Conference. If one considers the extensive reactor experience with materials such as the zirconium alloys, and the new information on irradiation damage, the coverage in this section is of limited value. The ceramic data are newer, albeit somewhat superficial.

In Volume II, Section C presents a generalized history of fuel elements. The imbalance due to lack of coverage since 1960 is apparent, when one sees only 4 pages devoted to ceramic fuels in a 90-page section

Section D discusses various moderators, including graphite, beryllium oxide, hydrides, light and heavy water, and organics. There have been substantial revisions in the parts dealing with beryllium oxide, the hydrides, and light and heavy water. While the graphite coverage is substantial, it predates 1960, and lacks much of the late information on irradiation effects. The beryllium oxide coverage is satisfactory, but is completely lacking in reference citations. In the organics chapter, the pre-1960 coverage is excellent and extensive. One could use it with considerable confidence as a complete coverage prior to 1960, and update from that time.

Section E represents a superficial coverage of metallic and ceramic control materials. There is very little to recommend it.

The final section (F) covers coolants. The chapter covering gaseous coolants is the best in either book in this reviewer's opinion. It presents an excellent, up-to-date, well-balanced picture of gaseous reactor coolants, covering selection and purification, as well as reactions with metallic and ceramic fuels, structural and cladding materials, and moderators. The graphical information is very good. The remainder of the section dealing with water and liquid metal coolants is much less satisfactory. Too much of the information is generalized, and too little presents the current state-of-the-art in water-cooled and liquid-metal-cooled reactors. The index is reasonably satisfactory, though not outstanding.

If one examines the two volumes as an entity, it is apparent that there are rather severe imbalances in the emphasis on the various chapters, and in the coverage relative to its current importance in the reactor field. For example, one might appreciate the excellent coverage in organics, but feel that 100 pages devoted to this topic is hardly justified. The reviewer feels that the editors devoted too little time to establishing the relative importance of the sections and chapters. In fact, the variability from chapter to chapter in referencing, handling of data, and methods of presentation leads one to believe that there was little reviewing or editing.

While many aspects of science do not change markedly over a span of four or five years, this does not apply to so rapidly a changing field as reactor and materials technology. A substantial share of the information presented is technically obsolete, due to changes in material compositions, fabrication processes, newer and better information on properties, and a better understanding of the behavior of materials in reactor environments Some of the information presented is excellent and up to date. Unfortunately, this is not true for the major portion of this book, and it is rather difficult to recommend a two-volume text where nearly 80% of the coverage is of historic rather than current technologic interest.

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About the Reviewer: Dr. Bush is presently consultant to the Director of the Pacific Northwest Laboratory of the Battelle Memorial Institute. He has been associated with Hanford operations since 1953, principally with the General Electric Company, where he held supervisory positions in metallurgy and in reactor fuel fabrication, following completion of his academic work at the University of Michigan. Irradiation effects and fabrication processes of nuclear materials are among the reviewer's major interests along with reactor safety and information retrieval processes. Dr. Bush is the author of numerous publications in these fields including the ASM-AEC monograph Radiation Effects in Reactor Structure and Cladding Materials *and chapters in the* Reactor Handbook.

Non-Destructive Testing in Nuclear Technology, Vol. I, II. Proceedings of a Symposium on Non-Destructive Testing in Nuclear Technology held by the IAEA in Bucharest, 17-21 May 1965. Published by the International Atomic Energy Agency, Vienna. Distributed by the National Agency for International Publications, Inc., 317 East 34th Street, New York 16, N. Y. (1965). Vol. I, 392 pp. $8.00. Vol. II, 446 pp. $9.00.

Forty-six technical papers from 15 different countries were presented at this symposium. In excess of 35 different nondestructive techniques for detecting defects in materials or for determining physical or mechanical properties of nuclear materials or components were discussed. Although none of the techniques discussed was entirely new, many unique variations and applications to specific problems were presented.

Ultrasonic, eddy-current, and radiographic methods for measuring wall thickness and for detecting mechanical defects in tubing, used as cladding for fuel elements, were discussed in many of the papers. Slight variations exist between the techniques used in Europe and the United States. For example, many of the European speakers reported the use of two transducers for detecting longitudinal cracks in tubing by an ultrasonic method; generally, only one transducer is used in the USA. Nevertheless, the basic theory of the techniques is the same. Most of the papers described testing for defects that penetrated five to ten percent of the wall thickness, and for wall thickness variations of about plus one percent. The only unusual technique, described by Bonnet and Jansen, involved the radiography of a single wall of a tube by placing rolled film on a high-density mandrel and inserting it into the tube. The complete assembly was then rotated in a lathe under a low-energy collimated x-ray source. This permitted them to obtain a much higher resolution radiograph.

Two papers discussed the ultrasonic inspection of metallic uranium billets and rolled rod for internal defects. In addition, five of the papers presented data obtained from ultrasonic attenuation studies. The attenuation of the ultrasonic beam through a uranium or a uranium-alloy matrix is related to grain size and is used to insure proper heat-treating techniques. Considerable attention was also given to the evaluation of coated fuel particles. Microradiography was discussed in three papers for this application. In this technique, enlarged images are obtained, either by an x-ray projection system or by photographic enlargements of fine-grain x-ray film. In either case, low-energy x-rays were used and enlargements varying from 30 to 100 X were obtained. From these microradiographs several things could be determined, including the thickness and the integrity of the fueled cores. Alpha counting techniques were also employed to detect uranium contamination of the coatings.

