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DATA TESTING OF ORNL ^{235}U EVALUATION

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I. INTRODUCTION

The purpose of this paper is to describe the results of data testing of the new ^{235}U evaluation[1] at the Oak Ridge National Laboratory (ORNL). A comparison is made between the new evaluation and ENDF/B-VI release 3 (ref. 2) for thermal cross sections, resonance integrals, *g*-factors, and the K1 parameter. In addition, results for benchmark calculations are presented and compared with results using ENDF/B-V, ENDF/B-VI release 2, and ENDF/B-VI release 3 ^{235}U evaluations.

The new evaluation is for the ^{235}U resolved resonance region (0 to 2250 eV). The SAMMY[3] program was used to fit measured data and to determine Reich-Moore resonance parameters. The previous evaluation used 11 different energy ranges for the resolved resonance region; the new evaluation has only one energy range, which eliminates the problem of nonphysical discontinuities in the cross sections at the boundaries (ref. 4, Table II) that is present for ENDF/B-VI release 3. The use of one energy range for the resolved resonance range is the recommended method given in the ENDF formats and procedures manual (ENDF-102). The use of one energy range does not impact the accuracy of the evaluated cross sections. The new evaluation also addresses the capture-to-fission ratio in regard to the predictability of criticality safety margins for systems with intermediate-energy spectra. Differences between the new evaluation and ENDF/B-VI release 3, using 1/E weighting, are as large as 7 and 50% for the fission cross section and the capture cross section, respectively. The new evaluation is unchanged from ENDF/B-VI release 3 above the resolved resonance region.

II. THERMAL CROSS SECTIONS, G-FACTORS, AND RESONANCE INTEGRALS

The thermal (2200 m/s) cross sections are as follows: $\sigma_f = 585.29$ barns, $\sigma_c = 98.95$ barns, $\sigma_s = 15.44$ barns, $\sigma_t = 699.68$ barns, $\bar{\nu} = 2.4320$, $\eta = 2.0803$. The fission resonance integral is 275.64 barns, the capture resonance integral is 140.35 barns, and resonance $\alpha = 0.5092$. The *g*-factors are as follows: $g_f = 0.9805$, $g_c = 0.9904$, $g_a = 0.9819$. The corresponding ENDF/B-VI release 3 parameters are: $\sigma_f = 585.04$, $\sigma_c = 98.64$, $\sigma_s = 15.04$, $\sigma_t = 698.72$, $\bar{\nu} = 2.4338$, $\eta = 2.0826$, fission resonance integral = 277.47, capture resonance integral = 143.36, and resonance $\alpha = 0.5167$. The *g*-factors are as follows: $g_f = 0.9786$, $g_c = 0.9897$, and $g_a = 0.9802$. The K1 parameter is defined as

$$K1 = \bar{\nu}\sigma_f g_f - \sigma_a g_a .$$

The calculated K1 is 723.78, which is in excellent agreement with the experimental value, 722.7 ± 3.9. The ENDF/B-VI release 3 value of K1 is 723.0. The percentage difference for α (the ratio of the capture to fission cross section) using the 199-group (VITAMIN-B6) structure, relative to ENDF/B-VI release 3,is shown in Fig. 1.

III. DATA TESTING OF CSEWG BENCHMARKS

With the exception of ^{235}U, data from the VITAMIN-B6 multigroup cross-section library[5,6] were used in the ENDF/B-VI benchmark[7] calculations. THE NJOY system was used to process the

ENDF/B-VI evaluations and generate cross-section files in NJOY format. The SMILER program was used to convert from NJOY format to the AMPX master interface format. The benchmark calculations have been performed with the SCALE-4 system.[8] The calculated k_{eff} values using the new ORNL evaluation are compared with previous results in Table 1.

The first five thermal reactor benchmarks are for the ORNL critical solution spheres: ORNL-1, -2, -3, -4, and -10. These are unreflected spheres of ^{235}U as uranyl nitrate and H_2O solutions. The L-series benchmarks are similar to the ORNL series, except that they include both reflected and unreflected spheres of ^{235}U as uranyl fluoride and H_2O solutions. The BAPL-1, -2, and -3 benchmarks are 1.3 wt% enriched uranium-oxide rods in a triangular-pitch lattice. The HISS(HUG), UH3-UR, and UH3-NI assemblies are intermediate-spectrum benchmarks.

Calculated k_{eff} values using the new ORNL evaluation are in good agreement with ENDF/B-VI release 3 for the thermal benchmarks (the average is only 0.04% lower). Results for the three intermediate-spectrum benchmarks, HISS(HUG), UH3-UR, and UH3-NI, are greatly improved relative to the earlier versions of ENDF/B. Compared with ENDF/B-VI release 3, the average k_{eff} for these benchmarks is 46 Δk (0.0046) lower. This change is of particular significance with regard to fissile material storage and transportation applications.

