LEGIBILITY NOTICE

A major purpose of the Technical Information Center is to provide the broadest dissemination possible of information contained in DOE's Research and Development Reports to business, industry, the academic community, and federal, state and local governments.

Although a small portion of this report is not reproducible, it is being made available to expedite the availability of information on the research discussed herein.

LA-UR -90-2055

Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36.

LA-UR--90-2055

DE90 013168

TITLE: GENERAL PURPOSE NUCLEAR DATA EVALUATIONS FOR ENDF/B-VI: IMPACT OF CROSS-SECTION STANDARDS

AUTHOR(S): Phillip G. Young, T-2

SUBMITTED TO: The American Nuclear Society for presentation at their Winter Meeting, November 11-15, 1990, Washington D.C.

DISCLAIMER

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

GENERAL PURPOSE NUCLEAR DATA EVALUATIONS FOR ENDF/B-VI: IMPACT OF CROSS-SECTION STANDARDS

P. G. Young

Theoretical Division
Los Alamos National Laboratory
Los Alamos, NM 87545

Over the past year the Cross Section Evaluation Working Group (CSEWG) has finalized and issued new evaluations for over 70 nuclides in Version VI of ENDF/B. These data provide the foundation for a new series of reactor benchmark calculations. An integral part of the evaluation effort for ENDF/B-VI has been the most ambitious effort ever undertaken to systematically and simultaneously reevaluate the cross sections used for neutron standards.[1] While a number of the materials and reactions identified as standards are directly involved in fission reactor calculations, the impact of the standards data is felt far beyond the specific standards reactions. The effect of the Version VI standards data file on several evaluations of data of interest for fission reactors is discussed in this paper, together with the methodology used to utilize the standards.

General purpose evaluations of several light elements that are important for reactor benchmark calculations were carried out at Los Alamos National Laboratory, including ^{1,2}H, ^{6,7}Li, ^{10,11}B, ^{14,15}N, and ^{16}O. The ^{1}H(n,n)^{1}H scattering, and the ^{6}Li(n,α) and ^{10}B(n,α)^{7}Li absorption (E_n < 1 MeV and 250 keV, respectively) cross sections are standard reactions and therefore were obtained directly from the simultaneous standards evaluation. With the exception of neutron total cross sections, which can be determined absolutely through transmission measurements, all the remaining evaluated reactions are dependent on standards through the underlying experimental data base. In particular, since the previous ENDF/B version was issued, a number of important new measurements have been completed with sufficient accuracy that the availability of precise standards information has become increasingly important. Good examples of such measurements are the precision (n,n) and (n,n') scattering measurements made at several laboratories for ^{6}Li (Ref. 2), ^{10}B (Ref. 3), ^{14}N (Ref. 4), and ^{16}O (Ref. 5), which typically rely on the ^{1}H(n,n) standard cross section. Other examples of standards application are a series of highly accurate experiments to determine the ^{7}Li(n,nt) cross section[6] as well as a number of less precise measurements of (n,p) and (n,α) cross sections for ^{14}N and ^{16}O (Ref. 7).

The simultaneous standards evaluation had even greater impact on the Los Alamos contributions to the actinide evaluations, in particular, for the evaluations of the fission

cross sections for ^{237}Np and ^{239}Pu, and prompt $\bar{\nu}$ for ^{235}U, ^{237}Np, and ^{239}Pu. In the case of the (n,f) cross sections, most of the experimental data base for ^{237}Np and ^{239}Pu is in the form of ratio measurements relative to the $^{235}U(n,f)$ cross section. Similarly, for $\bar{\nu}_p$ well over half of the available measurements are relative to $\bar{\nu}$ for ^{252}Cf, which is a primary standard, and several others are relative to $\bar{\nu}_p$ for thermal neutrons on ^{235}U, also a primary standard. The existence of a highly accurate and internally consistent standards data file, together with a data base of carefully performed ratio measurements, has permitted very reliable determination of $\sigma_{n,f}$ and $\bar{\nu}_p$ and their covariances for these actinides.

