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Standard for Radiological Accident Offsite Consequence Analysis (Level 3 PRA) to Support Nuclear Installation Applications

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The American Society of Mechanical Engineers

ANS

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FOREWORD

The American Society of Mechanical Engineers (ASME) Board on Nuclear, Clean Energy, Power, and Facilities Codes and Standards (BNCS) and American Nuclear Society (ANS) Standards Board have formed a Joint Committee on Nuclear Risk Management (JCNRM) to develop and maintain probabilistic risk assessment (PRA) standards. The JCNRM operates under procedures accredited by the American National Standards Institute (ANSI) as meeting the criteria of consensus procedures for American National Standards. The JCNRM holds two formal meetings per year, and users are invited to participate. Additional information about the JCNRM can be found on its committee page at https://go.asme.org/JCNRMcommittee.

This Level 3 Standard, ASME/ANS RA-S-1.3-2025, "Standard for Radiological Accident Onsite Consequence Analysis (Level 3 PRA) to Support Nuclear Installation Applications," sets forth requirements for determining Level 3 consequences as part of PRAs and related analysis methodologies that can be used to support risk-informed decisions for commercial nuclear power plants. This Standard also prescribes a process for applying these requirements for certain other applications involving a release of radioactive materials into the atmosphere [e.g., research reactors, fuel cycle facilities, and U.S. Department of Energy (DOE) non-reactor nuclear facilities]. In these cases, supplemental requirements may be needed. A separate standard, ASME/ANS RA-S-1.4-2021, "Probabilistic Risk Assessment Standard for Advanced Non-Light Water Reactor Nuclear Power Plants," has been published and states the requirements for 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 non-LWR applications.

This Standard was developed based on the body of knowledge and experience accumulated through the development and application of the ASME/ANS RA-S-1.1-2024, "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications," and ASME/ANS RA-S-1.2-2024, "Severe Accident Progression and Radiological Release (Level 2) PRA Standard for Nuclear Power Plant Applications for Light Water Reactors (LWRs)." This Standard, however, is not dependent upon these other PRA standards, although it is noted that the development of the final risk estimation for facilities (e.g., LWRs) can be performed using Level 1 and Level 2 (Level 1/2) PRA results (e.g., release frequencies, release characterizations) combined with the results of the Level 3 probabilistic consequence analysis.

During the development of this Standard and subsequent changes as a result of the balloting process and changes made to the ASME/ANS RA-S-1.1-2024 and ASME/ANS RA-S-1.2-2024, the writers have made every effort to be consistent with the aforementioned standards, and the JCNRM Writers' Guide. However, due to some of the unique attributes of a Level 3 PRA, there are places in this standard where consistency was not maintained. In each instance, this was a conscious and deliberate effort on the part of the writers to depart from the consistency in an attempt to highlight and focus on those items that make a Level 3 PRA distinctly different from its antecedent analyses, or to exclude items that are irrelevant in the context of a Level 3 PRA. Instances of inconsistency with the aforementioned standards are intentional. The writers request that the readers/users of this Standard keep that in mind as they use this Standard to support risk-informed applications.

Consequences covered within the scope of this Standard include radiation dose and induced health effects, as well as economic impacts, considering atmospheric transport and dispersion (ATD), demography, dosimetry, exposure pathways, and plant/site characteristics. The radioactive source terms and their frequencies often are passed on from supporting Level 1/2 PRA analyses.

The scope of a PRA covered by this Standard is primarily targeted for use to determine the impact of an accident at an NPP. However, the technology discussed here can be used to determine the impact of a release of radioactive material from any nuclear facility for which a release can be defined. The assessment can be on a conditional consequence basis (i.e., Level 3 analysis) or can be extended to estimate risk (i.e., Level 3 PRA).

This Standard describes requirements for calculating the consequences of radionuclide releases into the environment and how to present the results of such calculations. It is assumed that one or more computerized consequence models will be used. Therefore, emphasis has been placed on the information that is typically required as input and available output. As with any computer code, there are pitfalls associated with its use, and there are uncertainties inherent in the quality and representativeness of the input data and the fidelity of the modeling.

This Standard contains the requirements for the following technical elements of a consequence analysis: (1) Radionuclide Release Characterization (RE), (2) Protective Action Parameters and Other Facility Data (PA), (3) Meteorological Data (ME), (4) Atmospheric Transport and Dispersion (AD), (5) Dosimetry (DO), (6) Health Effects (HE), (7) Economic Consequences (EC), (8) Conditional Consequence Quantification and Reporting (QT), and (9) Risk Estimation (RI). The ninth technical element for risk estimation describes how the combined risk results of a Level 1, Level 2, and Level 3 PRA can be presented.