IV. CONCLUSIONS

Thermal cross sections, g-factors, resonance integrals, and the K1 parameter from the new ^{235}U evaluation are all in excellent agreement with measured values. Results from benchmark data testing indicate that there is no significant change, relative to ENDF/B-VI release 3 for the 13 thermal benchmarks in Table 1. Results for the intermediate-spectrum benchmarks are greatly improved

relative to ENDF/B-V and ENDF/B-VI release 3 values. Additional review and testing by other CSEWG data testers would be highly desirable.

V. REFERENCES

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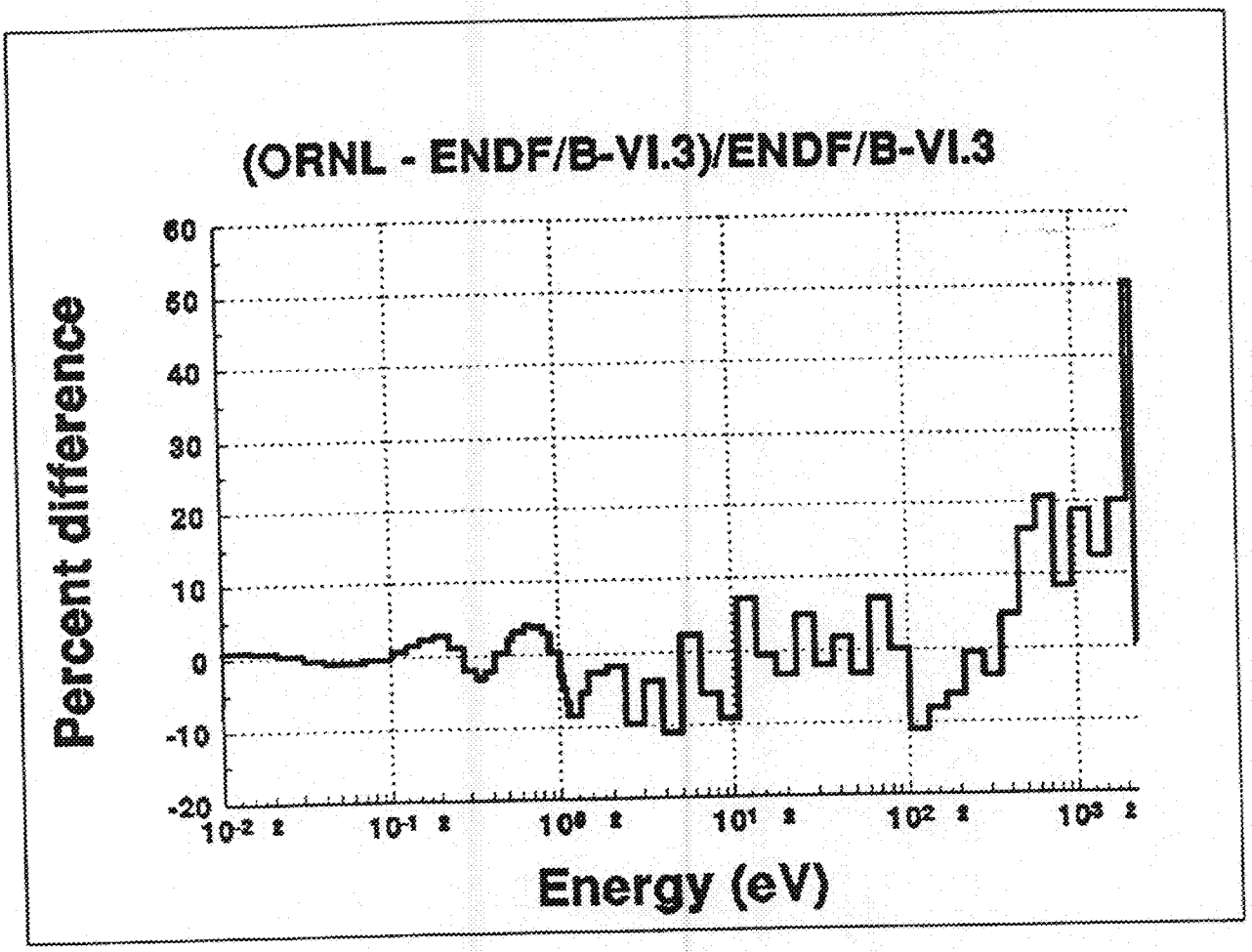

Fig. 1. ^{235}U alpha percent difference.

