Effects of Radiation on Man, by Arthur C. Upton, provides a readable overview of this complex subject. After a description of radiation sickness and its syndroms, it describes the effects of prenatal irradiation, on longevity, on the incidence of cancer, and later somatic and genetic incidences.

As can be seen from this summary, the book provides quite a diversified menu. At its price, it is a bargain!

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About the Reviewer: Lothar Nordheim is a consultant for Gulf General Atomic Incorporated where he previously served as Chairman of the Theoretical Physics Department and as a Senior Research Advisor. Educated in Europe, he taught at Purdue and Duke Universities and also held positions at the Oak Ridge National Laboratory and at Los Alamos. His work in theoretical physics covers a wide spectrum including reactor, neutron, and nuclear physics. He is a Fellow of the American Nuclear and Physical Societies and a member of the Editorial Board of Nuclear Science and Engineering.

Engineering Compendium on Radiation Shielding, Vol. 1: Shielding Fundamentals, and Methods. Editor-in-Chief, R. G. Jaeger. Springer-Verlag, New York, Inc., New York and Berlin (1968). $60.00.

It is probably feasible to write a reasonable sounding review of this long-awaited volume without ever opening the covers of the book, or at least without going past the table of contents. One could hail the brilliant constellation of authors, a veritable who's-who of shielding experts, and pay tribute to the band of devoted editors who brought the volume to a successful completion. The breadth and detail of coverage could be praised, noting especially how much information is here gathered together that had previously been available only in widely scattered report literature. The long gestation period of the volume could be regretted, as it undoubtedly resulted in some of the material being obsolete before publication. It would also be safe to express some mild unhappiness over occasional duplication and diversity of viewpoints arising from the large number and variety of authors represented. And above all, one could deplore the exorbitant price of the volume, which restricts the access of those who indeed need-to-know more than any security classification could.

It would all be indisputably true—especially the last point. However, this volume, which has been the object of such concentrated effort by authors and editors, and which is of such potential value to the shielding community, calls for a discussion both more detailed and less superficial. In genesis, the *Engineering Compendium* of *Radiation Shielding* had the aim of providing a handbook of engineering solutions to design problems. The emphasis was intended to be on the words *engineering* and *design.* Sponsorship and overall guidance has been supplied by three of the divisions of the International Atomic Energy Agency. Early in the discussions of the editorial board convened by the Agency it was decided to broaden the task "to include well-referenced basic data for the research worker," to quote the preface. The aim, it was decided, would be (quoting further) "a complete presentation of the subject, covering and linking both the technology and the science of shielding." What has been published so far is Vol. 1 *Fundamentals* and *Methods* and for the most part corresponds to the science of shielding. The technology is still to come in Vol. 2, which will consist of a chapter on shielding materials and a long section on a wide range of shielding design situations ranging from shipping casks to ship propulsion reactors.

The magnitude of the material gathered here in Vol. 1, and the manpower required for the assembling, leave one a little shaken. The text comprises about 530 double-column printed pages. By my count, some 67 authors contributed and a distinguished board of seven editors (including the late E. P. Blizard) were needed to ride herd on them and coordinate their efforts as far as possible. The number of distinct and separately authored articles is difficult to determine, but must well exceed 50, ranging from less than a page or two (cf., that on photoneutron sources) to 25 page articles (such as that on neutron penetration in hydrogenous media). This collection of separate papers is grouped in 8 chapters organized along what are by now reasonably standard lines. After an introductory chapter on radiation units and limits there is a lengthy discussion of radiation sources. A general chapter on attenuation methods is followed by individual chapters on gamma-ray and neutron attentuation. Point kernel methods get a whole chapter followed by the last two chapters on heating in shields and the treatment of ducts and voids.

One naturally thinks of the previous handbooks in the shielding field, starting with the "Reactor Shielding Design Manual" (TID-7004), then the shielding portion of the first edition of the U.S. Atomic Energy Commission's *Reactor Handbook* (declassified version in AECD-3645) and most recently, the shielding volume of the second edition of the *Reactor Handbook* (Wiley-Interscience, 1962). What has the present volume of the Compendium to offer beyond these? One obvious and very important advantage is a greater timeliness. The last previous handbook is dated 1962 but was in fact completed in 1959 or 1960. Another is an international viewpoint. Previous handbooks had been confined to the US effort (and sometimes only a small part of *that*). While the majority of the Compendium authors come from the US (43) some nine other countries are represented, the USSR, alone, supplying ten authors. Finally, the material is not restricted as in the past to reactor shielding but the needs of other radiation sources, such as accelerators, are considered.

