Excellence in Control of Radiation Exposures

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Abstract

Savannah River Site (SRS) operating contractors have continuously maintained excellence in the control of radiation exposures to both Site workers and the public in the surrounding area. In doing so, Site organizations and radiation protection officials have contributed significant advances to the nuclear industry in methods for controlling radiation exposures. These methods, developed and first used at SRS, are now routinely used throughout the U.S. nuclear industry. As a consequence of their use, the average lifetime occupational radiation dose to workers monitored at SRS is among the lowest of major U. S. nuclear facilities. The average annual radiation dose to any monitored worker has been maintained as a small fraction of federal criteria. Public doses have long been maintained at less than a few percent of federal limits and much, much less than the average citizen receives from natural radioactivity.

Introduction

SRS is one the largest nuclear sites in the country. Due to the primary mission of nuclear materials production for national defense programs through much of its history, a significant fraction of the nation's inventory of radionuclides has been generated, processed, or stored at the Site. Without stringent controls for radiation exposures, the occupational and environmental legacy of SRS could have been adverse to worker and public health, as has been witnessed in similar facilities in the former U.S.S.R. Fortunately, the founding team that started up SRS recognized this potential and ensured appropriate and conservative radiation exposure control methods were developed and used at SRS to avoid such negative worker health and environmental legacies.

During the course of establishing and maintaining one of the largest U.S. radiation protection programs, there have been numerous technical contributions in several areas. Such developments include dosimeters to measure routine radiation exposure, accident dosimeters, equipment to measure dosimeter response to radiation, instruments to monitor radiation levels or presence of radioactive material, and protective equipment such as plastic suits for work in airborne radioactivity areas. Such instruments and protective gear had to be developed onsite initially because no commercial source was available. These technical contributions, though important to the radiation protection program at SRS and throughout the nuclear community, are not the focus of this report, and have been described in other reports (Taylor et al. 1995). Rather, the purpose of this paper is to describe techniques introduced at SRS over its history to control radiation exposures, and by so doing, pay tribute to the many SRS managers and staff who contributed to development of these methods. It is regrettable that it is not possible to specifically mention all such contributors.

Worker Radiation Exposure Experience

Land clearing for facilities construction at SRS began in 1951, with the first reactor (R Reactor) becoming operational in December 1953. Other major radiological facilities became fully operational over the next three years. Site facilities included a total of five heavy-water production reactors, two chemical separations facilities, fuel fabrications facilities, tritium extraction facilities, two plutonium production facilities, waste management facilities, supporting facilities and analytical laboratories, and applied research and development laboratories. Hazards included the full gamut of fission and activation products as well as uranium and transuranic radioisotopes such as plutonium. Thus, the radiation protection program needed to be able to address containment of these radioactive materials, to control radiation exposure of workers who worked with these materials, and to minimize radiation releases to the environment and public exposures.

Radiological work at SRS has resulted in a cumulative radiation dose of approximately 65,000 rem to about 70,000 workers monitored for radiation exposure. Thus the average lifetime radiation dose to a monitored worker is about 1 rem, which is among the lowest for the major Department of Energy sites. Naturally, the largest collective doses were delivered during years of greatest production and have declined significantly over recent decades. The SRS annual collective worker dose has ranged from a high of slightly over 3,000 rem in 1960 to the current level of about 100 rem.

Approximately 84% of the SRS cumulative occupational radiation dose to workers is due to external dose received from beta or gamma radiation, and it has been monitored by dosimeters worn on the torso of the body. Nearly 6% of the cumulative worker dose is due to neutron exposure, also monitored by dosimeters worn on the body. Tritium taken into the body accounts for about 4% of the cumulative dose. Tritium dose is monitored by urine analyses. Intakes of radionuclides other than tritium account for about 6% of the SRS cumulative worker dose. These intakes must be determined through a variety of analyses, such as whole body or chest counting, urine or fecal analyses, and the use of metabolic models to assess intake amounts and dose.

The average SRS worker monitored for radiation exposure has received an annual radiation dose that has varied from a maximum of 0.5 to 0.6 rem per year in the 1960s to a current low of about 0.015 rem per year.

Worker Exposure Control Methods

Radiation protection officials had the benefit of experience from less than a decade of operations of nuclear facilities built during the Manhattan Project. There were no academic programs at that time specifically for radiation protection, and no readily available pool of highly experienced health physicists. Initial radiation protection staff experience was achieved through hiring staff from existing nuclear facilities, particularly those at Hanford and Oak Ridge, but only a few could be hired. Much of the success of the SRS radiation protection program is due to the ingenuity and diligence of the early management and technical staff. The program also benefited by great stability. For example, the first manager of the radiation protection program, C. M. “Pat” Patterson, who transferred to SRS from Du Pont Hanford operations, managed the program continuously until his retirement in 1978. W. C. “Bill” Reinig (one of the very first exempt employees at SRS in June 1951) then managed the radiation protection program for more than a decade.

Administrative Dose Control Levels

At the time SRS was starting up in the early 1950s, there were no national limits for worker or public radiation dose. There was guidance from various organizations that recommended worker dose be maintained below what would now be the equivalent of about 15 rem per year. As early as 1949, however, guidance as low as 5 rem per year had been discussed in a meeting including representatives from the United States, Britain, France, and Canada. Subsequently, when the Federal Radiation Council was established in 1958, a 5-rem-per-year federal guidance was developed. The initial radiation protection team instituted the policy that SRS workers would be restricted to receive no more than 3 rem per year from whole body radiation dose (this includes beta, gamma, neutron, and tritium dose). This practice was due to conservatism toward worker safety and health and concerns over adequate means to monitor neutron exposures. It is the first known application of an administrative dose control level at a nuclear site, at levels more conservative than federal guidance. This administrative control level remained in effect through 1992. Since 1992, DOE has established a DOE administrative control level of 2 rem per year for workers in the DOE complex and has ordered that each DOE site establish an administrative control level. The SRS administrative control level was lowered to 1.5 rem per year for 1993 and has been lowered since to a current level of 0.5 rem per year for most SRS workers.

