IEC-24

INTERNATIONAL EVALUATION COOPERATION TASK 1.1: INTERCOMPARISON OF EVALUATED FILES FOR ^{52}Cr, ^{56}Fe, AND ^{58}Ni

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Abstract: The cross sections and energy and angular distributions in the JENDL-3, JEF-2/EFF-2, and ENDF/B-VI evaluations for ^{52}Cr, ^{56}Fe, and ^{58}Ni are compared graphically. The purpose is to understand the reasons for observed discrepancies among the evaluations, and to suggest recommendations for improvements. The accomplishments to date are presented.

(^{52}Cr, ^{56}Fe, ^{58}Ni, cross section, evaluation)

1. Introduction

Task 1.1 is one of seven in a NEACRP/NEANDC Task Force on Evaluation Cooperation organized to promote international evaluation collaboration. The purpose of Task 1.1 is to graphically compare selected evaluations for structural materials from ENDF/B-VI (USA), JEF-2/EFF-2 (Europe), and JENDL-3 (Japan). The isotopes ^{52}Cr, ^{56}Fe, and ^{58}Ni are especially interesting because they are important components of steel and because new evaluations for them have recently been completed for each library. In Section 2, a summary of the completed comparisons is presented. An attempt to resolve major discrepancies is described in Section 3. Section 4 contains recommendations for remaining work and for improvements.

2. Summary of the Comparisons

The following comments are based on the consensus of a meeting of the subgroup held on Dec. 3, 1990, at the NEA Data Bank, Saclay, France. Detailed recommendations for improvements are available upon request. Only results of general interest or having the largest discrepancy are presented here.

The spread for the **nonelastic cross sections** is less than 3% for ^{52}Cr and ^{56}Fe and less than 15% for ^{58}Ni. This deviation is correlated with the partial reaction cross sections discussed below. For example, a 3% difference in the ^{56}Fe nonelastic cross section at 14 MeV could result from a 10% deviation in the ^{56}Fe$(n,2n)$ cross section and result in a 10% discrepancy in the total gamma-ray production cross section.

The **inelastic scattering cross sections** behave much like the nonelastic. Because these cross sections are important for shielding (pressure vessel surveillance, fusion blanket) calculations, perhaps 2% accuracy up to 14 MeV is needed. The intercomparison shows differences as much as 20% in the 2 to 4 MeV region.

The $(n,2n)$ **cross sections** seem satisfactory for chromium and nickel due to adequate data bases. However, the 20% spread in ^{56}Fe at 14 MeV could result in large discrepancies in calculated neutron transmission through thick iron spheres with a central 14-MeV source.

The (n,α) **cross sections** have large spreads among the evaluations. In general, there are two different shapes. Below 14 MeV, EFF-2 is relatively low and ENDF/B-VI is relatively high. The worst case is for ^{58}Ni which is shown in Fig. 1. The data shown are from Qaim et al. [1,2]. The possible explanation for this discrepancy is explored on the basis of further information furnished by the evaluators and is described in Section 3. It is recommended that more experimental data be taken at energies between 8 and 10 MeV for all three isotopes in view of the importance of this cross section in radiation damage studies. An IAEA CRP has been proposed to study this problem.

The **energy distributions of outgoing neutrons** show large differences, in particular for ^{58}Ni at 11 MeV, shown in Fig. 2. It was decided that more information was needed from the evaluators to understand these discrepancies. This follow-through is discussed in Section 3. Furthermore, experimental double differential measurements for iron at energies below 14 MeV are strongly encouraged.

The **cross sections for photon production** as a function of incident neutron energy were found to be in substantial disagreement: from 4 to 10 MeV for ^{52}Cr, above 8 MeV for ^{56}Fe, and above 4 MeV for ^{58}Ni. The discussion was centered on ^{56}Fe, shown in Fig. 3. Two suggested reasons for the discrepancies are given in Section 3.

3. The Larger Discrepancies

The following discussions are based on data supplied by the evaluators after the Dec. 3, 1990, meeting.

