

# Risk Assessment Standardization Methods for Risk-Informed Regulatory Applications

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**Abstract** – *This paper gives an overview of the NRC Risk Assessment Standardization Project (RASP) to provide consistent methods and formats for use by NRC staff in performing risk assessments in various risk-informed regulatory applications. The major program activities of RASP are developing standard methods for internal events analysis, assessing risk impacts of internal fires and flooding events, external events, large early release frequency, and low-power and shutdown events, and enhancing Standardized Plant Analysis Risk (SPAR) models and the GEM/SAPHIRE interface for SPAR model analyses. NRC recently issued a handbook on risk assessment of internal operating events. The handbook describes methods that may be used in risk analysis of plant conditions for Significance Determination Process (SDP) Phase 3 analyses, for the Accident Sequence Precursor (ASP) program, and for Management Directive (MD) 8.3 event assessments.*

## I. INTRODUCTION

In the U.S. Nuclear Regulatory Commission's (NRC) Reactor Oversight Process, the NRC staff performs risk assessments of inspection findings and reactor incidents to determine their significance for appropriate regulatory response [1]. Currently, several NRC groups are performing these risk assessments for Accident Sequence Precursor (ASP), [2] Significance Determination Process (SDP) [3] Phase 3 analyses, and Management Directive (MD) 8.3 [4] event assessments. Due to the different programmatic objectives of each NRC program, NRC staff initiated the Risk Assessment Standardization Project (RASP) to establish standard procedures and improve the methods of risk assessment in various risk-informed regulatory applications. Standardized methods of risk assessment would reduce the time to do routine risk analyses of operating events and licensee performance issues. In addition, the improved methods of risk assessment would avoid duplication of efforts, inconsistent assessments, and (sometimes) apparently dissimilar results. The development of standard procedures and methods of risk assessment also improves communication of risk information on specific issues both internally and externally.

## II. PROJECT OBJECTIVES

The primary focus of RASP is to develop consistent methods for risk analyses of conditions for

the ASP Program, for SDP Phase 3 assessments, and for peer reviews of ASP and MD 8.3 event assessments. The main objectives of RASP are to:

- provide standard methods and procedures for performing risk analyses of inspection findings and reactor incidents
- improve coordination among various NRC programs and groups performing risk analyses of licensee performance deficiencies or reactor incidents
- reduce the time to perform a risk analysis of licensee performance deficiencies or reactor incidents
- improve internal and external communications about risk
- provide solutions to technical issues associated with risk assessments and operating events
- provide NRC risk analysts enough information to evaluate the quality of licensee risk analysis results

The development of standard methods for risk analysis involves standardizing existing risk assessment methods used in the SDP Phase 3, MD 8.3, and ASP programs. Each of these NRC programs has different programmatic objectives. The objective of SDP Phase 3 analyses and MD 8.3 event assessments is to provide a reasonable estimate of the significance of an inspection finding or reactor incident based on "best available" information provided within a

relatively short time (i.e., in days or weeks). On the other hand, the ASP analyses provide a more detailed evaluation of potential precursor events to determine event significance, including uncertainty and sensitivity analyses. The ASP analysts have a longer time to evaluate “new additional” information (e.g., root cause analysis, research, and expert elicitation), and review the quality of the risk assessment by further discussions with the responsible licensee staff. Therefore, the development of standard risk assessment methods would be focused on developing guidance on generic and event-specific processes for risk analysis, and identifying the specific assumptions and requirements for performing risk assessments in SDP Phase 3, MD 8.3, and ASP programs.

### III. RASP ACTIVITIES

The major activities of RASP are:

- developing standard procedures and methods for internal events analysis
- developing standard procedures and methods for evaluating internal fires and flooding events, external events, large early release frequency, and low power and shutdown events
- enhancing NRC Standardized Plant Analysis Risk (SPAR) models and the GEM/SAPHIRE interface for SPAR model analyses
- providing readily available technical support to SDP analysts

These RASP activities are being performed by NRC staff in the Operating Experience and Risk Analysis Branch (OERAB) of the NRC Office of Nuclear Regulatory Research (RES) as part of a multiyear project. The activities are expected to result in the revision and development of procedures to consolidate and streamline risk analysis activities.