The early and continuous use of an administrative control level has been very effective at controlling individual and collective SRS worker doses. Very few individuals have ever exceeded the control level throughout the history of the Site, and each who has exceeded the control level was involved in a radiological incident where unplanned exposures or intakes of radionuclides occurred.

Radiological Work Permits

SRS at start-up instituted the development and use of Special Work Permits, which were required for radiological work where significant radiological hazards were present and where significant potential existed for larger exposures or for the spread of contamination. Later, such work permits, now generally called Radiological Work Permits, became common in the commercial nuclear power industry, and are now widely used throughout the U. S. nuclear industry. These permits include the level of hazard, such as dose rates available; the required protective gear and dosimetric requirements for the work; and a requirement for each person who enters to work in that area read, understand, and sign the permit.

Radiological Control Manual

SRS was one of the first nuclear facilities to develop and use a Radiological Control Manual (at SRS it was SRP DPSOP 40, *Radiological Controls*). This manual contained the rules for performing radiological work at SRS. Further, from very early in the Site's history, specific radiological safety procedures were instituted, called DPSOLs, which specified how the radiation protection program practices were performed. The early use of a radiological control manual and specific procedures for performing radiological work have been instrumental in controlling radiation exposures. Such practices are now used throughout the nuclear industry.

Dose-based Performance Goals

Starting in the early 1970s as the concepts of As Low As Reasonably Achievable (ALARA) were being developed by guidance agencies, SRS began using dose-based performance goals for maximum individual dose and for group collective dose. These goals have been aggressively pursued and lowered as Site operations permitted. For example, while the SRS Administrative Control Level was 3 rem per year for 1992, the goal was to have no worker receive more than 1.5 rem that year, and no one did. Goals for individual operating organizations have also been established. In addition to exposure performance goals, other radiological performance indicators have been added to this program over time.

ESH Review Committees

A significant contributor to the success of the ALARA goal process at SRS has been the establishment of a clear environment, safety and health management review process. Since such goals have been in place, a management safety committee chaired by the top contractor manager has periodically reviewed (monthly for most of this time) the radiological performance against goals. This committee, long called the

Site Central Safety Committee, reviews and provides focus on areas where improvement is needed or where special performance situations exist. A similar upper management committee approves goals set for the next year. Subcommittees for operating divisions contribute to the review and goal establishment process, and generate programs that enable improvement. The management review process has ensured that goals are aggressively pursued, and that goals for subsequent years are challenging.

Public Dose Experience

SRS has delivered a collective public radiation dose of about 5,000 rem to about 600,000 members of the public since site start-up (Carlton 1998). The maximum dose to any member of the public (the fence-line dose) was largest in the 1960s, when that dose was in the range of 0.1 to 0.5 rem per year. By the 1980s, the maximum public dose was in the range of 0.001 to 0.003 rem per year. Now, the maximum public dose is typically less than 0.0002 rem per year. The current federal limit for such exposures is 0.1 rem per year.

Methods for Control of Public Dose

Like the control of worker dose, SRS has developed methods to reduce the impact of Site operations on the environment and the public. As the Site was being cleared for construction of nuclear facilities, the radiation protection staff performed the first ever base-line study of environmental radiological conditions prior to construction and operation of Site facilities. This report has been highly useful in determining radioactivity concentrations in environmental media that is due to site operations as opposed to natural radioactivity (Reinig 1953).

In 1970, SRS established a dose-based technical standard for radioactivity releases from SRS facilities. This technical standard established that "we can and will operate this site in such a manner that no member of the public receives as much as 10 mrem in a year from site operations." Since establishment of this standard, it has always been met. In late 1982 and early 1983, as the Environmental Protection Agency was establishing numeric criteria for the Clean Air Act for radioactive releases, they adopted the SRS standard, and it remains the Clean Air Act atmospheric radiological release criteria for a nuclear facility to this day.

In addition to the dose-based overall atmospheric radiological release criteria, SRS also instituted in the 1970s specific atmospheric and liquid radiological concentration goals for specific release points, such as a facility stack or liquid release pipe into a site stream. Like the worker dose ALARA goals, these goals were aggressively and routinely reviewed and updated annually in a similar upper-management committee review process. The review process encouraged organizations operating radiological facilities to develop administrative and engineered improvements in their waste streams to meet ever more challenging goals. In recent years, these concentration goals have been replaced with dose fraction goals.

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Biography

Kenneth W. Crase is technical advisor to the Health Physics Technology organization of the Westinghouse Savannah River Company. Mr. Crase came to the Savannah River Site in July 1981. He has managed the environmental monitoring program and held various technical positions. He provides technical guidance to the SRS radiation protection program for workers and the environment.

He is a member of the Department of Energy Oversight Board for External Dosimetry for their Laboratory Accreditation Program, is an adjunct professor in the Nuclear Engineering and Health Physics Department of Georgia Institute of Technology and has taught graduate health physics courses via tele-lecture.

Mr. Crase received his Ph.D. in physics in 1971 at The University of Tennessee. He received his B. A. in physics at Berea College in 1966. He has previous radiation protection experience at Oak Ridge National Laboratory and at Lawrence Livermore National Laboratory and has taught college for four years.

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