Possible reasons suggested for the discrepancies seen in Fig. 1 for the (n,α) **cross sections** were: competition of other channels, alpha-particle optical model, level density in the residual nuclides, and preformation factors in pre-equilibrium models. It was concluded during the meeting that the last point should be studied first. The findings are: JENDL-3 used the Iwamoto-Harada model [3] for the preformation factors, EFF-2 used the Milazzo-Colli model [4], and ENDF/B-VI used the Kalbach model

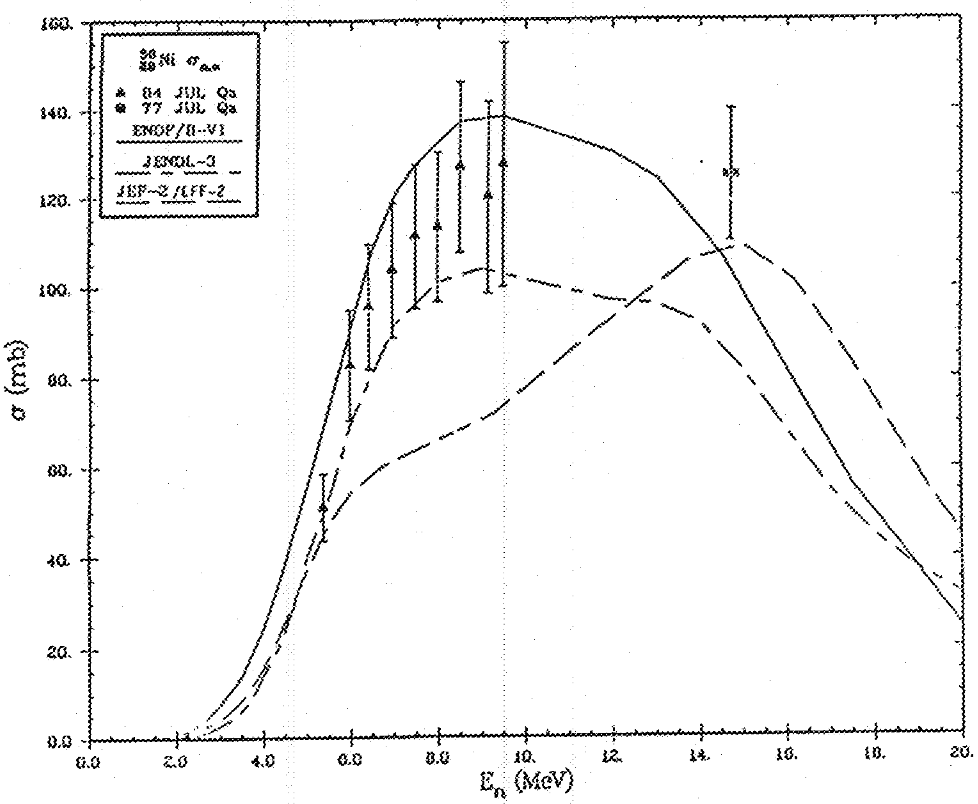

Fig. 1. Comparison of the $^{58}Ni(n,\alpha)$ cross sections from the three evaluations.

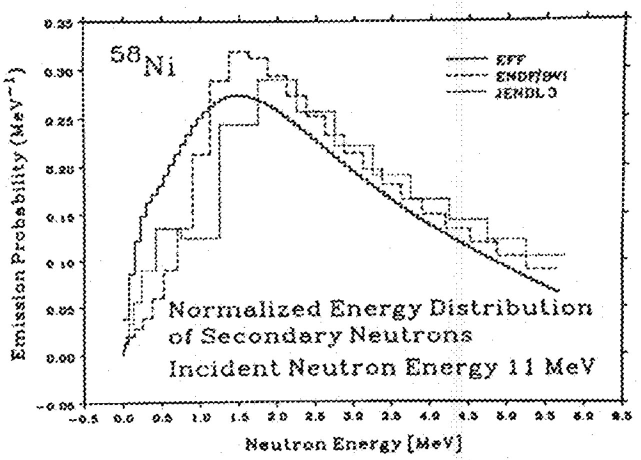

Fig. 2. Comparison of the ^{58}Ni secondary neutron distributions from the three evaluations.

