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Options for Scenario Selection Implementation

The staff has developed the State-of-the-Art Reactor Consequence Analysis (SOAR-CA) scoping activities including plant grouping, scenario selection, the use of core damage frequence (CDF) for determining its initial focus, the inclusion of uncertainty, and the inclusion of external events. Below is the staff's approach and bases, as presented to the Steering Committee and ACRS ,for the decisions made relating to the initial scoping activities for the SOAR-CA. Also included are the options and staff recommendations for the remaining decisions yet to be decided for the scoping process; this includes the steps that will be used in determining how the dominating scenarios for each class of plants will be applied in determining the consequence(s) at each individual site; the use of human reliability assessments within the SOAR-CA process; and the inclusion of mitigative measures within the SOAR-CA process .

Background

In the staff requirement memorandum (SRM)entitled Staff Requirements -SECY-05-0233 - "Plan for Developing State-of-the-Art Reactor Consequence Analyses," dated April 14, 2006, the Commission directed the staff to "examine significant radiological release scenarios having estimated likelihoods of one in a million or greater per year" as its "initial focus. This initial set of analyses should focus attention on the scenarios of greatest interest and provide useful insights into the effectiveness of current and postulated mitigation strategies." On the basis of this direction, the staff began assessing its options for grouping plants and scenario selection. To this end, staff experts with support from Sandia National Laboratories determined the initial group of plants (referred to as classes of plants) and the plants that fall within each plant class (refer to Attachment 1). The staff then developed matrices to provide a visual presentation of the different sites and scenarios by class of plants, and their core damage frequencies. Meetings were held among cognizant SOAR-CA team members from three offices to determine the most effective means of selecting the scenarios for BWR, Mark 1 containments, and Westinghouse 4 loop, large dry and sub-atmospheric containments (refer to Attachment 2 and 3). After considerable effort, the staff determined that the following process is the most effective means for determining the plants and scenarios that will be used as the initial input into the analysis process to meet the Commission overall intent of the SOAR-CA project.

Grouping of Plants

All operating nuclear power plants have been grouped by NSSS and containment design into classes of plants (refer to Attachment 1). The intent is to provide efficiencies in modeling and computer run times by grouping similar design reactor coolant systems, containments, and safety systems that would respond relatively the same with similar failure modes and similar source terms as a result of severe accidents.

Our initial effort to group these plants resulted in the following eight classes of plants:

- Class 1 - BWR 2, 3, and 4, Mark I Containments
- Class 2 - BWR 4 and 5, Mark II Containments
- Class 3 - BWR 6, Mark III Containments
- Class 4 - Babcox and Wilcox PWRs
- Class 5 - Combustion Engineering PWRs
- Class 6 - Westinghouse, Ice Condenser Containment Design
- Class 7 - Westinghouse, 2 and 3 loop, Large Dry and Sub-atmospheric Containment Design

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Class 8 - Westinghouse 4 loop, Large Dry and Sub-atmospheric Containment Design

Each of these classes of plants will have a representative reference plant modeled in MELCOR to determine the onset of core damage, containment failure, time to release and source term for each applicable isotope in % of classes of elements released from the core over time. Recognizing that some differences in performance and failures may occur within a class of plants, sensitivity studies will be performed, as appropriate.

Feedback Process

As the analyses progress for a class of plants, sensitivity analysis will be performed, as appropriate, to verify reasonable likenesses in plant performance amongst the plants with a plant class to ensure more accurate and realistic results. The continuous feedback of information is inherent to the process. The Commission will be kept informed of any changes in plant groupings through periodic briefing planned throughout the study.

Scenario Selection

As directed by the Commission in the April 14, 2006 SRM, the staff was to select scenario by applying "a screening radiological release frequency of 10^{-6} per reactor year (i.e., to analyze only those scenarios that have a release frequency of greater than one in a million)." The staff was also directed "to define release groupings such that release characteristics are representative of scenarios binned into those groups. However, where possible, the groups should also be sufficiently broad to be able to include the potentially risk-significant but lower frequency scenario." Also discussed is the staff's approach for including uncertainty and evaluating the impact from external events on scenario selection for SOAR-CA. Although each of these topics are discussed individually, please note that the issues have cross-cutting implications on each others.