TABLE 1
ORNL k_{eff} calculations using SCALE system[a]

BENCHMARK	ENDF/B-V	ENDF/B-VI.2	ENDF/B-VI.3	ORNL
ORNL-1	1.0007	0.9965	0.9974	0.9972
ORNL-2	1.0005	0.9964	0.9972	0.9970
ORNL-3	0.9975	0.9935	0.9943	0.9940
ORNL-4	0.9989	0.9950	0.9958	0.9955
ORNL-10	0.9993	0.9961	0.9971	0.9970
L-7	1.0082	1.0037	1.0006	1.0003
L-8	1.0088	1.0042	1.0050	1.0046
L-9	1.0052	1.0011	1.0020	1.0017
L-10	1.0062	1.0003	0.9986	0.9981
L-11	1.0035	0.9988	0.9997	0.9995
BAPL-1	0.9947	0.9975	0.9975	0.9970
BAPL-2	0.9965	0.9971	0.9976	0.9971
BAPL-3	0.9987	0.9972	0.9983	0.9979
HISS(HUG)	1.0254	1.0293	1.0133	1.0085
UH3-UR[b]	1.0121		1.0102	1.0057
UH3-NI[b]	1.0228		1.0176	1.0130
ORNL-AVE	0.9994	0.9955	0.9964	0.9961
L-series AVE	1.0064	1.0016	1.0012	1.0008
BAPL-AVE	0.9966	0.9973	0.9978	0.9973

[a]XSDRNPM, P_3 scattering, convergence 0.0001.

[b]Specifications revised 11-20-95.

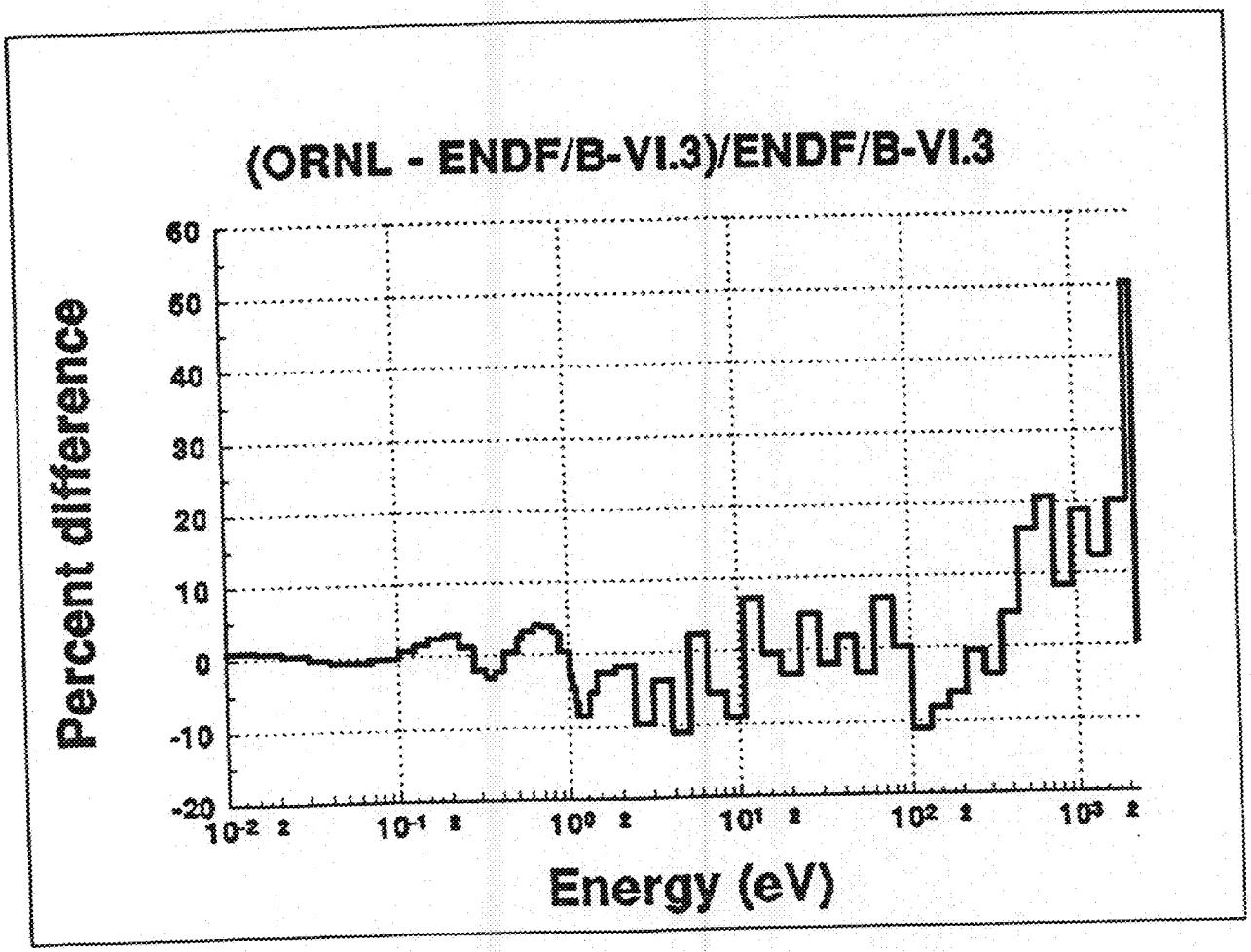

Fig. 1. ^{235}U alpha percent difference.