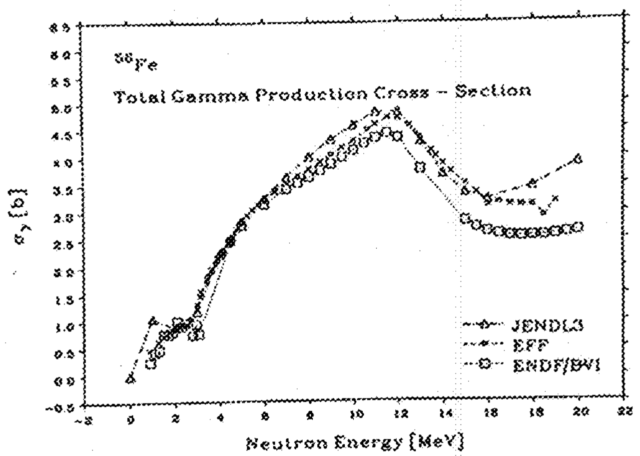

Fig. 3. Comparison of the ^{56}Fe photon production cross sections from the three evaluations.

[5] modified to include spin dependence [6]. The differences in these formulas cannot be easily sorted out because the precompound models in which these preformation factors reside are also different. This difficulty could be an interesting topic for further international cooperation work.

The evaluators for JENDL-3 and ENDF/B-VI have also furnished the **level densities for ^{55}Fe**, the residual nuclide in the $^{58}Ni(n,\alpha)$ reaction. The JENDL-3 values are substantially larger. However, trends in level densities and shape of the $^{58}Ni(n,\alpha)$ cross sections are not correlated. So the problem remains unresolved.

The **level densities for ^{58}Ni** used in JENDL-3 for calculating neutron emission spectra have the lowest temperature (steepest rise) and those for ENDF/B-VI the highest temperature. This trend is inconsistent with observed differences in the neutron emission spectra for E_n = 11 MeV shown in Fig. 2. The largest discrepancy seen in Fig. 2 is in the low $E_{n'}$ side where the calculated neutron emission spectra are the most sensitive to the level-density variations. Other explanations have to be sought.

The **cross sections for photon production in ^{56}Fe**, shown in Fig. 3, could be improved by consideration of two possibilities. The first is that the two major measurements for iron, Dickens et al. [7] and Chapman et al. [8], disagree. The former data are lower than the latter by nearly a factor of 2 around 8 MeV and 14 MeV. This may have caused some confusion. The preliminary conclusion is that Chapman's data are better at 8 MeV while Dickens' are better at 14 MeV. The second possibility has to do with a 3.5% spread in the evaluated nonelastic cross sections near 14 MeV for ^{56}Fe. Due to a photon multiplicity of 3, the spread in the nonelastic cross section at 14 MeV can produce a 10% discrepancy in photon production.

4. Recommendations

Some of the recommendations by this working group have already been mentioned in the above Sections. Three more suggestions are given below.

Due to the importance of the **resolved resonance range** in fission reactor applications it should be studied in detail in the near future. In addition, it was suggested to compare group constants (3 per decade) in order to find important differences.

The **double differential neutron emission** cross sections can be correctly represented only by the File-6 format. Since JENDL-3 does not use File-6 for this purpose, some problems in the comparison can be anticipated. A revision in JENDL-3 for at least one of the three isotopes to make use of the File-6 format is needed.

Vonach et al. [9] have provided an independent evaluation for the **14-MeV cross sections** of ^{52}Cr, ^{56}Fe, and ^{58,60}Ni based solely on experimental data. The initially evaluated nonelastic cross section and the sum of the partial cross sections were inconsistent and have been resolved by least-squares adjustment. It is recommended that all evaluators consider this evaluation in their future revisions.

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