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Author(s): Russell D. Mosteller

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Los Alamos
NATIONAL LABORATORY

TESTING OF THE ENDF66 NUCLEAR DATA LIBRARY WITH THE MCNP™ CRITICALITY VALIDATION SUITE

Russell D. Mosteller
Diagnostic Applications Group (X-5)
Applied Physics Division
Los Alamos National Laboratory

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ABSTRACT

The ENDF66 nuclear data library for the MCNP Monte Carlo code recently has been released for general distribution. MCNP calculations have been performed for the cases in the MCNP Criticality Validation Suite, as well as a few other benchmarks. The results from ENDF66 are compared with those from a combination of the URES and ENDF60 nuclear data libraries. ENDF66 is derived from release 6 of the Evaluated Nuclear Data File (ENDF/B-VI.6), while URES and ENDF60 are derived from ENDF/B-VI.4 and ENDF/B-VI.2, respectively.

The differences in the results were evaluated in terms of known differences between ENDF/B-VI.6 and ENDF/B-VI.4 and enhancements to ENDF66 not present in URES or ENDF60. The differences in the results are consistent with those differences.

TESTING OF THE ENDF66 NUCLEAR DATA LIBRARY WITH THE MCNP™ CRITICALITY VALIDATION SUITE

RUSSELL D. MOSTELLER
DIAGNOSTICS APPLICATIONS GROUP (X-5)
APPLIED PHYSICS DIVISION
LOS ALAMOS NATIONAL LABORATORY

PRESENTED AT THE 2003 ANNUAL MEETING OF THE AMERICAN NUCLEAR SOCIETY
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MCNP Monte Carlo Team
Applied Physics Division

Los Alamos
NATIONAL LABORATORY

OVERVIEW OF PRESENTATION

DESCRIPTION OF NUCLEAR DATA LIBRARIES

DESCRIPTION OF MCNP CRITICALITY VALIDATION SUITE AND ADDITIONAL BENCHMARKS

COMPARISON OF ENDF66 RESULTS WITH THOSE FROM URES AND ENDF60

CONCLUSIONS

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ENDF66 LIBRARY

CONTINUOUS-ENERGY NUCLEAR DATA LIBRARY FOR MCNP

DATA DERIVED FROM ENDF/B-VI.6

CONTAINS CROSS SECTIONS FOR 173 ISOTOPES

CONTAINS PROBABILITY TABLES FOR TREATMENT OF UNRESOLVED RESONANCE REGION FOR 67 ISOTOPES (STRATIFIED SAMPLING)

CONTAINS DELAYED-NEUTRON SPECTRA FOR 22 ISOTOPES

RECENTLY RELEASED TO RSICC FOR GENERAL DISTRIBUTION

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URES LIBRARY

CONTINUOUS-ENERGY NUCLEAR DATA LIBRARY FOR MCNP

DATA DERIVED FROM ENDF/B-VI.4

CONTAINS CROSS SECTIONS FOR 27 ISOTOPES

CONTAINS PROBABILITY TABLES FOR TREATMENT OF UNRESOLVED RESONANCE REGION FOR ALL 27 ISOTOPES

CONTAINS NO DELAYED-NEUTRON SPECTRA

RELEASED IN 1998

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ENDF60 LIBRARY

CONTINUOUS-ENERGY NUCLEAR DATA LIBRARY FOR MCNP

DATA DERIVED FROM ENDF/B-VI.2

CONTAINS CROSS SECTIONS FOR 122 ISOTOPES

CONTAINS NO PROBABILITY TABLES FOR TREATMENT OF UNRESOLVED RESONANCE REGION

CONTAINS NO DELAYED-NEUTRON SPECTRA

RELEASED IN 1994

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CRITICALITY VALIDATION SUITE

CASES WERE SELECTED TO ENCOMPASS A WIDE VARIETY OF

FISSILE ISOTOPES : ^{233}U, ^{235}U, ^{239}Pu
SPECTRA : FAST, INTERMEDIATE, THERMAL
COMPOSITIONS : METAL, OXIDES, SOLUTIONS
CONFIGURATIONS : BARE, REFLECTED, HOMOGENEOUS, LATTICES

