Book Reviews

Energy From Heaven and Earth. By Edward Teller. W. H. Freeman and Company, Publishers (1979). 233 pp. 59 illustrations. $15.00.

My favorite Edward Teller story goes back to 1964 when we both served on a National Academy Committee. It was the time when the newspapers were at their peak of anti-Tellerism. At intermission during the first meeting, a biologist who had never met Edward Teller exclaimed to me, "Is that really Edward Teller? He is the most reasonable, as well as brilliant, person in this room!"

This story is an appropriate prelude to a review of Teller's *Energy From Heaven and Earth*, for this book is a delightful display of Edward Teller's calm reason as well as broad knowledge. This contrasts sharply with other, more pretentious books on energy, particularly the Harvard Study Project *Energy Futures*, that serve not to enlighten, but to polarize the debate over nuclear energy. Teller is not blatantly pro-nuclear; he accepts all possible energy sources, and insists that we need all of them. He tends to be optimistic about the technological future. Perhaps best, he concedes, unlike many other energy experts, that some of his previous estimates–for example, the energy demand in 2000–were wrong.

This is not intended as a scholarly work. Instead, it is an elementary, nonmathematical guided tour of energy in all its manifestations. It begins with cosmic energies, then examines each of the energy technologies, and ends with Teller's recipes for a coherent energy policy. The book is in good part based on the 1975 Harvey Prize Lectures Teller delivered at the Technion in Israel. It therefore catches Teller's speaking style very accurately: the short, definite sentences leavened always with appealing humor.

Readers of *Nuclear Science and Engineering* will be fascinated by Teller's account of the origins of the Manhattan Project, and of the Advisory Committee on Reactor Safety. (I wonder if the present generation remembers that it was Edward Teller, more than any other individual, who was responsible for the original concern over reactor safety and who laid the basis for the scientific study of reactor safety.)

The country and the world needs antidotes such as *Energy From Heaven and Earth* to the current spate of anti-rational, let alone anti-nuclear, energy studies. The book would make a great gift for a nonexpert friend.

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About the Reviewer: Alvin Weinberg is presently the director of the Institute of Energy Analysis, a part of the Oak Ridge Associated Universities, and, additionally, is general editor of the Perspectives in Energy Series *published by the MIT Press. Weinberg's broad experience in these and related matters dates back to Met Lab days, followed, of course, by long service as the director of the Oak Ridge National Laboratory.*

Nuclear Safeguards Analysis. E. Arnold Hakkila, Ed. American Chemical Society, New York (1978). $22.00.

In spite of the current unrest among certain segments of the population, based on an aversion to nuclear energy, the present and future needs for electric power almost necessitate the operation of nuclear reactors. This means that safeguards for the control of uranium and plutonium must be considered of the utmost importance. This is not unique to the U.S., since many nations throughout the world obtain power from nuclear reactors. In all instances, uranium and plutonium of various isotopic composition are used or are formed in the power reactors.

The present volume, entitled *Nuclear Safeguards Analysis*, consists of 12 articles and is based on a symposium held in March 1978 at the 175th meeting of the American Chemical Society.

The Division of Technical Information of the Atomic Energy Commission published "Selected Measurements for Plutonium and Uranium in the Nuclear Fuel Cycle" in 1963. It was revised in 1972. The current volume is a compilation of articles on present practices, which updates this previous information.

The first article is an excellent summary on the "Safeguards Needs in the Measurement Area." A survey is made in the "realm of measurements" of the new techniques in chemical analysis as well as nondestructive testing of nuclear materials in the complex nuclear fuel cycle.

In addition to the possibility of terrorist groups obtaining material for a nuclear explosive, the diversion of nuclear materials to foreign countries for the preparation of their own nuclear explosives also has been a possibility. In 1966, Federal regulations were adopted placing a specific obligation on the domestic private industrial sector to safeguard strategic nuclear material.

Because in a plant the diversity of materials to be analyzed in feed, process, product, and waste streams may vary from nearly pure uranium and plutonium solutions to items such as casting crucibles, rubber gloves, floor sweepings, etc., it is necessary to have, in addition to chemical and instrumental methods, other methods that are nondestructive, rapid, and with satisfactory precision and accuracy for the case in point.

In addition to methods for determining uranium and plutonium composition, the isotopic composition of these elements is necessary.

To be certain of the accuracy of a method, even though it be very precise, it is necessary to have standards that are certified by a national agency, such as the National Bureau of Standards, or by an international organization, such as the International Atomic Energy Agency.

Preparation and secondary certification on uranium materials was started in the Uranium Section of the Chemistry Division of the Bureau of Standards. In 1949, on the removal of the Uranium Section to New Brunswick under the U.S. Atomic Energy Commission, this work continued. After several years, the Bureau of Standards took an added interest in uranium and plutonium standards.

The second and third articles show the present status of the standard reference materials by the National Bureau of Standards and that of the New Brunswick Laboratory, now located at Argonne, Illinois. It is interesting to note that the National Bureau of Standards has opened a laboratory at Argonne for use in plutonium, chemical, and isotopic standardization. The third article lists the standards available for uranium and plutonium content as well as those to be used for isotopic abundance measurements.

As far back as 1963, the International Atomic Energy Agency considered the issuance of international standards. It is interesting to note that some progress in the international field may be forthcoming.

