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steady-state neutronics methods for power reactor analysis

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Foreword

(This Foreword is not a part of American National Standard "Steady-State Neutronics Methods for Power Reactor Analysis," ANSI/ANS-19.3-2011.)

The intent of this American National Standard is to provide guidance for developing, validating, and utilizing steady-state neutronics methods to calculate neutron reaction-rate spatial distributions, power distributions, and effective neutron multiplication constants of nuclear power reactors and to provide guidelines by which the adequacy of design calculations may be demonstrated. This standard recognizes the diversity of the calculation procedures employed in reactor design. Consequently, the major thrusts of this standard are in the areas of methodology, verification, validation, and documentation. This standard is intended to cover reactor physics calculations for the entire nuclear industry, from fast to thermal power reactors. Since many different kinds of neutronics methods have been utilized for analyzing power reactors, and each has its own validation requirements for accuracy, it is necessary that this standard be of a general nature. Furthermore, this standard does not endorse or exclude the application of any methodology that has been adequately verified, validated, tested, and demonstrated to yield reliable reactor physics parameters.

For illustrative purposes, a list of computer codes currently being used throughout the nuclear industry is presented in the Appendix. This Appendix, however, is not part of the standard.

Compliance with the intent of this standard can be demonstrated for an intended area of applicability of the calculation system used, if the following requirements are met:

(1) Selection of models and methods

(a) consideration of reactor configuration, composition, and all conditions of operation that significantly affect the calculated quantities and justification for the resultant model approximations,

(b) preparation of multigroup cross sections and other parameters, if employed, in conformance with ANSI/ANS-19.1-2002 (R2011), "Nuclear Data Sets for Reactor Design Calculations," through the use of an application-dependent energy spectrum estimate,

(c) justification of geometric and neutronic transport approximations utilized in the spectrum calculation,

(d) inclusion of all important space and energy effects in the calculation utilized for the generation of few-group cross sections, if these are employed,

(e) demonstration of capability, as required by the application, to retrieve required neutron reaction rates in the physical reactor components from the computations and to justify any assumptions that need to be made in order to perform this retrieval,

(f) justification of the spectrum calculation interval used in nuclide depletion calculations and justification that the numerical integration time step is sufficiently small to ensure numerical stability and accuracy appropriate to the application;

(2) Calculation system verification and validation

Establish degree of agreement between results obtained with the system being verified with results of experiments or of calculations using a more

accurate model, over the intended area of applicability for the system being verified;

(3) Evaluation of accuracy

The accuracy and range of applicability of data and methods should be evaluated by establishment of biases and uncertainties, with degree of confidence, for the calculations that include allowance for uncertainties in the comparison data;

(4) Documentation.

The intent of this standard is to require the individual to (a) give careful consideration to those physical and numerical effects that may contribute to the validity of results; (b) document the reasons for selecting a specific calculation path; and (c) validate the calculation system used over the intended range of applicability by testing it against appropriate experiments, numerical benchmarks, and/or previously validated methods.

The requirement for documentation is a crucial part of this standard and will provide an auditable path. Areas omitted due to proprietary consideration shall be noted where possible.

The most important ways in which this revision differs from its earlier version, ANSI/ANS-19.3-2005, are as follows:

(1) The passages on common practices for pressurized water reactors, boiling water reactors, and liquid metal reactors have been revised to reflect the significant advances in reactor physics methods and computer codes made since the last revision. New passages have been added for heavy water reactor and high-temperature gas-cooled reactor methods;

(2) The Appendix, including the list of commonly used computer codes, has been updated. This revision reflects rapid development in two areas, namely,

(a) significant advances in reactor physics methods and calculation procedures as a result of a rapidly increasing experience base of operating power reactors,

(b) computer hardware and operating software developments that have permitted many traditional approximate methods to be replaced, with increased performance and user productivity as a result.

This standard might reference documents and other standards that have been superseded or withdrawn at the time the standard is applied. A statement has been included in Sec. 9, “References,” that provides guidance on the use of references.

This standard does not incorporate the concepts of generating risk-informed insights, performance-based requirements, or a graded approach to quality assurance. The user is advised that one or more of these techniques could enhance the application of this standard.

This standard for reactor physics calculations will undergo review and revision within 5 years. Suggestions for the improvement of this standard will be welcome. They should be sent to the attention of the Standards Department, American Nuclear Society, 555 N. Kensington Avenue, La Grange Park, IL 60526.

This standard was developed and later revised by Working Group ANS-19.3 of the American Nuclear Society, which at the time of this revision had the participation of the following members:

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