ASME/ANS RA-S-1.4-2013

Probabilistic Risk Assessment Standard for Advanced Non-LWR Nuclear Power Plants

TRIAL USE AND PILOT APPLICATION

Publication of this standard for trial use has been approved by The American Society of Mechanical Engineers and the American Nuclear Society. Distribution of this standard for trial use and comment shall not continue beyond 60 months from the date of publication, unless this period is extended by action of the Joint Committee on Nuclear Risk Management. It is expected that following this 60-month period, this draft standard, revised as necessary, will be submitted to the American National Standards Institute (ANSI) for approval as an American National Standard. A public review in accordance with established ANSI procedures is required at the end of the trial-use period and before a standard for trial use may be submitted to ANSI for approval as an American National Standard. This trial-use standard is not an American National Standard.

Comments and suggestions for revision should be submitted to:

Secretary, Joint Committee on Nuclear Risk Management
The American Society of Mechanical Engineers
Two Park Avenue
New York, NY 10016-5990

The American Society of Mechanical Engineers

ANS

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NOTE: The trial use period has been extended by the ASME/ANS Joint Committee on Nuclear Risk Management to December 31, 2019.

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FOREWORD

The American Society of Mechanical Engineers (ASME) Board on Nuclear Codes and Standards (BNCS) and the American Nuclear Society (ANS) Standards Board mutually agreed in 2004 to form the Nuclear Risk Management Coordinating Committee (NRMCC). NRMCC was chartered to coordinate and harmonize standards activities related to probabilistic risk assessment (PRA) between ASME and ANS. A key activity resulting from NRMCC was the development of PRA standards structured around the Levels of PRA (i.e., Level 1, Level 2, Level 3) to be jointly issued by ASME and ANS. In 2011, ASME and ANS decided to combine their respective PRA standards committees to form the ASME/ANS Joint Committee on Nuclear Risk Management (JCNRM).

In 2006, ASME BNCS established the New Reactor Task Group under the Committee on Nuclear Risk Management (CNRM) to evaluate the need for codes and standards to support the design, construction, licensing, and operation of advanced non–light water reactor (non-LWR) nuclear power plants (NPPs). Following the formation of JCNRM, the New Reactor Task Group is now known as the ASME/ANS JCNRM Advanced Non-LWR PRA Standard Writing Group (Non-LWR WG). The charter of the Non-LWR WG is to develop recommendations to JCNRM on requirements for the performance of PRAs for advanced non-LWRs. The expected applications of such PRAs include input to licensing and design decisions such as selection of licensing-basis events and safety classification of equipment, satisfaction of U.S. Nuclear Regulatory Commission PRA requirements for advanced non-LWRs, and support of risk-informed applications for advanced non-LWR NPPs. With the concurrence of JCNRM, the Non-LWR WG decided early on that a new PRA standard was needed to support a broad range of applications for advanced reactor designs.

To support a diverse mixture of reactor concepts, including high-temperature gas-cooled reactors, liquid metal–cooled fast reactors, and small modular reactors, CNRM decided early on to develop this new PRA standard on a reactor-technology-neutral basis using established technology-neutral risk metrics common to existing light water reactor (LWR) Level 3 PRAs. Such risk metrics include frequency of radiological consequences, e.g., dose, health effects, and property damage impacts. In order to support a wide range of applications defined by the non-LWR stakeholders, the scope of this standard is very broad and is comparable to a full-scope Level 3 PRA for an LWR with a full range of plant operating states (POSs) and hazards. Because some of the advanced non-LWR designs supported by this standard include modular reactor concepts, this standard includes requirements that support an integrated risk of multireactor facilities including accidents on two or more reactor units concurrently.

In preparing the technical requirements in this standard, the Non-LWR WG made use of source material from the existing ASME/ANS PRA standard ASME/ANS RA-Sa-2009 as revised in 2013 in ASME/ANS RA-Sb-2013 (Addendum B) as well as draft PRA standards under development by ANS for Low-Power-and-Shutdown PRA, Level 2 PRA, and Level 3 PRA. JCNRM has approved the use of draft ANS standards with a requirement to follow up with changes to reflect changes in the supporting standards. Such changes could necessitate a need for revisions to this standard. The use of source material from not-yet-approved PRA standards and the relative lack of experience in performing PRAs on non-LWR NPPs have shaped the decision by JCNRM to issue this standard for trial use. It is expected that changes that may be required to account for changes to the supporting standards will be accomplished as part of the effort to upgrade this trial-use standard to the requirements of the American National Standards Institute.

In preparing this draft standard, the non-LWR WG has worked closely with the Advanced Light Water Reactor Writing Group (ALWR WG) to ensure consistency in approach and language to address requirements for PRAs on plants in preoperational stages of the plant life cycle. The approach to

Capability Categories and supporting requirements for preoperational plant PRAs in this standard is consistent with the approach being taken by ALWR WG.

