Chapter 6. "Heat Generation and Transport" by J. Weisman. This chapter serves as an introduction to the calculation and use of hot-channel factors. Unfortunately, the author spends a great deal of time on one-group diffusion theory and leaves a real impression that thermal design is accomplished using Bessel functions and chopped-cosine power shapes.

Chapter 7. "Fluid System Design" by J. H. Rust. The first third of this chapter is well written and deals with single-phase flow pressure-drop correlations; most of the problem set deals with this area. The more interesting area of incompressible flow is slighted, since much more could have been said concerning the simultaneous solution of the continuity, momentum, energy, and state equations. Two-phase flow is treated primarily through correlations, tables, and graphs.

Chapter 8. "Heat Transfer" by J. H. Rust. In this chapter, fluid-flow heat transfer is treated almost completely in terms of empirical correlations, while conduction heat transfer is reduced to fairly simple one-dimensional solutions. Precious little is said about computer methods and how they work.

Chapter 9. "Elements of Stress Analysis" by J. Weisman. This is a very short chapter to explain stress and strain to the uninitiated. The ideas of stress decomposition are not fully explained. This material should have been combined with that in Chap. 10, or the derivations in Chap. 10 should have been included here.

Chapter 10. "Vessel and Piping Design" by J. Weisman. The stress-strain equations are derived here, but unfortunately in the middle of the chapter. Most of the rest of the chapter seems to have come out of an ASME handbook. The author's description of nil ductility temperature and its behavior as a function of neutron damage is a bright spot.

Chapter 11. "Fuel Element Design" by P. E. MacDonald and I-Chih Wang. This chapter is easily the most scholarly, thorough, and up-to-date chapter in the book. It excels not only in the discussion of basic phenomena, but also in presentation of data and correlations and in detailed description of how all the information is used in design computer codes. The chapter contains the only use of SI units in the book and is essentially free of typographical errors.

Chapter 12. "Radioactivity Releases" by J. H. Leonard. This chapter presents data on the various isotopes present in a reactor system, and discusses in a simple manner the leakage of these isotopes out of the fuel, out of the containment, and their subsequent dispersion into the atmosphere. Unfortunately, large accidents are not mentioned.

Chapter 13. "Loss-of-Cooling Accidents" by J. Weisman. The primary difficulty with this chapter is its choppiness. Descriptions of subjects such as flow coastdown and loss-of-coolant accident philosophy are excellent, while the treatment of other portions such as shock wave propagation are perfunctory.

Chapter 14. "Reactivity Insertion Accidents" by K. S. Ram. This is the most disappointing chapter in the book, since it begins with a discussion of temperature coefficients based on the old four-factor formula. The idea of having different temperatures in a reactor and defining a power coefficient is not even mentioned. Most of the chapter is spent deriving the analytic point kinetics models known as Nordheim-Fuchs and Bethe-Tait. The space would have been better utilized by giving more details of the workings of some of the accident analysis computer codes used in industry, plus the results obtained therefrom.

In summary, the book contains a fairly complete description of various aspects of nuclear reactor design, as advertised. Unfortunately, the treatment is often cookbook in nature, with relatively little derivation and an assumption that the reader already knows the vocabulary of the subject matter. The problems are often tailored to using tables, graphs, or given formulas to obtain a solution. Many problems cannot be done using only the knowledge given in the chapter. Some problems are poorly written.

One of my colleagues at the University of Virginia has already tried using this book as the text for a graduate course. Both he and his students were disappointed with it. While others may experience a somewhat different result, in my judgment it would be relatively difficult to teach from this book.

On the other hand, I found the book to be an interesting review and update of a number of subjects that are outside of my current areas of interest. To that extent, *Elements of Nuclear Reactor Design* has value as a reference book; I intend to keep my copy handy and refer to it from time to time.

Roger Alan Rydin (BS, electrical engineering, Northwestern University, 1957; MS, nuclear engineering, Massachusetts Institute of Technology, 1958; ScD, 1964) is associate professor of nuclear engineering at the University of Virginia at Charlottesville. He is the author of Nuclear Reactor Theory and Design, 1977, *and has written many articles on reactor dynamics and control, computational methods, reactor measurements, and medical physics. He is a member of the American Nuclear Society and is on the Mathematics and Computation Division Executive Committee.*

Material Accountability: Theory, Verification, and Applications

Author	Rudolph Avenhaus
Publisher	John Wiley and Sons, Inc. (1977)
Pages	187
Price	$24.95
Reviewer	W. C. Bartels

This monograph presents a mathematical treatment of the accountability of materials in bulk form. It is presented under the auspices of the International Institute for Applied Systems Analysis. Principles for material balance accountability and verification and related systems aspects are developed. The development of principles is elegant and theoretical. Applications are described for materials used in an industrialized society, including basic materials, materials produced, and waste materials. The monograph and this review are focused primarily on the detailed treatment presented for nuclear materials subject to international nuclear material safeguards. Several other applications are treated or briefly mentioned in the last third of the monograph, including materials accountability in the chemical industry, industrial metals, economics, socialist economies, environmental studies, and arms control.