In order to take optimal advantage of the improved data base, covariance analyses using the GLUCS Baysian analysis code[8] developed at Oak Ridge National Laboratory were performed for the $^{239}Pu(n,f)$ cross section evaluation and for the $\bar{\nu}_p$ evaluations for ^{235}U and ^{239}Pu for incident neutron energies greater than about 1 keV. In all cases the experimental data were normalized to the ENDF/B-VI standards prior to analysis. Simplified covariance matrices were estimated for the individual measurements from the experimental details. For the $^{239}Pu(n,f)$ evaluation, the ratio and absolute measurements were analyzed separately with GLUCS and then combined after normalization of the ratio results. In the case of $\bar{\nu}_p$ the present covariance analyses were joined to recent French evaluations[9,10] at lower energies. The ENDF/B-VI evaluation of the $^{239}Pu(n,f)$ cross section is compared in Fig. 1 to a selection of the normalized ratio data and to the previous ENDF/B-V.2 evaluation. Similarly, the ENDF/B-VI evaluation of $\bar{\nu}_p$ for ^{235}U is compared to a portion of the normalized experimental data base and to ENDF/B-V.2 in Fig. 2.

The ENDF/B-VI results in Figs. 1 and 2 are seen to be in better accord with the experimental data base than the earlier Version V.2 evaluations. Preliminary calculations[11] of the Los Alamos fast criticals GODIVA and JEZEBEL indicate greater consistency with those integral results than was the case with ENDF/B-V.2. It is our conclusion that the combination of the comprehensive standards analysis with careful evaluation techniques has resulted in a data file for ENDF/B-VI that is more accurate and internally self consistent than the previous ENDF/B-V.2 evaluations.

REFERENCES

1. R. Peelle and H. Condé, "Neutron Standards Data," *Proc. Int. Conf. on Nucl. Data for Science and Tech.*, Mito, Japan, 30 May - 3 June 1988 [Ed. S. Igarasi, Saikon Publishing. Co., Ltd., Tokyo, 1988], p. 1005.

2. A. B. Smith, P. T. Guenther, and J. F. Whalen, "Neutron Total and Scattering Cross Sections of ^{6}Li in the Low-MeV Range," *Nucl. Phys.* **A373**, 305 (1982).

3. S, Glendinning, S. El-Kadi, C. E. Nelson, R. S. Pedroni, F. O. Purser, R. L. Walter, A. G. Beyerle, C. R. Gould, L. W. Seagondollar, and P. Thambidura, "Elastic and Inelastic Neutron Cross Sections for Boron-10 and Boron-11," *Nuc. Sci. Eng.* **80**, 256 (1982)..

4. J. Chardine, G. Haouat, S. Seguin, and C. Humeau, "Diffusion Elastique et Inelastique de Neutrons sur ^{14}N Entre 7.7 et 13.5 MeV", Commissariat à l'Energie Atomique report CEA-N-2506 (1986).

5. G. Börker, R. Böttger, H. J. Brede, H. Klein, W. Mannhart, and B. R. L. Siebert, "Elastic and Inelastic Differential Neutron Scattering Cross Sections of Oxygen between 6 and 15 MeV," Physikalisch Technische Bundesanstalt - Bericht report PTB-N-1 (1989).

6. P. G. Young, J. W. Davidson, and D. W. Muir, "Evaluation of the ^{7}Li(n,n't)^{4}He Cross Section for ENDF/B-VI and Application to Uncertainty Analysis," *Fus. Tech.* **15**, 440 (1989).

7. V. McLane, C. L. Dunford, and P. F. Rose, "Neutron Cross Section Curves" in *Neutron Cross Sections, v. 2*, (Academic Press, Inc., 1988).

8. D. Hetrick and C. Y. Fu, "GLUCS: A Generalized Least-Squares Program for Updating Cross Section Evaluations," ORNL/TM-7341 (1980).

9. J. Frehaut, "Coherent Evaluation of $\bar{\nu}_p$ for ^{235}U, ^{238}U, and ^{239}Pu," Nuclear Energy Agency Nuclear Data Committee report NEANDC(E) 238/L (1986).

10. E. Fort, J. Frehaut, H. Tellier, and P. Long, "Analysis of the Experimental Results for ν Prompt of ^{239}Pu, ^{241}Pu, ^{235}U in the Resolved Range - Complementarity of the Integral and Microscopic Informations," *Proc. Int. Conf. on Nucl. Data for Science and Tech.*, Mito, Japan, 30 May - 3 June 1988 [Ed. S. Igarasi, Saikon Publishing. Co., Ltd., Tokyo, 1988], p. 687.

