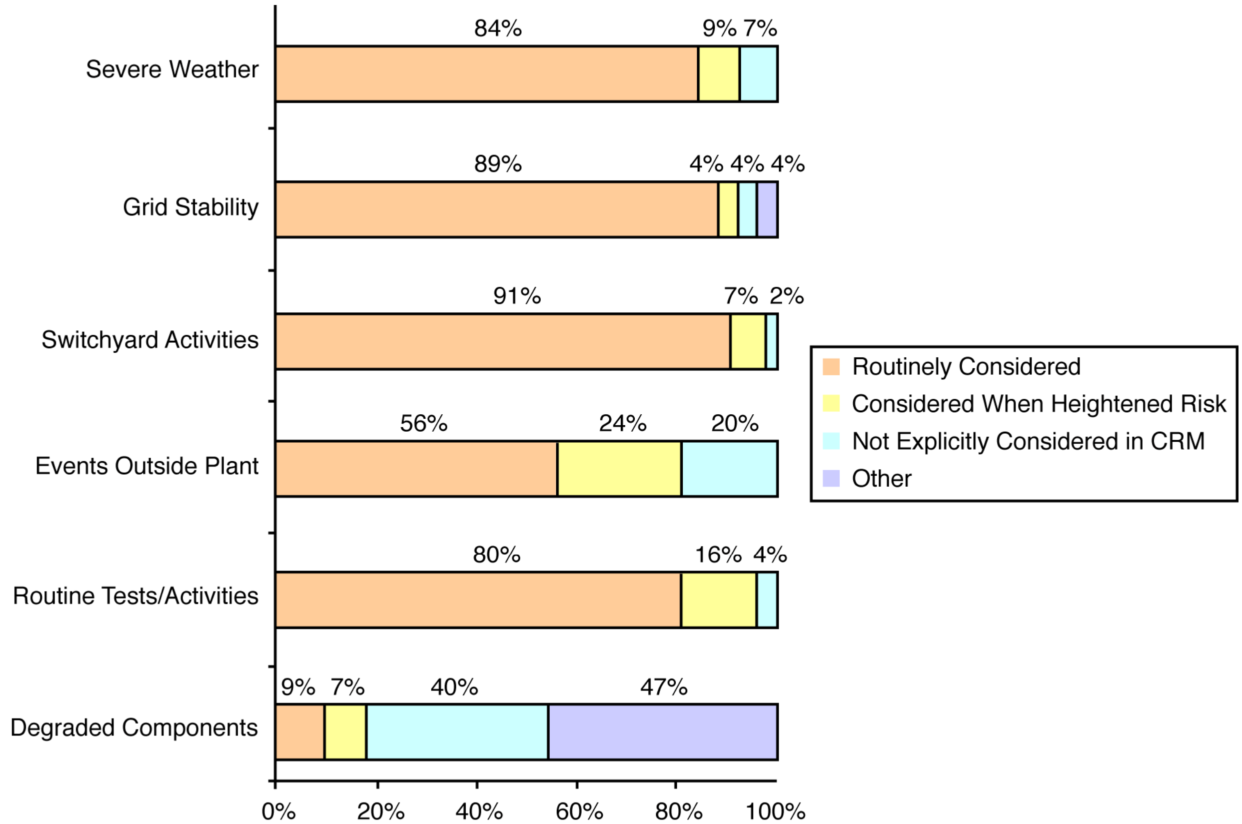

Figure 2-13
Plants Considering Non-Quantified Risk Factors in CRM Evaluations

Risk Factors Routinely Considered in CRM Evaluations

Based on the survey results, the most widely considered risk factor is switchyard maintenance/ test activities. This factor is routinely considered (that is, as part of each CRM evaluation) by 91% of the surveyed plants, closely followed by electric grid stability and severe weather conditions, which are routinely considered at 89% and 84% of the plants, respectively. While switchyard maintenance and grid stability are considered within the CRM model at 91% and 76% of the plants, respectively, only 60% consider severe weather within the CRM model. This is a decrease from 84% in the 2003 survey, but the decrease is largely due to differences in the responding plants (that is, plants who responded in 2003 but not in 2007, and vice versa).

One other risk factor that is routinely considered by a majority of plants (80% of those responding) is the performance of tests/activities that could cause a transient. This factor is also typically (82% of plants) considered within the CRM model (an increase from the 63% in 2003).

Only 2% to 7% of the plants surveyed do not explicitly consider one or more of these four risk factors in their CRM evaluations.

Slightly fewer than half (49%) of the plants surveyed have encountered situations where a non-quantified risk factor has changed the outcome of a CRM evaluation (for example, resulted in a higher risk color). This is nearly double the 26% of plants reporting such a situation in 2003. The situations that had changed the risk outcome included grid stability, switchyard work, severe weather, or combinations of these factors.

Other Risk Factors Considered in CRM Evaluations

The remaining two risk factors are routinely considered by roughly half (or fewer) of the plants: outside events that can affect the plant (56%) and operation with degraded risk-significant components (9%). Outside events and degraded components may be considered only during heightened risk conditions (24% and 7% of plants, respectively) or not explicitly considered in CRM evaluations at all (20% and 40%, respectively). Of those factors not addressed in the CRM model on a routine basis, no plants plan any changes in the way these factors are evaluated (compared to 26% that planned changes at the time of the 2003 survey).

A few plants identified other risk factors considered in their CRM evaluations. These other factors include items that are considered separately from the CRM model such as heavy lifts, normal HVAC outages, hazard barrier impairment, production risks, and temporary modification to SSCs.

Grid Stability Issues

As noted previously, grid stability is routinely considered as part of each CRM evaluation and is explicitly included in the CRM model at a majority of the plants responding. Roughly half (53%) of the plants responding apply an adjustment factor to the grid, initiating event frequencies in order to reflect current grid status in the CRM evaluation. The remaining plants do not consider grid stability in a quantitative manner. The adjustment factors may take the form of multipliers (2x, 5x, 10x the loss of off-site power frequency), which are subjectively chosen factors recommended by the NRC or EPRI in grid loss studies or are estimated values documented in a plant calculation.

Nearly two-thirds (64%) of the plants surveyed do not communicate the plant CRM risk status to the grid operator. Of the remaining plants, roughly half (13% total) provide status updates to the grid operator on a regular basis, and one-quarter (9% of total) do so only for unusual situations or unusually high risk.

There is a range of events that can trigger consideration of severe weather conditions in the plant CRM evaluation. These include severe storm warnings (89% of plants surveyed), ice storm warnings or watches (51%), severe storm watches (36%), and/or winter storm warnings or watches (22%). One plant assumes a heightened risk condition for the entire severe storm season when planning work as a way to ensure that the risk from severe weather is bounded, although the plant may be vulnerable to severe weather impact only for a portion of that time.

Evaluation of Containment Closure During Shutdown

The ability to close containment hatches in the event of an incident during refueling outages has been receiving increased attention from NRC inspectors. The final section of the survey gathered information on current industry practices in this area.

Figure 2-14 illustrates the factors being considered by the plants surveyed in their containment closure evaluations. The factors considered include time to boil (considered by 93% of the plants responding), expected containment closure time (75%), containment air temperature (15%), time to core uncovery (10%), and use of the containment equipment hatch (10%). A variety of criteria is used at the responding plants to determine the closure time available. Containment closure evaluations are generally performed prior to the start of an outage (78% of plants), daily during the outage (13%), or prior to high-risk evolutions (5%). At some plants, evaluations are performed for every work activity, twice daily, or based on specific outage needs or situations.

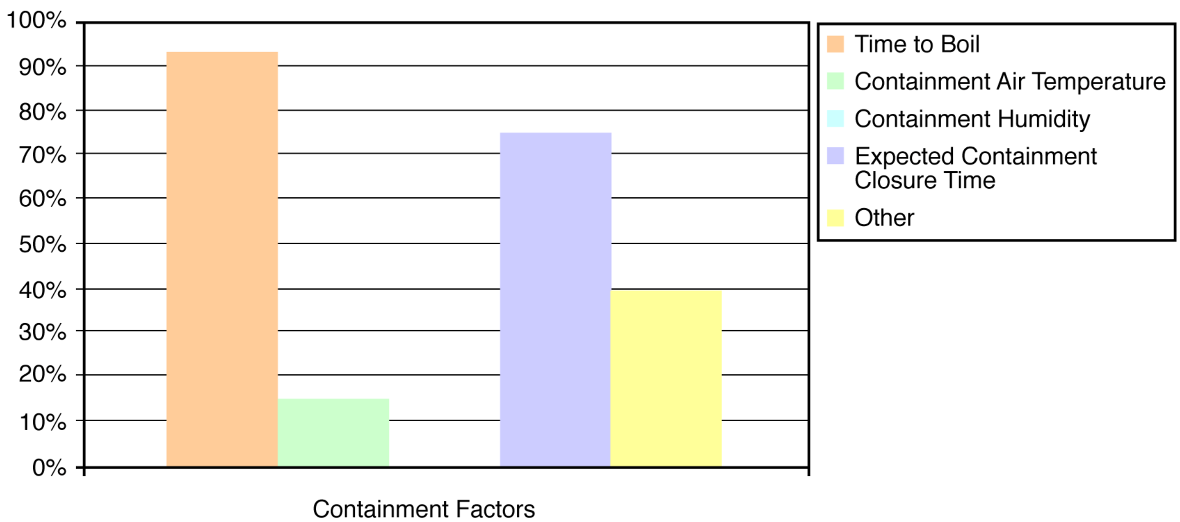

Figure 2-14
Plants Considering Factors in Containment Closure Evaluations

The majority (73%) of the plants responding have had no regulatory questions raised regarding their present containment closure evaluation practices. Perhaps as a result, 88% of the plants responding have no plans to modify their evaluation process in the near future. However, 18% of the plants have made changes to their evaluation process based on comments/challenges by the NRC. These changes have included no longer using a roll-up door as a closure device, performing a timing study to determine restoration time, performing new assessments when the planned maintenance schedule slips and overlaps other planned maintenance, and so on.

Lessons learned from CRM and containment closure evaluations during past outages include rising NRC expectations for the (a)(4) program and challenges to past interpretations of NUMARC 93-01.

3
DETAILED COMPILATION OF SURVEY RESULTS

This section provides detail about the specific responses provided to each survey question. By providing the actual responses from the participants, users of this report may be able to use the survey information for other CRM benchmarking purposes. However, none of the information in this section should be used without verification from the specific plant(s) that the information remains current and that it is acceptable to use the plant-specific information for other purposes.

The responses are presented mostly as they were written. However, some responses were edited and interpreted by the authors to clarify specific items or to limit the length of the response. In one case, the intent of a question may have been misinterpreted. Question B.12 was intended to survey the use of qualitative models for at-power CRM evaluations. Due to non-specific wording in the question, some plants interpreted the question to be inquiring about the use of qualitative measures in any mode (such as shutdown).

In some cases, acronyms were used in the responses. In general, the acronyms used are those frequently used in the industry. However, no attempt was made here to develop a glossary of these terms.

Survey Respondents

A total of 24 surveys were completed by 21 utilities, representing a total of 44 U.S. plant sites (73 units, representing 71% of the units in the United States) and one non-U.S. plant. In the compilation of the survey that follows, the designation P*x* is used to represent each pressurized water reactor (PWR) plant site (28 total), and B*x* represents each boiling water reactor (BWR) plant site (17 total). If a plant responded to the original 2003 survey as well, then the same designator has been used for that plant for this survey. Surveys were completed for the following utilities and plants:

- American Electric Power – D.C. Cook
- Arizona Public Service – Palo Verde
- Constellation Energy – Calvert Cliffs
- DTE Energy – Fermi 2
- Duke Power – Catawba, McGuire, Oconee
- Dominion – Kewaunee, Millstone, North Anna, Surry
- Energy Northwest – Columbia

- Entergy Northeast – Indian Point 2 and 3, FitzPatrick, Pilgrim, Vermont Yankee
- Exelon – Limerick, Peach Bottom, Oyster Creek, Dresden, Quad Cities, LaSalle, Clinton, Byron, Braidwood, Three Mile Island
- FirstEnergy – Perry
- FPL Energy – St. Lucie
- FPL Energy – Turkey Point
- Nebraska Public Power District – Cooper
- Nuclear Maangement Company – Prairie Island
- PPL – Susquehanna
- Progress Energy – Brunswick, Crystal River, Harris, Robinson
- South Carolina Electric & Gas – V.C. Summer
- Southern California Edison – San Onofre
- STPNOC – South Texas Project
- TVA – Browns Ferry, Sequoyah, Watts Bar
- TXU, Inc. – Comanche Peak
- Ontario Power Generation – Darlington

Compilation of Survey Responses

All percentages are based on the total number of plants that responded (45 in total). Percentages do not always total to 100%, due to multiple answers for some plants or plants that did not provide answers for all questions. For survey questions that were also included in the 2003 survey, percentages from the 2003 CRMF survey are provided in brackets [] for comparison. Note that while some changes in percentages between 2003 and 2007 are due to changes in practices at particular plants, some of the changes are due to differences in the utilities that responded to the surveys. Thirteen plants for which responses were provided in 2003 did not respond to the 2007 survey, while 18 plants that did not respond in 2003 did provide responses to the updated survey.

In general, the percentage responses given should be used as a guide, but the reader should review the actual responses by plant to understand how the responses affected the percentage calculations shown.

A. Configuration Risk Management Software Tools Currently Being Used

At-Power Conditions

☒ EOOS **40%** [38%]
B3, B14, B19, B20, B21, B23, P4, P5, P11, P20, P23, P30, P31, P32, P33, P34, P35, P36

☒ ORAM-SENTINEL **13%** [33%]
B18, B22, P8, P9, P10, P28

☒ PARAGON **24%** [0%]
B5, B6, B7, B8, B9, B10, B11, B16, P13, P14, P15

☒ Safety Monitor **16%** [28%]
B12, P1, P6, P7, P17, P19, P21

☒ Other **16%** [28%]
P5, P6, P7, P17
P29, P37: In-house, manipulates solved cutsets.
P38: Look-up table.

☐ None **0%** [0%]

Transition Modes

☒ EOOS **20%** [20%]
B14, B23, P5, P23, P31, P32, P33, P35, P36

☒ ORAM-SENTINEL **13%** [40%]
B18, B22, P8, P9, P10 (Modes 1–3), P28

☒ PARAGON **22%** [0%]
B5, B6, B7, B8, B9, B10, B11, P13, P14, P15

☒ Safety Monitor **13%** [20%]
P1, P6, P7, P17, P19, P21

☒ Other **36%** [30%]
B3, B19, B20, P11, P30: At power model Modes 1–3, shutdown approach Modes 4–6.
P4: Status sheets.
P5, P6, P7, P17
P8, P9, P10: DID sheet Mode 4.
P29: In-house, manipulates solved cutsets.
P37: Modified RISKMAN at-power model, manual calc for Mode 3 only.
P38: Look-up table Mode 1–3, ORAM Mode 4–6.

☒ None **33%** [20%]
B5, B6, B7, B8, B9, B10, B11, B12, B16, B21, *P13, P14, P15*, P20, P34

Shutdown Modes

☒ EOOS **24%** [10%]
B14, B19 (DID table backup), B23, P5, P20, P23, P31, P32, P34, P35, P36

☒ ORAM-SENTINEL **20%** [48%]
B18, B20 (DID table backup), B21, B22, P1, P21, P28, P37, P38

☒ PARAGON **24%** [0%]
B5, B6, B7, B8, B9, B10, B11, B16, P13, P14, P15

☒ Safety Monitor **9%** [13%]
P6, P7, P17, P19

☒ Other **40%** [30%]
B3, B14, P4, *P5, P6, P7, P17 (DID sheets)* P8, P9, P10, P11,
P20: Safety advisor personnel.
P23, P29, P30, P33, P35, P36: DID worksheet.

