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Book Reviews

Radiation and Shielding in Space. By James W. Haffner. Academic Press, New York and London (1967). 347 pp. $17.50.

This is the first book devoted to the subject of space radiation shielding. The author intended it to be of interest principally to two groups: 1) the aerospace scientists who have a need for the conclusions of space radiation shielding studies; and 2) the shielding experts who would like a summary of the discipline of space radiation shielding.

The book treats topics in four general areas: 1) the particulate radiations in space; 2) the effects of radiation on men and materials; 3) the interaction of radiation with matter and descriptions of some computer programs involving these interactions; and 4) space radiation shielding calculations. The book is divided into nine chapters. The first three chapters are devoted to the first area. These chapters review the information available (as of 1966) on solar cosmic rays, galactic cosmic rays, and the geomagnetically trapped radiation. Chapter IV is devoted to the second area; Chaps. V, VI, and VII, to the third area; and the remaining two chapters, to the fourth area.

In the first chapter on solar particle radiation, the author discusses the phenomenology of plages, sunspots, flares, and radio and x-ray bursts; reports the composition, energy spectra, time behavior, and spatial dependence of the solar wind and the solar cosmic rays; relates geomagnetic disturbances to the solar wind, polar cap absorption events to solar flares, the Forbush decrease of galactic cosmic rays to increased solar activity, and identifies the distortion of the magnetosphere by the solar wind; and briefly mentions models for both the solar wind and solar flares.

In the second chapter on galactic (cosmic) radiation, the author treats the mass distribution, energy spectra, time variations, and spatial distribution of the cosmic rays and their interactions with the geomagnetic field and with the earth's atmosphere. He concludes the chapter by a brief discussion of source theories, storage theories, and acceleration theories of the galactic cosmic radiation.

In Chap. III on the earth's trapped radiation belts, the author first reviews the motion of charged particles in a magnetic field; then describes the composition, spatial extent, energy distributions, and time variations of the trapped particles; and then refers to the various theories on source and loss mechanisms before introducing a description of the man-made geomagnetically trapped radiation.

Chapter IV on radiation effects is divided in two parts. The first part treats the effects on man; the second, on materials. This chapter begins with a brief discussion of radiation interaction mechanisms on the atomic and molecular level and also on the cellular level. The author then introduces dose units, describes the energy dependence of tissue flux-to-dose conversion factors, and discusses the concept of relative biological effectiveness. In the next section on acute human response, the author reviews expected effects of acute whole-body radiation doses, describes the critical-organ concept, and discusses the problem of selecting dose limits for astronauts. In the final sections dealing with man, the discussion deals with delayed effects (such as cataracts, cancers, leukemia, life-shortening, and mutations), the possibility of biological recovery and the effective residual dose concept, and the possible use of biological protective measures (such as chemicals, blood transfusions, bone marrow transplants, and skin grafts). The second part of this chapter summarizes radiation damage thresholds for various classes of materials (including solar cells and photographic film) and briefly mentions some of the problems encountered in attempting to apply the available radiation effects information to spacecraft.

The interaction of charged particles with matter is reviewed in Chap. V. The usual formulas are given for the specific ionization energy loss of heavy charged particles and electrons and for the thin-target electron bremsstrahlung energy loss. After treating these electromagnetic interactions, the author discusses information available on nuclear interactions. The remainder of the chapter deals with the range-energy relations for heavy charged particles and for electrons.

The interactions of neutrons and photons with matter is reviewed in Chap. VI. Neutron processes described are elastic and inelastic scattering and absorption; gamma-ray processes are the photoelectric effect, Compton scattering, and pair production. The author then introduces the Boltzmann transport equation and reviews some approaches for solving this equation. The techniques reviewed for neutrons are the P and S approximations to the differential Boltzmann equation, the point kernel approximations to the integral Boltzmann equation, combinations of these two techniques, and Monte Carlo techniques. The moments method is reviewed for calculating gamma-ray attenuation. The chapter closes with a brief discussion of the scattering of radiation (around shadow shields or through a bent opening or duct through a shield).

Chapter VII on computer codes indicates the type of information that is available from computer code centers and gives brief descriptions of a few selected codes: internuclear cascade, nucleon transport, range and stopping power, proton penetration, secondary gamma ray, bremsstrahlung, mission flux, electron transport, combined electron and proton transport, two simplified geometry codes (called the spherical spacecraft code and the Apollo spacecraft code), and shield weight optimization.

Chapter VIII gives estimates of doses and dose rates from solar and galactic cosmic rays and from the geomagnetically trapped radiation. The dose rates and doses are calculated at the center of a spherical aluminum shell shield of constant thickness. The calculations are based on the assumption that the radiation sources are isotropic. This chapter closes its treatment with discussions of the

attenuation of space radiation by the earth's atmosphere and the deflection of charged particles by the geomagnetic field.

