



Standard Guide for Benchmark Testing of Light Water Reactor Calculations¹

This standard is issued under the fixed designation E2006; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide covers general approaches for benchmarking neutron transport calculations for pressure vessel surveillance programs in light water reactor systems. A companion guide (Guide [E2005](#)) covers use of benchmark fields for testing neutron transport calculations and cross sections in well controlled environments. This guide covers experimental benchmarking of neutron fluence calculations (or calculations of other exposure parameters such as dpa) in more complex geometries relevant to reactor pressure vessel surveillance. Particular sections of the guide discuss: the use of well-characterized benchmark neutron fields to provide an indication of the accuracy of the calculational methods and nuclear data when applied to typical cases; and the use of plant specific measurements to indicate bias in individual plant calculations. Use of these two benchmark techniques will serve to limit plant-specific calculational uncertainty, and, when combined with analytical uncertainty estimates for the calculations, will provide uncertainty estimates for reactor fluences with a higher degree of confidence.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

[E261 Practice for Determining Neutron Fluence, Fluence Rate, and Spectra by Radioactivation Techniques](#)

[E262 Test Method for Determining Thermal Neutron Reaction Rates and Thermal Neutron Fluence Rates by Radioactivation Techniques](#)

¹ This test method is under the jurisdiction of ASTM Committee [E10](#) on Nuclear Technology and Applications and is the direct responsibility of Subcommittee [E10.05](#) on Nuclear Radiation Metrology.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[E706 Master Matrix for Light-Water Reactor Pressure Vessel Surveillance Standards, E 706\(0\) \(Withdrawn 2011\)](#)³

[E844 Guide for Sensor Set Design and Irradiation for Reactor Surveillance, E 706 \(IIC\)](#)

[E944 Guide for Application of Neutron Spectrum Adjustment Methods in Reactor Surveillance, E 706 \(IIA\)](#)

[E1018 Guide for Application of ASTM Evaluated Cross Section Data File, Matrix E706 \(IIB\)](#)

[E2005 Guide for Benchmark Testing of Reactor Dosimetry in Standard and Reference Neutron Fields](#)

3. Significance and Use

3.1 This guide deals with the difficult problem of benchmarking neutron transport calculations carried out to determine fluences for plant specific reactor geometries. The calculations are necessary for fluence determination in locations important for material radiation damage estimation and which are not accessible to measurement. The most important application of such calculations is the estimation of fluence within the reactor vessel of operating power plants to provide accurate estimates of the irradiation embrittlement of the base and weld metal in the vessel. The benchmark procedure must not only prove that calculations give reasonable results but that their uncertainties are propagated with due regard to the sensitivities of the different input parameters used in the transport calculations. Benchmarking is achieved by building up data bases of benchmark experiments that have different influences on uncertainty propagation. For example, fission spectra are the fundamental data bases which control propagation of cross section uncertainties, while such physics-dosimetry experiments as vessel wall mockups, where measurements are made within a simulated reactor vessel wall, control error propagation associated with geometrical and methods approximations in the transport calculations. This guide describes general procedures for using neutron fields with known characteristics to corroborate the calculational methodology and nuclear data used to derive neutron field information from measurements of neutron sensor response.

3.2 The bases for benchmark field referencing are usually irradiations performed in standard neutron fields with well-known energy spectra and intensities. There are, however, less

³ The last approved version of this historical standard is referenced on www.astm.org.