PREFACE

DATA DEVELOPMENT AND TESTING FOR FAST REACTOR DOSIMETRY

W. N. McELROY

Westinghouse Hanford Company, Richland, Washington 99352

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JOURNAL ARTICLES

The articles in this issue of *Nuclear Technology* are based on eleven invited and five contributed papers given at two sessions of the November 1973 Winter Meeting of the American Nuclear Society (ANS) in San Francisco, California.[1] The organization of these sessions was a joint effort of the session chairmen, T. C. Reuther, Jr. and P. B. Hemmig of the Division of Reactor Research and Development of the U.S. Atomic Energy Commission (USAEC), participants of the Interlaboratory LMFBR Reaction Rate (ILRR) program, the chairman, D. K. Dudziak, of the ANS Shielding and Dosimetry Division, and members of that division's program committee under the chairmanship of J. A. Lonergan.

The main impetus for these two sessions and the invited papers came from the ILRR program. However, even the invited papers, as well as the contributed papers, include material from the more general area of fuels and materials dosimetry and reactor physics. To provide the reader with an understanding of the relationship of the various papers herein, a description of the ILRR program and its relationship to the general area of fast-reactor dosimetry is now presented.

ILRR PROGRAM

The ILRR program[2] was initiated in 1971 under the sponsorship of the USAEC to develop a capability to determine consistent and reliable experimental values for reaction rates in various well-established and permanent neutron fields. The reaction rates obtained provide calibrations for the subsequent determination of fission rates, burnup, and flux-fluence spectra in high-flux test reactors. The purpose of this work is to provide basic information that is applicable to LMFBR fuels and materials development programs.

Strong operative links have been established between the ILRR program, the Center for Radiation Research Neutron Standards program[3] at the National Bureau of Standards (NBS), and the Centre d'Étude de l'Énergie Nucléaire-Studiecentrum Voor Kernenergie (CEN-SCK) Standard Neutron Field program at Mol, Belgium,[4] to help in the international standardization of dosimetry for LMFBR programs.[5]

The requirement of permanence of the neutron fields, as well as the need to use precise fission rate monitors, means that relatively low-intensity facilities must be used in the ILRR program. However, it is also necessary that the basic information obtained, and the techniques used, be applicable to high-flux environments [e.g., the Experimental Breeder Reactor II (EBR-II) at Argonne National Laboratory (ANL), Idaho; the Fast Flux Test Facility (FFTF) at Hanford Engineering Development Laboratory (HEDL), Washington; the high-flux Belgium Reactor-2 (BR2) at CEN-SCK, Mol, Belgium; etc.].

Explicitly, the ILRR program involves the following:

1. Irradiations in a series of permanent facilities with well-defined neutron spectra. The spectra in these facilities have generally been ascertained by both calculations and experiments. The existing facilities being used are the Coupled Fast Reactivity Measurements Facility (CFRMF) at Aerojet Nuclear Company, the 10% enriched ^{235}U critical assembly (BIG-10) at Los Alamos Scientific Laboratory, the Natural Uranium Secondary Standard Neutron Field ($\Sigma\Sigma$) at Mol, Belgium, the thermal, 1/E, and fission neutron fields at the National Bureau of Standards and Mol, and the Intermediate-Energy Standard Neu-

tron Fields (ISNF) under development at NBS and Mol. In addition, measurements have been made in a temporary facility, the Fast Test Reactor Engineering Mockup Critical (EMC) at Argonne National Laboratory.

2. The procurement and development of properly encapsulated and mass assayed activation foils for use in the above irradiations.

3. Tests of the consistency of the gamma-ray spectrometry results from the participating laboratories. For this purpose, different foil types are irradiated under reproducible conditions and then sent to the participating laboratories for gamma-ray counting.

4. The determination of absolute fission rates for ^{235}U, ^{238}U, ^{239}Pu, and ^{237}Np at foil irradiation positions in each facility by means of NBS fission chamber and secondarily by ANL solid-state track-recorder measurements.