☒ None **2%** [8%]
B12

B. Configuration Risk Management Program Characteristics

1. Which personnel are responsible for performing routine Maintenance Rule (a)(4) CRM assessments at your plant?

   ☒ PRA personnel: **16%**
   B12, B18 (supporting role), B22, B23, P29, P34, P38

   ☒ Dedicated CRM coordinator: **7%**
   P8, P9, P10

   ☒ Control room staff (including STAs): **36%**
   B3, B12, B19, B20, B23, P4 (after hours for some emergent work), P5, P6, P7, P11, P17, P28, P30, P31, P32, P37

   ☒ Maintenance planning/scheduling personnel: **89%**
   B3, B5, B6, B7, B8, B9, B10, B11, B14, B16, B18, B19, B20, B21, B23, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P21, P23, P28, P30, P31, P32, P33, P35, P36, P37, P38

   ☒ Other personnel. Please describe: **7%**
   B23: Work Week Managers
   P1: Work Week Managers are responsible for scheduling and executing each week's plant activities. They also perform the initial work week risk evaluation and schedule changes. On-shift Operations personnel are responsible for emergent and sometimes review of schedule change impacts.
   P29: Attempting to transition to maintenance planning.

2. Does your plant use "risk colors" or "risk zones" to communicate configuration risk? If so, what type of color/zone classification does your plant use?

   ☐ N/A—Colors/Zones are not used: **0%** [0%]

   ☐ 2 colors/zones are used (a "go/no go" approach): **0%** [0%]

   ☒ 3 colors/zones are used (such as green, yellow, and red): **4%** [13%]
   P1, P21

   ☒ 4 colors/zones are used (such as green, yellow, orange, and red): **93%** [87%]
   B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B18, B19, B20, B21, B22, B23, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P23, P28, P29, P30, P31, P32, P33, P34, P35, P36, P38

   ☒ Other: **2%** [0%]
   P37: Work week ICDP compared to 1E-6 and 1E-5

3. If different risk communication systems are used for at-power than those used for shutdown conditions, please describe those systems here:

   B3, B19, B20, P11, P30: Shutdown risk assessments also used four color scheme but they represent DID plant conditions.
   B12: Shutdown has additonal risk communication system. The Outage Control Center (OCC), which is manned for outages, and the control room have shutdown safety status boards that are maintained by the shutdown risk advisors.
   B14, P23, P35, P36: Shutdown uses two or three colors (site specific). Meets defense requirements is green, does not meet is red. (To be revised to three colors).
   B18, P28: Same four-color scheme.
   P1, P21: On-line risk Modes 1–3 uses a three color communication scheme, and shutdown risk uses a four color communication scheme.
   P20: Shutdown is an "n+1" model in EOOS that uses green/red. Shutdown also includes input from a "shutdown safety advisor," which is typically a PRA function.
   P29: No PRA tool for shutdown.
   P33: Shutdown safety assessment also uses a four-color grading scheme for risk level (although it uses different criteria for grading). The shutdown safety assessment information for the outage unit is communicated through the daily outage report (paper format and emailed to all site personnel). The at-power unit PRA risk information is displayed on a plant's web page. The at-power unit PRA risk information is also distributed daily in the plant's scheduling report, which is in paper format.
   P37: At-power CRMP uses ICDP, and shutdown uses DID colors.

4. If your plant uses quantitative risk criteria (for example, CDF, LERF, ICDP, and so on) to establish the risk zone/color:

   a) What types of data are used?

☐ N/A – Quantitative risk criteria are not used: **0%** [3%]	☒ Incremental CDP or LERP: **29%** [8%] B18, B22, B23, P1, P5, P6, P7, P17, P20, P29, P31, P32, P38
☒ Instantaneous CDF: **76%** [88%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B18, B19, B20, B21, P8, P9, P10, P11, P13, P14, P15, P19, P21, P23, P28, P29, P30, P31, P32, P33, P34, P35, P36	☒ Instantaneous LERF: **38%** [33%, and 50% planned to use this type] B5, B6, B7, B8, B9, B10, B11, B21, P13, P14, P15, P21, P28, P29, P31, P32, P33
☒ CDP over a unit of time: **4%** [5%] B12, P4	☒ LERP over a unit of time: **2%** [0%] P4
☒ Incremental CDP over a unit of time: **13%** [13%] B14, P23, P33, P35, P36, P37	☒ Incremental LERP over a unit of time: **2%** [8%] P33
☒ Other: **2%** [3%] **P20:** Administrative limits for green/yellow.	

b) Are the quantitative criteria used in conjunction with other criteria (a blended approach), or are qualitative criteria used exclusively? If so, describe.

B3, B19, B20, P11, P30: Qualitative considerations, such as external event impacts that are not within the EOOS scope, can impact the risk color.
B5, B6, B7, B8, B9, B10, B11, P13, P14, P15: PARAGON provides quantitative (PRA) assessment and qualitative/deterministic (SFAT/PTAT) assessment. The most conservative result is used.
B12: A blended approach is used. Various non-quantified factors are considered.
B14, P23, P35, P36: Blended approach that also looks at weather, grid conditions, switchyard maintenance, actuation system testing, and other non-quantified issues and adjusts the risk color as determined by the Work Week Manager.
B16: A blended appraoch is used. Defense in-depth is used with instantaneous CDF. The schedule is also reviewed qualitatively to identify activities that may significantly increase the probability of a plant event.
B18: Blended approach.
B21, P4, P29, P37: Quantitative only.
B23: Qualitative criteria are used in conjunction with other criteria.
P8, P9, P10: Blended approach of quantitative criteria and qualitative assessment trees with the highest color representing the risk for the unit.
P20: Quantitative limits are only used to specify the decision maker for plant configuration. The decision maker can use qualitative criteria also.
P21: Qualitative criteria are used to assess the impact of external events such as fire. The severe weather is assessed by using a multiplier with the loss of offsite power initiator.
P28: CDF from at-power PRA is compared to threshold values to determine the risk color for a given plant configuration.
P34: Quantitative and qualititative approaches are used. The final risk color is based on the worst of these two assessments.

5. How is the baseline risk defined for your plant (that is, the risk level that is used as a basis for comparison of each configuration-specific risk level)?

☐ N/A—Quantitative risk measures are not used: **0%** [0%]

☐ The CDF (or LERF) calculated by the PSA (assuming average maintenance unavailability): **0%** [8%]

☒ The CDF (or LERF) calculated based upon no plant equipment out of service: **100%** [92%]
B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B18, B19, B20, B21, B22, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P21, P23, P28, P29, P30, P31, P32, P33, P34, P35, P36, P37, P38

☐ Other: **0%** [0%]

6. If your plant uses quantitative instantaneous risk measures, what is the basis for setting the risk zone thresholds?

☒ N/A—Instantaneous risk measures are not used: **18%** [0%]
B22, P1, P5, P6, P7, P17, P37, P38

☒ Multiples of the baseline risk value (for example, 2x risk, 5x risk, 10x risk, and so on): **56%** [48%]
B3, B5, B6, B7, B8, B9, B10, B11, B12, B18, B19, B20, B21, P4, P8, P9, P10, P11, P13, P14, P15, P21, P29, P30, P34

☒ Fixed risk values (for example, based on Regulatory Guide or EPRI PSA Applications Guide values): **36%** [15%]
B14, B16, B18, B23, P4, P19, P28, P23, P31, P32, P33, P35, P36
P8, P9, P10: Orange threshold based on practice of limiting maintenance to 50% or less of a LCO. Many systems important to risk have an LCO of 72 hours, so maintenance will normally be limited to approximately 36 hours or less. The plant could operate at an annualized incremental CDF of 2.4E-04/yr for 36 hours and not exceed the 1.0E-06 threshold. Red threshold based on PSA Applications Guide and NUMARC 93-01.

☒ Other **20%** [70%]
B3, B19, B20, P11, P30: Green/yellow threshold is based on 2X Average CDF. Yellow/orange threshold is based on CDF associated with most risk-significant component allowed/expected to be out of service online, plus 5%. Orange/red threshold is based on EPRI PSA Applications Guide value of 1E-3/yr.
P19: Site nuclear safety goal is threshold between green/yellow. The yellow/orange threshold is half NEI 93-01 MR instantaneous risk values. The orange/red threshold is set at NEI 93-01.
P20: The top two thresholds (orange and red) use 1.0E-06 for CDP and 1.0E-07 for LERP. Green/yellow CDF uses zero maintenance TDEFW impact. Green/yellow LERF uses a limit of 9.0E-06.
P29: Based on review of EPRI Benchmarking Report.
P33: Risk rate color category—Color identifier assigned to the unit equipment out of service configuration based on the configuration-specific CDF. A color category of red indicates that the risk rate is too high, and must be reduced immediately by placing equipment back in service, or implementing contingency or commensurate measures. The other color categories are assigned based on the length of the Risk-Informed AOT. Also determine the risk management action level—
a measure of the relative risk-significance of a given configuration, based on its CDF, LERF, ICDP or ILERP. The configuration risk level, and the corresponding Risk Management Action Levels, are defined as follows:

High: ICDP $\geq$ 1E-5 or ILERP $\geq$ 1E-6
A. Do not voluntarily enter these configurations. The Operations Committee must authorize operation for any length of time in this condition.
B. Immediately restore equipment to service, or implement RMAs to restore at least a medium action level.
Medium: 1E-6 $\geq$ ICDP $\geq$ 1E-5 or 1E-7 $\geq$ ILERP $\geq$ 1E-6
Assess non-quantifiable factors or develop and implement RMAs to prevent entry into a high action level.
Low: ICDP $\leq$ 1E-6 and ILERP $\leq$ 1E-7
Normal work controls apply.

What are the specific quantitative thresholds that are used (please provide the actual baseline values and threshold values) and their bases (please describe how the thresholds were determined)?

Plant	CDF				LERF			
	Base	Yellow	Orange	Red	Base	Yellow	Orange	Red
B3		2x average with main-tenance	Most risk-sig SSC OOS plus 5%	1.0E-3				
B5, B6, B7, B8, B9, B10, B11	< 2x base	2x base	10x base	20x base or 1E-03				
B12	< 2x base	2x base	10x base	1.0E-3				
B14	< 1E-6 for one week	> 1E-6 ICDP for one week	1E-4 or > 1E-5 for one week	1.0E-3				
B18	< 2x base	2x base	10x base	20x base	Incremental CDP based on 1E-6			
B19		2x avg. with maint.	Most risk-sig. SSC OOS plus 5%	1.0E-3				
B20		2x avg. with maint.	Most risk-sig. SSC OOS plus 5%	1.0E-3				
B21	< 3x base	3x base	20x base	40x base				
B22	< 1E-06 ICDP	1E-06 ICDP	5E-06 ICDP	1E-05 ICDP	< 1E-07 ILERP	1E-07 ILERP	5E-07 ILERP	1E-07 ILERP
B23	< 1E-06 ICDP	1E-06 ICDP	1E-05 ICDP	1E-03 ICDP	< 1E-07 ILERP	1E-07 ILERP	1E-06 ILERP	1E-04 ILERP
P4	< 2x base	2x base	11x risk, CDP > 1E-5	25x risk, CDP > 1E-4				
P8	1.01E-5	2.02E-5 (2x base)	2.5E-4	1.0E-3				
P9	2.81E-5	5.64E-5 (2x base)	2.5E-4	1.0E-3				
P10	4.03E-5	8.06E-5 (2x base)	2.5E-4	1.0E-3				

Plant	CDF				LERF			
	Base	**Yellow**	**Orange**	**Red**	**Base**	**Yellow**	**Orange**	**Red**
P11		2x avg. maint	Most Risk-sig. SSC OOS plus 5%	1.0E-3				
P13, P14, P15	< 2x base	2x base	10x base	20x base or < 1E-03				
P19	< 8E-5	8E-5	5E-4	1.0E-3				
P20	< 2.04E-4	2.04E-4	3.73E-4	1.10E-3	< 9.0E-6	9.0E-6	3.67E-5	1.10E-4
P21	5.33E-6	3.00E-5	1.69E-4	7.00E-4	3.79E-6	6.54E-6	1.13E-5	2.00E-4
P23	< 1E-6 for one week	> 1E-6 ICDP for one week	1E-4 or > 1E-5 for one week	1.0E-3				
P28	< 1.0E-4	1.0E-4	5.0E-4	1.0E-3				
P29	< 2x base	> 2x base	> 10x base	> 20x base				
P30		2x avg. with maint.	Most risk-sig. SSC OOS plus 5%	1.0E-3				
P33	RI-AOT > 2 weeks	RI-AOT ≤ 2 weeks	RI-AOT ≤ 72 hr	1.0E-3	RI-AOT > 2 weeks	RI-AOT ≤ 2 weeks	RI-AOT ≤ 72 hr	1.0E-04
P34	< 2x base	> 2x base	> 4x base	3.0E-4				
P35	< 1E-6 for one week	> 1E-6 ICDP for one week	1E-4 or > 1E-5 for one week	1.0E-3				
P36	< 1E-6 for one week	> 1E-6 ICDP for one week	1E-4 or > 1E-5 for one week	1.0E-3				
P37				1.0E-3				

7. If your plant uses quantitative cumulative, time averages, or configuration duration measures, what is the basis for setting the risk zone thresholds?

   ☒ N/A—Cumulative, time average, or duration measures are not used: **60%** [55%]
   B3, B5, B6, B7, B8, B9, B10, B11, B16, B19, B20, B21, B22, P8, P9, P10, P11, P13, P14, P15, P19, P21, P28, P30, P33, P34, P38

   ☒ Cumulative risk accrued over a moving time period (for example, day, week, quarter): **9%** [18%]
   B12, P20, P29, P37

   ☒ Cumulative risk expected to be accrued during each planned configuration change: **27%** [3%]
   B14, B18, P1, P5, P6, P7, P17, P23, P31, P32, P35, P36

   ☒ Other: **4%** [48%]
   B23: Time between risk resets—time that delta risk is slightly greater than zero.
   P4: Assumes up to 48 hours orange, 96 hours yellow.

   Do you have an annual risk target for cumulative risk (please describe):

   No: **58%**, several did not respond [38%, several did not respond]
   B3, B5, B6, B7, B8, B9, B10, B11, B16, B19, B20, P1, P4, P11, B14, P13, P14, P15, P20, P23, P28, P30, P33, P35, P36
   P29: There is an informal indicator that monitors maintenance risk against average model risk.
   Yes: **27%** [46%]
   B12: We do track cumulative risk week by week and compare to the expected yearly CDF, assuming average maintenance availabilities.
   B23: 80% of with-maintenance risk.
   P5, P6, P7, P17: 1E-6 CDP/1E-7 LERP.
   P8, P9, P10, B18: Monthly accumulated CDP not exceeding 25% of baseline CDP.
   P19: The annual site nuclear safety goal is set at 8E-05 per year, based on past performance and staying below Regulatory Guide 1.174 threshold of 1E-4.
   P37: 12-month rolling cumulative risk—zero maintenance baseline risk plus configuration risk must be less than 110% of the reference PRA model average annual maintenance CDF.

8. If your plant uses peak instantaneous risk as a measure to determine the risk color, how is the expected or actual duration of a risk increase considered when making risk management decisions?

   ☒ N/A—Peak risk is not used: **18%** [10%]
   B22, P1, P4, P8, P9, P10, P19, P37

   ☒ An allowable time for the risk increase is calculated based on a CDP or LERP limit: **33%** [15%]
   B3, B16, B19, B20, B23, P5, P6, P7, P11, P17, P30, P31, P32, P33, P38

   ☒ Cumulative risk is maintained below a fixed limit for a specified time period (for example, a week, a calendar quarter, and so on): **7%** [13%]
   B18, P28, P29

   ☒ Peak risk is used in conjunction with a cumulative measure: **13%** [18%]
   B12, B14, P23, P34, P35, P36

☒ Other: **29%** [50%]
B5, B6, B7, B8, B9, B10, B11, P13, P14, P15: 12-month aggregate risk is trended against the nominal base CDF.
B21: Duration is not considered.
P20: When a threshold is reached, it changes the level of approval for an activity to proceed. The approver uses the threshold as one input.
P21: The experience and judgement of the work control coordinators are used in conjunction with Technical Specifications. Most of the maintenance work is of short duration, so this is not a concern.