Using **CDF** (10^{-6} per year) as the Initial Scenario Selection Screening Threshold

The staff recommends using the SPAR models CDF as opposed to release frequency as its benchmark for scenario selections (refer to Attachment 2 and 3). The matrices for the first two classes of plants are based on the CDF of 10^{-6} per year, and results in 3 class dominant scenarios for one class of plants and 5 class dominant scenarios for the second. For scenarios that involve bypass of containment (e.g., interfacing-systems LOCA), the staff recommends lowering the screening threshold by an order of magnitude (i.e., a CDF equal to 10^{-7}) to meet the guidance in the SRM, "include the potentially risk-significant but lower frequency scenarios" (for example, the interfacing systems LOCA scenarios that bypass containment). If further consideration is needed for the remaining six classes of plants, we will obtain the necessary guidance from the steering committee. The basis for this recommendation is as follows:

a. currently the NRC does not have Level 2 PRA models, and therefore, we cannot accurately determine scenario release frequencies
b. using CDF instead of release frequency provides a greater margin of scenario inclusion because CDF is always greater than or equal to the release frequency (never less than)
c. using release frequency may require numerous licensee interactions with licensees

that have an updated Level 2 PRA models to ensure proper scenario selection[1]

d. the staff has direct access to well developed, up to date, SPAR models and the capable of determining the uncertainty associated with each scenario

Scenario Selection by Class of Plants

The accident scenario selection process for the SOAR-CA project includes determining dominating scenario for each class plants using SPAR model CDF (verses release frequency) of $\leq 10^{-6}$ per reactor year (i.e., greater than or equal to one in a million reactor years). In addition, as directed by the Commission in the April 14, 2006 SRM, the staff also considered including "potentially risk-significant but lower frequency scenario" by setting the CDF threshold to $\leq 10^{-7}$ per reactor year for such scenarios to as interfacing system LOCAs that bypass containment. This will provide the staff with an effective means of identifying class dominant scenarios that will be used as the initial input into the human reliability assessment (HRA) and MELCOR model as presented in the general process outlined above.

The basis for this recommendation is as follows:

a. identifying dominating scenarios by plant class more closely adheres to the guidance provided in SECY-05-0233[2]

b. identifying dominating scenarios a plant-by-plant basis could result in some plants with no scenarios at the recommended initial threshold provided by the Commission

c. using the plant class approach to select scenarios is better suited to current in-house PRA tool limitations (e.g., no level 2 PRA models and limited external event information resources), and to better account for the uncertainties due to these limitations

d. a plant-specific approach could considerably increase the resources needed for this project (e.g., increase MELCOR calculations) and the amount of industry/licensee interactions with potentially no measurable increase in realism

Evaluation of the Impact on Scenario Selection from External Events

The staff recommends the use of a qualitative approach to identify dominant external event contributors for each plant group. The staff intends to obtain the necessary external event PRA information from each licensee with an updated IPEEE. The staff will determine the mean values from those plants with an updated IPEEE and apply the mean values, as appropriate, to the plants without update IPEEE. This assessment will be used to identify any external event accident scenarios not already identified in the internal event screening process.[3]

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[1] Many licensees do not have updated Level 2 PRAs.

[2] Page 8 of the Enclosure states that, "scenarios will be selected, for general classes of reactors, based on their contribution of risk."

[3] Preliminary reviews indicate that most of the dominant external event contributors are similar to the dominant scenarios identified in the internal events screening.

IPEEEs and EE SPAR models are our only internal source of detailed information on external events. However, in some cases these sources are inadequate to perform a rigorous quantitative assessment for the following reasons:

a. IPEEEs are not necessarily external event PRAs.[4] Many plants used margin analysis and did not quantify CDFs for seismic and other external events. Only about half of the plants quantified CDFs for fire.

b. The data contained in IPEEEs are 15 years old and most plants used screening values in their analysis (i.e., CDFs may be conservative).

c. EE SPAR models quantify CDFs for the dominant external event contributors identified in the IPEEEs. However, using the CDFs generated from these models may be problematic due to the following reasons:
   1. most EE SPAR models use the data exclusively contained in the IPEEEs
   2. generic data are used when the required data are not provided in the applicable IPEEE
   3. only 12 EE SPAR models have been developed
   4. the 12 existing EE SPAR models have not undergone QA

The staff believes that using this approach will allow the evaluation of external events from fire, flood, and seismic events in a reasonable and reliable manner with realistic results. As the assessment evolves and actual results are produced, the staff will update the steering committee, ACRS, and the Commission through planned briefing throughout the study.