5. The determination of decay rates in irradiated activation foils for (a) key fission products important for monitoring high-flux fuels tests, and (b) certain nonfission reactions important for characterizing the energy spectrum for such tests.

6. The determination of ^{4}He production reaction rates, especially for ^{6}Li and ^{10}B, by high-sensitivity helium mass spectrometry to provide (a) a highly accurate independent integral measurement on the consistency of their differential cross sections, and (b) to demonstrate the practical use of these reactions as stable-product helium generation fluence monitors.

7. The determination of fission yields and fission-yield ratios by the combined use of the measured decay rates (for the production of key fission products such as ^{95}Zr, ^{103}Ru, ^{137}Cs, and ^{140}Ba) (item 5 above) and the measured fission rates (item 4). These, in turn, will be combined with fission-yield-ratio measurements in EBR-II, FFTF, etc., for the same fission products and those determined by mass spectrometry (particularly ^{143}Nd, ^{145}Nd, ^{146}Nd, ^{148}Nd, and ^{150}Nd) to establish a direct calibration base for high accuracy (2 to 5%) mixed-oxide fuel-fission rate and burnup measurements. This calibration procedure will be traceable to NBS fission chamber measurements using NBS reference fissionable deposits and presently quoted to an accuracy of 1.5 to 2%.

8. The use of ILRR program measured values of fission yields and reaction rates for data testing of evaluated fission yields and evaluated dosimetry cross sections, particularly for those on the ENDF/B file. The measured values of reaction rates will be compared with the values calculated from the neutron spectrum and evaluated energy-dependent cross sections. The extent of agreement between the measured and calculated values indicates consistency at this time of evaluated cross sections and neutron energy spectra for well-characterized neutron fields.

The initial ILRR goal is a (1σ) accuracy of $\pm 2\frac{1}{2}\%$ or better for the reaction rate measurements of the principal fission products of ^{235}U, ^{238}U, and ^{239}Pu. For the fission products of ^{237}Np and nonfission reactions, the accuracy goal has been ±5% or better, although a value of $\pm 2\frac{1}{2}\%$ or better is desired for the determination of flux-spectra fluence for mixed-oxide fuel experiments.

Until the time of the ANS meeting, most of the ILRR program reaction-rate measurements had been made in the CFRMF at ANC. This included experiments identified in items 4 through 6 above. A few foil activations were made in the EMC facility at ANL. However, this was not a permanent facility, and the value of the results is limited by the inability to satisfactorily compare the results from various laboratories. Results are reported in one paper on fission rate and fission product measurements for ^{232}Th irradiated in a ^{252}Cf neutron field. This work was an independent effort, separate from the ILRR program.

The individual laboratories have, of course, performed measurements relating to this program which are independent of the ILRR program. In all cases, information for the various irradiation facilities exists in varying degrees of completeness for reaction rates, neutron spectrum, flux gradients, and flux-level reproducibility, etc. Generally, the ILRR program requires better and more complete information than is presently available.

OTHER PROGRAMS AND RELATIONSHIPS

Although the irradiation facilities to be used in the ILRR program have neutron spectra which extend from thermal to fission, the primary emphasis is on spectra which resemble those of FFTF and EBR-II and other fast reactors. This is necessary since the goal of the program is to provide experimental fission yields and techniques for measuring reaction rates and flux-fluence spectra that are applicable to these reactors. Also, it is for these spectra that one wishes to test the calculated integral cross sections (or reaction rates). Therefore, ILRR program work is being carefully integrated with other efforts to measure reaction rates in high-flux reactors, especially EBR-II, BR2, etc., in order to contribute to the international standardization of dosimetry for LMFBR fuels and materials development programs.

For the USAEC effort, most of the high-flux measurements have been done in EBR-II which represents the "real world" of high-flux fast test reactors. Data from these EBR-II experiments are included at several points in the following papers. It should be remembered, however, that in several ways the data from such facilities may not have the same quality as the ILRR experiments. For example, the redundant gamma-ray counting may not exist, and in the case of high-flux test reactors the neutron flux spectra can change significantly with time and core loading.

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