LA-UR-85-1730

RECEIVED BY OSTI JUN 07 1985

CONF-850507--17

LA-UR--85-1730

DE85 012728

TITLE: APPLICATION OF EVALUATED FISSION-PRODUCT DELAYED-NEUTRON PRECURSOR DATA IN REACTOR KINETICS CALCULATIONS

AUTHOR(S):

R. T. Perry, W. B. Wilson, T. R. England, M. C. Brady

SUBMITTED TO: International Conference on Nuclear Data for Basic and Applied Science, Santa Fe, NM, May 13-17, 1985

DISCLAIMER

MASTER

Los Alamos Los Alamos National Laboratory
Los Alamos, New Mexico 87545

FORM NO. 836 R4
ST NO. 2629 5/81

APPLICATION OF EVALUATED FISSION-PRODUCT DELAYED-NEUTRON PRECURSOR DATA IN REACTOR KINETICS CALCULATIONS

ROBERT T. PERRY
Texas A & M University, College Station, Texas, U.S.A.
WILLIAM B. WILSON, TALMADGE R. ENGLAND
Los Alamos National Laboratory, Los Alamos, N.M., U.S.A.
MICHAELE C. BRADY
Texas A & M University, College Station, Texas, U.S.A.

Astract Evaluated fission-product yield and decay data have been used to describe 105 delayed neutron precursors explicitly in point reactor kinetics calculations. Results calculated for ^{235}U thermal fission show that rod-drop reactivity values obtained from kinetics calculations with 6-group precursor data are considerably higher than those calculated with explicit delayed-neutron precursor data. The calculated kinetics associated with positive reactivity steps are significantly different.

INTRODUCTION

The temporal production of β^-,n delayed neutrons following fission have routinely been described using six precursor groups. These groups originated as 6-term, 12-parameter fits to experimentally measured count rates following fission-pulse and saturation-irradiation experiments with critical assemblies.[1,2] Use of the 6-group delayed-neutron representation in reactor kinetics calculations has become an industry standard.

Six-group data, describing the aggregate temporal delayed-neutron behavior, have been progressively reevaluated[3] for versions of ENDF/B.[4] Also measurements, nuclear model code calculations, and evaluation efforts continue to expand the data describing the production and decay of the individual fission-product delayed-neutron precursor nuclides. The fission-product decay data and fission yields of ENDF/B-V[4] and the updated precursor decay data of England et al.[5] form one consistent reference set of data with which a variety of delayed-neutron properties have been calculated.

This data set includes the identity, decay constant, neutron branching (P_n) value, detailed neutron emission spectrum, and fission yield of 105 delayed neutron precursors. Each of these are yielded directly in fission; all but one are also produced by

the decay of one or more parent fission-product nuclides. The description of the temporal activity and delayed-neutron production rate of each of the 105 precursors requires the description of the temporal activity of 121 additional parent radionuclides.

DELAYED-NEUTRON PRODUCTION RATE CALCULATIONS

Modifications were made to ATREK-3[6] point reactor kinetics code to solve the differential equations describing the production and decay of each of the radionuclides. Code input was divided into problem-dependent, nuclide-decay,and fission-yield data files. The modified code AIREK-10, which calculates precursor inventory and nuetron density (or power) at specified times following a reactivity insertion, was validated for pulse and saturation calculations by comparison of delayed-neutron production rates calculated with CINDER-10[7], producing essentially identical results for all cooling times calculated (≤500s). Similar agreement was observed between AIREK-10 calculated neutron densities (power) and analytic solutions obtained for step reactivities of +$0.50, using a library of 7 fictitious precursors with complex couplings, and of -$3.00, using the library of all 226 radionuclides.

AIREK-10 226-nuclide and 6-group calculations were made of delayed-neutron production rates following a ^{235}U thermal fission pulse, as shown in Fig. 1. The 6-group data sets were taken from Keepin, et al. [1,2], ENDF/B-V[4], and from England, et al.;[5] this last 6-group set sorts the 105 individual precursor contributions by half-life into the 6 temporal groups, ignoring the effects of parent nuclides. The comparison of production rates calculated with each of the 6-group sets to that calculated with 226 nuclides, given in Fig. 2, shows that all of the 6-group functions predict a lower delayed neutron production rate for the first 2-3 s, after which the production rate is calculated to be higher. (The total number of delayed neutrons per fission $\bar{\nu}_d$ is the same in all calculations.)

POINT REACTOR KINETICS CALCULATIONS

Calculations of relative neutron density, or power, were made with AIREK-10 following +$0.50 and -$1.00 reactivity steps, using the ENDF/B-V 6-group and 226-nuclide ^{235}U thermal-fission libraries. These results for the first 20 s following the reactivity steps, given in Fig. 3, show fair agreement for negative $1 reactivity steps but significantly higher neutron density (power) increases calculated with explicit nuclide data for positive 50¢ reactivity steps. Figure 4, showing typical reactor rod-drop calibration curves calculated for ^{235}U thermal fission using the same two libraries, indicate that a reactivity measurement evaluated at $3.00 with explicit nuclide data would be evaluated at $3.23 with the ENDF/B-V 6-group functions.

CONCLUSIONS

Reactivity evaluations made for ^{235}U thermal fission with 6-group functions are significantly higher than those made with explicit nuclide data. Explicit nuclide reactivity calculations could seriously impact design and operating-reactor reactivity evaluations for all fuels.

