IEC-105

REPORT TO THE NEANSC WORKING PARTY ON INTERNATIONAL EVALUATION COOPERATION FOR THE MAY, 1994 MEETING IN OAK RIDGE

Subgroup 15: Self-Shielding in the Unresolved Resonance Region for Structural Materials

Monitor: D. C. Larson, ORNL
Coordinator: F. Froehner, KfK

Objective: The objective of this Subgroup is to 1) understand the effects of self-shielding above the resonance region on shielding and transport benchmark calculations, 2) determine the importance of a correct treatment of the effects, and 3) recommend procedures for representing the physics in this region in a manner consistent with processing code capabilities.

Scope: The scope of this Subgroup includes consideration of the important structural material isotopes, particularly 52Cr, 56Fe and 58,60Ni. The energy range is typically from the energy of the first inelastic level to about 4 MeV, or to an energy where the inherent widths of overlapping resonances washes out experimentally observable structure.

Membership: L. Leal, ORNL
R. MacFarlane, LANL
P. Petrizzi, ENEA, Frascati
T. Nakagawa, JAERI
A. Hasegawa, JAERI
M. Mattes, IKE Stuttgart
H. Weigmann, IRMM Geel
A. Hogenbirk, ECN Petten
V. Manokhin, CJD Obninsk

Work Program: (Provided mainly by F. Froehner) Initially, the work will be centered on extending studies of the effects of self-shielding in the resolved resonance region in 56Fe from 850 keV to 7 MeV to understand effects of properly including this effect on benchmark testing. Often, above the resolved resonance region in the structural materials, the sharp structure is abruptly changed to an energy-averaged smooth cross section. One avenue being investigated is the use of fluctuation factors to describe the self-shielding effects. High resolution total cross section data from Geel and ORELA will be compared, and fluctuation factors extracted. A method will be developed to properly represent these factors within available evaluation formats to allow processing by standard processing codes. The work will be extended to 58,60Ni following completion of the iron work.

Status: Smoothed total cross sections and fluctuation factors were extracted at KfK from the Geel high-resolution measurement of neutron transmission through 48 mm of natural Fe (Berthold et al. 1992) for energies between 862 keV and 7 MeV. (Below this range one has resolved resonance parameters, above it the fluctuations are drowned in counting statistics.) Smooth cross sections and fluctuation factors were sent to Petrizzi, Hogenbirk, Nakagawa and M. Mattes for benchmark calculations. In the meantime the

Geel 16 mm data and the ORNL data on Fe56 have been treated in the same way, both at Geel and KfK. Conclusions on the accuracy of average total cross sections for iron will be presented at Gatlinburg in May. Berthold from Geel came to KfK twice to compare his data with Monte Carlo calculations that he performed with the self-shielding code SESH. The objective was (1) to find out how well the resonance structure is actually resolved in the Geel data, (2) to see whether Monte Carlo calculations based on resonance ladder sampling are able to predict the cross section fluctuations. Optical-model calculations performed with the SCAT2 code at KfK provided SESH input, in particular energy-dependent strength functions (ratios of resonance widths to level spacings) and effective nuclear radii. It was confirmed that up to 7 MeV mainly the partial waves with $l=0,1,2,3$ contribute. As SESH in its present shape cannot cope rigorously with inelastic channels an approximate treatment of their influence had to be used. Another difficulty was the failure of available optical potentials to reproduce the averaged Fe total cross section below 2-3 MeV.

Hot off the press from Fritz: Spurred on by the difficulties encountered with Monte Carlo I finally managed to generalize the analytical result presented at Aix, viz. that the variance of the (zero-temperature) total cross section is proportional to the OM transmission coefficient for pure scatterers. If nonelastic processes are important (for 56Fe above about 1 MeV) the variance is simply proportional to the difference between the OM compound nucleus formation cross section and the average nonelastic cross section as obtained from Hauser-Feshbach theory with width fluctuations. Calculated relative standard deviations agree well with the Geel data, indicating that all essential structure was in fact resolved - contrary to what I thought at Aix.

Plans:

Future plans depend very much on the assessment of the benchmarking results by fission and fusion data users. At the moment it is sure that the resonance structure observed for iron, and somewhat less definitely also for nickel and chromium, is important for shielding applications and activation calculations. It is therefore planned to superpose the fluctuations on the IRK group constant evaluation for Fe56 (Vonach et al. 1992) at least for those cross section types that dominate shielding (total, elastic, inelastic) and activation. Concerning activation it must be realized, however, that Fe56 cross sections cannot really replace those of Fe54, Fe57 and Fe58 in natural Fe. High-resolution transmission measurements on natural Ni and Cr and possibly on their main isotopes, similar to those performed on Fe and Fe56 at Geel and Oak Ridge, should be made. On the theoretical side the problem of optical potentials for energies below 2-3 MeV needs attention, and a resonance-sampling Monte Carlo code with full account of inelastic scattering should be developed for prediction of yet unmeasured fluctuations.