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SENSITIVITY AND A PRIORI UNCERTAINTY ANALYSIS
OF THE CFRMF CENTRAL FLUX SPECTRUM

by

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The Coupled Fast Reactivity Measurements Facility (CFRMF), located at the Idaho National Engineering Laboratory, is a zoned-core critical assembly with a fast-neutron-spectrum zone in the center of an enriched ^{235}U , water-moderated thermal driver¹. The central fast zone is produced by a water-free filter assembly which tailors the neutron energy spectrum incident on it from the thermal driver. The filter consists primarily of a large depleted uranium block clad externally with stainless steel and boral. It has an axial experiment hole lined with stainless-steel clad concentric cylinders of ^{10}B and ^{235}U . Spanning the neutron energy range ($1 \text{ keV} \leq E_n \leq 10 \text{ MeV}$), the central neutron spectrum is a Cross-Section's Evaluation Working Group (CSEWG) benchmark field for data testing of fission-product, actinide and dosimeter cross sections important to fast reactor technology.

An accurate knowledge of the central neutron spectrum is important to data-testing analyses which utilize integral reaction-rate data measured for samples placed in the CFRMF field. The purpose of this paper is to present the results of a study made with the AMPX-II² and FORSS³ code systems to determine the central-spectrum flux covariance matrix due to uncertainties and correlations in the nuclear data for the materials which comprise the facility. AMPX-II is a code system for generating coupled multigroup neutron-gamma-ray cross-section libraries from data in ENDF format. FORSS is a code system used to study relationships between nuclear cross sections, integral experiments, reactor performance parameter predictions and associated uncertainties.

The starting cross section data base was a preliminary 100-group ENDF/B-V library which has been used extensively at ORNL for fast-reactor data testing. A 15-region cylindrical model was defined for the CFRMF. A 100-group self-shielded cross section library was generated for this

problem with BONAMI2 (Bondarenko treatment). Detailed transport calculations (S_8, P_3) were made with XSDRNPM, and 26-group cross sections were obtained for each region by collapsing the 100-group cross sections.

The 15-region, 26-group XSDRNPM cross sections were input to FANISM, which generated 26-group angular fluxes and generalized adjoints (28 FANISM runs with S_4, P_3). These fluxes and adjoints, as well as the 26-group microscopic cross sections, were combined by JULIET to obtain 26-group sensitivity coefficients for the important data of each nuclide in each material. The BUBBLE code, an ad hoc code written specifically for this purpose, was used to fold the sensitivities with the cross-section and fission-spectrum covariance matrices (ENDF/B-V) to generate a relative-flux covariance matrix.

The JULIET code was modified to compute the necessary generalized adjoint sources. The response functions for this analysis are the relative neutron fluxes for each group g averaged over the central region J ;

$$R_g = \frac{\phi_{gJ}}{\sum_i \phi_{iJ}} = \frac{\sum_{ij} \phi_{ij} \delta_{ig} \delta_{jJ}}{\sum_{ij} \phi_{ij} \delta_{jJ}}, \quad (1)$$

where δ_{ig} is the Kronecker delta, and i and j are group and interval indices, respectively. The generalized adjoint sources were computed from

$$S_{i'j'}^* = \frac{1}{R_g} \frac{\partial R_g}{\partial \phi_{i'j'}} = \frac{\delta_{i'g} \delta_{j'J}}{\phi_{gJ}} - \frac{\delta_{j'J}}{\sum_i \phi_{iJ}}. \quad (2)$$

Sensitivity coefficients were generated for all CERMF nuclear data of any importance (2548 sensitivity profiles). Several sensitivities are quite large, including those for ^{10}B capture, ^{238}U elastic and inelastic scattering, ^{238}U capture, H total, Fe total, ^{238}U χ and ν , and ^{235}U χ and ν . The main

coupling between the thermal driver core and the central fast-flux spectrum is through the ^{235}U fission spectrum. Total sensitivities for ^{238}U determined by adjoint sensitivity theory compare well with those computed by the direct method.

Table 1 lists the central relative flux as well as the relative standard deviations obtained from this analysis. The uncertainties in the fast-group fluxes are mainly due to uncertainties in the fission spectrum and the inelastic-scattering cross sections of ^{238}U . The ^{238}U scattering data has large uncertainties as well as large sensitivities, so it is the main contributor to the flux standard deviations throughout the energy range. Capture and fission cross-section uncertainties for ^{238}U are also large contributors. The ^{10}B cross-section sensitivities are very high, but the corresponding uncertainties are low, so ^{10}B does not affect the spectrum standard deviations as much as the ^{238}U data.

Finally, the full flux-spectrum covariance matrix for the CFRMF is strongly correlated. Thus, there is a strong motivation for including the off-diagonal elements in data-testing and cross-section adjustment application.

REFERENCES

1. JW Rogers, D. A. Millsap, and Y. D. Harker, "CFRMF Neutron Field Flux Spectral Characterization," Nucl. Technol., 25, 330 (1975)
2. N. M. Greene et al., "AMPX: A Modular Code System for Generating Coupled Multigroup Neutron-Gamma Libraries from ENDF/B," ORNL/TM-3706 (1976)
3. J. L. Lucius et al., "A Users Manual for the FORSS Sensitivity and Uncertainty Analysis Code System," ORNL-5316 (1977)

TABLE 1. CFRMF CENTRAL RELATIVE FLUX PER UNIT LETHARGY WITH RELATIVE STANDARD DEVIATIONS DUE TO CROSS SECTION UNCERTAINTIES

<u>Group Index</u>	<u>Upper Energy Boundary (eV)</u>	<u>Central Relative Flux</u>	<u>% Relative Std. Deviation</u>
1	1.7330+7	0.6684-3	12.59
2	1.0000+7	0.1097-1	8.63
3	6.0633+6	0.5029-1	8.50
4	3.6788+6	0.1065+0	8.14
5	2.2313+6	0.1424+0	6.84
6	1.3534+6	0.2197+0	3.67
7	8.2085+5	0.3272+0	2.47
8	4.9787+5	0.3149+0	2.39
9	3.0197+5	0.2493+0	2.52
10	1.8316+5	0.1801+0	5.09
11	1.1109+5	0.1283+0	4.17
12	6.7380+4	0.8945-1	4.37
13	4.0868+4	0.5201-1	5.15
14	2.4788+4	0.3529-1	3.89
15	1.5034+4	0.2341-1	3.53
16	9.1188+3	0.1619-1	3.53
17	5.5308+3	0.1403-1	3.02
18	3.3546+3	0.1008-1	2.89
19	2.0347+3	0.8847-2	2.68
20	1.2341+3	0.8104-2	2.97
21	7.4852+2	0.5149-2	2.95
22	4.5400+2	0.3193-2	2.88
23	2.7536+2	0.2358-2	3.10
24	1.6702+2	0.5474-3	2.98
25	1.0130+2	0.8697-3	4.00
26	6.1442+1	0.1644-5	3.14