The Shielding Compendium thus seems to have every factor in its favor. And yet, turning its pages and making use of articles both in teaching and research, a definite sense of dissatisfaction, or better: unsatisfaction, develops. A number of the reasons for this feeling of disappointment are easy to identify. For example, on closer examination some of the advantages over the older handbooks have a tendency to evaporate, or at least show some drawbacks too. Thus, although the volume did not become available here till early this year, many of the articles had been written as long as three and four years ago. Even if I did not know this of personal knowledge, it would be clear from the reference lists, which rarely show anything beyond 1965. In a field where change can at times be rapid, the risk of "stale" information can be high. Some of the articles were, however, obviously written close to press time, resulting occasionally in a curious distortion of perspective. For example, both the NIOBE and the S_N solutions of the transport equation get articles about 10 to 11 columns long each. There is nothing (except perhaps the dates of the respective references) to inform the reader

that NIOBE on the one hand is only of historical interest (and pretty dusty history at that) while S_N has developed into one of the most important and powerful calculational methods available to the shielder. Many of the articles show pretty much the same content as their counterparts in the 1962 *Shielding Handbook*. This is particularly the case with the sections on radiation sources, which do not even reflect the most recent work of their own authors. One article, Sec. 6.7 on geometrical transformations, has been reproduced *in toto* from the 1962 edition of the *Shielding Handbook*.

The international distribution of the authors is not without its drawbacks either. It is valuable for the skilled expert to be exposed to a new and varied viewpoint. But the ordinary reader is to be forgiven if he is more confused than informed by successive articles on related topics written by authors with differing practices and recommendations. For example, the very first article by the US experts Rossi and Wyckoff, is a reproduction, with commentary, of the basic 1962 NBS *Handbook 84* on radiation quantities. There is here, i.a., a careful definition of such quantities as absorbed dose, kerma and quality factor (RBE to us old timers). The third article by the equally distinguished Soviet author Goussev, covers the relations between various doses and fluence or flux density. An apparent attempt has been made, somewhat clumsily, to graft on modern terminology to a different practice. But it may be noted that the manner of assigning Quality Factors differs from that recommended in the first article, and what is called "absorbed dose" for fast neutrons seems (from Eq. 1.3-13) to be "kerma" instead. After giving the Russian kerma-fluence relations, the almost universally used (in the US) Snyder-Neufeld dose-equivalent/unit fluence curve is casually mentioned (without reference) and displayed on a graph that is literally smaller than the Apollo-11 postage stamp. (Incidently, the only index reference to Snyder-Neufeld is to an offhand mention in an article on neutron ducts.) A similar juxtaposition, confusing to the tyro, occurs in Chap. 5 where three successive sections discuss (among other items) energy-dependent removal cross sections from the British, Russian, and Swedish viewpoints.

The broadening of the field beyond reactor sources is done in a spotty and half-hearted manner. Accelerator sources mainly appear in a 32-page section devoted mostly to an uneven, often absurdly detailed, discussion of the various types of particle accelerators. Perhaps the sponsorship of the IAEA precludes any wholehearted discussion of shielding in civil-defense; the 12-page section on air-scattering is quite inadequate as an introduction to that important and complex field. (As a side-note, both the US and the Canadian C. E. Cliffords are represented on the list of authors; no indication is given, however, that the author of Sec. 4.5.1. is the C. E. Clifford from Canada.)

Perhaps the basic problem confronting the Compendium arose when the decision was made to extend it from a purely engineering handbook to cover the fundamental scientific aspects of shielding. At that time it should also have been decided whether to stick to the austere format of a handbook, or whether to try for a monograph-like extensive exposition. Instead, the Compendium hovers uncertainly between the two choices and fulfills the function of neither properly. As a handbook, there are too many words. As a monographic survey, it is a broth with too many cooks—chopped up, diverse in viewpoints and levels, badly organized and therefore frequently repetitious. Thus, point-kernel methods are discussed in generalities in Chap. 3, and then, some distance below, the entire chapter 6 is devoted to the subject, repeating much of what was given as the earlier introduction. (Chap. 6, though ostensibly applicable to all radiation was clearly written only with gamma radiation in mind, and the bias comes to view explicitly in many of the sections). Again, empirical representation of buildup factors are described at length and with great clarity in Sec. 4.3.1.2. A fraction of the data for air is repeated in Sec. 4.5.3.2. Much of the discussion (and some of the tables) then reappears in Chap. 6, notably in Secs. 6.1.4.2, 6.5.1.3, and 6.5.1.4. Finally (or did I miss some?) Sec. 7.1.4.3 is entitled "Empirical Relations For the Buildup Factor." Most of these discussions are indeed cross referenced; but the multiplicity of appearances testifies to the editorial problems posed by the type of presentation chosen. It is difficult to understand, also, why the long and useful Sec. 3.3.1 entitled "Neutron Attenuation in Hydrogenous Media by the Method of Moments" appears in Chap. 3 on Radiation Attenuation Methods, rather than in the area of 5.2: "[Neutron] Attenuation in Hydrogeneous Media (methods and results)."

