Development of a National Standard on External Event PRA

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ABSTRACT

The American Nuclear Society is developing a national Standard for use of probabilistic risk assessment (PRA) techniques, applicable to external events for licensed commercial nuclear power plants. The Standard will be consistent with that developed by ASME for Level 1, internal events. This paper presents a status report on the ongoing efforts in the development of the ANS Standard.

The scope of the effort is to define the requirements for conducting a quality PRA for external events. These include among others seismic, high winds, external flooding and man-made events such as aircraft impact, nearby transportation accidents, and those involving nearby industrial facilities. Note that the fire PRA is not within the scope of this Standard (a separate Standard is being developed by NFPA). PRAs developed using this Standard will be capable of providing a reasonable estimate of baseline risk from earthquakes and other external events, as measured by criteria such as core damage frequency (CDF) and large early release frequency (LERF).

INTRODUCTION

For the last two years, the American Nuclear Society (ANS) has been developing a national Standard for the use of probabilistic risk assessment (PRA) techniques, applicable to external events for licensed commercial nuclear power plants. The Standard is intended to be consistent with and to be used together with another PRA-methodology Standard being developed by ASME for Level 1, internal events PRA [1]. Similarly, this Standard is intended to be used with another new ANS Standard covering PRA for low-power/shutdown operations, when that Standard, now under development, is completed.

This paper presents a status report on the ANS external-events-PRA Standard being developed by a Working Group consisting of the coauthors of the present paper. The scope of the Standard-development effort has been to define the requirements for conducting a quality PRA for external events. The external events covered include among others earthquakes, high winds, external flooding, and man-induced events such as aircraft impact, nearby transportation accidents, and accidents involving nearby industrial facilities. (Note that the internal-fire PRA is not within the scope of this Standard.) PRAs that meet this Standard will be capable of developing a reasonable estimate of baseline risk from earthquakes and other external events, as measured by criteria such as core damage frequency (CDF) and large early release frequency (LERF).

The development of this Standard has been guided by the ANS Risk Informed Standards Consensus Committee, whose membership includes representatives from the utilities, the government (USNRC, U.S. Department of Energy), NSSS vendors, industry groups, and engineering consulting companies active in the PRA area.

The Standard contains requirements for a PRA useful for risk-informed decision making. It includes not only requirements, but also commentary that provides further explanations, discussions of alternative approaches, and references.

When this paper was written in early 2001, a draft of the Standard had been released by ANS for public comments. The Writing Group's expectation is that by summer 2001 the public comments will have been assimilated and the Standard will be ready for release.

BACKGROUND

External events have been examined as part of PRA since the early 1980s. The PRA Procedures Guide [2] provides guidance on screening of external events and the performance of detailed PRA on selected events such as earthquakes and external flooding. Over the years, the nuclear power industry and the NRC have conducted external event PRAs for over 50 nuclear power plants in the United States. Several external event PRAs have also been completed for nuclear facilities in other countries. Procedures and databases have been developed through the research efforts and sponsorship of the Electric Power Research Institute, USNRC and the U.S. Department of Energy. The Writing Group is of the opinion that the methodologies for external event PRA have matured, and that the industry has developed substantial collective experience and insights from the many PRAs that have been completed. Therefore, development of a national Standard on external event PRA is not only desirable and timely, but also entirely feasible.

By the time of SmiRT 16 in the summer of 2001, we expect that the Standard will have gone through public review and be available for use by the utilities and the NRC in risk-informed decisions. The paper will describe the contents of the Standard and the Standard's intended uses.

SCOPE

The scope of this Standard includes not only traditional PRA analyses, which are intended to be realistic, but also screening analyses and bounding analyses (or demonstrably conservative analyses) that use aspects of PRA methodology, but are not full-scope PRAs themselves. Many risk-informed applications can and do use such screening and bounding analyses.

Seismic Margin Assessments

The Standard also includes requirements for the widely-used Seismic Margin Assessment (SMA) methodology. SMA methods employ many of the same analysis tools and data as a seismic PRA, and the decision to include SMA methods within the Standard is motivated by the desire to allow an SMA to be used for some risk-informed applications.