The first major RASP activity was focused on the development of a handbook for risk assessment of “internal events” operating events. The handbook was issued for use by NRC staff. The format of the handbook will be used as a template to develop standard methods for evaluating the risk impacts of internal fires and flooding events, external events, large early release frequency, and low-power and shutdown events. In concert with the development of standard methods of risk assessment, one important activity is the enhancement of SPAR models and the GEM/SAPHIRE interface for SPAR model analyses because SPAR models are used for risk assessments in NRC regulatory activities. The enhancements would

improve specific modeling aspects of SPAR models to eliminate inconsistent analysis results. Specific details of the proposed work on each RASP activity are discussed below.

#### *III.A. Development of Standard Procedures and Methods for Internal Events Analysis*

The first task is to develop guidance on generic and event-specific methods and processes for the analysis of internal events. Guidance for generic analysis methods will focus on various aspects of risk quantification. These aspects addressed the following: treatment of human errors and adjustment of human error probabilities using the SPAR-H human reliability analysis method, treatment of common-cause events and adjustment of common-cause failure probabilities, updating of system and component failure probabilities and initiating event frequency estimates, determining the duration of a degraded condition, evaluating the need for bounding, sensitivity, and uncertainty analyses, and considering plant design features, top event dependencies, etc. when developing or modifying event and fault trees. Guidance for generic processes will focus on screening operating events for potential accident precursors, doing a preliminary risk analysis of a degraded condition, doing a risk analysis of an initiating event, conducting expert elicitations, and developing guidance for peer reviews. Guidance for event and condition-specific analysis of internal events will be developed for loss of offsite power (LOOP) events including partial LOOP events, steam generator tube ruptures, primary system pressure boundary cracks and leaks, loss-of-coolant accidents due to breaks of various sizes, stuck-open or inadvertent opening of safety relief valve events, and high-energy line breaks.

In developing this guidance, the NRC staff’s approach is to standardize existing methods used in the SDP Phase 3, MD 8.3, and ASP programs wherever possible. If there are significant differences between the existing risk assessment methods used in the three NRC programs, an expert panel of senior PRA analysts will review and resolve the significant discrepancies. The guidance will note any acceptable differences found between the methods used in the three NRC programs.

#### *III.B. Development of Standard Procedures and Methods for Evaluating Internal Fires and Flooding Events, External Events, Large Early Release Frequency, and Low-Power and Shutdown Events*

This task involves developing new methods and guidance for the SDP Phase 3, MD 8.3, and ASP analysis of the risk impacts of internal fires and flood events, external events, low-power and shutdown events, and large early release frequency (LERF) situations. In the case of external events, low-power and shutdown events, and LERF impacts, the guidance development will be closely coordinated with the development of SPAR models for these types of events. The guidance for risk analysis will provide a systematic process to initiate and complete a preliminary analysis, including examples and worksheets for required steps of the analysis method. The guidance will also contain instructions on collecting event and plant-specific information (i.e., the facts) and developing assumptions (with links to generic methods and event-specific methods), manipulating SPAR models using the SAPHIRE code, evaluating results, and treating parameter and modeling uncertainties. The guidance will also provide instructions for calculating site-specific initiating event frequencies and event-affected component failure probabilities.