Nonmandatory appendices are provided to clarify the requirements of this Standard. Appendix 1-A has been included to provide examples of use of the action verbs in the supporting requirements (SRs). Appendix 2-A, Explanatory Notes Regarding Application of the SRs, provides additional information content through notes and commentaries associated with many SRs as nonmandatory information. Appendix 2-B, Computer Codes, has been included to identify codes currently used to support Level 3 PRAs and to illustrate typical input parameters and output reports of the calculation results. It is acknowledged that some topics are subject to continuing development since consequence modeling is not a precise science and contains significant inherent uncertainties. Where an understanding of the current state of the art is deemed necessary for a sensible interpretation of the results, a discussion of this topic is included. Other areas that are described in some detail are those in which the user's choice of input data and assumptions can significantly affect the output. Examples include evacuation and sheltering in place, and dry deposition velocity.

This Standard was developed by subject matter experts (SMEs) affiliated with U.S. nuclear utilities, national laboratories, individual consultancies, and the U.S. Nuclear Regulatory Commission (NRC). International participation has been solicited throughout the development process but was very limited. While several examples have been included in nonmandatory appendices that discuss international applications [e.g., use of the Code System for MARIA (COSYMA, a computer code for consequence modeling) for food pathway modeling], it is acknowledged that most examples are U.S.-centric. However, international users should be able to adapt the examples to their specific applications and regulatory requirements.

This publication, ASME/ANS RA-S-1.3-2025, "Standard for Radiological Accident Offsite Consequence Analysis (Level 3 PRA) to Support Nuclear Installation Applications," was approved by the ASME BNCS and the ANS Standards Board. ASME/ANS RA-S-1.3-2025 was approved by ANSI on February 12, 2025.

ACKNOWLEDGMENTS

The ASME/ANS RA-S-1.3 Working Group wishes to provide special appreciation and recognition of the hard work, knowledge, and insights provided by Jocelyn Mitchell, who passed away during the latter stages of the original standard development. Her guidance, support, contributions, and continued encouragement were keys to completing this Standard. She helped the group maintain appropriate balance of technical requirements through her continual scrutiny of superfluous additions, which were in her words, "gilding the lily."

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Standard for Radiological Accident Offsite Consequence Analysis (Level 3 PRA) to Support Nuclear Installation Applications

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Revisions and Errata. The committee processes revisions to this Standard on a periodic basis to incorporate changes that appear necessary or desirable as demonstrated by the experience gained from the application of the Standard. Approved revisions will be published in the next edition of the Standard.

In addition, the committee may post errata on the committee web page. Errata become effective on the date posted. Users can register on the committee web page to receive e-mail notifications of posted errata.

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(a) The most common applications for cases are

(1) to permit early implementation of a revision based on an urgent need

(2) to provide alternative requirements

(3) to allow users to gain experience with alternative or potential additional requirements prior to incorporation directly into the Standard

(4) to permit the use of a new material or process

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(1) a statement of need and background information

(2) the urgency of the case (e.g., the case concerns a project that is underway or imminent)

(3) the Standard and the paragraph, figure, or table number

(4) the editions of the Standard to which the proposed case applies

(d) A case is effective for use when the public review process has been completed and it is approved by the cognizant supervisory board. Approved cases are posted on the committee web page.

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Interpretations are published in the ASME Interpretations Database at https://go.asme.org/Interpretations as they are issued.

Committee Meetings. The ASME/ANS JCNRM regularly holds meetings that are open to the public. Persons wishing to attend any meeting should contact the secretary of the committee. Information on future committee meetings can be found on the committee web page at https://go.asme.org/JCNRMcommittee.

PART 1
GENERAL REQUIREMENTS FOR RADIOLOGICAL ACCIDENT OFFSITE CONSEQUENCE ANALYSIS (LEVEL 3 PRA) TO SUPPORT NUCLEAR INSTALLATION APPLICATIONS

Section 1-1
Introduction

1-1.1 OBJECTIVES

This Standard sets forth requirements for the consequence analysis portion of probabilistic risk assessments (PRAs) used to support risk-informed decisions for accidents involving the release of radioactive materials into the atmosphere. This portion of a PRA is typically known as a Level 3 analysis. This Standard also sets forth requirements for risk estimation based on combining the results of the Level 1 and Level 2 (Level 1/2) PRA portions (e.g., release frequencies, release characterizations) and the results of the consequence analysis for a Level 3 PRA.

1-1.2 SCOPE AND APPLICABILITY

Consequence analysis assesses the effect of releases of radionuclides on the surrounding population and the environment. It is expected that the primary use of this Standard is to evaluate the risk impacts of atmospheric releases from light water reactor (LWR) nuclear power plants (NPPs), although this Standard could support the risk impacts of releases from other facilities that process, use, or store radioactive materials. In these cases, supplemental requirements may be needed.

This Standard may be applied to atmospheric releases associated with multiple reactors at a single site. For such analyses, the Level 1 and Level 2 analyses need to define pertinent aspects of the releases for use in the Level 3 analysis.

This Standard only includes limited treatment of the impact on doses of the release of radioactive materials that could reach liquid pathways (i.e., due to deposition onto land and bodies of water). To date, there have

(The text presented in blue font in this Standard comprise hyperlinks to enable efficient access to referenced sections and elements, requirements, notes, references, etc.)