Option and Recommendations

Applying Dominating Scenarios in Determining Consequence(s)

The dominating scenarios identified for a class of plants does not imply that the corresponding CDF meets or exceeds the inclusion threshold for each individual site within the class (refer to Attachment 2). For example, the staff initially considered including scenarios 1, 3, and 4 as dominating scenarios for BWR, Mark 1, plants. Note that 9 of the 16 plants do not have a CDF approximately $\leq$ 1.0E-6. In addition, the first site listed in Attachment 2 does not have a single sequence that meets or exceeds the threshold ($\leq$ 1.0E-6) set by the Commission for initial inclusion in the consequence analyses. These observations raised the questions of how to use the dominating scenarios in the individual plant consequence analyses. The staff identified the following three options to address this concern:

Individual Plant Determination - Using the reference plant source term for each dominating scenario for that class of plant, perform a consequence analysis for each dominating scenario and each site with a CDF that meets or exceeds the threshold ($\leq$ 1.0E-6) set by the Commission for inclusion in the consequence

[4] IPEEEs were performed to identify potential plant vulnerabilities to external events.

analyses. This will provide realistic results and limit the reported consequences base on risk insights. It will limit the concerns associated with the need to link risk with consequence in the final presentation of the results. After including uncertainty, external events, and mitigating measures, some sites may not have any consequences to report, potentially impacting stakeholders' confidence in the process and the reported results. In addition, differences in CDF often can be attributed to variations in methodology and/or equipment reliability values that may not accurately reflect a difference in the associated risk.

Group Determination - Using the reference plant source term, perform a consequence analysis for each dominating scenario for all the sites within a plant class regardless of the individual CDF values. This would provide realistic results for each site and each dominating scenario for every plant within a class. In addition, it will eliminate the effects of using different methodologies and/or equipment reliability values that do not accurately reflect associated risk. However, this approach would emphasis the need to link risk with consequences in the final presentation of the results. Not effectively linking risk with consequence will potentially limit the credit given to licensees for improved performance and plant enhancements, as well as mitigating measures, which is an important concept the Commission wanted the staff to include. Although the staff believes it can adequately link risk and consequence, some stakeholder would focus on the consequences independent of risk regardless of how strong a link is developed.

Qualitative Determination - Perform a qualitative assessment of the SPAR elements for each site and each dominating scenario with a CDF one decade or more lower ($\leq$ 1.0E-7) than the threshold set by the Commission for inclusion in the consequence analyses to determine if any substantial improvements in design and/or performance exist. This is one application for human reliability assessment (HRA) in the SOAR-CA. If the HRA identifies substantive improvements, that scenario would not be included in the consequence analyses for that particular site. If no substantive differences in design and/or performance are identified, then that scenario would be included in the consequence analyses for that particular site regardless of the CDF. This approach would allow for an informed/justifiable approach for including or excluding scenarios from a particular site's consequence analyses providing a extra margin of confidence in the process and improved realistic results. This option would require addition resources and may have an impact on schedule. Licensees would be required to provide the necessary information to perform the HRA review.

All three options are viable, however, the staff recommends the "individual plant determination" because it provide realistic results and limit the reported consequences base on risk insights; it limits the need to link risk and consequence, and it has no impact on schedule.

Applying Mitigating Measures in Determining Consequence(s) -

During early development of the SOAR-CA project, the staff had discussions with management on giving licensees credit for mitigative measures that were implemented. In a recent briefing of the Deputy Executive Directors for Operations, it became clear that the expectation was to give licensees credit for mitigating measures that they were committed to. Although this is not standard practice, it is consistent with Commission direction. In addition, a large number of the new mitigating measures have been generically committed to by licensees and are identified and described in sufficient detail to perform qualitative HRAs. Because most of these mitigative measures will be documented as guidance similar to Severe Accident Mitigating Guidelines, little or no new information will be available to perform an improved HRA after implementation. However, some licensees will take exception to a small number of the new generic mitigating measures, the number of exceptions are expected to be very small. In addition, licensees are expected to commit to some additional readily available mitigating measures that may not be identified prior to completing the applicable sites' consequence analyses. This will result the partial loss of credit for some of the measures the Commission would like to credited.

The intended HRA for "committed-to" generic mitigating measures, will be to identify reliable, independent, spatially separated (where applicable) mitigative measures that have a reasonably high expectation of being implemented in the time available, with the level of documentation and training provided that can provide a high confidence of preventing core damage or containment failure. Dominating scenarios will not be included in the consequence analyses for those plant with HRAs that indicate core damage can be prevented. Dominating scenarios will be included in the consequence analyses for those plant with HRAs that indicate containment failure can be prevented, however, MELCOR will be adjust to prevent containment failure to significantly reduce the source term.

The above description regarding the two uses of HRA and the inclusion of mitigative measures are the only options identified by the staff and represents the staff's recommendation for these activities. These options are consistent with the direction in the SRM, and meets the Commission's intended objective.