Consolidated Fuel Reprocessing Program

CALCULATED K-EFFECTIVES USING ENDF/B-V DATA FOR U+Pu SOLUTION CRITICAL EXPERIMENTS

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Effective multiplication factors for 12 critical experiments have been calculated using multigroup cross sections derived from the ENDF/B-V library. All 12 experiments contained mixed plutonium and uranium nitrate solutions. The range of hydrogen-to-fissile plutonium atom ratios spanned by these experiments was 200 to 2200. A comparison with K-effectives calculated with ENDF/B-IV data is presented.

The most recent version of the Evaluated Nuclear Data File, ENDF/B-V, was released in July 1979. This point data was collapsed to a 227-group library released in June 1980. An "in-house" 27-group library was recently prepared at ORNL from the larger, 227-group master library. This 27-group library was used with KENO-IV to calculate K-effectives. The AMPX-II computer code module, NITAWL, was used to perform the Nordheim integral treatment for the resolved resonance region.

Before 1981, 64 critical experiments had been conducted with mixed plutonium and uranium nitrate solution. The K-effectives for these experiments have been calculated with KENO-IV and a 27-group library.

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derived from ENDF/B-IV data. Calculated K-effective were correlated according to hydrogen-to-fissile plutonium atomic ratios, and a first-order, least-squares, Legendre polynomial fit was made to the multiplication factors for calculated configurations not containing boron or gadolinium. Equation (1) is the fit to these 45 unpoisoned experiments.

\[ K\text{-effective} = 1.00775 + 3.90466\times10^{-6} \frac{[H]}{(^{239}\text{Pu} + ^{241}\text{Pu})} \]  

To evaluate the ENDF/B-V derived library, a subset of 12 experiments was selected from the larger group of 64. These 12 experiments spanned the range of hydrogen-to-fissile plutonium ratios covered by the larger set. The subset included experiments performed with a solution with a high (23 wt\% of Pu) $^{240}$Pu content as well as experiments conducted with low (5 wt\% of Pu) $^{240}$Pu solutions. Two experiments performed with soluble gadolinium in the solution were calculated. Both British and U.S. experiments were included in the subset. The group also included experiments conducted in spherical vessels and some conducted in cylindrical tanks.

A second, linear fit was made to the ENDF/B-IV calculations of this subset of experiments only (again only unpoisoned experiments were correlated with hydrogen-to-fissile plutonium atomic ratio). The linear fit is given by Eq. (2). The good agreement between Eqs. (1) and (2) (maximum difference in calculated K-effective is 0.004 at H/Pu = 2200) indicates that the small subset is a representative sample of the entire group.

\[ K\text{-effective} = 1.00978 + 0.969837\times10^{-6} \frac{[H]}{(^{239}\text{Pu} + ^{241}\text{Pu})} \]
Calculated K-effectives using the ENDF/B-V derived cross sections are shown in Fig. 1. A linear fit to these data, defined in Eq. (3), is also shown.

\[ K\text{-effective} = 1.01023 + 1.60003 \times 10^{-6} \frac{H}{(^{239}\text{Pu} + ^{241}\text{Pu})} \] (3)

The linear fit to the ten ENDF/B-IV calculations, Eq. (2), is plotted as a dotted line. All ENDF/B-V calculated values were within two standard deviations of the values calculated with ENDF/B-IV derived cross sections. Thus, it is seen that the cross-section data from the more recent ENDF/B-V library does not substantially improve agreement between calculation and experiment.

Agreement in calculated K-effectives does not guarantee that the same flux spectra would be calculated with each library. The one-dimensional, discrete ordinates code, XSDRNPM,\(^5\) (also a module of AMPX-II) was used to calculate flux spectra for the experiments with the smallest and largest hydrogen-to-fissile plutonium atom ratios. Figure 2 shows the calculated, volume weighted spectra. It is evident that good agreement is seen in all groups except the fastest and most thermal.

Calculated K-effectives have been examined for 12 critical experiments conducted with mixed uranium and plutonium solutions. Essentially, the same results are obtained with ENDF/B-V cross sections as are obtained with ENDF/B-IV data. Calculated flux spectra for two experiments are also in good agreement.
Figure 1

K-EFFECTIVE CALCULATION OF HOMOGENEOUS U + PU EXPERIMENTS USING KENO-IV AND 27 GROUP CROSS SECTIONS FROM ENDF/B-V

Linear fit to ENDF/B-V calculations

Linear fit to ENDF/B-IV calculations

- PNL, High Pu-240
- UKAEA
- PNL, Low Pu-240
- PNL, Spheres
- PNL, Gd poisoned

H/(Pu-239 + Pu-241) (at.)
Figure 2
CALCULATED FLUX SPECTRA USING XSDRNPM AND TWO 27 GROUP CROSS SECTION LIBRARIES

Energy (eV)

Flux/Total Flux

- H/Fissile Pu=237 (at.), ENDF/B-V
- H/Fissile Pu=237 (at.), ENDF/B-IV
- H/Fissile Pu=2170 (at.), ENDF/B-V
- H/Fissile Pu=2170 (at.), ENDF/B-IV

$10^{-1}$ $10^{-2}$ $10^{-3}$
References