The scope of an SMA is more limited than the scope of a seismic PRA, so some risk-informed applications cannot be supported by an SMA while others can be supported only to a limited extent. In particular, an SMA using the so-called "EPRI SMA method" [3], which is the approach used for almost all of the SMAs that have been performed in the U.S., does not employ a systems model that permits the calculation of a full core-damage frequency (CDF), nor does the systems-analysis approach account for non-seismic unavailabilities and human errors in a systematic way. This means that there are important limitations to the types of risk-informed applications that such an SMA can support. Important ideas have been advanced [4] to remedy some of the aspects of this limitation, and work to evaluate these ideas is underway in the seismic PRA/SMA community [5]. It is expected that when widespread acceptance of the latest approaches occurs, the Standard will be extended to incorporate requirements to allow broader uses of SMAs in risk-informed applications.

Another particular limitation is very important: The systems analysis aspect of an SMA contemplates only the evaluation of success paths that would prevent a core-damage accident sequence. Within an SMA there is no explicit way to separate those core-damage accident sequences that might lead to a "large early release" from other core-damage sequences that would not lead to such a release. Hence the entire area of risk-informed applications related to LERF is beyond the capabilities of an SMA unless explicit enhancements are undertaken.

External Events PRA: Building on Internal Events PRA

The approach to any external events PRA typically uses as its starting point the internal events PRA model, to which must be added a number of systems, structures and components (SSCs) not included in that model, but which could fail due to the fact that the accident initiator is an external event. Some "trimming" of that model is also common, to eliminate parts of it not relevant to the external events analysis. Both the part of the internal events model dealing with CDF and the part dealing with LERF are used as starting points.

Technical Requirements: Structure and Coverage

For each technical element that comprises an external events PRA, this Standard includes both "High Level Requirements" and "Supporting Requirements". The High Level Requirements are a set of requirements that encompass beneath them al of the Supporting Requirements. The High Level Requirements are general in their language, in recognition of the diversity of approaches that have been used to develop the existing industry PRAs and the need to allow for technological innovations in the future. Highly prescriptive High Level Requirements are judged undesirable, and perhaps even unworkable. These High Level Requirements are intended to be used by both the PRA analyst team and the peer review team.

The High Level Requirements and the Supporting Requirements, taken together, are formulated in a way that is intended to support the applications being considered. Specifically, a PRA can meet the High Level Requirements and Supporting Requirements at various levels-of-detail and various scopes that need not extend beyond what is adequate to support the intended application.

Risk Assessment Application Process

The Standard incorporates by reference the requirements for applications found in the ASME PRA Standard [1]. The ASME requirements, and by extension the requirements in this Standard, cover a process to determine the capability of a PRA to support various applications. The use of a PRA will be different from application to application. The Standard, which is application non-specific, is concerned only with the capability of the PRA to support an application. The PRAs technical capabilities are evaluated against the Standard requirement-by-requirement, rather than by evaluating whether the

PRA as a whole has all of the appropriate technical capabilities to “meet the Standard”. Therefore, only those PRA elements required to support the application in question need to meet the technical capability level of the Standard. For any given application, supplementary analyses may be used in place of, or to augment, those elements which do not fully meet the technical capabilities represented by the requirements in the Standard.

Types of Applications

The types of risk-informed PRA applications contemplated under this Standard are very broad, and include applications related to design, procurement, construction, licensing, operation and maintenance. Both regulatory risk-informed applications and applications not involving the NRC’s regulations are contemplated. In this regard, the approach is intended to be identical to that used in the ASME Standard [1].