9. Have you performed truncation sensitivity studies on your quantitative CRM Model?

☒ No: **58%**
B3, B19, B20, B21, B23, P1, P5, P6, P7, P8, P9, P10, P11, P17, P20, P29, P30, P31, P32, P33, P37, P38
B14, P23, P35, P36: Based upon other studies, the CRM model is not at convergence at the truncation used to get results in a time frame needed to support the plant. Thus, there is a tradeoff between time required to run model and the CDF convergence.

☒ Yes. Please provide a brief description of the process used and any insights that resulted from the study: **42%**
B5, B6, B7, B8, B9, B10, B11, P13, P14, P15: Consistent with base model sensitivities.
B12: Verified less than 5% change in CDF.
B16
B18: Truncation value was determined based on sensitivity evaluations for a balance between results accuracy and computation time.
B22: Basically use 5 orders of magnitude.
P4: Reviewed results and color changes associated with key equipment and solution times. Currently, we use 5.0E-10 as truncation.
P19: A truncation level of 1E-10 for CDF and 1E-11 for LERF were assessed to meet the intent of the ASME PRA Standard. However, the Safety Monitor only allows for one culling limit to be set. Until this issue is addressed by the Safety Monitor users' group, we are working on developing a way to set the culling limit for CDF at 1E-10 and solving at 1E-11 for LERF.
P21: An asymptotic curve was produced as expected. The hump in the curve occurred at approximately 1E-10. To ensure conservatism in picking a truncation, a truncation of 1E-11 for CDF and 1E-12 for LERF was chosen for detail evaluations. Because the CRMP is only concerned with large changes in risk, then a value of 1E-08 was chosen as a balance between detail and speed of calculations.
P28: Baseline CDF as a function of truncation limit was plotted and a truncation value chosen past the knee in the curve.
P34: CDF continues to rise as truncation level falls; study looked at truncation levels from 10-9 to 10-13.

10. Has your CRM Model been validated against the official PRA model?

☒ N/A—the official PRA model is directly used as the CRM model: **42%**
B5, B6, B7, B8, B9, B10, B11, B16, B21, P13, P14, P15, P19, P20, P29, P31, P32, P33, P37

☒ No, a validation has not been performed and documented: **2%**
P28

☐ An informal validation was performed, but the process is not officially documented: **0%**
☒ A formal validation is performed and documented for each CRM model version: **36%**
B12, B18, B22, B23, P1, P4, P5, P6, P7, P8, P9, P10, P17, P21, P34, P38

☒ Other (please describe): **20%**
B20, P30: EOOS models are the same as the official PRA model, informal validation has been performed, but not officially documented.
B3, B19, P11: CRM models are based on collapsed sequence logic utilizing the PRA models, informal validation has been performed, but not officially documented.
B14, P23, P35, P36: The CRM model is the model of record run at a different truncation and test and maintenance events set to zero.

11. What is the scope of your quantitative CRM model? (Check all that apply)

☐ N/A – quantitative models are not used. **0% [0%]**	
☒ Internal Events CDF: **100%** [100%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B18, B19, B20, B21, B22, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P21, P23, P28, P29, P30, P31, P32, P33, P34, P35, P36, P37, P38	☒ LERF (internal events only): **16%** [0%] B18, B22, P1, P4, P21, P31, P32
☒ Internal Flooding CDF: **84%** [55%] B3, B5, B6, B7, B8, B9, B10, B11, B14, B18, B19, B20, B21, B22, B23, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P23, P28, P29, P30, P33, P34, P35, P36, P37, P38	☒ LERF (same scope as CDF model): **53%** [45%] B5, B6, B7, B8, B9, B10, B11, B18, B21, B22, B23, P5, P6, P7, P13, P14, P15, P17, P19, P20, P29, P33, P37, P38
☒ Internal Fires CDF: **16%** [18%] P7, P8, P9, P10, P19, P29, P37	
☒ Seismic CDF: **9%** [5%] P7, P19, P29, P37	
☒ Other external events CDF: **11%** [13%] P8, P9, P10, P29, P37	
☐ Other: **0%** [13%]	

12. If your plant uses [survey failed to specify at-power] qualitative models (either exclusively or in conjunction with quantitative models), what safety functions are evaluated by the CRM tool? (Check all that apply)

☒ N/A—Qualitative models are not used [at-power]: **38%** [33%]
B14, B21, P1, P5, P6, P7, P17, P19, P20, P23, P29, P31, P32, P33, P35, P36, P37

☒ Decay heat removal: **60%** [48%]
B3, B5, B6, B7, B8, B9, B10, B11, B12, B16, B18, B19, B20, B23, P4, P8, P9, P10, P11, P13, P14, P15, P21, P28, P30, P34, P38

☒ Inventory control: **58%** [48%]
B3, B5, B6, B7, B8, B9, B10, B11, B12, B16, B18, B19, B20, B23, P4, P8, P9, P10, P11, P13, P14, P15, P28, P30, P34, P38

☒ Status of key support systems such as electric Power and component cooling water: **60%** [53%]
B3, B5, B6, B7, B8, B9, B10, B11, B12, B16, B18, B19, B20, B23, P4, P8, P9, P10, P11, P13, P14, P15, P21, P28, P30, P34, P38

☒ Containment integrity: **60%** [50%]
B3, B5, B6, B7, B8, B9, B10, B11, B12, B16, B18, B19, B20, B23, P4, P8, P9, P10, P11, P13, P14, P15, P21, P28, P30, P34, P38

☒ Reactivity control: **60%** [50%]
B3, B5, B6, B7, B8, B9, B10, B11, B12, B16, B18, B19, B20, B23, P4, P8, P9, P10, P11, P13, P14, P15, P21, P28, P30, P34, P38

☒ Quantitative CDF/LERF results (expressed as a risk color only): **16%** [30%]
B18, B22, B23, P8, P9, P10, P21

☒ One or more overall functions are provided, which express the status of a group of other functions. These functions are ☐ individually weighted / ☐ considered equally
Weighted: **2%** [3%]
B16
Considered Equally: **9%** [30%]
P8, P9, P10, P34

☒ Other, or comments on above selections. Please describe: **13%** [33%]
B3, B19, B20, P11, P30**:** Qualitative considerations are included during power operation but these are not models. The qualitative approach used during shutdown addresses the above key safety functions.
B16: High pressure injection, low pressure injection.

13. What is the basis used for defining the risk color associated with each safety function? [These responses reflect qualitative models used for both shutdown and at-power conditions, due to wording ambiguities in question B.12.]

☒ N/A – Qualitative models are not used: **40%** [8%]
B14, B21, B22, P1, P5, P6, P7, P17, P19, P20, P23, P29, P31, P32, P33, P35, P36, P37

☒ Number of available systems/trains to perform the function (that is, N+2, N+1, N, N-1, and so on): **56%** [65%]
B3, B5, B6, B7, B8, B9, B10, B11, B12, B16, B18, B19, B20, B23, P4, P11, P13, P14, P15, P20, P21, P28, P30, P34, P38

☒ Other (or comments on above selections): **7%** [28%]

P8, P9, P10: For online risk colors, systems important to each safety function were determined. Then the systems were weighted, considering their risk significance, to produce the end color. The Maintenance Rule expert panel reviewed the assessment trees and end colors. For shutdown, the systems important to each safety function were determined, and only those systems that would reduce risk by approximately an order of magnitude were considered. The systems were then assigned a point value, which can be totaled and compared to a risk threshold.

14. Have the risk thresholds/color zone definitions in use at your plant evolved over time? If so, what were the primary reasons for the evolution? Check all that apply.

☒ N/A—the risk thresholds have not changed significantly since CRM began at the plant: **13%** [30%]
B12, B16, B22, P28, P37, P38

☒ Changes were made as a result of enhancements to CRM models, tools, or data: **11%** [25%]
B21, B23, P4, P31, P32

☒ Changes were made as a result of refinements in management philosophy towards CRM: **47%** [25%]
B5, B6, B7, B8, B9, B10, B11, B14, B23, P1, P13, P14, P15, P19, P21, P23, P31, P32, P33, P35, P36

☒ Changes were made after benchmarking with other sites: **40%** [30%]
B3, B14, B18, B19, B20, P4, P5, P6, P7, P11, P17, P23, P29, P30, P31, P32, P35, P36

☒ Changes were made for other reasons: **42%** [15%]
B5, B6, B7, B8, B9, B10, B11, P13, P14, P15: To attain fleet consistency.
B14, P23, P35, P36: NRC input.
P8, P9, P10: Shutdown risk thresholds have evolved to improve consistency across the fleet. For online, we are currently re-evaluating the color results.
P20: Operations Manager request.
P34: Results of WANO audit.

Please describe briefly what types of changes have been made:

B5, B6, B7, B8, B9, B10, B11, P13, P14, P15: Attained fleet consistency regarding multipliers and color outputs for SFAT/PTAT.
B3, B19, B20, P11, P30: Changes were made in order to have a consistent approach to the risk thresholds and color zone definitions among the various plants.
B14, P23, P35, P36: Changed risk thresholds to have the green/yellow be consistent across fleet. Most changes these days are to add more blended input on issues that are not quantified or subjective. Examples include grid condition and switchyard maintenance.
P4: Added weather warning and grid status bars.
P5, P6, P7, P17: Fleet consensus. Most limiting ACTs selected for fleet.
P8, P9, P10: Equipment hatch control, upper internal effect on crediting volume of water in the refueling cavity, and use of the DID point system as described in question 13.
P20: The green/yellow CDF threshold was changed to be based on TDEFW pump impact, and the actual value changes from PRA update to PRA update.
P29: Set all Constellation sites with the same thresholds based on EPRI benchmarking document.
P31, P32: Colors and thresholds.

P34: Thresholds changed to reduce the number of high-risk tasks to better reflect current understanding.

15. If your plant uses both quantitative and qualitative risk measures for at-power CRM, have you correlated the quantitative and qualitative risk color thresholds?

☒ N/A—both quantitative and qualitative measures are not used: **44%** [28%]
B3, B19, B20, B21, P1, P4, P5, P6, P7, P11, P17, P19, P20, P28, P29, P30, P31, P32, P33, P37

☒ No. The quantitative and qualitative measures have not been correlated: **44%** [45%]
B5, B6, B7, B8, B9, B10, B11, B12, B16, B18, B22, B23, P8, P9, P10, P13, P14, P15, P21, P34

☒ Yes. The measures have been correlated (please provide any comments about the correlation process): **11%** [28%]
B14, P23, P35, P36: Color can be increased as determined by work week manager. Risk impact of quantitative can be reduced based upon specific case and PSA unit input consultation. Example would be temporary air compressor in place of plant air compressor during maintenance.
P38

16. Please feel free to provide any additional comments or clarifications about your plant's use of at-power risk colors or zones here:

B5, B6, B7, B8, B9, B10, B11, P13, P14, P15: Some stations have calibrated the DID model to the PRA model, but current thinking is **not** to do this, thereby preserving the diversity inherent in the two different approaches.
B22: Risk Management—Integrated process of assessing and reducing the likelihood and/or consequences of an adverse event. The focus of this process is a numerical estimate of plant risk, involving sound, informed decision making. This process will be based on the PSA risk matrix, engineering judgment, operational understanding, operating experience and outage experience. The intended result is to identify Higher Risk Evolutions and optimize the level of DID relative to key safety functions. Fundamental inputs to this process are shutdown margin, magnitude of decay heat generation, RCS water inventory available, integrity of the RCS boundary, and integrity of environmental containment structures.
B23: Qualitative considerations can sometimes override quantitative insights, in a conservative direction.
P4: Trying to identify yellow and higher colors and focus attention on those specific tasks to minimize time at these risk levels.
P8, P9, P10: Lack of standardization of risk color thresholds across the industry makes it difficult for the NRC to compare the relative risk of different plants.
P28: There is a deterministic or qualitative display in the Sentinel program that shows different risk colors for safety functions, but only the PRA color is used to determine plant risk and make decisions on what equipment is electively removed from service.

C. Definition of Plant Configuration Changes

This portion of the survey was completed by 45 plants.

1. Which of the following plant activities are considered to be configuration changes for the purposes of your CRM program? Which of these changes are specifically evaluated (either qualitatively or quantitatively)?

   Note: Italicized plant codes identify cases of multiple or inconsistent responses—for example, where a plant does not consider a particular condition to be a configuration change, but it does include the condition in the CRM evaluation.

Plant Changes	Considered a Configuration Change?	Explicitly Evaluated?
a. Mode.	☒ **82%** [85%] B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B21, B22, B23, P1, P4, P5, P6, P7, P8, P9, P10, P13, P14, P15, P17, P19, P20, P21, P23, P28, P29, P31, P32, P33, P35, P36, P38	☒ Always: **60%** [72%] B5, B6, B7, B8, B9, B10, B11, B12, B16, B21, B23, P1, P4, P5, P6, P7, P8, P9, P10, P13, P14, P15, P17, P19, P21, P28, P38 ☒ Sometimes (for example, during high risk periods): **31%** [13%] *B3,* B14, *B19, B20,* B22, *P11,* P23, P29, *P30,* P31, P32, P33, P35, P36 ☒ Never: **7%** [3%] B18, P20, P34
b. Planned and unplanned maintenance (removal and/or return to service) of SSCs included in TS LCOs.	☒ **87%** [97%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B16, B19, B20, B21, B22, B23, P1, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P21, P28, P29, P30, P31, P32, P33, P34, P37, P38	☒ Always: **29%** [49%] B16, B21, B23, P1, P8, P9, P10, P19, P20, P21, P28, P33, P34 ☒ Sometimes: **67%** [49%] B3, B5, B6, B7, B8, B9, B10, B11, B12, *B14,* B19, B20, B22, P5, P6, P7, P11, P13, P14, P15, P17, *P23*, P29, P30, P31, P32, *P35, P36*, P37, P38 ☒ Never: **2%** [0%] B18

Plant Changes	Considered a Configuration Change?	Explicitly Evaluated?
c. Planned and unplanned maintenance (removal and/or return to service) of High Safety Significance SSCs or SSCs explicitly modeled in your Level 1–2 PRA.	☒ **100%** [100%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B18, B19, B20, B21, B22, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P21, P23, P28, P29, P30, P31, P32, P33, P34, P35, P36, P37, P38	☒ Always: **93%** [100%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B18, B19, B20, B21, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P21, P23, P28, P29, P30, P33, P34, P35, P36, P37, P38 ☒ Sometimes: **7%** [0%] B22, P31, P32, ☐ Never: **0%** [0%]
d. Planned and unplanned maintenance (removal and/or return to service) of Low Safety Significance SSCs or SSCs not modeled in your Level 1–2 PRA.	☒ **73%** [74%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B16, B19, B20, B22, B23, P4, P8, P9, P10, P11, P13, P14, P15, P19, P20, P21, P28, P29, P30, P31, P32, P34, P37, P38	☒ Always: **22%** [28%] B16, P4, P8, P9, P10, P19, P20, P21, P34, P37 ☒ Sometimes: **42%** [51%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B19, B20, B22, P11, P13, P14, P15, P29, P30, P38 ☒ Never: **33%** [10%] B14, B18, B23, P1, P5, P6, P7, P17, P23, P28, P31, P32, P33, P35, P36
e. Maintenance-related alterations (for example, erecting scaffolding, installing shielding, and so on).	☒ **82%** [49%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B19, B20, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P20, P21, P23, P29, P30, P31, P32, P35, P36, P38	☒ Always: **4%** [18%] B16, P29 ☒ Sometimes: **82%** [49%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B18, B19, B20, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P21, P23, P30, P31, P32, P35, P36, P37, P38 ☒ Never: **11%** [13%] B22, P20, P28, P33, P34
f. Maintenance activities that may lead to a spatial impact (for example, opening a fluid pressure boundary, use of heat or flame, and so on).	☒ **58%** [62%] B3, B12, B14, B16, B19, B20, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P17, P20, P23, P29, P30, P31, P32, P35, P36, P38	☒ Always: **4%** [8%] B16, P4 ☒ Sometimes: **44%** [67%] B12, B14, B18, B23, P1, P5, P6, P7, P8, P9, P10, P17, P19, P23, P29, P33, P35, P36, P37, P38 ☒ Never: **49%** [10%] B3, B5, B6, B7, B8, B9, B10, B11, B19, B20, B22, P11, P13, P14, P15, P20, P21, P28, P30, P31, P32, P34

