PREFACE

PHYSICS OF NUCLEAR MATERIALS SAFEGUARDS

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The intent of the nuclear materials safeguards program is the prevention of diversion of nuclear materials from their declared usage into unlawful usage. Methods are being developed which will facilitate early detection of diversion. The general aspects of the program have been discussed quite extensively during the last several years[1-3] since the inception of the program.

Several new techniques and major improvements in existing techniques have been introduced since 1967. Some of these new techniques are starting to play useful and important roles in quality control in the nuclear industry. In some instances they complement the existing quality control assay techniques and in other cases the new nondestructive nuclear assay techniques make possible measurements which were hitherto impossible, especially for relatively large samples. In many instances the achieved accuracies are comparable to those obtained by conventional techniques. For large heterogeneous samples, nondestructive techniques often provide the only meaningful assays. Detailed descriptions of most of the nondestructive nuclear material assay techniques can be found in Refs. 2 and 3.

The purpose of the proceedings of the special session published in this issue of *Nuclear Technology* is to discuss the basic reactor and nuclear physics aspects of the nondestructive active (i.e., using external radiation source) techniques. The techniques discussed are those which were or are being developed and used in the field of nuclear material safeguards and quality control.

The proceedings consist of six papers, each followed by a discussion. The first paper, "Physics of Nuclear Materials Safeguards Techniques," by Gozani, reviews briefly the existing techniques and discusses the basic interactions of neutrons and photons, as interrogating particles, with the nuclear materials being assayed and non-nuclear matrix materials. Existing areas that require further studies are discussed. The second paper, "Near Barrier Fission Induced with Photons," by Huizenga, discusses the physics of interactions of low energy photons in the energy region below the fission barrier (typically 6 MeV) to slightly above. Expressions are given for the various quantities of interest and comparisons are made with some of the available experimental data. Similar treatment of near barrier fission induced by neutrons by the same author can be found in Ref. 4. The third paper, "Low Energy Photofission of Heavy Elements—Experimental Results," by Bramblett et al., describes some experimental techniques used in the field of low energy photonuclear research. Recent experimental results are summarized and discussed. The fourth paper, "Theory of Delayed-Neutron Physics," by Tomlinson, discusses the theory of emission of delayed neutrons and compares the current theories with experimental data. The fifth paper, "Physics of Delayed Neutrons—Recent Experimental Results," by Keepin, contains some most recent experimental results on delayed neutron yields. The sixth paper, "Application of Neutron Techniques in the Nondestructive Assay of Fissile Materials,"

by Stegemann, discusses mainly the applications of the lead pile spectrometer to the nuclear materials safeguards area along with some new extensions of this technique. The discussions recorded during the sessions follow each paper and may serve as a further illumination of some of the aspects touched upon in the papers.

The authors represent as much as possible the international expertise in the specific area as well as the laboratories involved in major programs in the development and application of nuclear materials safeguards techniques.

REFERENCES

1. *Proc. Intern. Conf. Constructive Uses of Atomic Energy,* Washington, D.C., November 10-15, 1968.

2. *Proc. Symp. Safeguards Research and Development,* WASH-1147, Los Alamos-San Diego, October 27-29, 1969, U.S. Atomic Energy Commission.

3. *Proc. Symp. Progress in Safeguards Techniques,* Karlsruhe, July 6-10, 1970, International Atomic Energy Agency.

4. J. R. HUIZENGA and R. VANDERBOSCH, *The Nuclear Fission,* to be published by Academic Press, Inc.