Categories of PRA Capability: ASME Approach vs. The Approach Here

As stated earlier, neither the ASME Standard [1] nor this Standard has been developed to support any specific applications, but are rather concerned only with the capability of a PRA to support an application. PRA capabilities fall on a continuum. For convenience the ASME Standard has identified three different capability levels. These three different capability levels (called “Categories” I, II, and III) manifest themselves in the ASME Standard through the presence, for each technical issue covered, of three different Supporting Requirements written to cover the three different capability levels. To quote the ASME Standard in its Section 1.3, “PRA Capabilities are evaluated for each Supporting Requirement, rather than by specifying a ‘capability level’ for the whole PRA. Therefore, only those aspects of a PRA element required to support the application in question need the capability level appropriate for that application. For a given application, supplementary analyses may be used in place of, or to augment, those aspects of PRA elements that do not fully meet the requirements . . .”. The introduction to the ASME Standard contains a more complete explanation. Although ASME’s Supporting Requirements are different for each Category, all of ASME’s Supporting Requirements fall under a single set of High Level Requirements, independent of which Category they fit. However, the three-category approach has not been used here in the ANS Standard for external events PRA. Rather, the requirements in this Standard are written for only one “category” of PRA capability, corresponding to the ASME Standard’s Category II. The user should be aware that in developing this Standard the ANS Standards development Working Group has tried to adhere closely to the ASME Standard’s Category II, which represents a high-quality PRA useful for a broad range of risk-informed decisions. A PRA that meets this Standard should have the capability to be used for the same sorts of applications contemplated for the ASME Standard’s Category II capabilities (see ASME Chapters 1 and 4 for a more detailed discussion of typical applications). Such a PRA should also be capable of supporting Category I applications.

An analysis using the “Seismic Margin Assessment” methodology does not produce the same types of results as a seismic PRA. For example, it does not produce a core damage frequency estimate and cannot support certain applications contemplated under the ASME Standard’s Categories I and II. However, a well-executed SMA represents a good fit to many of the applications contemplated for ASME’s “Category I”, especially insofar as an SMA is generally well-suited to the categorization of structures, systems, and components (SSCs) according to their seismic capacity, and to the screening of SSCs according to their safety significance. A well-executed SMA can work well for some applications contemplated for ASME’s “Category II”, but a judgment must be made for each application on a case-by-case basis.

PRA Technical Requirements

The most important part of the Standard is the specific technical requirements for each PRA technical element.

The approach to developing the PRA technical requirements has concentrated on “what to do” rather than “how to do it”. In that sense, specific PRA methods for satisfying the technical requirements are not prescribed, although certain established PRA methods were contemplated by the Working Group as the technical requirements were being developed.

Therefore, alternative methods and approaches to meet the technical requirements of this Standard may be used if they provide results that are equivalent or superior to the methods usually used.

Acceptable Methods: One key aspect of this Standard is the specification, where possible, of one or more acceptable methods for accomplishing a specific requirement. In many places, the Commentary part of the Standard contains words such as, “Reference X provides an acceptable method for performing this aspect of the analysis”. The plain meaning of this wording should be clear, namely that using the methodology or data or approach in Reference X is one way to meet the Standard. The intent of any Requirement that uses this language is to be permissive, meaning that the analysis team can use another method without prejudice. However, it is important to understand that the intent of the Standard goes beyond the plain meaning. In other words, whenever the phrasing “acceptable method” is used, the intent is that if the analysis uses another method, the other method must accomplish the stated objective with a comparable level of detail, a comparable scope, etc. It is not acceptable to use another method that does not accomplish the intent of the Requirement at least as well as the “acceptable method” would accomplish it. Whenever an alternative to the “acceptable method” is selected, it is understood that the peer-review team will pay particular attention to this topic.

PRA Configuration Control

In order to conform to this Standard, it is necessary for a PRA to be maintained under a PRA Configuration Control Program. The requirements for this are included in the Standard. The objective of the PRA Configuration Control Program is to ensure that the PRA reflects the as-built, as-operated facility to a degree sufficient for the applications in which the PRA is used.

Peer Review

In order to conform to this Standard, a PRA must be subjected to a peer review, to evaluate the capability of each of its elements to support the range of intended applications. The Standard contains extensive requirements for the peer review. General peer-review requirements are supplemented by specific requirements applicable to seismic PRA, seismic margin assessment, and the PRA analysis of other external events.

Documentation Requirements

The Standard contains several general documentation requirements that apply through the Standard. In addition, under the Technical Requirements for each external event, there are a few additional documentation requirements specific to that external event.

REFERENCES

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