Plant Changes	Considered a Configuration Change?	Explicitly Evaluated?
g. Use of compensatory actions for maintenance activities (for example, temporary equipment, crossties, and so on).	☒ **84%** [69%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B19, B20, B21, B23, P1, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P21, P23, P30, P31, P32, P33, P35, P36, P38	☒ Always: **16%** [13%] B14, B16, P1, P21, P23, P35, P36 ☒ Sometimes: **69%** [82%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B18, B19, B20, B21, B23, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P28, P30, P33, P37 ☒ Never: **11%** [0%] B22, P31, P32, P34, P38
h. Potential prompt restoration actions for SSCs removed from service.	☒ **84%** [54%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B16, B18, B19, B20, B21, B22, B23, P1, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P21, P29, P30, P31, P32, P33, P34, P38	☒ Always: **9%** [10%] B16, B18, P20, P21 ☒ Sometimes: **78%** [69%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B19, B20, B22, B23, P1, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P28, P29, P30, P31, P32, P33, P34, P37, P38 ☒ Never: **11%** [10%] B14, B21, P23, P35, P36
i. Performance status of redundant, in-service SSCs (for example, degradation).	☒ **67%** [44%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B16, B19, B20, B22, B23, P1, P8, P9, P10, P11, P13, P14, P15, P19, P20, P21, P29, P30, P31, P32, P38	☒ Always: **24%** [5%] B3, B16, B19, B20, P1, P11, P19, P21, P30, P29, P38 ☒ Sometimes: **56%** [69%] B5, B6, B7, B8, B9, B10, B11, B12, *B14,* B18, B22, B23, P8, P9, P10, P13, P14, P15, P20, *P23,* P31, P32, *P35, P36*, P37 ☒ Never: **4%** [10%] P28, P34
j. Equipment or system alignments (for example, pumps running or standby, valves open or closed, and so on).	☒ **80%** [82%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B16, B18, B19, B20, B22, B23, P1, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P21, P29, P30, P31, P32, P33, P38	☒ Always: **22%** [38%] *B14,* B16, B18, P1, P19, P20, P21, *P23, P35, P36* ☒ Sometimes: **69%** [51%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B19, B20, B22, B23, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P29, P30, P31, P32, P33, P37, P38 ☒ Never: **4%** [8%] P28, P34

Plant Changes	**Considered a Configuration Change?**	**Explicitly Evaluated?**
k. Tests of equipment or systems commencing or ending.	☒ **82%** [87%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B16, B19, B20, B22, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P21, P29, P30, P31, P32, P33, P34, P38	☒ Always: **22%** [41%] B16, P1, P4, P8, P9, P10, P19, P20, P28, P29 ☒ Sometimes: **73%** [46%] B3, B5, B6, B7, B8, B9, B10, B11, B12, *B14,* B18, B19, B20, B22, P5, P6, P7, P11, P13, P14, P15, P17, P21, *P23*, P30, P31, P32, P33, P34*, P35, P36*, P37, P38 ☐ Never: **0%** [0%]
l. Environmental conditions (for example, grid instability, severe weather, and so on).	☒ **82%** [79%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B16, B18, B19, B20, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P21, P29, P30, P31, P32, P33, P34, P38	☒ Always: **91%** [72%] B3, B5, B6, B7, B8, B9, B10, B11, B12, *B14,* B16, B18, B19, B20, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P21, *P23,* P29, P30, P31, P32, P33, *P35, P36*, P37, P38 ☒ Sometimes: **4%** [18%] P28, P34 ☒ Never **2%** [0%] B22
m. Other (please describe):	☒ **20%** [28%] **B3, B19, B20, P11, P30:** Activities that heighten the potential for a trip or LOOP **B14, P23, P35, P36:** Certain actuation/trip system testing—CRD breaker testing	☒ Always: **11%** [3%] B3, B19, B20, P11, P30 ☒ Sometimes: **11%** [0%] B14, P23, P35, P36, B12 (heavy lifts, hazard barriers) ☐ Never **0%** [0%]

2. Does your plant consider an unplanned change of any item listed in question C.1 as a change in the maintenance configuration?

   ☒Yes: **76%** [41%]
   B3, B5, B6, B7, B8, B9, B10, B11, B12, B16, B18, B19, B20, B22, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P21, P29, P30, P31, P32, P34, P38

   ☒No: **22%** [56%]
   Which items from B.1 would not constitute a change in maintenance configuration at your plant?
   B14, P23, P35, P36: Equipment in technical specification that is not in the PSA and has no effect on CDF if out of service. Items a, b, d, e, k.
   B23: Taking component of LSS OOS, scaffolding and shielding modifications—except when the potential to impact risk-significant equipment is established.
   P1: Equipment failures for components that are not in the plant PRA are not considered as a change in maintenance configuration. However, sometimes working on, testing, or changing alignments of components that are not in the PRA, but that can cause a transient or trip (such as feedwater heater level testing, or swapping operating heater drain pumps) is considered to elevate the potential for a unit trip, and is added into the work week schedule for evaluation from that aspect.
   P20: Mode change.
   P28: Those marked "never."
   P33: d, e, f, i.
   P37

For an unplanned change in your plant maintenance configuration, is a reassessment normally done to determine new risk metrics, such as those identified in question B.4?

   ☒Yes: **98%** [92%]
   B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B18, B19, B20, B22, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P21, P23, P28, P30, P29, P31, P32, P33, P34, P35, P36, P37, P38

   ☐No: **0%** [8%]

Please provide any further details about the process or comments:

B3, B19, B20, P11, P30: Unplanned maintenance (also known as emergent activities) require a reassessment and update of the active items list in EOOS in order to display the current plant configuration and associated risk.
B22: The equipment to plant risk matrix uses information from the PRA to provide insights on the increased risk associated with maintenance activities that prevent more than one train or subsystem of equipment from performing their primary function. The matrix is intended to obtain information regarding PRA acceptability only. This procedure only applies to MODES 1 and 2. For risk assessments in MODES 3, 4 or 5, refer to ORAM. The selection of equipment in the matrix is based on equipment included in the scope of the Maintenance Rule and equipment that is voluntarily taken out for maintenance as part of the 12 week maintenance schedule. The insights provided by the matrix can also be applied to situations where the equipment is removed from service based on corrective maintenance.
P19: The work planning process assumes that all equipment planned to be out of service during the week is out of service all at the same time for the entire week. So, if an analyzed component changes its actual out of service time or return to service time within the week, then a reassessment is not performed because it is already bounded by the initial assessment. If any change outside of the initial assessment occurs, then the configuration is re-assessed.
P21: Even though this is not required by (a)(4), we evaluate all maintenance performed on risk-significant equipment for risk.
P28: When equipment within the scope of the CRM model is found to be broken, the schedulers rerun SENTINEL to determine the new risk level for the plant.
P33: Emergent maintenance activities are re-assessed using EOOS (performed by the Shift Manager or STA).

4. If the plant is currently in a non-baseline configuration (for example, due to planned maintenance or other activities) and an additional configuration change occurs, such as due to an unplanned event or the performance of other plant work, how is the risk impact of this new change assessed/integrated with the existing non-baseline configuration risk?

☒ The **risk color/zone** resulting from the combined activity is the primary factor used: **73%** [85%]
B3, B5, B6, B7, B8, B9, B10, B11, B12, B16, B18, B19, B20, B21, P4, P8, P9, P10, P11, P13, P14, P15, P19, P20, P21, P28, P29, P30, P31, P32, P33, P34, P38

☒ A new **allowable time** is calculated for the combined activity and work is managed to meet that allowable time limit. This new allowable time limit ☐ **does /** ☐ **does not** consider the cumulative risk already accrued as a result of the first configuration change: **22%** [15%]
Does: **7%** [8%]
B23, *P19*, *P32*
Does not: **16%** [8%]
P1, P5, P6, P7, P17, *P31*, P38

☒ Overall cumulative risk over a fixed time period (for example, the work week) is the primary factor used, considering the impacts of all configuration changes performed during the period: **2%** [0%]
P37

☒ Other (please describe): **9%** [38%]

B14, P23, P35, P36: If the new instantanous risk is green and the expected duration is less than one week, the new instantaneous risk is used until the maintenance configuration changes. If the new maintenance configuration is expected to be greater than one week, a new ICDP is calculated. If the instantanous risk is something other than green, an ICDP is determined based upon expected duration. The purpose of the ICDP is to determine the need for specific compensatory measures due to a specific maintenance configuration. You cannot put specific compensatory measures in place because a whole bunch of stuff happens in a week that gives a yellow ICDP.

What is the time allowed by plant procedure (or typical time) to complete a reassessment under these circumstances?

B3, B20, P11, P30: Not aware of any proceduralized time, but the expectation is that emergent work risk assessments will be performed ASAP.
B5, B6, B7, B8, B9, B10, B11, P13, P14, P15: Procedurally limited to 24 hours, typically completed in very much less time.
B12: Reassessment is expected as soon as practical, not to interfere with emergency response, and repair does not wait for the reassessment. Control room personnel are trained to perform risk assessments and a risk assessor is on call.
B14, P23, P35, P36: As soon as practical, no defined time frame. Typically within an hour.
B16: Real-time assessment done ASAP.
B18: ASAP, usually within 2 hours.
B19: Procedure has a 24 hour time frame, but the expectation is that emergent work risk assessments will be performed ASAP.
B23:As soon as possible, 15 minutes or so, with time allowed for plant stabilization from the condition.
P1: Unless re-assessing risk would interfere with responding to plant condition, our procedures simply indicate that it should be done at an expeditious timeframe, or that the PRA group should be called for assistance.
P4: Do without delay.
P5, P6, P7, P17: Not specified.
P8, P9, P10: 2 hours.
P19: As soon as practical with deference to the control room STA's availability (that is, STA control room duties to put plant in a stable condition takes precedence over performing a reassessment).
P20: No specific timeframe for this is included in procedures, but there is no reason why a risk assessment would be delayed, because it is performed in the control room by the control room staff.
P21: The new risk assessment is to be performed as soon as possible after the plant has been placed in a safe configuration.
P28: There is no time allowance specified to perform the reassessment, because it can be done very quickly for equipment in the CRM model.
P29: Generally, the risk assessment is requested immediately. Timely maintenance as needed is not held up. No additional PRA-modeled maintenance items or tests are allowed until the new risk assessment is completed.
P31, P32: As soon as possible, normally immediately.
P33: As soon as possible, and emergent activities are assessed by the shift manager or the STA.
P34: One shift, 12 hours.
P37: Not specified in procedure, but within 2–3 hours.

5. For an unplanned change in your plant maintenance configuration, what action is taken if the unplanned change cannot be explicitly evaluated?

   B3, B19, B20, P11, P30: Evaluated implicitly (that is, qualitatively). The work control procedures provide some guidance for performing qualitative evaluations. Anything not covered in the procedure would either have to be qualitatively addressed by other means, or dispositioned as not being risk-significant. Plant personnel can also request additional assistance from the PSA group.
   B5, B6, B7, B8, B9, B10, B11, P13, P14, P15: Qualitative assessment.
   B12: A risk assessor is on call to assist or perform the assessment as required. Also, there is a process for evaluating non-quantified risk factors.
   B14, P23, P35, P36: Restore the highly risk-significant equipment first. Typically, this is known without any formal evaluation.
   B16, B21, P1, P4, P19, P33, **P38:** Contact the PRA group for assistance.
   B18: By shift manager's direction.
   B22: Evaluated via risk matrix and ORAM-SENTINEL.
   B23: Call PRA group for guidance. Usually this will result in a bounding assessment if they cannot explicitly assess this.
   P5, P6, P7, P17: Not specified.
   P8, P9, P10: Typically, we take a conservative stance in risk assessment by assuming the worst case. Other groups, such as Plant Engineering and PRA, are consulted to evaluate the condition.
   P20: The control room may assign an environmental impact, such as increasing the loss of offsite power initiating event frequency in EOOS. Or, if they really get stuck, they will call the PRA group.
   P21: The risk is evaluated as soon as it is possible.
   P28: If the unplanned change is that additional equipment that is not in the CRM-model is found out of service or is removed from service, then no re-evaluation is performed because the status of this equipment does not significantly affect plant risk.
   P29: See previous item 4. Generally, PRA will determine how the evolution impacts risk.
   P31, P32: PRA group is called, and a qualitative assessment may be performed.
   P34: On judgment of the shift manager, Engineering resources are called in to help.
   P37: SRO uses qualitative assessment and judgement. Notifies duty risk management engineer if necessary.

6. For an unplanned change in your plant maintenance configuration, what action is taken if the new risk metrics are unacceptably high?

   B3, B19, B20, P11, P30: For emergent work activities that result in a risk color of orange or red, RMAs are established, such as compensatory measures. The on-shift shift manager is immediately notified of the risk condition and its cause. For emergent work activities that result in a risk color of red, actions are taken either to restore out-of-service equipment or place the plant in a safer condition.
   B5, B6, B7, B8, B9, B10, B11, P13, P14, P15: Reduce to acceptable and/or take appropriate compensatory action.
   B12, P4, **P38:** RMAs are explicitly stated in procedure for unplanned entry into elevated risk categories.
   B14, P23, P35, P36: Work around the clock, unless compensatory measures are put in place and are determined to be adequate.
   B16: Actions would be taken to determine the contingencies required and to exit the high risk situation.
   B18: Perform the recovery/repair first and reconcile the risk later.
   B21: Protected equipment program entered and work performed around the clock.

B22: If the CDF risk is made to be green, < 1E-6 and LERF is made to be < 1E-7.
B23: Defer or back out of maintenance if possible, until the unacceptable configuration no longer exists.
P1: Try to restore equipment as soon as possible, and contact the PRA group for generation of RMAs.
P5, P6, P7, P17: RMAs initiated.
P8, P9, P10: Implement RMAs, and evaluate the actions necessary to exit the high risk configuration.
P19: Procedure is followed. If the ACT will be exceeded, or the orange or red thresholds are exceeded, then RMAs are implemented.
P20: Procedures specify different levels of approval for different risk thresholds. *Unacceptably high* implies that we would not be in that configuration.
P21: Site procedures require that plant management become involved and that the appropriate level of concurrence for any actions are taken to address the new configuration.
P28: This has never happened in practice, but there is general guidance to return/repair equipment as quickly as practical to reduce plant risk.
P29: No new discretionary maintenance or testing can be completed. Plant management must determine if a shutdown is required, and all significant equipment must be returned to service ASAP.
P31, P32: Note entering the configuration, or adopt compensatory actions.
P33: Contact the PRA Group to determine appropriate actions. A Phase-Two Risk Assessment would be performed by the PRA group. This assessment gives details on which equipment to protect (equipment if removed from service would cause a risk level of red), and which operator actions and initiating events have become more important due to the configuration.
P34: On judgment of shift manager, either the task is postponed or the director of operations is contacted for approval. The DO will require input from Engineering.
P37: Notifies duty Operations and plant managers. Accelerates restoration of ongoing risk-important maintenance configuration, defers scheduled maintenance on risk-important equipment, identifies and implements RMAs, and enters condition in corrective action program.

7. Please feel free to provide any additional comments or clarifications about your plant's definition of *configuration,* and how changes are evaluated here:

B14, P23, P35, P36: The purpose of a definition of a configuration is to determine if RMAs are needed. Thus, we have a definition for *configuration*. What was happening was each work week manager had their own definition, and the result was chaos. The specific maintenance configuration risk is assessed and managed. In order to manage a configuration, the specific functions impacted must be identified and compensatory measures put in place to address the specific function. Thus, we have defined configuration as specific equipment out of service for a specific period of time. Based upon the ICDP impact, compensatory measures are applied to address whatever specific function is lost or reduced in defense in depth. If another component fails or is removed as planned, this is a new maintenance configuration, and the determination is made as to what, if any, new RMAs are needed for the new maintenance configuration. We do not try to manage a week's worth of maintenance as one configuration lumped together, because the risk never goes back to baseline. This would result in using general/generic RMAs. These types of actions are either part of normal business or would be at best ineffective—at worst, they would cause a loss of credibilty with the Operations department staff.
B23: In general, a configuration is a time duration from the point at which the plant enters a condition with the time to moderate risk (yellow) is less than one year, until the time that it exits this condition.
P28: The maintenance schedulers primarily use the PRA portion of SENTINEL to assess plant risk, and they have the latitude to determine if equipment is available or not based on the work being performed.
P33: Configuration—identification of plant equipment alignment is based on the availability status of

Maintenance Rule (a)(4) in-scope equipment. At any instant in time, a given plant configuration exists. Once there is a change in availability status of any MR (a)(4) in-scope SSC, there is also considered to be a corresponding change in plant configuration.