REFERENCES

1. G. R. Keepin, T. F. Wimett, and R. K. Zeigler, Phys. Rev. 107, 1044 (1957).
2. G. R. Keepin, T. F. Wimett, and R. K. Zeigler, J. Nucl. Energy 6, 1 (1957).
3. S. A. Cox, ANL/NDM-5 (1974).
4. Evaluated Nuclear Data Files, Vers. V, dist. by NNDC, Brookhaven National Laboratory.
5. T. R. England, W. B. Wilson, R. E. Schenter, and F. M. Mann, Nucl. Sci. Eng. 85, 139 (1983).
6. L. R. Blue and M. Hoffman, AMTD-131 (1963).
7. T. R. England, R. Wilcxynski, and N. L. Whittemore, Los Alamos National Laboratory rept. LA-5885-MS (1975).

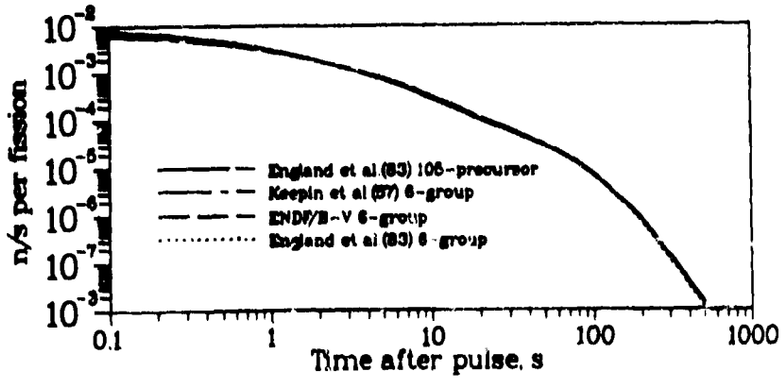

FIGURE 1 Calculated delayed neutron production rates following a ^{235}U thermal fission pulse.

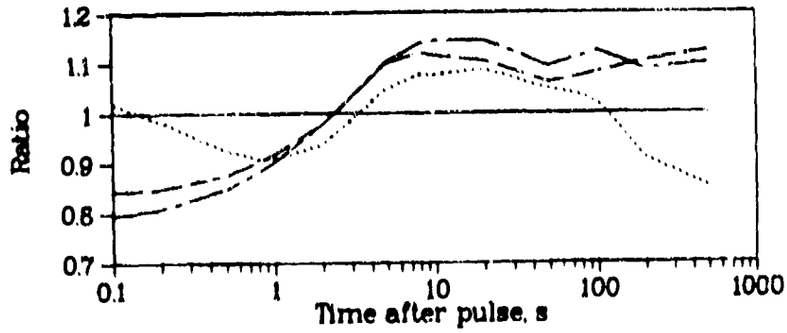

FIGURE 2 Ratio of 6-group to 105-precursor calculated delayed neutron production rates following a ^{235}U thermal fission pulse.

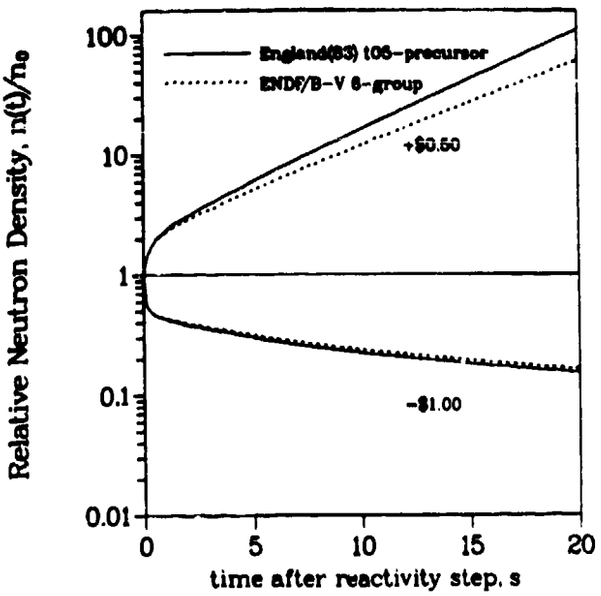

FIGURE 3 Comparison of 105-precursor and ENDF/B-V 6-group calculated neutron density following +$0.50 and -$1.00 step reactivity inputs, ^{235}U thermal fission.

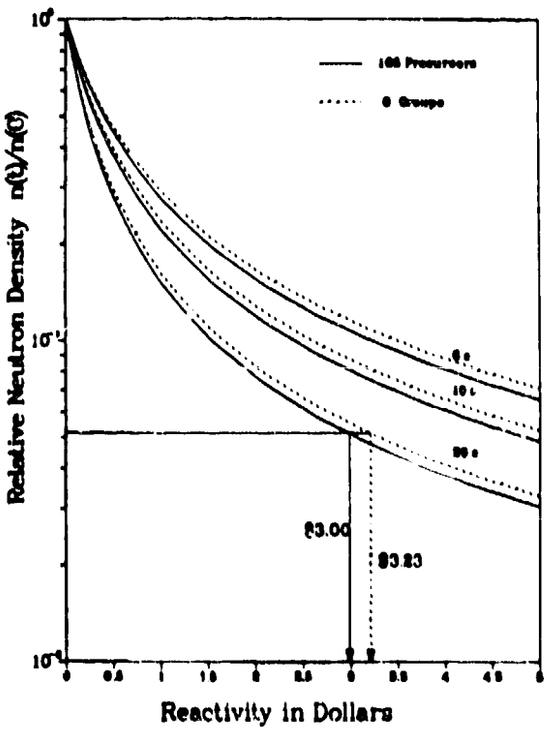

FIGURE 4 Rod calibration curves, ^{235}U thermal fission.