Owing to the cost and scarcity of Bureau of Standard certified standards, it is not reasonable to use them as working standards. Plant standards after verification will of necessity be used, but they will have to be referred finally to the National Bureau of Standards materials. The secondary standards distributed by the New Brunswick Laboratory represent typical materials currently found in nuclear fuel cycles.

A nonlinear method for including the mass uncertainty of standards and the system measurements errors in the fitting of calibration curves is given in the fifth article, by workers at the Lawrence Livermore Laboratory.

In the seventh, the use of isotopic safeguards technique is described. This work has been in progress at Battelle-Pacific Northwest Laboratories for a decade or more. The plutonium content of spent fuel at the input of a reprocessing plant was the basic reason for developing the isotopic safeguards concept. Because of the large number of isotopic variables and functions possible, automated decision and identification techniques need to be incorporated. Computer calculations have greatly improved the efficiency and precision of the method. Examples are given of the plutonium-uranium ratio and of the consistency in isotopic analysis of samples from actual reactor cores.

The sixth article, from the European Institute for Transuranic Elements and Kernforschungszentrum Karlsruhe in the Federal Republic of Germany, reports the progress in the verification of reprocessing input analyses for nuclear materials safeguards. An automatic x-ray fluorescence spectrometer with automatic sample preparation and a laboratory for automatic isotope dilution analyses is in routine use for analyzing samples taken by Euratom safeguards inspectors. An automatic mass spectrometer aided by a high-vacuum lock is used for continuous sample feeding.

The current status of the energy-dispersive absorption edge densitometry (x-ray absorption edge spectrometry) is detailed by the Los Alamos Scientific Laboratory (LASL) group in the eighth article. In the future, densitometry techniques should see considerable usage in the following areas: the analytical laboratory, in-line instrumentation for safeguards and process control, and portable instrumentation by inspectors. A description of the technique is given.

The application of on-line alpha-particle monitors in process streams is reported in the ninth article by Allied-General Nuclear Services in Barnwell, South Carolina. It would appear that the studies, in the initial stage, and the application to safeguards analysis should await future developments.

The use of well-type Ge(Li) detectors is reported by Battelle-Pacific Northwest Laboratories in the tenth article. The analyses of microgram and submicrogram quantities of ^{235}U and ^{239}Pu are required for process control, nuclear safeguards, and effluent measurements. This article describes a well-type Ge(Li) detector for nondestructive analysis for rapid evaluation of ^{239}Pu and ^{235}U. It appears that for nuclear safeguards analysis certain variables have to be investigated. A potential application in nuclear safeguards accountability and uranium in waste streams may be of value.

The description of a portable calorimeter system for the nondestructive assay of mixed-oxide fuels as developed at the Argonne National Laboratory is detailed in the eleventh article. This piece of work is one of the outstanding presentations of this symposium. Few, if any, loose ends need to be considered.

Calorimetric assay provides a precise, nondestructive method to determine the plutonium content of samples based on the heat emitted by decaying radionuclides. This measurement, in combination with a gamma-ray spectrometer analysis of sample isotopic content, yields the total mass of plutonium in the sample. The technique is applicable to sealed containers and is essentially independent of sample matrices, configuration, and elemental composition. These instruments are designed to use a feedback system that applies power to maintain the sample chamber at a constant electrical resistance and therefore at a constant temperature. This device consists of the calorimeter, sample preheater, and a microprocessor–controlled data-acquisition system. An increase in the precision reported would be helpful.

An interesting description of an accountability measurement system at an operating fuel reprocessing facility is presented in the twelfth article from the Idaho Chemical Processing Plant. This plant is a multipurpose facility capable of recovering unfissioned uranium from enriched uranium fuel elements from research, tests, propulsion, and power reactors. The 25 yr of operation of this plant give it considerable experience in making and evaluating uranium accountability.

The process flow diagram gives an indication of the large number of samples requiring analysis. A photo of the remote analytical facility indicates the complexity of the operations. A description of the sampling and the diverse means of analyzing the sample is given. The structure and functions of the accountability measurements system are presented. Its performance is evaluated to illustrate the relation of analytical methodology to the overall measurement system.

Even if one is not directly interested in the nuclear safeguards problem, the description of the process is of considerable interest as general chemical knowledge.

While the emphasis on data collection is usually the result of complete measurement systems, just as important is the analysis of materials-accounting data to detect diversion of special nuclear materials. The fourth article, entitled "Decision Analysis for Nuclear Safeguards," reported by LASL, examines efficient methods for analyzing and interpreting safeguards data. An interesting example is presented on the application of decision analysis to materials accounting in a nuclear fuel reprocessing plant. To the analytical chemist, this is more illuminating than some of the mathematical-statistical treatments presented.

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About the Reviewer: Clement Rodden, now retired from the directorship of the U.S. Atomic Energy Commission New Brunswick Laboratory, had a distinguished career in heavy-element analytical procedures. Following graduate studies at New York University, he was associated with the Medical School of George Washington University. Rodden had a 12-yr tenure at the U.S. Bureau of Standards, where much of the uranium analysis for the Manhattan Project was done, before serving as director of the New Brunswick Laboratory from the time it was established in 1949 until his retirement in 1969. He is author and editor of several books on analytical methods for uranium and plutonium, including Analytical Chemistry of the Manhattan Project.