P8, P9, P10

– **Risk level green**: Green conditions denote minimum risk. The plant is fully capable of performing the associated safety functions. Green is the baseline for the SFATs and PTATs. No additional risk assessment actions are required from plant personnel.

  - RMA green: Normal work controls would be employed for configurations having nominal safety significance. This means that the normal plant work control processes are followed for the work activity, and that no additional actions to address RMAs are necessary.
  - *Work planning phase*: WWM reviews the scheduled risk evaluation.
  - *Work execution phase*: Operations SRO assigned to the WCC shall verify the work schedule and issue clearance to begin work.

– **Risk Level Yellow**: Yellow conditions denote a reduced safety condition. The plant's ability to perform the associated safety function is reduced but acceptable.

  - RMA yellow: RMAs for yellow conditions focus on providing increased risk awareness. Operations and maintenance personnel shall discuss the planned work activity within their respective organizations to increase operator and maintenance awareness of the risk of the work activity.

– **Risk Level Orange**: Orange conditions denote that the key safety function is in a degraded condition, and steps shall be taken to manage this condition. An orange condition is a high-risk configuration, and requires that RMAs be put into place to mitigate the risk impact from the out of service SSC.

  - RMA orange: Orange electronic risk assessment tool results that cannot be resolved by schedule changes will normally require complex or critical activity plans. Exemptions to this requirement may be granted by the online manager in cases where the orange result is caused by a single work activity and no benefit is seen from developing a complex activity plan. This allowance for waiver of the complex or critical activity plan shall not be interpreted to allow waiver of the RMAs. RMAs for high risk configurations (orange or red conditions), are required by NUMARC 93-01 to mitigate the risk impact from the out of service SSC, and cannot be waived. The online manager or designee shall develop RMAs for planned orange conditions. When entering a planned activity which the electronic risk assessment tool has assessed as an orange condition, prior Plant Operational Review Committee (PORC) is required. Planned activities that have received PORC approval in the past do not require additional PORC review. Changes made to planned activities that have been previously reviewed and approved by the PORC shall be reviewed by the PORC chairperson to determine if a subsequent review by the PORC is required.
  - *Work Execution Phase*: Operations will verify the work schedule and OWPM guidance on the activities, and then release the work for execution. Maintenance must understand when a work activity affects risk-significant SSCs, the risk level of that work, and any required actions as designated in a risk management plan. When entering an orange condition from emergent work, an operations SRO assigned to the WCC will ensure development of a work plan to restore the SSC. This may require input from other groups as necessary. The

Operations Shift Manager (OSM) will evaluate the restoration plan and have final authority whether the plan is implemented. Additionally, at the discretion of the OSM, development of a written risk management plan for actions to be taken in the event of further degradations may be required.

- **Risk Level Red**: The key safety function is immediately and directly threatened.
  - RMA red: Red ORAM-SENTINEL results should only occur due to emergent items. Intentional entry into condition red is not normally allowed, and it will not be scheduled without PORC approval and a written risk management plan. If an unplanned entry into red is made due to emergent conditions, operations shall ensure a PIP is written to evaluate the conditions. Restoration of equipment should not be delayed due to conducting the risk assessment. A red condition is a high-risk configuration, and requires that RMAs be put into place to mitigate the risk impact from the out-of-service SSC. The Operations shift manager or designee shall develop RMAs for emergent red conditions.

D. CRM Attributes to Support RITS

1. To what level is the basic event to component mapping for the CRM model developed?

   ☒ Mapping is primarily at the system or train level: **4%**
   P28, P37

   ☒ Mapping is at the major component level (for example, 50 to 150 major components): **13%**
   P8, P9, P10, P31, P32, P38

   ☒ Mapping considers a significant number of individual plant components: (for example, 500 or more): **44%**
   B3, B12, B14, B18, B19, B20, B22, P5, P6, P7, P11, P17, P19, P20, P21, P29, P30, P33, P35, P36

   ☒ Mapping considers a very large number of individual plant components (for example, 2,000 or more): **22%**
   B14, B16, B21 (more than 3,000 for 2 units), B23, P1, P4, P23, P34, *P35, P36*

   ☒ Other. Please describe: **24%**
   B5, B6, B7, B8, B9, B10, B11, P13, P14, P15: About 300–400 components.
   P29*:* Note that this is a map to impact solved cutsets at this time—specific macros are written to define the impact.

2. Has the basic event to component mapping been formally validated?

   ☒ No, a validation has not been performed and documented: **7%**
   P1, P20, P28

   ☒ An informal validation was performed, but the process is not officially documented: **36%**
   B3, B12, B16, B18, B19, B20, B22, B23, P4, P11, P19, P29, P30, P31, P32, P38

   ☒ A formal validation is performed and documented for revision of the mapping data: **56%**
   B5, B6, B7, B8, B9, B10, B11, B14, B21, P5, P6, P7, P8, P9, P10, P13, P14, P15, P17, P21, P23, P33, P34, P35, P36

   ☒ Other (please describe): **2%**
   P37: BE to tag mapping is formally validated for use in component importance calculations. The CRMP program uses train level mapping as checked in item 1 above).

3. Which personnel have the authority to make changes to the basic event mapping?

   ☒ PRA modeling personnel: **100%**
   B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B18, B19, B20, B21, B22, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P21, P23, P28, P29, P30, P31, P32, P33, P34, P35, P36, P37, P38

   ☐ Dedicated CRM coordinator: **0%**

   ☐ Maintenance Rule coordinator: **0%**

☒ Maintenance planning/scheduling personnel: **2%**
P20: Some changes are requested by planning/scheduling and we never have had a problem meeting a request. PRA Lead Engineer approves changes.

☐ Other personnel. Please describe: **0%**

4. Please describe the current procedural framework for the CRM Program. For example, what procedures exist for CRM model maintenance and upgrade, day-to-day CRM evaluations, CRM personnel qualification, and so forth?

B3, B19, B20, P11, P30: PSA group has a procedure which pertains to model updating/upgrading. Any model updates require updating the EOOS model as well. Each plant has its own procedure for evaluating both online and shutdown risk.
B5, B6, B7, B8, B9, B10, B11, P13, P14, P15: Corporate-level procedures for:
Work Management—On-Line Work Control Process
Outage Management—Shutdown Safety Management Program
Corporate level Training and Reference Materials (T&RMs):
Risk Management—On-Line Risk Management
Risk Management—Shutdown Risk Management
Risk Management—FPIE PRA Model Update
Risk Management—ORAM-SENTINEL and PARAGON Tool Update
Risk Management—ORAM-SENTINEL and PARAGON Model Capability
Some stations have local guidance that address local nuances.
B12: CRM model maintenance and upgrade is documented by using engineering calculation format, which is proceduralized. Day-to-day CRM evaluations are performed by the dedicated on-line risk assessor (a qualified PRA Engineer) when at-power, and during transitions, as described in the administrative procedure for Risk-Informed Safety Assessment and Risk Management, and by the shutdown DID advisors when shut down, as described in the administrative procedure for Shutdown Defense in Depth Assessment and Management.
B14, P23, P35, P36: Each site has an individual CRM procedure and the fleet has a procedure on the maintenance of the CRM model and its updating.
B18: Plant admin procedure.
B21: EOOS model is updated when a new risk model is rolled out.
B22, **P38:** New procedures are approved but will not be implemented until January 2008.
B23: High level guidance is provided in the plant's conduct manuals. Other guidance is provided in Operations Department work instructions or PRA Group work instructions.
P1: Our procedures require us to assess the risk for the planned work week ahead of time. If the schedule changes, or PRA equipment fails, then the new configuration is reassessed. We have an On-Line Risk Management procedure. If the newly assessed risk is too high, or if the on-shift personnel need help with the assessment, they contact the PRA section for assistance.
P4: On-Line Assessment Procedure and Shutdown Assessment Procedure.
P5, P6, P7, P17: Procedural guidance exists for CRM model maintenance, upgrade, day-to-day use, but some aspects of the guidance are very general. No guidance on CRM quals.
P8, P9, P10: CRM model maintenance and upgrade are controlled by a PRA group workplace procedure. Day-to-day CRM evaluations are controlled by fleet administrative procedures.
The PRA group has a position specific guide for qualifying personnel.
P19: Actual use of the PRA/DID is proceduralized in a site procedure owned by Maintenance Planning with Operations, PRA, and work window manager responsibilities outlined. PRA model

maintenance and upgrade is contained in an engineering division site procedure and project instructions owned by the PRA Group.
P20: A department level procedure governs CRM model changes. Another procedure governs day to day CRM evaluations. PRA and Planning and Scheduling personnel have individual documented qualifications that have to be met.
P21: The PRA group has a desktop instruction which provides guidance for CRM model maintenance and upgrade. The other items are governed by Work Control site procedures.
P28: Procedures require plant risk to be determined for all scheduled work performed on-line or during outages. The CRM-model has not been updated since the 1990s based on subsequent PRAs not determining a significant change in the plant risk profile. CRM personnel receive on the job training.
P29: Corporate procedures dictate how to manage the shutdown model and the process required.
P31, P32: Administrative procedures at the plant, and desktop procedures at the PRA group.
P33: Plant procedure gives guidance on the CRM basis and usage. Two appendices are included that describe the process to perform a Phase 1 risk assessment (weekly configuration risk calculations for the planned maintnenace activities that cause PRA modeled equipment to become unavailable). The Phase 1 assessment is performed by the work week scheduler and updated by Operations during the work week if emergent conditions arise. An appendix for the Phase 2 evalaution also gives details on how to perform this calculation (performed by the PRA group only.
P34: Full procedural framework at corporate (policy) level; procedural framework at working level (procedures) remains a work in progress.
P37: Procedures exist for PRA model maintenance and update, translation of PRA model to CRMP model, CRMP program, CRMP system guidelines, and RMAs.

5. Please indicate those CRM personnel who receive periodic CRM-specific training:

☒ PRA modeling personnel: **44%**
B3, B12, B14, B16, B18, B19, B20, B23, P4, P11, P19, P20, P21, P23, P29, P30, P34, P35, P36, P37

☒ Dedicated CRM coordinator: **11%**
B12, B16, P19, P31, P32

☒ Maintenance Rule coordinator: **7%**
P4, P21, P38

☒ Maintenance planning/scheduling personnel: **64%**
B3, B5, B6, B7, B8, B9, B10, B11, B14, B16, B18, B19, B20, B21, P4, P11, P13, P14, P15, P21, P23, P30, P31, P32, P33, P35, P36, P37, P38

☒ Operations personnel: **80%**
B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B18, B19, B20, B22, B23, P4, P8, P9, P10, P11, P13, P14, P15, P19, P20, P21, P23, P30, P31, P32, P33, P35, P36, P37, P38

☒ Other personnel. Please describe: **4%**
B23: Work Week Managers/Operations Work Control
P28: No periodic CRM training

6. Does the CRM model explicitly consider any time-in-cycle (for example, based on fuel burnup) or time-of-year (for example, changes in success criteria for cooling water systems) factors as part of the CRM quantification?

   ☒ N/A—it has been determined that there are no time-of-cycle or time-of-year factors that are risk-significant for the plant: **11%**
   B16, B21, P33, P34, P37

   ☒ No. There may be potential risk impacts of such factors, but they are not considered in the CRM model: **44%**
   B3, B12, B18, B19, B20, B22, P4, P5, P6, P7, P8, P9, P10, P11, P17, P19, P20, P30, P31, P32

   ☒ The CRM model considers time-in-cycle factors. Please briefly describe here: **9%**
   P1: The CRM has burnup related dependencies on the number of pressurizer relief valves needed to ensure satisfactory bleed and feed cooling.
   P13, P14: Consider fuel burnup for ATWS considerations.
   P29: These include ATWS mitigation capability from boron charging and impact on PORV challenges due to insufficiently negative MTC.

   ☒ The CRM model considers time-of-year factors. Please briefly describe here: **24%**
   B6, B7: Consider summer/winter for service water/ultimate heat sink considerations.
   B14, P23, P35, P36: Summer/winter impacts HVAC dependenies and turbine building cooling systems.
   B23: Cooling water system success criteria based upon RHR reservoir/lake temperature.
   P21: There is consideration for the number of fans needed in the diesel rooms and also the number of circulating water pumps needed as a function of the time of year.
   P28: Only to the extent that UHS (river) temperature effects the number of heat exchangers needed to meet DBA requirements.
   P29: Model's grid stress changes per time of year and due to increased strainer/screen fouling at other times of year.
   P38: Diesel generator maintenance looks at grid configurations during peak load times summer/winter.

7. How is the treatment of dependent human and recovery actions addressed in the CRM model?

   ☒ Dependencies between human actions and/or recovery actions are treated in the same manner as in the base PRA model: **78%**
   B3, B12, B14, B16, B18, B19, B20, B21, B22, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P17, P19, P20, P21, P23, P28, P29, P30, P31, P32, P33, P34, P35, P36, P37, P38

   ☐ Configuration-specific sensitivity studies have been performed to identify/address additional dependencies that might result during periods of heightened risk: **0%**

   ☒ The CRM model adjusts human action and recovery events on a configuration-specific basis as key equipment is removed from/returned to service. Please briefly describe here: **22%**
   B5, B6, B7, B8, B9, B10, B11, P13, P14, P15

   ☐ The CRM model considers human action dependencies in another manner. Please briefly describe the process here: **0%**

8. Have risk-important uncertainties in the CRM model been identified and evaluated?

☒ No: **91%**
B3, B5, B6, B7, B8, B9, B10, B11, B14, B16, B18, B19, B20, B21, B22, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P21, P23, P28, P29, P30, P31, P32, P33, P34, P35, P36, P38

☒ Yes. Please briefly state how the evaluation was performed here: **9%**
B12: Indirectly as the evaluation of risk-important uncertainties was addressed in the PRA model of record, which was imported into the CRM model.
P19: Followed EPRI Methodology.
P20: Assumptions for the PRA/CRM model are quantitatively and/or qualitatively evaluated. A parametric uncertainty study is performed for major updates.
P37: Use key uncertainties and assumptions identified for the PRA model. Sensitivity studies are performed as appropriate.

9. What processes and criteria exist for addressing errors identified in the CRM model or tool (including criteria to suspend use of the CRM tool until errors are corrected)? Please describe below:

B3, B19, B20, P11, P30: Potential corrections are evaluated on a case-by-case basis. If they impact the base model, the need for an interim model change is determined per procedure. If it is an application (EOOS) specific change (for example, mapping), it is usually corrected promptly or additional interim guidance is provided. Any time a new configuration is added to the EOOS database, it is evaluated before being released for official use. Any errors when running EOOS are usually due to deficiencies in the EOOS code itself or interruptions in network availability.
B5, B6, B7, B8, B9, B10, B11, P13, P14, P15: From the procedure for A PRA Model Error Requiring an Unscheduled Update for an error that affects the results of the PRA in a fashion that affects applications. For example, a fault tree error that would cause an MOV's classification in the MOV program to change would have to be corrected, as would an error that would change the FV of an MSPI-monitored component beyond allowable bounds. An error that does not affect the conclusions may be placed in an Updating Requirement Evaluation (URE) for the next periodic update. An example of this would be a basic event description that is wrong, but the basic event is appropriately handled in the model. Also, if an error has a large impact on CDF or LERF, such as a 25% change or a significant shift in distribution, an unscheduled update should be considered.
B12: The corrective action program is used for addressing errors identified in the CRM tool. There is no set criteria; errors would be addressed on a case-by-case basis.
B14, P23, P35, P36: Corrective action program and model maintenance on how quickly an error must be corrected (Delta CDF impact). No proceduralized criteria for suspending use.
B18: Once identified, errors are corrected immediately and documented in the plant logging system.
B21: Corrective action process—model must be corrected if there is a factor of two change.
B22: Problem event resolution (PER) is made, which is tracked until the issue is resolved. This requires a corrective action plan and immediate actions taken.
B23: PRA group's work tracking database identifies modeling issues. If any are found that individually or in aggregate call into question the use of the tool, then an at-risk model modification may be performed.
P1: Errors found are identified and corrected. In most cases encountered so far, these have all been conservative errors and have been corrected in a timely manner without suspending use of the CRM tool.
P4, P8, P9, P10, P31, P32, P37: Identified errors are entered into the corrective action program.