PREPARATION OF TECHNICAL INQUIRIES TO THE JOINT COMMITTEE ON NUCLEAR RISK MANAGEMENT

INTRODUCTION

The ASME/ANS Joint Committee on Nuclear Risk Management (JCNRM) will consider written requests for interpretations and revisions to risk management standards and development of new requirements as dictated by technological development. JCNRM's activities in this latter regard are limited strictly to interpretations of the requirements or to the consideration of revisions to the requirements on the basis of new data or technology. As a matter of published policy, The American Society of Mechanical Engineers (ASME) does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity, and accordingly, inquiries requiring such consideration will be returned. Moreover, ASME does not act as a consultant on specific engineering problems or on the general application or understanding of the standard's requirements. If based on the inquiry information submitted, it is the opinion of JCNRM that the inquirer should seek assistance, the inquiry will be returned with the recommendation that such assistance be obtained.

To be considered, inquiries will require sufficient information for JCNRM to fully understand the request.

INQUIRY FORMAT

Inquiries shall be limited strictly to interpretations of the requirements or to the consideration of revisions to the present requirements on the basis of new data or technology. Inquiries shall be submitted in the following format:

(a) Scope. The inquiry shall involve a single requirement or closely related requirements. An inquiry letter concerning unrelated subjects will be returned;

(b) Background. State the purpose of the inquiry, which would be either to obtain an interpretation of the standard's requirement or to propose consideration of a revision to the present requirements. Provide concisely the information needed for JCNRM's understanding of the inquiry (with sketches as necessary), being sure to include references to the applicable standard edition, addenda, part, appendix, paragraph, figure, or table;

(c) Inquiry Structure. The inquiry shall be stated in a condensed and precise question format, omitting superfluous background information and, where appropriate, composed in such a way that "yes" or "no" (perhaps with provisos) would be an acceptable reply. This inquiry statement should be technically and editorially correct;

(d) Proposed Reply. State what it is believed that the standard requires. If in the inquirer's opinion a revision to the standard is needed, recommended wording shall be provided;

(e) Typewritten/Handwritten. The inquiry shall be submitted in typewritten form; however, legible, handwritten inquiries will be considered;

(f) Inquirer Information. The inquiry shall include name, telephone number, and mailing address of the inquirer;

(g) *Submission.* The inquiry shall be submitted to the following address: Secretary, Joint Committee on Nuclear Risk Management, The American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990.

USER RESPONSIBILITY

Users of this standard are cautioned that they are responsible for all technical assumptions inherent in the use of PRA models, computer programs, and analysis performed to meet the requirements of this standard.

CORRESPONDENCE

Suggestions for improvements to the standard or inclusion of additional topics shall be sent to the following address: Secretary, Joint Committee on Nuclear Risk Management, The American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990.

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SECTION 1
INTRODUCTION

1.1 Objective

This standard sets forth the requirements for probabilistic risk assessments (PRAs) used to support risk-informed decisions for advanced non–light water reactor (non-LWR) nuclear power plants (NPPs) and prescribes a method for applying these requirements for specific applications. To support application of this standard to PRAs for a diverse set of reactor designs such as modular high-temperature gas-cooled reactors, liquid metal–cooled fast reactors, and small modular reactors, based on non-LWR technology, and other advanced non-LWRs, the requirements in this standard were developed on a reactor-technology-neutral basis.

1.2 Scope

This standard establishes requirements for a PRA for advanced non-LWR NPPs. The requirements in this standard were developed for a broad range of PRA scopes that may include the following:

(a) Different sources of radioactive material both within and outside the reactor core but within the boundaries of the plant whose risks are to be determined in the PRA scope selected by the user. The technical requirements in this trial-use version of the standard are limited to sources of radioactive material within the reactor coolant system (RCS) pressure boundary (RCPB).[1] Technical requirements for other sources of radioactive material such as the spent fuel system are deferred to future editions of this standard;

(b) Different plant operating states (POSs) including various levels of power operation and shutdown modes;

(c) Initiating events caused by internal hazards, such as internal events, internal fires, and internal floods, and external hazards such as seismic events, high winds, and external flooding;

(d) Different event sequence end states, including core or plant damage states (PDSs), and release categories that are sufficient to characterize mechanistic source terms, including releases from event sequences involving two or more reactor units or modules for PRAs on multireactor or multiunit plants;

(e) Evaluation of different risk metrics including the frequencies of modeled core and PDSs, release categories, risks of off-site radiological exposures and health effects, and the integrated risk of the multiunit plant if that is within the selected PRA scope. The risk metrics supported by this standard are established metrics used in existing light water reactor (LWR) Level 3 PRAs such as frequency of radiological consequences (e.g., dose, health effects) that are inherently technology neutral. Surrogate risk metrics used in LWR PRAs such as core damage frequency and large early release frequency are not used as they may not be applicable to non-LWR PRAs;

(f) Quantification of the event sequence frequencies, mechanistic source terms, off-site radiological consequences, risk metrics, and associated uncertainties, and using this information in a manner consistent with the scope and applications PRA.

[1] For pool-type reactors with no RCPB, the scope includes sources within the RCS.