Several papers discussed means of detecting the distribution and the homogeneity of fuels within a fuel element. A variety of techniques was described, depending somewhat on the type of fuels, geometry of the fuel element, and the desired accuracy. These techniques included microradiography, external-gamma and x-ray attenuation measurements, Archimedes principle, and gamma counting. More information with higher accuracy was obtained using gamma counting techniques; however, gamma counting is more time-consuming and more sensitive to geometrical considerations than most of the other techniques. In most cases, the gamma counting was done on the 184-keV peak for the determination of the concentration of ^{235}U. Bond testing of fuel elements was accomplished by either ultrasonic pulse echo or through transmission techniques, with emphasis on the automation of these techniques. Fuel-element closure welds were inspected both by radiographic and ultrasonic methods. Leaks in these welds were detected by helium leak-testing techniques.

Dimensional analysis, including the measurements of core width and thickness, cladding thickness, tube diameter, and fuel plate spacing were determined by x-ray, gamma attenuation, ultrasonics, eddy currents, air gauges, and various pneumatic and mechanical linkage devices.

Dimensional analysis, radiography, leak-testing, and visual examinations of irradiated fuel elements were carried out remotely. In two cases, betatrons were used to obtain radiographs. McKane and Honkonen reported that they performed dimensional analysis on samples under water to reduce dimensional changes that would occur in air, due to self-heating of the sample.

Gamma counting techniques were used to determine the burnup of irradiated fuels. The gamma peak from ^{144}Pr (half-life of 285 days) was used to determine the number of fissions attributed to ^{235}U. The gamma peak for ^{106}Rh (half-life of 370 days) was used to determine the number of fissions attributed to ^{39}Pu.

Several papers covered the determination of physical and mechanical properties of either fueled or unfueled components as a function of temperature or irradiation dose. These techniques included the measurement of the mechanical resonant frequencies of rods for computing the dynamic elastic constants. Internal friction was measured by resonant damping and by ultrasonic attenuation techniques, and the electrical conductivity was measured by eddy current techniques.

The use of radiographic and ultrasonic techniques to determine the integrity of welds in pressure vessels was discussed in several papers. Some discussion of the base materials was also presented. McGonnagle discussed the application of the ASTM Boiler Code for Nuclear Vessels in Sec. 3.

Eddy current and ultrasonic techniques were used to detect defects in heat exchanger tubing both before and after assembly in the heat exchanger.

Nearly every phase of nondestructive testing of nuclear materials and components was covered in this symposium. Many of the papers dealt with complete nondestructive quality-control programs used at different sites.

An enormous amount of technical data is contained in these papers and it is far beyond the scope of this review to give complete coverage of all these data.

It is worthy to note that, in general, the nondestructive testing techniques and standards used in nuclear technology are quite similar and almost uniform around the world.

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About the Reviewer: Jack P. Clark is a Senior Engineer with the Materials Evaluation Group in the Engineering Operation of the Nuclear Materials and Propulsion Operation, Nuclear Technology Department of the General Electric Company.

From 1952 to 1956, Mr. Clark studied mechanical engineering at the University of Cincinnati. In 1956, he joined the General Electric Aircraft Nuclear Propulsion Department, where he worked in the field of nondestructive testing. In 1961, he was registered as a professional engineer in the state of Ohio, and, since that time, he has devoted his whole time to nondestructive testing at General Electric's Nuclear Materials and Propulsion Operation.

He is the author of several papers on specialized nondestructive testing techniques, and is familiar with most of the nondestructive tests and techniques in use in the nuclear industry in the United States.

He is past Chairman and Vice Chairman, and is presently a member of the Board of Directors of the Miami Valley Chapter of the Society for Nondestructive Testing.

Naval Reactors Physics Handbook, Vol. I, Selected Basic Techniques. A. Radkowsky, Editor, Naval Reactors, DRD, USAEC, (1964). 1545 pp. (Available from Superintendent of Documents, Washington, D. C., 20402). (Price unknown).

Although this volume is called a Handbook, it is in spirit more of a review and status report of the accomplishments of the Naval and Shippingport PWR reactor physics programs. As might be expected in so massive a tome (1545 pages, 76 authors), the work is of uneven quality and of varying vintage. However, it is clear that the Naval Reactors program has come a long way since the days when Radkowsky worked at Argonne on the neutron transport properties of water, Henry worked at Bettis on nodal methods in reactor kinetics, or Hellens worked on few-group calculations for water lattices. The accomplishments of the program are many and varied as is indicated by a mere listing of the names of some of the authors: Hurwitz, Selengut, Francis, Klein, Amster, Kaplan, Feiner, Goldman, Harris, Gelbard, Wachspress, etc., and others such as Krasik, Sampson, Stark, Weil, Ehrlich, Zweifel, Krieger, Nelkin, and Varga whose contributions were important at early stages of the work.

The reviewer's acquaintance with Rickover's domain dates back to 1952. In 1951, the USAEC asked BNL to investigate the feasibility of a proposed slightly enriched uranium-water reactor for power and plutonium production. The next year, this proposed reactor was scrapped, but the BNL uranium-water lattice experiments were continued in support of an aircraft carrier reactor proposed by Rickover. When this proposal also went down the drain, the Shippingport PWR reactor sprang up to take its place and to support a cooperative experimental program be-