Permissible Dose: A History of Radiation Protection in the Twentieth Century

J. Samuel Walker

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This book is the third in a series on the history of nuclear regulation, sponsored by the Nuclear Regulatory Commission (NRC). Dr. Walker, historian of the NRC, writes with an insider's personal grasp of the issues. (Previous volumes: *Controlling the Atom: The Beginnings of Nuclear Regulation*; and *Containing the Atom: Nuclear Regulation in a Changing Environment*.) While the previous volumes dealt with regulatory issues, this book deals with the development of radiation protection concepts and regulations since 1896.

The book is very well written, easy to follow, and well organized. The author achieves his stated goal of showing continuity and change in the concept of "maximum permissible doses" (MPDs), whether they relate to fallout, nuclear power, medicine, or industry. MPDs have governed and directed the applications of radiation in industry, medicine, and weaponry. Walker paints a clear picture of the roles of various federal agencies in drawing up radiation safety regulations, and of the interagency discord, turf wars, complexity, overlapping and conflicting missions, confusion, and sometimes acrimony over concepts that are based on scant data and are almost incomprehensible to the lay public. Details are sometimes sketchy, but Walker does an excellent job of telling the main points of the story in a clear, almost conversational manner.

Walker traces the concept of MPD from the early days of x-rays, when the initial excitement gave way to the realization that x-rays could be very harmful. The same sequence was true of radium. In the early days several concepts emerged: the dose–response relationship; the latent period; and dose reduction through shielding, distance, and time. Formal guidelines for radiation safety date from 1913, and have been undergoing constant revision ever since.

U.S. and international radiation safety committees, established in the early 1930s, developed a "tolerance dose" based on skin erythema; after improved detectors became available, this was codified to an MPD of 0.1 R/day (United States) or 0.2 R/day (international). The National Committee on Radiation Protection (NCRP) was formed in 1946 under the pioneer Lauriston S. Taylor; it replaced the "tolerance dose" with a "maximum permissible dose," which it defined as a dose "not expected to cause appreciable bodily injury to a person at any time during his lifetime." (Note that the dose was not called "harmless.") Initially this MPD was 0.3 R per 6-day workweek, based on the "most critical" tissues: blood-forming organs, gonads, and lens.

Enter the Atomic Energy Commission (AEC), established under the Atomic Energy Act of 1946. The AEC was handed a dichotomous role: to oversee the development and testing of nuclear weapons, and at the same time to certify to the public that testing was safe. Its preoccupation with military applications led to its authority being limited to reactor-produced (byproduct) materials and not accelerator-produced or naturally radioactive materials. Furthermore, tight security in the late 1940s led to testy relationships between the AEC and the NCRP; the AEC was hesitant to share possibly classified data with any outside groups.

In the mid-1940s, experiments were undertaken under the auspices of the AEC to determine the metabolism of plutonium and uranium, the well-known "radiation experiments." These experiments have been widely criticized because the patients were not told of the nature of the experiment and did not provide documented informed consent. Walker correctly points out a fact that many sources overlook: the research standards of those days did not require either. The results provided valuable information that led to the formulation of MPDs of internal emitters. Current informed-consent standards date from 1947 and have undergone many revisions.

As NRC historian, Walker describes the development of AEC activities with authority. Under the Atomic Energy Act of 1954, the AEC became responsible for promoting and regulating nuclear industries. It was another dichotomy: both encouraging development and certifying safety. These conflicting duties led to federal and public clamor for change, especially as the concept of "safety" was based on MPDs that were poorly understood and frequently revised—often for political reasons—and that varied from agency to agency. But it was not until 1974 that the AEC was dissolved, its duties divided between the newly formed NRC and the short-lived Energy Research and Development Administration. A Joint Committee on Atomic Energy was appointed to oversee radiation-related issues in all federal agencies. Once again, there was frequent tension and dis-

agreement, largely because of a lack of firm data on low-level radiation effects that could lead to agreed-upon MPDs.

Several personalities emerged during these years who had a significant influence on policy-making in radiation safety. Physician-scientists Tamplin and Gofman issued several publications critical of the AEC's MPD levels, and advocated much lower levels. Their most widely read publication was a book called *Radiation and Human Health*, which was published by the Sierra Club (evidently they couldn't find a technical publisher). Oddly, Walker does not mention this book, although he reviews the Tamplin–Gofman controversy over several pages.

Although Tamplin and Gofman did not perform original research to validate their claims, others did. The Najarian report on workers at the Portsmouth (New Hampshire) naval shipyard was an original epidemiologic report that found an increased incidence of leukemia, even in areas where radiation exposures had been within the MPD. The Mancuso–Stewart report found similar cancer increases among workers at the Hanford plant in Washington. Government rebuttals to these reports were accepted by some radiation scientists but rejected by others; in any event, they did not allay public mistrust and were viewed as cover-ups. This scepticism was no doubt exacerbated by a lack of understanding of what an MPD was, and a general mistrust of federal agencies. Here Walker leads the reader through the maze of what is *safe* and what is *permissible*, distinctions that escaped many critics of the time.