^{235}U CASES WERE SUBDIVIDED INTO HEU, IEU, AND LEU

INPUT SPECIFICATIONS FOR ALL 26 CASES WERE TAKEN FROM THE *INTERNATIONAL HANDBOOK OF EVALUATED CRITICALITY BENCHMARK EXPERIMENTS*

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ADDITIONAL CASES INCLUDED IN STUDY

CASE	SPECTRUM	DESCRIPTION
UH_3 (6)	INTERMEDIATE	UH_3 (HEU) REFLECTED BY DEPLETED U
ZEUS (1), (3)	INTERMEDIATE	HEU MODERATED BY C AND REFLECTED BY CU
ZEBRA-8H	INTERMEDIATE	IEU (37.5 WT.%) REFLECTED BY NORMAL U AND STEEL (k_∞ EXPERIMENT)

INPUT SPECIFICATIONS WERE TAKEN FROM THE *INTERNATIONAL HANDBOOK OF EVALUATED CRITICALITY BENCHMARK EXPERIMENTS*

MCNP CALCULATIONS

CALCULATIONS WERE PERFORMED WITH MCNP4C2 FOR ENDF66 AND FOR A COMBINATION OF URES AND ENDF60 (REPLICATED BY MCNP5)

RESULTS ARE BASED ON 6,000,000 ACTIVE NEUTRON HISTORIES

ENDF60 CROSS SECTIONS WERE USED ONLY FOR ISOTOPES THAT ARE NOT INCLUDED IN URES

RESULTS FROM URES+ENDF60 CALCULATIONS ARE GENERALLY REPRESENTATIVE OF ENDF/B-BI.4

CASES SELECTED FOR FURTHER STUDY

- ALL CASES WITH DIFFERENCES GREATER THAN TWO STANDARD DEVIATIONS
- ALL SOLUTION CASES AND ALL CASES WITH WATER MODERATOR OR REFLECTOR

REACTIVITY WAS EXPECTED TO DECREASE FOR URANIUM CASES WITH INTERMEDIATE SPECTRA, BASED ON DIFFERENCES BETWEEN ENDF/B-VI.6 AND ENDF/B-VI.4

REACTIVITY DIFFERENCES OBSERVED FOR SOLUTION CASES WERE UNEXPECTED, AND THEREFORE ALL CASES WITH WATER WERE SELECTED FOR FURTHER STUDY

IMPACT OF DELAYED-NEUTRON SPECTRA ON REACTIVITY DIFFERENCES

FUEL	CASE	$\Delta k_{Delayed}$
^{233}U	FALSTAFF (2)	0.0012 ± 0.0006
^{233}U	ORNL-11	0.0001 ± 0.0003
HEU	GODIVER	0.0007 ± 0.0004
HEU	UH_3 (6)	0.0011 ± 0.0004
HEU	HISS/HUG	-0.0002 ± 0.0003
HEU	ZEUS (1)	0.0007 ± 0.0004
HEU	ZEUS (2)	0.0 ± 0.0004
HEU	ZEUS (3)	0.0002 ± 0.0004
HEU	HEU-MT-003 (4)	0.0012 ± 0.0004
HEU	ORNL-10	0.0005 ± 0.0002

IMPACT OF DELAYED-NEUTRON SPECTRA ON REACTIVITY DIFFERENCES (CONT'D)

FUEL	CASE	$\Delta k_{Delayed}$
IEU	BIG TEN	-0.0016 ± 0.0003
IEU	ZEBRA-8H	-0.0023 ± 0.0003
IEU	IEU-CT-002 (3)	0.0006 ± 0.0004
LEU	BAW XI (2)	0.0005 ± 0.0004
LEU	SHEBA-II	0.0011 ± 0.0004
Pu	JEZEBEL-240	0.0005 ± 0.0003
Pu	PU-MF-011	-0.0001 ± 0.0004
Pu	HISS/HPG	-0.0002 ± 0.0003
Pu	PNL-33	-0.0003 ± 0.0004
Pu	PNL-2	0.0009 ± 0.0006