P5, P6, P7, P17: Procedure plus multiuser, network based PRA configuration control database to track errors and resolutions.
P20: A PRA Changes database is used to collect information about necessary changes. In some instances, work-arounds are recommended to Planning/Scheduling until changes can be implemented.
P21: The errors are documented on a SMART form, which is the method used by the plant corrective action program. This requires an evaluation of past risk assessments and the documentation of corrective measures. Also, a root cause can be required.
P28: Historically, errors that have been found in the CRM tool affect only a specific plant configuration, so it has never been necessary to stop using the CRM tool.
P29: CRMPs and Condition Reports are written, and then model cutsets and/or split fractions are updated as needed.
P33: Significant errors would have an Action Request (CAP) written to document and updated as soon as possible. Non-significant errors are also documented in an Action Request. The item is tracked and EOOS is updated at the next convenient opprtunity.
P34: The errors would be identified using a Station Condition Record, and the solution would follow the standard processes of the corrective action program.
P38: Problem Event Report, PER, is made and tracked until the item is resolved. The immediate actions taken consider the impact of the error on the model. If the model is nonconservative, configuration changes to components impacted by the error are resolved by the PRA staff prior to the configuration change.

10. What processes and criteria exist for evaluating the impact of plant changes (for example, design changes and procedure changes) on the CRM model and the need to perform a model update to address these changes? Please describe below:

B3, B19, B20, P11, P30: The PSA group has a process in place (per procedure) to address plant changes that could impact the PSA model, and therefore the CRM model. To summarize, plant/model changes that do not significantly impact results are entered into a Model Change Request (MCR) database and incorporated as part of the next PSA update. More significant plant/model changes are incorporated ASAP. In addition, there may be instances where a plant/model change is incorporated into the CRM model immediately, but the change is deferred in the PSA model.
B5, B6, B7, B8, B9, B10, B11, P13, P14, P15: URE, see item 9.
B12: The PRA model of record is in WinNUPRA, and there exist processes and criteria for evaluating impact of plant changes to that model. The CRM model is only changed as the PRA model of record is changed.
B14, P23, P35, P36: Same as PRA base model. All plant changes and procedure changes evaluated and CDF impact evaluated. Based upon impact, the change is either started immediately (> 1E-06 increase in CDF) or deferred to the next update (negligible), or a new interm update is planned and executed when resources are available (small CDF increase or CDF decrease).
B18: PRA engineer is responsible for evaluating the design changes, determining the impact, and revising the CRM procedure.
B21:All changes are evaluated. If a model change is required, it is done for the next periodic update, or if the change results in a factor of two change.
B22: Plant procedure governs all plant changes and their effect on the PRA model. Procedure changes are not reviewed for the effect on the PRA model. The model update, which occurs every other cycle, perfroms a review of affected procedures to determine required changes to the PRA model. Plant-completed modifications are reviewed from the time of the last update to ensure changes have been included in the model.

B23: Plant modifications are qualitatively evaluated for PRA model impact based on reviews of procedure and design change notices, usually well in advance of implementation.
P1: PRA section procedures exist for control of the PRA/CRM model, and changes to plant procedures and equipment are evaluated to assess needed changes to the model. The PRA section is notified by the design change group when modifications are proposed/completed so that they can be assessed. Similarly, the site procedure group notifies/solicits comments from the PRA group for changes to EOPs.
P4: Design control process defines PRA as cross-organization review. There is also a monthly review of document changes and their impact on PRA model.
P5, P6, P7, P17: Procedures with 10 delta CDF/LERF criteria for immediate change versus wait until next model update (3 years).
P20: PRA personnel attend meetings where these changes are discussed. A department level procedure requires reviewing, discussing and potentially incorporating these changes for major model updates.
P21: The PRA group is included in the design and procedure change process. It is the responsibility of the PRA group to assess the impact of these changes on the model and to institute any actions that are required.
P28: In practice, there has not been a plant change that affected the CRM model.
P29: PRA screens are done for modifications and procedure changes. If PRA is impacted, then we are informed, and the impact on the overall plant model and the CRM model are determined and acted upon as needed.
P31, P32: Follow the PRA update process unless there are errors directly affecting the OLRM; then they are addressed on a case-by-case basis.
P33: All modifications are reviewed by the PRA group to determine the impact on the PRA model. If a model change is necessary, then a CAP is written and tracked. The update of the model should occur around the same time the modification installation is completed.
P34: PRA group reviews all design changes for the impact on CRM tools and initiates changes. Design mod documentation requires CRM documents to be updated.
P37: Design change impacts are reviewed by the PRA group as they are routed for plant impact assessment. Procedure change impacts are reviewed at each model update.
P38: Plant procedures for design changes include a review for impact on the PRA model.
P8, P9, P10: Risk assessment tool change process requirements of 10CFR 50.65 (a)(4) include that the risk assessment tools for the plant will be representative of the as-built, as-operated plant. The electronic risk assessment tool change process to maintain the risk assessment tool involves personnel from several departments.

Severe accident analysis group (SAAG) personnel, electronic risk assessment tool site experts, Maintenance Rule expert panel members, operations and site engineering personnel are responsible for identifying required changes for the electronic risk assessment tool from reviews of plant engineering changes, reviews of plant operation changes, or other identified needs.

SAAG personnel are responsible for the identification of changes emerging from PRA model changes. SAAG shall also develop the prototype of the necessary changes to the model.

The site Maintenance Rule coordinator is responsible for identification of required changes to the electronic risk assessment tool resulting from changes to the Maintenance Rule safety significance.

During the review process of all engineering changes, effects to the PRA and electronic risk assessment tool models will be evaluated. If the change is significant, electronic risk assessment tool and/or PRA model changes will be performed in a reasonable timeframe to reflect the as-built plant. If the change is not significant, any required change will be incorporated in the next scheduled model update.

The electronic risk assessment tool site experts are responsible for proposing a desired way of accomplishing the required change in the electronic risk assessment tool. The proposal should be reviewed by the Maintenance Rule coordinator prior to development of the coding changes by the SAAG model owner.

The SAAG personnel are responsible for the development of the modeling changes in the electronic risk assessment tool.

The Maintenance Rule expert panel is responsible for the review of modeling changes to the electronic risk assessment tool and for any design changes to the safety function assessment trees or plant transient assessment trees. The Expert Panel is also responsible for reviewing any color changes to those trees or to the PRA color thresholds.

Plant changes that have been reviewed and found to be significant have a signoff for completion of PRA and electronic risk assessment tool model revisions. Supporting interfacing program changes must also be completed (WMS, ProjectView, and so on) before the engineering change can be considered complete. SAAG or the electronic risk assessment tool site expert shall complete these signoffs.

The Electronic Risk Assessment Tool Site Expert is responsible for the development of changes to other site data that are required by the Electronic Risk Assessment Tool changes, such as changes to WMS, ProjectView, and Electronic Risk Assessment Tool Coding Guidance documents.

The electronic risk assessment tool site expert is responsible for communicating to site personnel the changes to the electronic risk assessment tool models.

Work control personnel are responsible for the review of existing model work orders for applicable changes to the coding of those work orders due to the electronic risk assessment tool changes.

Work control personnel are responsible for the review of existing equipment database entries for applicable changes to the coding of those entries due to the electronic risk assessment tool changes.

E. Treatment of Fire and Other External Events

1. How are the following external events currently considered in your CRM evaluations? Please check all that apply:

Internal Fires

☒ Shown to not be an important risk contributor for the plant: **2%**
P28
☒ A risk contributor, but not considered in the CRM evaluation: **76%**
B3, B5, B6, B7, B8, B9, B10, B11, B14, B18, B19, B20, B21, B22, P1, P4, P5, P6, P7, P11, P13, P14, P15, P17, P20, P23, P30, P31, P32, P33, P34, P35, P36, P38
☒ Evaluated using bounding-type risk evaluations: **2%**
B12
☒ Evaluated quantitatively as part of the CRM evaluation: **20%**
B23, P8, P9, P10, P19, P21, P29, *P31*, P37

External Floods

☒ Shown not to be an important risk contributor for the plant: **58%**
B5, B6, B7, B8, B9, B10, B11, B12, B14, B18, B21, B22, B23, P13, P14, P15, P19, P20, P21, P23, P28, P31, P32, P33, P34, P38
☒ A risk contributor, but not considered in the CRM evaluation: **49%**
B5, B6, B7, B8, B9, B10, B11, B3, B19, B20, P1, P5, P6, P7, P11, *P13, P14, P15,* P17, P30, P35, P36
☒ Evaluated using bounding-type risk evaluations: **2%**
P4
☒ Evaluated quantitatively as part of the CRM evaluation: **11%**
P8, P9, P10, P29, P37

Seismic Events

☒ Shown to not be an important risk contributor for the plant: **56%**
B5, B6, B7, B8, B9, B10, B11, B12, B14, B21, B22, B23, P13, P14, P15, P20, P21, P23, P28, P31, P32, P33, P35, P36, P38
☒ A risk contributor, but not considered in the CRM evaluation: **31%**
B3, B18, B19, B20, P1, P5, P6, P7, P8, P9, P10, P11, P17, P30
☒ Evaluated using bounding-type risk evaluations: **4%**
P4, P34
☒ Evaluated quantitatively as part of the CRM evaluation: **7%**
P19, P29, P37

High Winds

☒ Shown to not be an important risk contributor for the plant: **20%**
B18, B21, B22, P19, P20, P28, P31, P32, P38

☒ A risk contributor, but not considered in the CRM evaluation: **20%**
B3, B19, B20, P5, P6, P7, P11, P17, P30
☒ Evaluated using bounding-type risk evaluations: **44%**
B5, B6, B7, B8, B9, B10, B11, B12, B14, P4, P8, P9, P10, P13, P14, P15, P23, P34, P35, P36
☒ Evaluated quantitatively as part of the CRM evaluation: **20%**
B23, P1, *P8, P9, P10,* P21, P29, P33, P37

2. Are you currently performing, or planning to perform in the near-term, a state-of-the-art PRA for the following external events?

Internal Fires
☒ Not planning to perform PRA in near-term: **20%**
B3, B12, B18, B19, B20, B21, P11, P28, P30
☒ Planning to perform PRA in near-term: **24%**
B22, B23, P4, P5, P6, P7, P17, P21, P34, P37, P38
☒ PRA is currently underway: **29%**
B5, B6, B7, B8, B9, B10, B11, B16, P13, P14, P15, P31, P32
☒ PRA (planned or underway) is in support of NFPA-805: **27%**
B14, P1, P8, P9, P10, P19, P20, P23, P29, P33, P35, P36

External Floods
☒ Not planning to perform PRA in near-term: **80%**
B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B18, B19, B20, B21, B22, B23, P4, P8, P9, P10, P11, P13, P14, P15, P19, P20, P21, P23, P28, P30, P33, P34, P35, P36, P37
☒ Planning to perform PRA in near-term: **20%**
P1, P5, P6, P7, P17, P29, P31, P32, P38
☐ PRA is currently underway: **0%**

Seismic Events
☒ Not planning to perform PRA in near-term: **82%**
B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B18, B19, B20, B21, B22, B23, P1, P4, P8, P9, P10, P11, P13, P14, P15, P20, P21, P23, P28, P30, P31, P32, P33, P35, P36, P37
☒ Planning to perform PRA in near-term: **16%**
P5, P6, P7, P17, P29, P34, P38
☒ PRA is currently underway: **2%**
P19

High Winds
☒ Not planning to perform PRA in near-term: **82%**
B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B18, B19, B20, B21, B22, P11, P4, P8, P9, P10, P13, P14, P15, P19, P20, P21, P23, P28, P30, P31, P32, P33, P34, P35, P36, P37
☒ Planning to perform PRA in near-term: **13%**
P5, P6, P7, P17, P29, P38
☒ PRA is currently underway: **2%**
B23

3. What approach will be used to incorporate the new PRA models into the CRM evaluation process after they have been completed?

☒ N/A—PRA models for external events are not being developed in the near-term: **22%**
B3, B12, B16, B19, B20, B21, B22, P11, P28, P30

☐ The new PRA models will not be incorporated into the CRM process (for example, existing process will continue to be used): **0%**

☒ The new PRA models will be incorporated directly into the CRM quantitative models (that is, all modeling details will be included): **27%**
B23, P1, P4, P5, P6, P7, P17, P19, P21, P29, P33, P34

☒ A simplified model will be developed from the new PRA models for incorporation into the CRM quantitative models: **9%**
B18, P8, P9, P10

☒ Other. Please briefly describe here: **42%**
B5, B6, B7, B8, B9, B10, B11, P13, P14, P15: TBD
B14, P23, P35, P36: As to whether the fire and other external events are incorporated into the CRM is depending upon what the NRC determines is required. Directly incorporating fire will result in a CDF penalty for those plants with a fire PRA when compared to those plants without a fire PRA.
P20, P31, P32: To be determined. Not sure how the fire PRA level of detail and scope may affect the efficacy of the CRM tool.
P37: Current PRA includes above external events. An upgrade of the fire PRA is planned in the next several years.
P38: The method to incorporate the models in the CRM process is under evaluation.

4. If bounding evaluations are currently used to consider external events' risks, have the evaluation results been validated to support CRM evaluations?

☒ N/A—Bounding evaluations are not used for external events: **53%**
B3, B16, B18, B19, B20, B21, B22, B23, P1, P5, P6, P7, P11, P17, P19, P21, P28, P30, P31, P32, P29, P33, P37, P38

☒ No, the bounding evaluations have not been validated: **29%**
B5, B6, B7, B8, B9, B10, B11, B12, P4, P13, P14, P15, P20

☒ Yes, the bounding evaluations have been validated. Please briefly describe the validation process here: **18%**
B14, P23, P35, P36: Most of the bounding evaluations have depended on the IPEEE, or other very specific analysis, such as a tornado missile study for a specific target.
P8, P9, P10: Some informal validation has been performed by adjusting initiators in the PRA and evaluating the results.
P34: Bounding evaluations are part of the regulatory safe operating envelope. They were validated as part of the regulatory approval process.

5. If bounding evaluations are currently used, how are the results of these evaluations integrated into the CRM process? Please briefly describe here:

   B3, B19, B20, P11, P30, P29: N/A
   B5, B6, B7, B8, B9, B10, B11, P13, P14, P15: SFATs and PTATs have High Risk Evolution (HRE) condition blocks used (toggled on) for actual high-risk evolutions, as well as external conditions considered to be risk-significant. These HREs generally change the risk assessment by one color and are considered to be bounding.
   B12: Qualitatively in blended assessments.
   B14, P23, P35, P36: Provided separately from the quantitative CRM model. Typically, these evaluations show negligible ICDP (< 5E-07). This is applied to the blended approach. Compensatory and RMAs are determined based upon risk insights.
   P8, P9, P10: Used in the qualitative portion of ORAM-SENTINEL to increase the color results for specific safety functions.
   P20: We perform specific bounding evaluations on a case-by-case basis for licensing submittals and RAIs.
   P34: The CRM uses a blended quantitative and qualitative approach. Bounding studies are included in the qualitative approach.

F. Treatment of Non-Quantified Risk Factors

All percentages are based on the total number of responding plant sites (45 in total). Percentages do not always total to 100%, due to multiple answers for some plants, or plants that did not provide answers for all questions. In general, the percentage responses given can be used as a guide, but the reader should review actual plant responses to understand how the responses affected the percentage calculations.

Note that the italicized plant IDs in the survey below indicate situations in which a plant has provided multiple responses to a single question. For example, a plant may indicate that a factor is considered within its CRM model, but also indicate "other" in order to provide further clarification.