Avenhaus acknowledges early in the monograph that some may feel that a much more sophisticated formalism has been used than is necessary for treatment of his illustrative applications. A presentation of the principles of materials accountability that is more readily understood would be interesting and helpful to most readers with responsibilities in the field of nuclear materials accounting. The 1975 American Nuclear Society monograph, *Nuclear Materials: Accountability, Management, Safeguards*, by James E. Lovett gives such information. The 1973 U.S. Atomic Energy Commission publication, *Statistical Methods in Nuclear Material Control*, by John L. Jaech gives comprehensive information on applications of statistics to nuclear material control.

Avenhaus analyzes the safeguards application where materials accounting is applied to nuclear materials inventories and flows measurable and verifiable by a measurement technique. The plant operator measures all material and the inspection team verifies the plant operator's data by independent measurements of materials chosen on a random sampling basis. The material balance principle is applied to detect data falsification for the purpose of diverting material and evading detection. The contest between the inspection team and a would-be diverter is expressed in terms of zero-sum games, with payoffs to diverters and inspectors expressed in terms of probabilities of detection. The technique is then used to address the question of determining the optimal strategy for an inspection team. Examples considered include inventories containing different numbers of batches, materials, and measurement variances. Although the plant operator and inspector team are not required to use the same measurement technique, each is assumed to use only one measurement technique on any specific material to be measured.

The treatment in this monograph does not give sufficient attention to the common practice of an inspectorate that makes better use of the modern inspection tools at its disposal. Current practice includes the use of more than one verification technique by inspectors. Simple and quick measurements, as by nondestructive assay, are now made to detect any gross diversion from a large part of an inventory, while painstaking measurements to weigh, sample, and analyze materials are made on a far smaller part of an inventory to detect systematic bias. The ability of an inspection team to detect diversion has been greatly increased in this and other ways, including tamper-indicating monitors now in use to provide credible information on operations during the absence of inspectors.

The aspect of this game theory treatment that I found most difficult to accept is the degree of emphasis on a specific, preestablished limit to the amount of inspection effort allowed, even after an abnormality or discrepancy appears to have been found. According to Avenhaus, a second action level would follow such a discovery, but it would be limited to recalibration of instruments and a check for transcription errors and, if the difference persists, a report to the "international authority." Avenhaus does not look favorably, for instance, on making additional measurements and does not consider any other immediate action to clarify the situation. He feels there is a need to avoid disturbing the operation of a plant that must be protected against "overambitious" inspector teams. In my opinion, the possibility of further action should not be set aside so quickly because the immediate resolution of an identified, significant abnormality will be in the interest of the plant operator, his national government, and their presumed goal of international credibility.

William C. Bartels (BS, physics, Fordham University, 1944; MS, physics, Polytechnical Institute of Brooklyn, 1947) is a member of the American Nuclear Society (ANS) Nuclear Fuel Cycle Division and a past member of the Executive Board and Program Committee of that Division. He is also a member of the Institute for Nuclear Materials Management and has presented papers and participated in symposia of the International Atomic Energy Agency on nuclear materials safeguards. He has initiated and arranged for several ANS special sessions of invited papers and publication in Nuclear Technology *of groups of papers in such areas as safeguards and physical protection for nuclear materials. Prior to working in safeguards, Mr. Bartels was similarly active in reactor physics at various U.S. laboratories and private companies.*

Boiling Liquid-Metal Heat Transfer

Author	O. E. Dwyer
Publisher	American Nuclear Society (1976)
Pages	446
Price	$37.95
Reviewer	Adrian M. Tentner

One of the American Nuclear Society monograph series, this book provides an overview of the technical status of boiling liquid-metal heat transfer. Written for researchers, design engineers, and graduate students in nuclear, mechanical, and chemical engineering, the book contains detailed explanations of the theoretical aspects of liquid-metal boiling. The author refers to numerous papers and reports on original research in presenting a large amount of experimental data and various liquid-metal pool boiling heat transfer correlations.

Much of the information in the book, such as the calculated and experimental results, is based on sodium, thus rendering the book particularly useful to those involved in liquid-metal fast breeder reactor development and safety analysis. However, considerable information on potassium, mercury, rubidium, and cesium is also included.

Major sections of the book deal with incipient boiling superheats and growth of spherical bubbles in superheated liquid, the ebullition process in nucleate boiling, nucleate and film boiling heat transfer in pool boiling of liquid metals, and critical heat flux in nucleate pool boiling of liquid metals.

The book is well written, and the treatment of theoretical aspects of liquid-metal boiling is sufficiently basic so that useful application of them can be made to the