A detailed and dependable index is an essential aspect of any handbook; it is all the more important here where closely linked material is scattered rather widely. A random sampling, admittedly too small to be statistically significant, raises some doubts. The references to the neutron dose-fluence relation have already been mentioned. The index entry for "buildup factor, empirical formula" lists one of the pertinent sections; two others are under "analytic representation," and the remaining two do not seem to be indexed at all. Look up "meson," and what you get are some casual mentions of photomeson production; the discussion on p. 64 of μ-meson shielding, does not appear to be indexed at all. The index listing to "Monte Carlo" references three applications. I'm sure there must be many more Monte Carlo applications described in the text. A cursory search turned up the Monte Carlo version of the matrix method, and Leimdorfer's two long (and very very well presented) articles on gamma-ray and neutron albedos where, as the author points out, most of the work has been done by Monte Carlo. None of these are indexed under Monte Carlo.

It may be thought base ingratitude and tasteless carping to present these criticisms, when one considers the rich feast that the indefatigable authors and editors have spread before us. And it should be emphasized that the feast is indeed rich. Many of the articles are masterful presentations of material hitherto available only in a report literature so scattered as to require an expert in the specialty to collect it. The article on removal-diffusion methods is an extremely helpful exposition of a subject full of much arcana and craft-mystery. Similarly, Secs. 4.1 and 4.2 (distributed separately in September 1966 as NBS8681) represent an invaluable and authoritative, almost definitive, survey of gamma-ray absorption coefficients. But, to change metaphors, when you are offered a jewel at a Tiffany price, you examine it carefully under a magnifying glass for any possible flaws, no matter how small.

The price—there's the rub. It is the one aspect of this publication that colors all of one's thinking about it, that constantly intrudes in the evaluating process. The Shielding Compendium ought to be on the desk of everyone even remotely concerned with shielding. At the price charged, that's obviously impossible. In the preface, the editors hope "that it will be useful in teaching at colleges and universities." Indeed, the shielding course is probably the best place for the newcomer to be introduced to the Compendium, where he has a competent instructor to correct or supplement the deficiencies of the presentation. The

Shielding Compendium ought to be in the hands of every student in courses on radiation shielding—a recommendation obviously made ludicrous by the price. It is difficult enough to convince the usual college library to purchase a copy, at two or three times the price of comparable monographs. One can imagine the reluctance of libraries in the developing countries to acquire a copy even for reference. By setting the cost at this figure, the IAEA and the publishers have in one single action negated most of the value of the publication.

The economic arguments used by the publisher are clear. The market is small—a publisher in the US has estimated that after the initial library purchases, a textbook on shielding would sell less than 200 copies per year. On the other hand, the cost of producing the Compendium in the manner it has been issued is obviously high. The printing is superb, the binding excellent, the paper heavy and glossy. Even the rate of misprints has been kept down to tolerable levels.[a] These attributes would be virtues in most other publications, but because of their effect on the economics they are here definite drawbacks (except of course for the level of proofreading). The half-life of most information and design practices in shielding is probably five years or less. A new edition should certainly be out before then. Probably the physical quality of the publication need not be such that it survives more than five years of use. Further, with so restricted and easily identified a market, it seems quite reasonable that governmental programs should subsidize part of the publication and distribution. After all, they have already subsidized most of the time of the authors anyway. The proper mode of publication and distribution should therefore have been through one of the regular report-issuing mechanisms of the nuclear energy programs. Preferably each of the chapters should have been issued separately as soon as the material became available, much in the way ORNL is publishing the DASA Handbook on Weapon Effects Shielding.

The IAEA and the publishers, this reviewer is strongly convinced, have therefore commited a colossal blunder of judgement in the manner of publication chosen. But we have to live with the Compendium as it is, at least for the present edition. One of the editors is fond of pointing out the cost is only a buck an ounce. Another way of putting it, however, is that the book costs practically two-thirds its weight in solid silver. Whichever way you prefer, the Compendium is obviously a matter of some weight. This suggests a new line of reasoning. A glossy coated paper, such as used in the Compendium, may consist of something like 15% by weight of kaolin, with the composition $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$. The rest is cellulose which is roughly $C_6H_{10}O_5$ in average composition. The mixture of hydrogen and medium weight atoms that make up the paper should therefore be a reasonably efficient material to shield against fast and intermediate neutrons, and provide some gamma shielding. If you run into difficulty, therefore, in persuading your laboratory director or project manager to approve the purchase of the Shielding Compendium, clinch the argument by pointing out that it can serve a double function. In a pinch, if your design calculations don't work out, you can use the volume itself for added shielding!

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About the Reviewer: We again welcome Herb Goldstein to these columns together with his crisp and definitive review of the compendium of shielding information. Dr. Goldstein is Professor of Nuclear Engineering at Columbia University. He needs no introduction to the nuclear community.

[a]The Shielding Division of the American Nuclear Society has undertaken to publish non-trivial misprints in their column in *Nuclear News*. Accordingly, the printing errors noted in the course of preparing this review have been sent to the Vice Chairman of the Division, Dr. H. E. Hungerford, a procedure which is strongly recommended to those who discover other misprints.