Mission analysis studies are discussed in Chap. IX. After discussing the effect of mission timing on space radiation doses, the author summarizes some of the studies that have been conducted to estimate mission doses and shield requirements for both earth orbital missions and deep space missions. After brief discussions of shield weight optimization studies and of operational procedures for reducing the dose, the author concludes this final chapter by mentioning active shielding concepts.

The book contains 710 references, 113 figures, and 34 tables. References are listed at the end of each chapter. Since much of the material treated has been the subject matter of several books, it is difficult for an author to be an expert or even up-to-date in each of the areas. One example of this deficiency is the fact that there is no mention of the dose-equivalent concept or the quality factor. Besides its share of typographical errors and outdated material, the book suffers in some instances from a lack of preciseness. The book would have benefited if the manuscript had been subjected to critical reading prior to publication.

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About the Reviewer: Richard Madey is Professor of Physics at Clarkson College of Technology in Potsdam, New York. He teaches courses in nuclear physics and in space science and is engaged in research in these areas. Prior to coming to Clarkson, he was Chief of Applied Physics Research at Republic Aviation Corporation. Previously, he conducted research in high-energy physics at the Lawrence Radiation Laboratory at Berkeley and at the Brookhaven National Laboratory. He received his PhD from the University of California at Berkeley and a BEE degree from Rensselaer Polytechnic Institute.

Pressure Vessel Design and Analysis. By M. B. Bickell and Carlos Ruiz. St. Martin's Press (1967). xii + 578 pp. $21.00.

The scope of the book is described best in a summary paragraph that appears on the jacket. It states: "The authors first deal with the establishment of Design Requirements and the Principal Codes; then treat in turn the Selection of Materials, Preliminary Layout, Elastic Stress Analysis, Cylindrical Shells, Spherical Shells, General Shells of Revolution, Applications to the more usual Vessel Components, Stress Analysis of Piping Systems; Survey of the Adequacy of the Design; and Potential Causes of Failure including Plastic Collapse, Fatigue and Incremental Collapse, Low Stress Brittle Fracture, Creep and Buckling."

There are too few books available devoted to both preliminary design and detailed analysis of pressure vessels. In this respect it fills a significant void. The material is developed in a logical order; however, it is unfortunate that each major topic is not treated with equal clarity, depth, and sophistication. The first three chapters on preliminary design (design requirements, selection of materials, and preliminary layout) are extremely general and may be of limited value. Most of the remaining thirteen chapters contain a clear, well-organized, and sophisticated treatment of stress analysis and related subjects and make the book a useful addition to any pressure vessel designer's bookshelf.

The authors appear to have missed an important point concerning the basic purpose of national pressure vessel codes. Consequently, in a few instances, the presentation seems to be somewhat less than completely objective; one example is cited. Paragraph 3.2, which pertains to allowable design stresses, states in part: "An apparent inconsistency is thus brought to light, namely, the fact that for a given material, different design stresses may be considered acceptable depending on the Code chosen.... This wide difference is explained by a more cautious approach in the U.S.A. than in Germany, but it is not necessarily true that a vessel designed to the lower stress is safer than a vessel for which the higher limit is used.... In the U.S.A., the acceptance of higher design stresses for the A.S.M.E. Section III may, ultimately, lead to a gradual approximation to European practice. However, at present the designer has to resign himself to the anomalous situation that a vessel considered to be safe in one country would be deemed unsafe in another."

The reviewer would paraphrase the last sentence to: "However, at present the designer has to resign himself to the anomalous situation that a vessel which is accepted for use in one country might not be accepted in another." The same theme is repeated in a few other places in the book. It is believed that the rapport between authors and readers might have been increased had a more positive approach been taken. Specifically, national codes could have been discussed in the light of 1) purpose, 2) limitations, 3) areas which are technically weak and in need of improvement because of recent technological advances, and 4) what action code-writing bodies are taking to update the documents.

Finally, it is not always clear when a statement concerning a detail of construction, etc., is based on a code requirement or is the result of a fundamentally rigorous stress analysis. A detail of construction that complies with a code will usually be satisfactory but may not be the best and, in some instances, it may be completely unsatisfactory. Unfortunately, some readers may be caught off guard!

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About the Reviewer: R. W. Schneider is Assistant Superintendent of the Inspection Engineering Department. He completed his undergraduate and graduate work in engineering at Lehigh University, Bethlehem, Pennsylvania. He is active on the Pressure Vessel Research Committee and on ASME Boiler and Pressure Vessel committees where he serves as chairman of the ASME Subgroup on Design Rules.