1. Are the following potential risk factors considered in your CRM, how are such factors considered, and under what conditions?

Risk Factor	When Considered	How Considered
Severe weather conditions (for example, thunderstorms, tornadoes, hurricanes, and so on)	☒ Routinely, as part of each CRM evaluation: **84%** [82%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B18, B19, B20, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P20, P21, P23, P28, P29, P30, P33, P35, P36, P37 ☒ Only when normal CRM evaluation indicates a heightened risk situation: **9%** [11%] B22, P19, P34, P38 ☒ Not explicitly considered in CRM evaluation: **7%** [3%] B21, P31, P32 ☒ Other (Please describe): **2%** [5%] P38	☒ Considered within CRM model: **60%** [84%] B3, B14, B18, B19, B20, B22, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P17, P19, P20, P21, P23, P29, P30, P33, P35, P36 ☒ Considered separately: **22%** [8%] *B3,* B12, B16, *B19, B20, P11*, P28, *P30*, P34, P37 ☒ Addressed by another non-CRM plant program/group: **11%** [8%] *P8, P9, P10,* P31, P32 ☒ Other (please describe): **13%** [18%] ***B3, B19, B20, P11, P30:*** Included as specific activiy in EOOS, increases applicable IE frequency, for example, LOOP x2. **P38:** Planned DG maintenance > 72 hours requires verification with weather service that no thunderstorms or potential for tornados are predicted.

Risk Factor	When Considered	How Considered
Electric grid stability	☒ Routinely, as part of each CRM evaluation: **89%** [32%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B16, B18, B19, B20, B23, P11, P13, P14, P15, P30, B14, P23, P1, P4, P5, P6, P7, P8, P9, P10, P17, P20, P21, P28, P29, P31, P32, P33, P35, P36, P37 ☒ Only when normal CRM evaluation indicates a heightened risk situation: **4%** [16%] B22, P19 ☒ Not explicitly considered in CRM evaluation: **4%** [18%] B21, P34 ☒ Other (Please describe): **4%** [32%] ***P29***: Increased LOOP probabilities in the summer months. *P38*	☒ Considered within CRM model: **76%** [39%] B3, B5, B6, B7, B8, B9, B10, B11, B14, B18, B19, B20, B22, B23, P11, P23, P1, P4, P8, P9, P10, P13, P14, P15, P19, P20, P21, P29, P30, P31, P32, P33, P35, P36 ☒ Considered separately: **29%** [42%] *B3*, B12, *B14*, B16, *B19, B20, P11*, P23, P28, *P30, P35, P36*, P37 ☒ Addressed by another non-CRM plant program/group: **40%** [3%] *B5, B6, B7, B8, B9, B10, B11, B14*, *P8, P9, P10*, *P13, P14, P15,* P23, P28, *P35, P36* ☒ Other (please describe): **36%** [0%] ***B5, B6, B7, B8, B9, B10, B11, P13, P14, P15***: Work control process provides specific thresholds used as inputs to the CRM model. ***B3, B19, B20, P11, P30:*** Included as specific activiy in EOOS, increases applicable IE frequency, for example, LOOP x2. **P38:** Considered for periods of planned extended DG or AFW TDP maintenance.
Switchyard maintenance/test activities	☒ Routinely, as part of each CRM evaluation: **91%** [84%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B18, B19, B20, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P21, P23, P28, P29, P30, P31, P32, P35, P36, P37, P38 ☒ Only when normal CRM evaluation indicates a heightened risk situation: **7%** [11%] B22, P33, P34 ☒ Not explicitly considered in CRM Evaluation: **2%** [0%] B21 ☐ Other (Please describe): **0%** [8%]	☒ Considered within CRM model: **91%** [76%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B18, B19, B20, B22, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P21, P23, P29, P30, P31, P32, P33, P35, P36, P37, P38 ☒ Considered separately: **18%** [11%] *B3*, B16, *B19, B20, P11*, P28, *P30*, P34 ☒ Addressed by another non-CRM plant program/group: **2%** [0%] *P28* ☒ Other (please describe): **11%** [13%] ***B3, B19, B20, P11, P30:*** Included as specific activity in EOOS, increases applicable IE frequency, for example, LOOP x2.

Risk Factor	When Considered	How Considered
Other events outside the plant (for example, affecting ultimate heat sink, and so on)	☒ Routinely, as part of each CRM evaluation: **56%** [32%] B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B18, B23, P1, P4, P8, P9, P10, P13, P14, P15, P21, P23, P29, P35, P36 ☒ Only when normal CRM evaluation indicates a heightened risk situation: **24%** [16%] B3, B19, B20, P5, P6, P7, P11, P17, P19, P30, P33 ☒ Not explicitly considered in CRM evaluation: **20%** [18%] B21, B22, P20, P28, P31, P32, P34, P37, P38 ☐ Other (Please describe): **0%** [32%]	☒ Considered within CRM model: **64%** [39%] B3, B5, B6, B7, B8, B9, B10, B11, B18, B19, B20, P1, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P21, P29, P30, P33 ☒ Considered separately: **29%** [42%] *B3*, B12, B14, B16, *B19, B20,* B22, *P11*, P23, *P30*, P35, P36, P38 ☒ Addressed by another non-CRM plant program/group: **7%** [3%] P31, P32, P37 ☒ Other (please describe): **11%** [0%] ***B3, B19, B20, P11, P30***: Included as specific activiy in EOOS, increases applicable IE frequency, for example, LOOP x2.
Performance of routine plant tests/activities that could initiate a transient (for example, trip, loss of power or other key support system, and so on)	☒ Routinely, as part of each CRM evaluation: **80%** [68%] B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B18, B19, B20, B22, B23, P1, P4, P8, P9, P10, P11, P13, P14, P15, P20, P21, P23, P28, P29, P30, P34, P35, P36, P37, P38. ☒ Only when normal CRM evaluation indicates a heightened risk situation: **16%** [5%] P5, P6, P7, P17, P19, P31, P32 ☒ Not explicitly considered in CRM Evaluation **4%** [0%] B21, P33 ☐ Other (Please describe): **0%** [32%]	☒ Considered within CRM model: **82%** [63%] B3, B5, B6, B7, B8, B9, B10, B11, B16, B18, B19, B20, B22, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P21, P29, P30, P31, P32, P34, P37, P38 ☒ Considered separately: **13%** [5%] *B3*, B12, *B19, B20, P11, P30* ☒ Addressed by another non-CRM plant program/group: **2%** [26%] P28 ☒ Other (please describe): **9%** [16%] **B14, P23, P35, P36:** Some plants directly use multiplication factors in the CRM model others uses qualitative approach.

Risk Factor	When Considered	How Considered
Operation with a risk-significant component in an "operable but degraded" condition	☒ Routinely, as part of each CRM evaluation: **9%** [13%] B12, B18, P1, P29 ☒ Only when normal CRM evaluation indicates a heightened risk situation: **7%** [29%] B22, P19, P37 ☒ Not explicitly considered in CRM evaluation: **40%** [53%] B3, B16, B19, B20, B21, *B22*, B23, P5, P6, P7, P11, P17, P28, P30, P31, P32, P33, P34 ☒ Other (Please describe): **47%** [3%] **B5, B6, B7, B8, B9, B10, B11, P13, P14, P15:** Case-by-case basis considering how bad it is and what if. **B14, P23, P35, P36:** As determined by plant staff based on how degraded it is. **P4:** Component credited in PRA if it is available. **P8, P9, P10:** Operable components are typically considered available, but each case is evaluated independently. **P20:** Separate evaluation. **P21:** An evaluation is performed by PRA group, **P38**	☒ Considered within CRM model: **38%** [24%] B5, B6, B7, B8, B9, B10, B11, B18, P1, P8, P9, P10, P13, P14, P15, P19, P29 ☒ Considered separately: **22%** [16%] B3, B12, B19, B20, B22, P11, P30, P31, P32, P37 ☐ Addressed by another non-CRM plant program/group: **0%** [8%] ☒ Other (please describe): **16%** [8%] **B14, P23, P35, P36**: PRA assistance is requested and provided on a case by case basis. ***P20***: PRA reviews and evaluates. The documentation could be an email or something more formal. **P21**: The model might be changed to accommodate this event. The action taken would be determined by the PRA group and the severity of the degradation. **P38:** PRA staff considers 91-18 degraded components for impact to CRM model and adjustments are made accordingly.

Risk Factor	When Considered	How Considered
Other factors not listed above (please describe):	☒ Routinely, as part of each CRM evaluation: **2%** [8%] **B12:** Heavy lifts, outages of normal HVAC affecting key plant areas, unavailability of hazard barriers for risk-significant equipment, outages of risk-significant control room instrumentation. ☐ Only when normal CRM evaluation indicates a heightened risk situation: **0%** [5%] ☒ Not explicitly considered in CRM Evaluation: **7%** [0%] **P31, P32**: Scaffolding and missile barriers. B23 ☒ Other (Please describe): **31%** [5%] **B5, B6, B7, B8, B9, B10, B11, P13, P14, P15**: Production risk is considered and addressed as HRE. **B14, P23, P35, P36:** As needed, such as temporary modifications to SSCs, temporary degraded conditions such as fire wrap or barriers.	☐ Considered within CRM model: **0%** [11%] ☒ Considered separately: **7%** [8%] B12, P31, P32 ☐ Addressed by another non-CRM plant program/group **0%** [0%] ☒ Other (please describe): **9%** [0%] **B14, P23, P35, P36:** PRA assistance is requested and provided on a case by case basis.

Please provide any additional comments or details about your evaluation practices for these factors here:

B14, P23, P35, P36: Must keep brain engaged. The computer cannot provide all the answers. If the computer could provide all the anwers I could get a kid off the street to just punch the buttons and would not need SROs involved.
P28: All of the above risk factors are evaluated qualitatively. They may result in some work being rescheduled, but the risk level of the plant is never changed from that predicted in the at-power PRA based on these factors.
P29: Currently have a very detail-oriented CRM process for PRA risk assessment. Includes virtually all potential trip risks. Considering reducing the scope of this as practical to reduce the large number of items being tracked to allow more focus on the more risk-significant items and screen the low trip risk items.

2. If grid reliability/stability is considered in a quantitative fashion in the CRM program, how is this considered in the evaluation?

   ☒ N/A—Grid reliability/stability is not quantitatively considered in the CRM program: **47%**
   B5, B6, B7, B8, B9, B10, B11, B12, B16, B21, B22, P8, P9, P10, P13, P14, P15, P28, P34, P37, P38

   ☒ An adjustment factor is applied to the grid initiating event frequency(ies). Please briefly describe the process used to determine the adjustment factors here: **53%**
   B3, B19, B20, P11, P30: Low risk factor (2x), medium (5x), and high (10x). In some cases (for example, offsite feeder outages), an attempt is made to quantify the multiplier. Otherwise, the risk factor (and multiplier) are subjective and are just intended to heighten awareness (for example, taking an EDG out of service during a degraded grid condition).

B14, P23, P35, P36: Depending on severity, and the multiple is either 5x or 10x LOSP.
B23: Elevation to a 2x or 10x multiple, based upon the extent of voltage degradation or grid stability.
P1: Factors have been estimated and documented in a plant calculation.
P4, P19, B18: Increase the LOOP initiating frequency.
P5, P6, P7, P17: Probability adjusted to 95% confidence limit.
P20: A multiplier of 2 or 3 on Loss of Offsite power frequency at the discretion of control room operators.
P21
P29: Used the factors recommended by the NRC and EPRI on the grid loss studies.
P31, P32: Qualitatively assigned high medium and low with adjustment of loss of offsite power frequency by a factor of 10, five, and two.
P33: The LOOP frequency is increased by a factor of 10 for Adverse Weather Conditions such as thunderstorm watches and others, as issued by the National Weather Service. The LOOP frequency is increased by a factor of 10 for System Condition orange. The LOOP frequency is increased by a factor of 20 for a System Condition of red. Switchyard Maintenance also affects LOOP frequency. If one of four offsite power sources is unavailable, the LOOP is increased by 1.6. If two of four offsite power sources are unavailable, the LOOP is increased by 3.6.

☐ The risk color (or overall CDF) is adjusted by a factor. Please briefly describe the process used to make this adjustment: **0%**

☐ Another approach is used. Please briefly describe the approach here: **0%**

3. Is the plant's CRM risk status transmitted to the grid operator?

☒ No: **64%**
B5, B6, B7, B8, B9, B10, B11, B21, B22, B23, P1, P4, P5, P6, P7, P8, P9, P10, P13, P14, P15, P17, P19, P28, P29, P31, P32, P33, P34

☒ Yes, but for unusual situations or unusually high risk: **9%**
B18, P21, P37, P38

☒ Yes, the grid operator receives routine updates on a regular basis: **13%**
B12, B14, B16, P23, P35, P36

☒ Other. Please briefly describe here: **11%**

P11, P30: Procedure requires notification of system/district operator for risk level changes associated with plant electrical systems.
B20: Procedure requires coordination with grid operator(s) for risk level changes associated with outages of HPCI, RCIC, EDGs, and delayed access power source, to ensure that grid reliability will not be challenged during these periods.
P20: A status button is used to denote situations where this communication has to occur. Any loss of offsite power multiplier of 2 or more and/or any of numerous components out of service will light this button.
P38: Planned DG maintenance is transmitted to load dispatcher. Note, our utility owns its grid and communications between plants and load dispatchers are proceduralized.

4. If severe weather conditions are explicitly considered in your CRM program, what events trigger the entry into a special condition or heightened risk awareness situation?

☒ N/A, severe weather is not considered as part of the CRM program: **9%**
B21, P31, P32, P34

☒ Severe storm warnings (severe thunderstorms, tornado): **89%**
B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B18, B19, B20, B23, P1, P4 (5x LOOP frequency), P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20 (including hurricanes), P21, P23, P28, P29, P30, P33, P35, P36, P37, P38

☒ Severe storm watches: **36%**
B3, B16, B19, B20, B23, P4 (10x LOOP frequency), P8, P9, P10, P11, P20, P28, P29, P30, P33, P38

☒ The plant remains in a heightened risk situation throughout the severe storm season: **2%**
B22

☒ Ice storm warnings or watches **51%**
B3, B5, B6, B7, B8, B9, B10, B11, B16, B19, B20, B23, P1, P8, P9, P10, P11, P13, P14, P15, P29, P30, P38

☒ Winter storm warnings or watches: **22%**
B3, B16, B19, B20, P8, P9, P10, P11, P29, P30

If you wish to provide any additional information about how severe weather thresholds are used at your plant, please provide this information here:

B5, B6, B7, B8, B9, B10, B11, P13, P14, P15: Thresholds prescribed in site severe weather procedures.
B14, P23, P35, P36: Hurricane threat or wind speeds of 73 mph or higher.
P8, P9, P10: Based upon National Weather Service declaration for the area surrounding the plant.
P28: Severe weather is qualitatively considered in decisions to remove from service equipment needed to mitigate an SBO.

5. For any of the above factors that your CRM model cannot currently address on a routine basis, does your plant have any plans to change the way that one or more of the factors is evaluated?

   ☒ No: **98%** [68%]

B3, B5, B6, B7, B8, B9, B10, B11, B12, B14, B16, B18, B19, B20, B21, B22, B23, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20 (plan on better documenting basis for evaluation methods), P21, P23, P28, P29, P30, P31, P32, P33, P34, P35, P36, P37, P38

☐ Yes, the treatment of grid reliability issues will be modified. Please describe what changes in the evaluation of grid reliability issues are planned: **0%** [0%]

☐ Yes, the treatment of other factors will be modified. Please describe the factors that will be considered and what changes in the evaluation of the factor(s) are planned: **0%** [0%]

☐ Yes. Please describe the factors that will be considered and what changes in the evaluation of the factor(s) are planned: **0%** [26%]

6. Have situations arisen in which the consideration of these non-quantifiable factors has changed the outcome of a CRM evaluation (for example, resulted in a higher risk color)?