The report of the Advisory Committee on the Biological Effects of Radiation (BEIR, 1972) attempted to define MPDs based on a linear model of the dose–response relationship, extrapolating low-level effects (which had never been documented) from known high-level effects. They found that genetic risks were lower than had been previously estimated but somatic effects were greater, again throwing doubt on the official definitions of the MPD. The main significance of BEIR 1972 was the characterization of the linear model (some effect at any dose, however low) as being "workable." BEIR 1980 reaffirmed those findings, citing the paucity of data on low-level effects. (Walker omits two important points that would clarify why no low-level effects had been documented: radiation is quite inefficient at causing cancer at low doses, and the cancers it does cause at high doses are not distinguishable from ordinary cancers, so there is no "marker" of radiation-induced malignancy.) BEIR 1990 refined these findings, adding that the risk of leukemia was probably 3–4 times higher than in BEIR 1980. As a result, the International Council on Radiation Protection lowered their MPD from 5 rem per year to 2, while the NRC left it at 5.

Walker presents an excellent discussion of the conflicting regulations forwarded by the AEC/NRC and the Environmental Protection Agency (EPA). The EPA was propelled into the arena when it was given responsibility for air quality, which it interpreted as applying to effluent gases from nuclear reactors. The resulting EPA regulations required radiation doses at the fence that, in practice, were too low to measure (10 mrem/y), which is lower than the normal fluctuations in natural background radiation. Meanwhile the NRC introduced the concept of "as low as reasonably achievable" in 1975, in part to avoid having to specify MPDs for every conceivable operation involving radiation. Walker also describes how policies and statements from the various agencies affected public attitudes, and later in the book devotes a chapter to public fear and risk perception. New regulations were constantly being introduced, usually leading to increased costs with no documentation of increased benefits, and usually with no documentation of risk.

Meanwhile the NRC had been struggling with the realization that controlling extremely small radiation exposures was probably unnecessary and wasteful, and in 1982 introduced the concept of a "de minimis" dose of 0.1 mrem, below which no harm could be expected (the first use of *harmless* rather than *permissible*). This was soon replaced by "below regulatory concern." NRC also introduced the term "man-rem" for population exposures, which was soon replaced by the more politically correct "person-rem."

Medical radiation sources, which account for 90% of the radiation the public receives other than natural background, had received very little attention from federal agencies, and as a result there were no federal guidelines on MPDs. These were usually set by the states, but many states had not come that far; nor had medical schools, nursing schools, or technologist training programs incorporated the concept of MPDs into their curricula. The result was that many medical radiation workers overexposed themselves and their patients. This situation was addressed during the 1970s by the extraordinary proliferation of federal agencies regulating radiology, radiation therapy, and nuclear medicine; these included the EPA, NRC, Occupational Health and Safety Administration, the Department of Transportation, the Department of Energy, the Food and Drug Administration, the Department of Health, Education and Welfare (now the Department of Health and Human Services), the Social Security Administration (overseeing Medicare and Medicaid), the Veterans Administration, and, overseeing the whole lot, the General Accounting Office. Each agency had a hand in the promulgation of regulations regarding radiation safety; some specified MPDs, but most did not.

Because low-level radiation effects are delayed by weeks, months, or years, data on low-level effects continued to come in slowly after the exposures in Hiroshima and Nagasaki, and after the Chernobyl accident. Walker devotes an entire chapter to the Japan experiences, and another to the reactor accidents at Three Mile Island and Chernobyl, commenting on how the information gleaned from them has contributed to current concepts of the MPD. He also dwells on how awkward handling of public relations affected public attitudes about nuclear power. Although Walker mentions the linear and linear-quadratic models of the dose–response relationship several times, he does not define or

illustrate them in such a way that the lay reader can understand what they mean. A simple graph would help.

Radiation hormesis (the beneficial effect of small doses) is not mentioned by name, although the concept is briefly noted. Since evidence for radiation hormesis has become much more convincing in recent years, and since this concept would obviously have an impact on the MPD for low-level radiation, it should have been covered in greater detail, even though Walker's main thread is history.

All in all, I found this book to be very good reading, smoothly and yet authoritatively written and well documented (the references are conveniently given as footnotes). It is a historian's perspective of the development of radiation safety regulations and maximum permissible doses, with salient commentary on the social and political effects of the various federal efforts to define what is safe, and to regulate it. It should be of great interest to anyone concerned with radiation safety.

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