11. R. E. MacFarlane, personal communication, May, 1990.

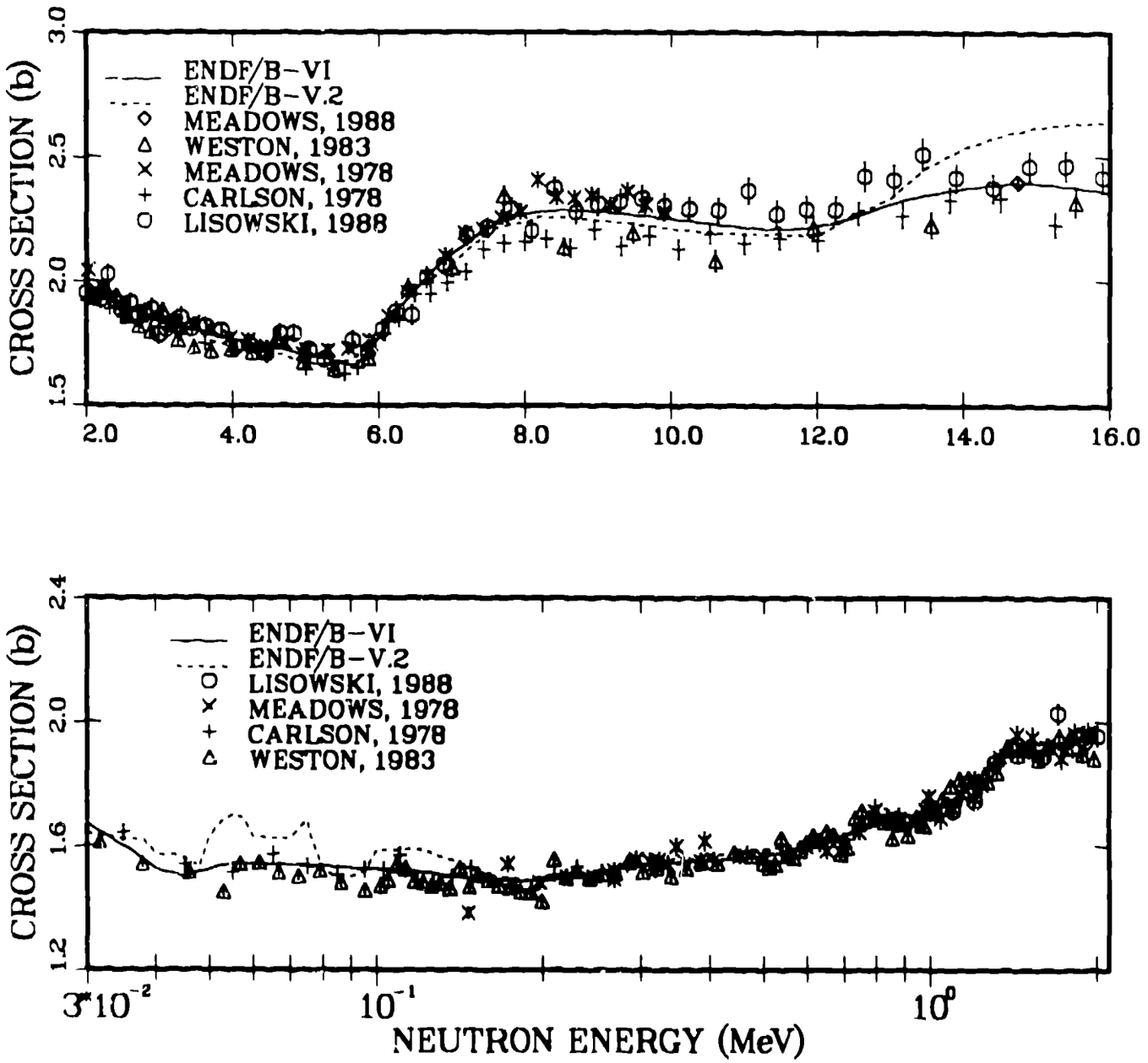

Fig. 1 Comparison of the ENDF/B-VI evaluation of the ^{239}Pu(n,f) cross section with a selection of experimental data normalized using Version VI standards data, and with the previous ENDF/B-V.2 evaluation.