### *III.C. Enhancements to SPAR Models, and GEM/SAPHIRE Interface for SPAR Model Analyses*

This task involves enhancing SPAR models and the GEM/SAPHIRE interface to ensure that quality risk assessment tools are readily available to NRC staff performing risk assessments. The expected guidance will include developing procedures for making enhancements to SPAR models, guidance for commonly performed GEM/SAPHIRE manipulations, a user-friendly SDP Phase 2 interface for SPAR models, and a web-based toolbox for risk analysis of operating events. The procedures for enhancing SPAR models will provide clear instructions on improving specific modeling aspects of SPAR models (e.g., modifying the reactor coolant pump seal failure model, updating the nonrecovery probabilities for various types of loss of offsite power events, etc.). As a supplement to the enhancement procedures, guidance will be developed on commonly performed GEM/SAPHIRE manipulations to construct and modify event and fault trees and to update basic event parameters for SPAR model analysis. A user-friendly SDP Phase 2 interface for SPAR models will be developed to provide risk insights from SDP analyses using SPAR models. A web-based toolbox will be developed to consolidate up-to-date information for SDP and ASP analyses and MD 8.3 event assessments. The web-based toolbox will contain links to guidance documents, databases (e.g., completed ASP and SDP analyses), frequently used reference documents (e.g., NUREG publications), and

release notes for guidance documents and SPAR model enhancements.

### *III.D Technical Support for SDP Analysts*

This activity involves providing technical support to SDP analysts on the efficient use of the various RASP products such as guidance for standard risk assessment methods, enhanced SPAR models, new software tools, and the web-based toolbox. The expected technical support will include the maintenance of RASP products and their quality, as-requested enhancements to risk assessment methods and SPAR models, and peer reviews of SDP Phase 3 analyses. Peer reviews of SDP Phase 3 analyses will focus on unique and complex cases to assure consistency and scrutability of analysis results.

## IV. RECENT RASP PRODUCTS

RES staff in OERAB has prepared Revision 0 of a handbook for risk assessment using “internal events” models to evaluate operating events. The handbook was issued for trial use as optional and supplemental guidance in performing risk assessments of operating events and conditions. The handbook describes methods that can be used in risk analysis of plant conditions for SDP Phase 3, ASP and MD 8.3 event assessments. The handbook is a compendium of methods, best practices, examples, tips, and precautions for using SPAR models to evaluate the risk from reactor incidents. Specifically, the handbook provides ground rules, or boundary conditions for analysis (e.g., treatment of equipment and operator success), standard methods (e.g., common-cause failure determination and modeling), SPAR model precautions and limitations (e.g., event tree modeling assumptions), and modeling considerations for specific conditions or events (e.g., high-energy line break or loss of offsite power event). The handbook will be updated based on user comments and insights gained from field use of the document. New topics will be added as the NRC staff gains experience with using the handbook. The format of the handbook will be used as a template to develop standard methods for evaluating the risk impacts of internal fires and flooding events, external events, large early release frequency, and low-power and shutdown events.

## V. SUMMARY

The development of standard risk assessment methods is focused on developing guidance on generic and event-specific processes for risk analysis, and identifying the specific assumptions and requirements

for performing risk assessments in SDP Phase 3, MD 8.3, and ASP programs. Revision 0 of a handbook for risk assessment of “internal events” operating events has been issued for use as optional and supplemental guidance in performing risk assessments of operating events and conditions. This handbook describes methods that should be used in risk analysis of plant conditions for SDP Phase 3 and ASP analyses and MD 8.3 event assessments. Future RASP products will include handbooks of standard methods for risk analysis of internal fires and flooding events, external events, large early release frequency, and low-power and shutdown events. The project will also issue guidance on enhancing SPAR models and the GEM/SAPHIRE interface. The enhancements would improve specific modeling aspects of SPAR models to eliminate inconsistent analysis results.

The Risk Assessment Standardization Project will provide consistent methods and formats for use by NRC staff in performing risk assessments in various risk-informed regulatory applications. The development of standard methods for risk analysis of nuclear reactor events should improve the NRC staff’s capability to respond to nuclear reactor incidents, and to do more thorough and consistent peer reviews of event assessments per Management Directive 8.3. Improving coordination among various NRC groups performing risk analyses should focus NRC staff resources and attention on the analysis of the more

risk important events. The use of standard methods should facilitate risk communication by improving focus, clarity, and consistency. This will enhance the staff’s ability to meet SDP timeliness goals for the significance assessment of inspection findings, and improve the consistency and credibility of the SDP and ASP analysis results. The use of standard methods will also reduce the review time by external stakeholders.

#### REFERENCES

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