

ENDF/B-VI Library Generation and Testing for the SCALE Code System

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INTRODUCTION

As part of a continuing effort to develop and maintain state-of-the-art radiation transport capabilities, research and development at Oak Ridge National Laboratory (ORNL) is leading to improvements in radiation transport and nuclear data generation capabilities. With the release of SCALE 5.0 [1] in June 2004, vastly improved modeling tools are available to the nuclear analyst for performing a wide variety of radiation transport analyses. Additionally, a new version of the AMPX cross-section processing system [2] has been developed at ORNL to generate continuous-energy and multigroup cross-section libraries from Evaluated Nuclear Data Files (ENDF/B). [3] Work has been performed at ORNL to develop multigroup and continuous-energy ENDF/B-VI libraries for use with SCALE, and the objective of this paper is to document the ENDF/B-VI library generation and testing effort for the SCALE code system.

CROSS-SECTION LIBRARY GENERATION

One of the advancements with SCALE 5.0 is the improved resolved-resonance self-shielding treatment with the CENTRM/PMC sequence.[4, 5] CENTRM provides a continuous-energy or pointwise (PW) solution to the one-dimensional (1-D) discrete ordinates form of the Boltzmann transport equation in order to provide problem-dependent PW flux spectra that can be used in PMC to generate self-shielded multigroup (MG) cross sections in the resolved-resonance region. Additional resonance processing improvements will be made available with the next release of SCALE 5 (Version 5.1), and details concerning the resonance processing improvements are provided in a companion paper at this meeting [6].

In order to support the MG and PW radiation transport capabilities in SCALE 5.1, MG and PW ENDF/B-VI.7 cross-section libraries have been generated using the AMPX cross-section processing system. Because 238-group ENDF/B-V cross sections have been distributed with previous versions of SCALE, a 238-group ENDF/B-VI.7 library has been developed that will facilitate comparisons with the ENDF/B-V library. Likewise, corresponding temperature-dependent PW ENDF/B-VI.7 cross sections have been generated for CENTRM, and these PW data can be used in conjunction with MG ENDF/B-VI libraries in SCALE. The MG and

PW ENDF/B-VI libraries have 328 nuclides that also include 15 thermal-scattering [i.e., $S(\alpha,\beta)$ data] moderators. Work is currently in progress to develop a fine-group library (400+ groups) that will be distributed after SCALE 5.1.

Both KENO V.a and KENO VI are MG Monte Carlo (MC) codes that are available in SCALE for performing criticality safety calculations. Continuous-energy versions of KENO V.a and KENO VI (i.e., Point KENO V.a and Point KENO VI) have been developed and are being tested at ORNL for release with a future version of SCALE 5. [7] In order to support the current Point KENO development effort, AMPX has been used to generate a test cross-section library consisting of 50 ENDF/B-VI.7 nuclides that include all the U and Pu isotopes in addition to thermal moderator data for H in H₂O and H in CH₂. Work is currently in progress to develop a complete Point KENO ENDF/B-VI cross-section library that will be distributed with Point KENO V.a and Point KENO VI after SCALE 5.1. A companion paper at this meeting provides additional details concerning the development and testing of Point KENO CSAS sequences for SCALE. [8] Because results of the Point KENO testing are presented in another paper at this meeting, only results of the MG library testing are presented in this paper

LIBRARY TESTING WITH SCALE

In order to test the 238-group ENDF/B-VI library, 273 benchmark cases were calculated using the 238-group ENDF/B-VI and ENDF/B-V libraries. Of the total number of cases, 243 cases are critical benchmarks that include (1) low-enriched, (2) intermediate-enriched, and (3) highly enriched uranium systems, in addition to (4) mixed-oxide (5) plutonium, and (6) ²³³U systems. In addition to the critical benchmark experiments, 30 cases are calculational benchmarks from the Organization for Economic Co-Operation and Development/Nuclear Energy Agency (OECD/NEA) Criticality Working Group Benchmark 20 problem. [9] Selected cases from the benchmark suite are described briefly in Table I. The corresponding International Criticality Safety Benchmark Evaluation Project (ICSBEP) handbook [10] identification numbers are provided for the critical benchmarks in Table I.

The benchmark testing involved calculations with the CSAS1X, CSAS2X, CSAS25, and CSAS26 sequences in SCALE 5. For the calculation sequences, CENTRM was used for resonance self-shielding in the resolved region, and the BONAMI module (i.e., Bondarenko factor method) was used for resonance self-shielding in the unresolved region. Corresponding PW ENDF/B-VI CENTRM cross-section data were used with the 238-group ENDF/B-VI library, and PW ENDF/B-V CENTRM cross-sections were used with the 238-group ENDF/B-V library. The calculated results for the selected benchmark cases are provided in Table II. Note that the OECD/NEA benchmark problem was calculated using the 1-D discrete ordinates code XSDRNPM in the CSAS1X sequence. The ENDF/B-VI calculated results are consistent with the ENDF/B-V results and demonstrate the use of the ENDF/B-VI data with SCALE 5.

TABLE I. Selected Benchmark Case Descriptions

Case	Description
lst06-4	LEU-SOL-THERM-006 Case 4: U(5.64)O ₂ (NO ₃) ₂ solution with boron absorber rods
ict02m-3	IEU-COMP-THERM-002 Case 3: SS clad U(17)O ₂ annular fuel rods in H ₂ O with Gd absorber
hct010-08	HEU-COMP-THERM-010 Case 8: U(62.4)O ₂ and BeO fuel rods moderated and reflected with H ₂ O
tca09	MIX-COMP-THERM-004 Case 9: U(nat.)O ₂ -PuO ₂ fuel rods moderated and reflected with H ₂ O
pmf45-6	PU-MET-FAST-045 Case 6: Pu (w/ Ni coating) disks stacked with Ta disks reflected with Fe and H ₂ O
usi-001-sol1-r1-Be	U-233-SOL-INTER-001 Case 1: ²³³ UO ₂ F ₂ solution sphere w/ Be reflector
case4a	OECD/NEA Benchmark 20 fuel-dissolver problem: U(2.5)O ₂ spherical pellets in borated solution

TABLE II. Calculated Results for Benchmark Cases

Case	ENDF/B-VI.7	ENDF/B-V
lst06-4	1.00179 (0.00053)	1.00030 (0.00060)
ict02m-3	1.00111 (0.00053)	1.0020 (0.0006)
hct010-08	0.99987 (0.00065)	1.00360 (0.00062)
tca09	0.99950 (0.00049)	1.00436 (0.00056)
pmf45-6	1.00381 (0.00069)	1.01650 (0.00066)
usi-001-sol1-r1-Be	0.98720 (0.00090)	0.98739 (0.00076)
case4a	0.99913	0.99745

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