IMPACT OF PROBABILITY TABLES FOR UNRESOLVED RESONANCE REGION ON REACTIVITY DIFFERENCES

CASE	PT WORTH (Δk) ENDF66	PT WORTH (Δk) URES+ENDF60	Δk (ENDF66 - URES+ENDF60)
GODIVER	-0.0003 ± 0.0004	-0.0008 ± 0.0004	0.0005 ± 0.0004
ZEUS (2)	-0.0003 ± 0.0004	-0.0007 ± 0.0004	0.0004 ± 0.0006
BIG TEN	0.0055 ± 0.0003	0.0052 ± 0.0003	0.0003 ± 0.0004
ZEBRA-8H	0.0128 ± 0.0003	0.0120 ± 0.0003	0.0008 ± 0.0004
PU-MF-011	-0.0008 ± 0.0004	-0.0009 ± 0.0004	0.0001 ± 0.0006

COMPARISON OF ENDF66 AND URES+ENDF60 RESULTS WITH BENCHMARK VALUES

CASE	BENCHMARK k_{eff}	Δk ENDF66	Δk URES+ENDF60
FALSTAFF (1)	1.0000 ± 0.0084	-0.0098 ± 0.0084	-0.0103 ± 0.0084
ORNL-11	1.0006 ± 0.0029	-0.0037 ± 0.0029	-0.0045 ± 0.0029
GODIVER	0.9985 ± 0.0011	-0.0022 ± 0.0011	-0.0032 ± 0.0011
UH_3 (6)	1.0000 ± 0.0047	-0.0083 ± 0.0047	-0.0066 ± 0.0047
HISS/HUG	1.0000 ± 0.0040	0.0098 ± 0.0040	0.0125 ± 0.0040
ZEUS (1)	0.9976 ± 0.0008	-0.0057 ± 0.0009	-0.0034 ± 0.0009
ZEUS (2)	0.9997 ± 0.0008	-0.0049 ± 0.0009	-0.0020 ± 0.0009
ZEUS (3)	1.0010 ± 0.0009	-0.0023 ± 0.0009	0.0006 ± 0.0009
ORNL-10	1.0015 ± 0.0026	-0.0029 ± 0.0026	-0.0040 ± 0.0026

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COMPARISON OF ENDF66 AND URES+ENDF60 RESULTS WITH BENCHMARK VALUES (CONT'D)

CASE	BENCHMARK k_{eff}	Δk ENDF66	Δk URES+ENDF60
BIG TEN	0.9948 ± 0.0013	0.0125 ± 0.0013	0.0145 ± 0.0013
ZEBRA-8H	1.0300 ± 0.0025	0.0106 ± 0.0025	0.0126 ± 0.0025
SHEBA-II	0.9991 ± 0.0029	0.0126 ± 0.0029	0.0097 ± 0.0029
JEZEBEL-240	1.0000 ± 0.0020	-0.0022 ± 0.0020	-0.0014 ± 0.0020
PU-MF-011	1.0000 ± 0.0010	-0.0026 ± 0.0010	-0.0029 ± 0.0010

CONCLUSIONS ABOUT ENDF66

ACCURATELY REFLECTS CHANGES IN ENDF/B-VI.6 DATA

- ^{235}U CROSS SECTIONS IN INTERMEDIATE-ENERGY RANGE
- SLIGHT REDUCTION IN 1/V PORTION OF RADIATIVE CAPTURE CROSS SECTION FOR HYDROGEN

INCORPORATES IMPROVED PHYSICS MODELS

- DELAYED-NEUTRON SPECTRA
- PROBABILITY-TABLE TREATMENT FOR UNRESOLVED RESONANCE REGION

AGREEMENT IMPROVES FOR SOME BENCHMARKS BUT DETERIORATES FOR OTHERS, MOST NOTABLY HEU CASES WITH INTERMEDIATE SPECTRA

MCNP5

FINAL VERSION RECENTLY SENT TO RSICC FOR TESTING AND DISTRIBUTION

DISTRIBUTION PACKAGE INCLUDES SEPARATE WINDOWS INSTALLERS (USING INSTALLSHIELD) FOR MCNP5 EXECUTABLE AND NUCLEAR DATA

INSTALLERS SET ENVIRONMENTAL VARIABLES SO THAT MCNP5 CAN BE RUN FROM ANYWHERE ON PC WITHOUT FURTHER SETUP

SEPARATE X-WINDOWS SOFTWARE (REFLECTION, EXCEED, ETC.) REQUIRED FOR GRAPHICS

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