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Validation of Neutron Transport Methods for Nuclear Criticality Safety Calculations

Secretariat
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American National Standard

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Foreword

(This Foreword is not a part of American National Standard "Validation of Neutron Transport Methods for Nuclear Criticality Safety Calculations," ANSI/ANS-8.24-2007.)

This standard goes beyond ANSI/ANS-8.1-1998; R2007, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors," to provide additional detail about processes and techniques for the validation of computer-based neutron transport calculational methods used in nuclear criticality safety analyses. The ANS-8.24 working group has used its experience, results of conferences on area of applicability and validation, and outside experts to expand on the concepts identified in ANSI/ANS-8.1-1998; R2007. More detail and method descriptions are provided here. Section 4.3 of ANSI/ANS-8.1-1998; R2007 establishes the basic criteria for performing validation of calculational methods. This section contains material that was originally in a separate standard, ANSI/ANS-8.11-1975 (Withdrawn 1983), "Validation of Calculational Methods for Nuclear Criticality Safety," but that was subsumed into ANSI/ANS-8.1-1983; R1988 (Withdrawn in 1998), "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors." As there is currently a greater reliance on computer calculations in criticality safety applications, it was felt that a separate standard describing the requirements for the validation of computer-based neutron transport methods was again needed.

Criticality safety analysts have indicated the need for additional guidance beyond that provided by ANSI/ANS-8.1-1998; R2007. For example, ANSI/ANS-8.1-1998; R2007 indicates validation shall be performed by comparison to "critical and exponential experiments" and that the area of applicability for the validation should be established from this comparison. However, criticality safety analysts would benefit from requirements and recommendations on establishment of the area of applicability as well as criteria that should be considered in the extension of the area of applicability, and the use of bias and bias uncertainty based on comparison to experiments. The existing database of critical experiments was developed largely in a period when the fissile material operations and technical criteria were different from many of the current and planned operations involving fissile material. However, as the number of experiments that focus on current and planned operations has decreased, the industry need to optimize operations and reduce unnecessary conservatism has increased. Thus, the scrutiny and importance placed on validation has increased in recent years. This standard provides requirements and recommendations on proper validation processes and techniques for computer-based neutron transport calculational methods to expand on the basic criteria established in ANSI/ANS-8.1-1998; R2007.

This version of the standard was drafted by Working Group ANS-8.24 of Subcommittee 8 of the American Nuclear Society. The membership of the working group at the time of issuance was as follows:

F. E. Trumble, *Washington Safety Management Solutions, LLC*
L. L. Wetzel, *BWX Technologies, Inc.*

This standard was prepared under the guidance of ANS Subcommittee 8, Fissionable Materials Outside Reactors, which had the following membership at the time of its approval:

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Contents

Validation of Neutron Transport Methods for Nuclear Criticality Safety Calculations

1 Introduction

This standard amplifies the basic requirements and recommendations for validation as described in ANSI/ANS-8.1-1998; R2007, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors" [1],[1] as applied to computer-based neutron transport calculational methods. Requirements and recommendations for the validation of neutron transport calculational methods applied to nuclear criticality safety analyses are provided in this standard. In particular, this standard provides requirements and recommendations for selecting benchmarks; estimating the bias and bias uncertainty; selecting appropriate margins, both within and beyond the benchmark applicability; and documenting the validation. To conform with this standard, all operations shall be performed in accordance with its requirements.

2 Scope

This standard provides requirements and recommendations for validation, including establishing applicability, of neutron transport calculational methods used in determining critical or subcritical conditions for nuclear criticality safety analyses.

3 Definitions

3.1 Limitations

The definitions given below are of a restricted nature for the purpose of this standard. Other specialized terms are defined in *Glossary of Terms in Nuclear Science and Technology* [2] and in *Glossary of Nuclear Criticality Terms* [3].

3.2 Shall, Should, May

The word "shall" is used to denote a requirement; the word "should" is used to denote a recommendation; and the word "may" is used to denote permission, neither a requirement nor a recommendation.

3.3 Glossary of terms

benchmark: An experiment used for validation.

benchmark applicability[2]: The benchmark parameters (e.g., material compositions, geometry, neutron energy spectra) and their bounding values from which the bias and bias uncertainty of a calculational method are established.

bias: The systematic difference between calculated results and experimental data. Positive bias is where the calculated results are greater than the experimental data.[3]

bias uncertainty: The uncertainty that accounts for the combined effects of uncertainties in the benchmarks, the calculational models of the benchmarks, and the calculational method.

calculational margin: An allowance for bias and bias uncertainty plus considerations of uncertainties related to interpolation, extrapolation, and trending.

calculational method: The mathematical procedures, equations, approximations, assumptions, and associated numerical parameters (e.g., cross sections) that yield the calculated results.

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[1] Numbers in brackets refer to corresponding numbers in Section 9, "References."

[2] Benchmark applicability embodies the same concept as area of applicability as defined in ANSI/ANS-8.1-1998; R2007 [1].

[3] The sign of the bias is arbitrary. For the purpose of this standard, it has been defined to be positive when the calculated values exceed the experimental values, but it could be defined otherwise.