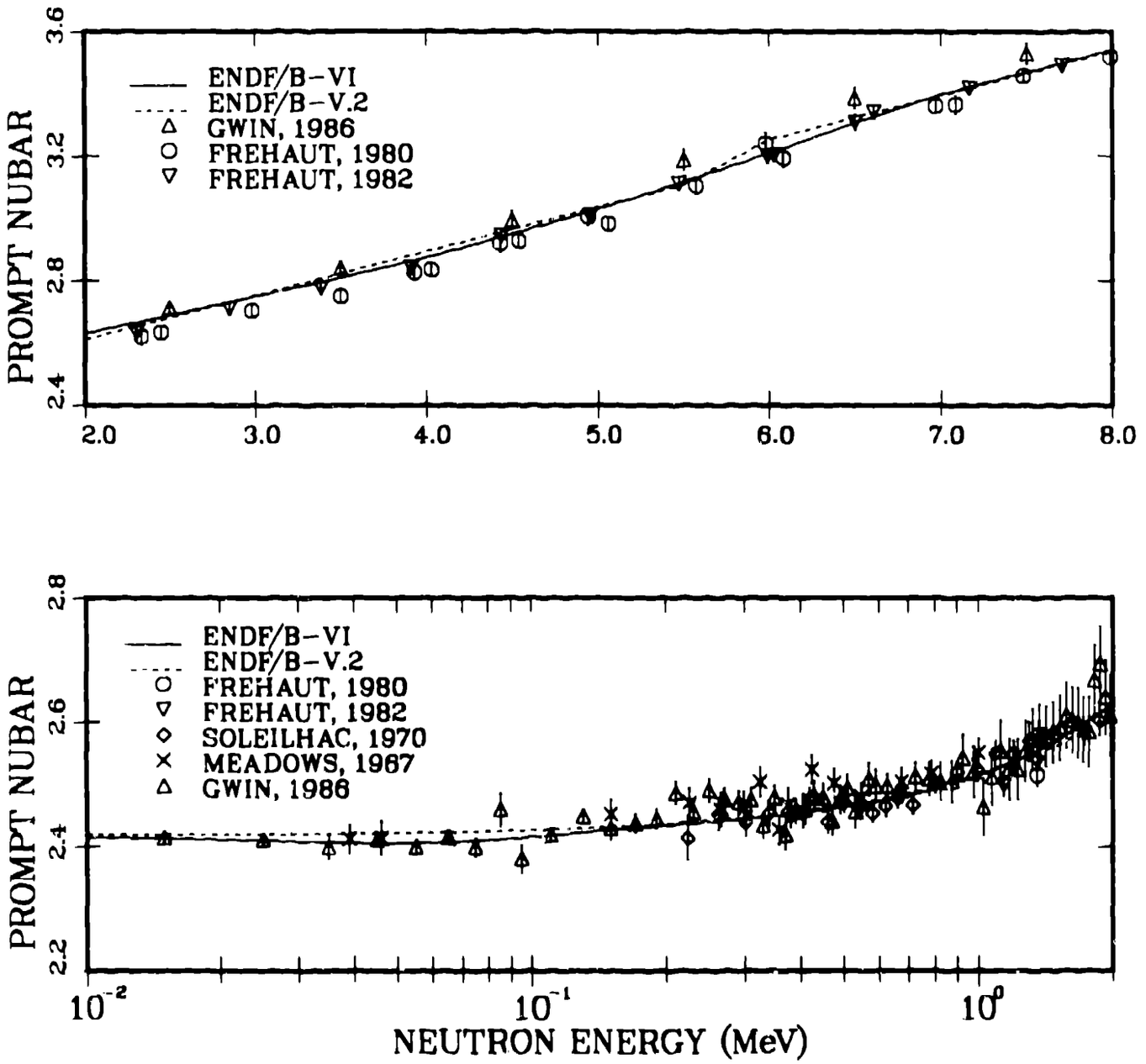

Fig. 2 Comparison of the $\bar{\nu}_p$ evaluation in ENDF/B-VI for ^{235}U with part of the experimental data base and with ENDF/B-V.2. The experimental data were all obtained relative to ^{252}Cf $\bar{\nu}$ and have been normalized to ENDF/B-VI standards.

FIGURE CAPTIONS

1. Comparison of the ENDF/B-VI evaluation of the ^{239}Pu(n,f) cross section with a selection of experimental data normalized using Version VI standards data, and with the previous ENDF/B-V.2 evaluation.

2. Comparison of the $\bar{\nu}_p$ evaluation in ENDF/B-VI for ^{235}U with part of the experimental data base and with ENDF/B-V.2. The experimental data were all obtained relative to ^{252}Cf $\bar{\nu}$ and have been normalized to ENDF/B-VI standards.