INTEGRATED EXPOSURE-MONITORING

Have We Been Here Before?

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Abstract. This paper outlines briefly the history of radiation protection, touches on some of the early incidents of overexposure, describes monitoring (detection and measurement) methods and the development of standards for health protection, and compares the monitoring of radioactive materials to that of nonradioactive toxic chemicals. The authors suggest that the lessons learned from the radiation experience will be helpful in dealing with the current problems of hazardous chemicals.

Eighty-six years have elapsed since Röntgen announced his discovery of X rays. It was noted almost immediately by other workers that these X rays produced erythema, or reddening of the skin, and loss of hair. Higher doses resulted in skin burns and ulcers. The resulting tissue destruction immediately suggested the use of X rays for selective destruction of tumor tissue, and in January 1896 a physician treated a patient for breast cancer using X rays and shielded the rest of the body with sheet lead.

In 1897, the first volume of the American X-ray journal reported on 69 cases of X-ray injury from around the world.

In 1896, about a year after the discovery of X rays, Becquerel discovered radioactivity in uranium. By 1900 the natural radioactivity in uranium ore had been concentrated to the extent that it produced skin burn. Becquerel discovered the need for radiation protection when he carried a sealed glass tube containing a radium salt in a pasteboard box in his vest pocket, resulting in the development of an erythema on his chest, which ulcerated and left a scar when it healed. Madame Curie also developed radiation burns on her hands after handling a small tube of radium enclosed in a thin metal box.

The early years of experience with ionizing radiation led to an improved understanding of the damage that might be expected from excessive radiation exposure; however, they did little to forewarn of the effects from lower level chronic exposure or late effects after an acute exposure.

Although some types of damage, such as skin cancer, appeared only a few years after acute local X-ray burns on the hands, the delayed effects of the lower level chronic or acute dosage were found to have a latent period of 10 to 30 yr. By 1922, many radiologists had died of leukemias attributed to radiation.

Experience with internal emitters was also accumulated over many years. The most serious exposures to radium were to young women employed in the radium-dial painting industry, between 1916 and 1925. These workers moistened brushes, dipped into luminous paint containing radium and mesothorium, with their lips. From about World War I through about 1930, radium was used as a tonic for many ills and was administered...
in drinking water as well as by intravenous injection. The delayed effects of internal exposure began to become apparent by about 1930 with the development of bone cancers in some of the radium dial painters. Of several thousand occupational and therapeutic exposures, about 80 radiogenic cancers have occurred.

In general, there exists a massive literature on the adverse effects of radiation, a sample of which includes: liver cancers from injection of Thorotrast for radiological studies; lung cancers in uranium miners; cancers in island populations and Japanese fishermen exposed to heavy fallout from atmospheric weapons tests in the Pacific; and the cancers and possible genetic effects in survivors of the Hiroshima and Nagasaki atomic bombings.

It is probably safe to say that more is known about the effects of ionizing radiation than about the effects of any other of the many toxic agents which man has introduced or concentrated in his environment. This is so because potential hazards of radiation were recognized from the tragic early experience, and as a result considerable research in this field was conducted by such agencies as the Atomic Energy Commission, the U.S. Public Health Service, and the U.S. Department of Defense. In fact, expenditures for research on health and metabolic effects and on mechanisms and pathways of exposure were vast in comparison with expenditures for studies of the effects of many manmade chemical pollutants of air, water, and food, whose effects have not as yet been fully investigated.

In many respects, the basis for modern radiation protection lies in this body of research and in the methods developed for radiation monitoring and measurement. Many of the monitoring and measurement methods were developed from effects of radiation observed shortly after the discovery of radiation itself. For example, general effects such as skin erythema (1895), ionization of air (1896), X-ray film darkening and color change in pastilles or chemically treated paper (1902), and scintillations in certain chemicals (1910 - 20) had been observed but were relatively insensitive or were not developed to a useful stage until much later.

In 1925, the skin-erythema dose was proposed as a measure for radiation dosage, but its interpretation was subjective and dependent on the subject's skin coloration, energy of the radiations, and other factors. About 1925, Fricke and Glasser developed the ionization chamber, which could very accurately measure a radiation dose and in its present form constitutes a secondary standard for the measurement of radiation. In 1928 the International Commission on Radiological Units (ICRU) defined a physically quantitative unit for dose measurement called the röntgen. With the development of electronics and the constant need for better instrumentation during the Manhattan Project, and the recent development of solid-state devices, a large number of usable methods has become available. These include the Geiger-Müller counter, gas proportional counters, crystal or liquid scintillation counters, and solid-state detectors such as intrinsic or lithium-drifted germanium or silicon detectors. The latter detectors, when used with appropriate electronics such as the 4096-channel analyzer, can provide spectra for many isotopes simultaneously with minimal sample preparation.

A need for portable, rapid monitoring methods developed with the beginning of the