☒ No: **51%** [66%]
B3, B12, B16, B18, B19, B20, B21, B22, B23, P4, P5, P6, P7, P11, P17, P19, P28, P30, P31, P32, P29, P33, P38

☒ Yes: **49%** [26%]
Please describe the circumstances (for example, the factor(s) involved, and the reasons why the CRM evaluation was changed, and so on).
B5, B6, B7, B8, B9, B10, B11, P13, P14, P15: Grid reliability, switchyard work, tornado warning, certain testing, and so on.
B14, P23, P35, P36: External flood concerns and degraded barriers.
P1: The combination of some of these factors, along with plant maintenance configuration, can result in undesirable high risk situations.
P8, P9, P10: Most non-quantified factors will result in elevation of the color result.
P20: Plant procedures include that plant risk will be considered yellow any time service water is aligned to reactor building cooling units (water hammer issue).
P21: The occurrence of severe weather automatically raises the color one level.
P34: Use of blended approach. Worst color of quantitative and quantitaive approaches is used.
P37: Severe storms or hurricane warnings have delayed maintenance on DGs, switchyard work.

7. Please feel free to provide any additional comments or clarifications about your plant's consideration of non-quantifiable risk factors here:

No responses provided to this question in 2007 or 2003.

G. Containment Closure Evaluations During Shutdown Conditions

This portion of survey was completed by 40 plants (no responses in this section from plants B3, B19, B20, P34, and P33).

1. Briefly describe the types of containment closure evaluations that are typically performed for your plant. Please note that some of the more specific questions below might limit the need for input here:

   B5, B6, B7, B8, B9, B10, B11, P13, P14, P15: See question 2.
   B14, P23, P35, P36: Generic one-time evaluation to determine how long it takes to achieve ctmt closure and time to boil in core.
   B16: No LERF is used, remaining questions unanswered.
   B23: It is evaluated as part of our outage defense in-depth process.
   P1: Containment closure evaluations are only done qualitatively for ability to quickly close an open penetration. Time required to close the open equipment hatch at our plant is estimated to take about 12 to 24 hours, and requires electrical power for the crane, due to design of the hatch and airlock.
   P4: Testing to determine time for containment closure.
   P8, P9, P10: See response to questions 2 and 3.
   P11, P3: Loss of cooling heatup rates are calculated for 1) core at mid-loop, 2) core with RCS filled, 3) core with cavity flooded, and 4) spent fuel pit with core offloaded.
   P19: Evaluated in DID process with consideration of time to boil.
   P20: Containment closure is practiced once per outage to ensure it meets timelines. I know time to boil is considered, as for other factors, I'm not sure.
   P21: The evaluations are for closure of the equipment hatch dependent on the time to boil, and evaluation of closure of the equipment hatch during fuel movement.
   P28: Containment closure times are determined for penetrations that need to be closed from inside containment and for penetrations that can be closed from outside containment. The allowable time to close penetrations from inside containment is based on the time to high containment temperatures (from core boiling). The time allowed to close penetrations from outside containment is based on the time to core uncovery.
   P37: Outage shutdown risk evaluation includes a containment equipment hatch closure plan for each outage.
   P38: Instructions for containment closure in Modes 5 and 6 are controlled by plant procedure for the breaching, tracking and closure of the large equipment hatch, containment air locks, and any penetration providing direct access from the containment atmosphere to the outside atmosphere. This procedure contains administrative controls to reasonably ensure that containment closure can be achieved prior to core boiling that could result from a loss of RHR, coupled with the inability to initiate alternate cooling or within 15 minutes of a fuel handling accident.

2. What factors are considered in these evaluations?

   ☒ Time to Boil: **93%**
   B5, B6, B7, B8, B9, B10, B11, B12, B14, B18, B22, B23, P1, P4, P5, P6, P7, P8, P9, P10, P11, P13, P14, P15, P17, P19, P20, P21, P23, P28, P29, P30, P31, P32, P35, P36, P38

   ☒ Containment Air Temperature: **15%**
   P8, P9, P10, P28, P31, P32

   ☐ Containment Humidity: **0%**

☒ Expected Containment Closure Time: **75%**
B5, B6, B7, B8, B9, B10, B11, B12, B14, B18, B23, P1, P8, P9, P10, P11, P13, P14, P15, P23, P19, P21, P29, P30, P31, P32, P35, P36, P37, P38

☒ Other factors. Please describe here: **40%**
B14, P23, P35, P36: Use of ctmt equipment hatch.
B18: Complexity level involved.
B23: Movement of recently irradiated fuel.
P1: RCS inventory conditions and heat removal methods.
P5, P6, P7, P17: Time to core uncovery.
P8, P9, P10: For equipment hatch, time to diagnose, alert, establish closure, and evacuate containment must be less than time to boil (includes an allowance for conservatism). Dedicated personnel are designated for establishing closure—all penetrations. Drills are performed to time-validate equipment hatch closure times.
P37: Time to core uncovery, plant operating configuration—for example, RCS level.
P38: Within 15 minutes of a fuel handling accident, decay heat, RCA water inventory, secondary side inventory, RCS temperature, power availability, RCS integrity, and makeup capability.

3. When are the containment closure evaluations usually performed?

☒ Prior to the start of the outage: **78%**
B5, B6, B7, B8, B9, B10, B11, B12, B14, B18, B22, B23, P1, P5, P6, P7, P11, P13, P14, P15, P17, P19, P23, P29, P30, P31, P32, P35, P36, P37, P38

☒ Daily during the outage: **13%**
B12, P11, P21, P28, P30, P38

☒ Prior to performing high risk evolutions: **5%**
P19, P21

☒ Other. Please describe here: **23%**
B14, P23, P35, P36: If needed based upon specific outage needs, such as RCP motor replacement.
P1: Depends on the situation that may evolve regarding smaller penetrations. The equipment hatch status and use is determined prior to the outage for planned evolutions, as is maintaining the personnel airlock doors open during defueling and refueling.
P4: Twice daily.
P8, P9, P10: Two sites perform evaluations for every work activity, one site has performed an evaluation that relies upon the loss of decay heat removal procedure to establish closure.

4. Briefly describe the evaluation criteria used to determine the closure time available:

B5, B6, B7, B8, B9, B10, B11, P13, P14, P15: Basically time to boil versus expected closure time, but this can vary on a case-by-case basis.
B12: Walkthroughs are performed and also unannounced drills once into an outage. Also, tools and containment closure status is checked at least once a day.
B14, P23, P35, P36: One-half time to boil.
B18: Based on ops estimate.
B22: Unknown.

B23: Bounding configuration, manpower available, and other potential extenuating circumstances or performance shaping factors (elevated stress level, high temperatures, and so forth.
P1: Time to boil is estimated based on a calculation from our nuclear section and depends if the loops are full or not. The time for closure is qualitatively estimated for the penetration and conditions involved.
P4: Time to boil is calculated.
P5, P6, P7, P17: NUMARC 91-06 plus time to core uncovery.
P8, P9, P10: For equipment hatch, time to diagnose, alert, establish closure, and evacuate containment must be less than time to boil. This includes an allowance for conservatism. For other penetrations, time to boil is used as the closure criteria.
P11, P30: Heat sink versus decay heat load (DHL) and amount of fuel in core. DHL calculated using BTP 9.2 in Standard Rev. Plan. Also calculate makeup flow to compensate for saturation and boiloff.
P21: The closure time is based on the time to boil. The criteria most often used is the ability to have containment closure within 15 minutes of an incident.
P28: See question 1, above.
P31, P32: Ability to perform in the time available before time to boil or inhabitable containment.
P37: Expected hatch closure time must be less than time to core uncovery.
P38: Graphs and tables contained in the procedure. The graph or table used depends on plant conditions.

5. Does your plant have any plans to modify the evaluation process in the near future?

☒ No: **88%**
B5, B6, B7, B8, B9, B10, B11, B12, B14, B18, B22, B23, P1, P4, P5, P6, P7, P8, P9, P10, P13, P14, P15, P17, P19, P21, P23, P28, P29, P31, P32, P35, P36, P37, P38

☒ Yes. Please briefly describe the planned changes here: **5%**
P11, P30: Normally include use of rollup door in one of our plant's tech specs.

6. Have any regulatory questions been raised at your plant concerning present evaluation practices?

☒ No: **73%**
B5, B6, B7, B8, B9, B10, B11, B14, B18, B21, B22, B23, P1, P8, P9, P10, P13, P14, P15, P19, P20, P21, P23, P29, P31, P32, P35, P36, P37

☒ Yes, but no changes have been made to the process as a result of regulatory questions (for example, questions were resolved without the need for any changes): **8%**
B12, P4, P28

☒ Yes, changes were made to the evaluation process as a result of the questions. Please briefly describe those changes here: **18%**
P5, P6, P7, P17: Based on negative NRC comments—changing definition of *unavailable* to be consistent with NUMARC 93-01 Appendix B definition, plus requirement for timing study to determine restoration time consistent with automatic operation or sufficiently large margin until component function required, requiring documented HEPs for all test recovery factors including screening factors, evaluating impact on assumed reliability in (a)(4) risk assessment tool for components in (a)(1), ensuring new assessments performed when planned maintenance schedule slips and overlaps other planned maintenance, evaluating degradations of (a)(4) components for potential impact on assumed reliability in (a)(4) risk assessment tool, utilizing component restoration advice

and current important operable component information from (a)(4) risk assessment tool regardless of configuration risk color, documenting all (a)(4) assessments in station logs, improving tracking of ACT for components out longer than a work week, stopping transition to shutdown risk model for (a)(4) risk assessments due to numerous issues associated with defending component availability when not in automatic and lack of sufficient HEP documentation.
P11, P30: Use of rollup door as a closure device was challenged by the NRC. Therefore, use of the rollup door is suspended.
P38: A containment penetration was left off the list of those required to be closed. The penetration was added to the list.

7. Do you have any lessons learned to share with the CRMF community as a result of use of the evaluations during past outages? If so, please provide any insights here:

P5, P6, P7, P17: NRC expectations are rising for (a)(4) program and past interpretations of NUMARC 93-01 are being challenged.
P8, P9, P10: For ice condenser plants, the NRC expects that H2 ingnitors be maintained available to mitigate the consequences of a core damage event. One plant received a violation for not maintaining closure on a breached steam generator. One plant received a violation for improperly foaming a penetration.
P11, P30: Use of rollup door as a closure device was challenged by the NRC. Therefore, use of the rollup door is suspended.
P37: Equipment hatch remains closed during mid-loop operations.

4
CONCLUSIONS

The industry survey (which was responded to by a large fraction of U.S. plants in both 2003 and 2007) demonstrates that CRM continues to evolve into an increasingly formalized process at U.S. nuclear power plants, but there also continue to be variations within the industry on implementation. The updated industry survey discussed in this report provides a large body of knowledge about current practices and also provides some insight into how those practices have evolved since the 2003 survey.

Although the information presented in this document focuses on the mechanics of CRM, one must keep in mind that the most important information obtained from CRM software tools and their associated thresholds is the identification of any appropriate RMAs that should be taken to reduce the risk of a given configuration. Only by considering the combined use of the CRM tools with the associated procedures and processes for risk management can the effectiveness of a risk management program be determined.

Survey respondents typically are using four risk categories (for example, colors) to classify the risk level of a plant configuration. Based on the survey response, use of instantaneous risk thresholds is the most common approach to CRM, although many plants also use some form of accrued and/or cumulative risk thresholds in addition to instantaneous risk. We note that this is an evolution that is likely to continue; for example, as plants continue to implement risk-informed applications, it is prudent to evaluate the integrated risk impact of these initiatives. Possibly, the ultimate example of this is the application to risk-informed completion times (RITS Option 4B), where an integrated evaluation of risk impact is a requirement of the implementation guidance [8].

The use of duration-based measures for configuration changes can serve as a useful complement to instantaneous risk measures. However, the degree to which these duration-based measures are used, and the methods used to define and evaluate these measures, showed significant variation throughout the industry. A relatively small fraction of plants assess the impacts of duration on an ongoing basis. However, it is noted that other regulatory and administrative requirements impose practical limitations on the length of maintenance outages on important plant equipment.

Consideration of configuration duration may be prudent (and is required for implementation of RITS Initiative 4B—see *Risk-Managed Technical Specifications (RMTS) Implementation Guidelines* [8] for a complete discussion) in order to completely characterize the risk contribution for a given configuration. The industry survey results indicate there is a large variation in approaches used to consider the impact of configuration duration. This is an area in which plants may wish to review their implementation of risk measures to manage accrued risk impacts, particularly if implementation of more advanced risk-informed applications is planned.

Guidance provided in NUMARC 93-01 [5] recommends that CRM for the Maintenance Rule should consider the impact of a configuration on key safety functions (for example, considering the remaining degree of redundancy for trains or systems supporting key safety functions). More than half of the plants responding to the survey use qualitative CRM models, either exclusively or in conjunction with a quantitative model, to evaluate the status of key safety functions while at power.

As a minimum, a blended approach could be expected to include subjective consideration of quantitative CRM results based on plant experience, in order to determine if special restrictions or contingencies are needed. This type of blended approach goes hand in hand with the expectation that applications of the PRA are risk-informed and not strictly risk-based.

The survey results indicate that variability continues to exist in the plant activities and conditions that are considered a configuration change and that are included in CRM evaluations. The extent to which various activities are evaluated (for example, during all CRM evaluations, only during periods of heightened risk, only for configurations that are likely to be impacted by the risk factor, and so on) also varies from plant to plant. The existing variability may be appropriate for current CRM applications, given the differences in plant design, plant location, and different types of models/software tools used to evaluate configuration-specific risk. There is a great deal of consistency, however, in the types of RMAs used at the plants responding to the surveys.

The implementation of RITS Initiative 4B may require some additional technical features and administrative programs; however, many of the items (or portions of them) applicable to CRM as specified in the implementation guidance provided in NEI 06-09 may already be in place at many nuclear power plants. The technical features that may require some additional effort (based on the survey responses) prior to implementation of RITS 4B include a formal validation process for the basic event mapping, consideration of time-in-cycle and time-in-year factors, and human action dependencies on equipment that may be out of service.

The results of this industry survey indicate that a wide variety of risk factors are considered as part of each plant's CRM program. Many of the non-quantified risk factors are, in fact, quantified to a significant degree at a large fraction of plants. However, there is sizeable variation among plants as to the methods used to assess the various risk factors and the conditions under which the risk factors are considered (for example, as part of each CRM evaluation, evaluated only under heightened risk conditions, and so on). These variations may be appropriate, given plant-specific design differences as well as plant-specific differences in how CRM is performed.

The ability to close containment hatches in the event of an incident during refueling outages has been receiving increased attention from NRC inspectors. The survey responses indicate that containment closure evaluations are being performed, and the majority consider time to boil and expected containment closure time. These evaluations are typically performed prior to the start of an outage.

Suggestions for Further Research

The current CRM methods and criteria in use in the industry continue to provide significant benefit to the work management process and are considered by the survey respondents to be adequate to support the requirements of the Maintenance Rule. But, the responses to the survey also identified areas that may lead to potential challenges should plants attempt to implement some of the more advanced risk-informed applications, such as RITS. These challenge areas could benefit from investigation into the following areas to support the use of CRM models, tools and techniques for the next generation of risk-informed applications:

- Development of guidance for when a CRM evaluation must consider configuration duration or cumulative risk as well as an evaluation approach to consider duration in a straightforward manner.
- Evaluation of approaches for incorporating the fire PRA model or results into the CRM process.
- Development of guidance/best practices for CRM program attributes. Example development could include presentation of industry examples, attributes of DID/qualitative measures, and so on.
- Evaluation of methods to consider operation with degraded risk-significant components.
- Evaluation of approaches for considering containment closure evaluations during outages. This could include a collection of best practices. As the approaches used may vary by reactor and containment type, a range of plants would need to be studied.
- Grid reliability evaluations for CRM. Example development could include guidance for qualitative and quantitative approaches for considering the risk impacts of off-normal grid conditions.

Lastly, the CRMF sponsored the development of a methodology framework to evaluate the impacts of external events for CRM in 2005 [9, 10]. Demonstration of the use of this framework through pilot applications (including plants with and without developed external events PRA models) may also provide useful guidance for the industry as the scope of CRM evaluations is broadened to consider these additional risk contributors.

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