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Radiation Exposures in Perspective

Introduction

The Department of Energy's (DOE) critical mission to address the nation's most pressing energy, environmental and nuclear challenges also presents potential radiation exposure risks to its workers and the people and environment surrounding DOE sites.

Safety is an integral part of the DOE mission. The Department takes seriously its responsibilities to manage and control exposures and releases of radioactive material so that the levels are "as low as reasonably achievable" (ALARA).

This Operating Experience Summary provides a perspective on DOE occupational radiation exposures and environmental releases based on the latest data from the Radiation Exposure Monitoring System (REMS) and Annual Site Environmental Reports (ASER) databases. The summary also compares DOE's occupational radiation exposures to those from natural and other sources of radiation.

Sources of Radiation

All life on Earth is constantly exposed to "background radiation" i.e., naturally occurring sources of radiation in our environment. The majority of the radiation dose an average person receives from background radiation is due to factors derived from where they live, such as elevation, soil, and radon composition, and from routine activities, such as air travel, smoking, or medical procedures (Table 1).¹

Ionizing radiation from both natural and man-made sources consists of energy and particles (ions) with sufficient energy to detach electrons from atoms.

Exposure to ionizing radiation can result in biological damage to the cells and DNA of our body.

Table 1. Common sources of radiation dose.

Source/Activity	Average Dose/Year (or as noted)
3-hour airplane ride	1 mrem
Building materials	7 mrem
Per chest x-ray	10 mrem
Soil	21 mrem
Internal to our body	29 mrem
Cosmic	33 mrem
Smoking 20 cigarettes/day	36 mrem
Per mammogram	42 mrem
Radon gas	228 mrem
Average background radiation	620 mrem
Per CT scan (cardiac)	2000 mrem

* 3 years of ASER reports

** 10-year average, rounded

Radiation exposure to workers in the performance of their duties is called "occupational exposure." DOE workers have the potential to be exposed to ionizing radiation when working with or around radioactive materials. The Department bases radiation risk on the biological effects associated with the most likely types and levels of exposure. DOE manages radiation exposure risks by tracking and measuring how much dose from ionizing radiation a person receives when working at, visiting, or living near a DOE site. The measurement of ionizing radiation and its effects on the body can be calculated in different ways, but for this summary, we will use millirem (mrem) as the unit of radiation dose.

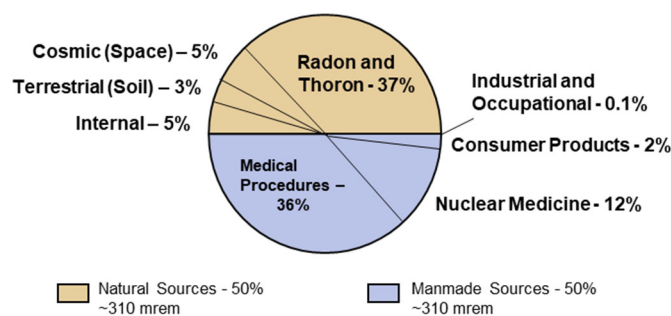
¹ Flakus, F. Radiation in perspective: Improving comprehension of risks.

Regulatory Framework for DOE Radiation Protection

The Department's radiation protection programs are defined by federal law in Title 10, Code of Federal Regulations, Part 835, Occupational Radiation Protection (10 C.F.R. 835) and guided by agency requirements found in DOE Order 231.1B, *Environment, Safety and Health Reporting* and DOE Order 458.1 Change 3, *Radiation Protection of the Public and the Environment*.

Under 10 C.F.R. 835, the total effective dose for a DOE worker may not exceed 5,000 mrem per year, with more specific limits set for doses to the eye, skin, or other specific organs. The annual exposure limit to a member of the public as stipulated in 10 C.F.R. 835 is 100 mrem. For perspective, the average person receives about 620 mrem per year from natural and man-made sources² (Figure 1.)

Figure 1. Sources of Radiation Exposure in the United States.



Source: NCRP Report No.160 (2009)

Note: DOE occupational exposure is included within the 0.1% contributed from "Industrial and Occupational."

These regulations and Orders require that DOE operations keep radiation doses as low as reasonably achievable. The ALARA principle has been a requirement in DOE programs for decades and has successfully resulted in exposure levels that continue to be much lower than regulatory limits.

The risk of increased health effects is extremely low when exposures are kept below the regulatory limits.

Exposures at high levels where there can be immediate biological effects and more probable health risks are quite rare at DOE. Regardless, the ALARA principle must be applied to control any and all exposures.

Radiation Exposure Monitoring System (REMS)

DOE Order 231.B requires that annual radiation monitoring records for each individual be submitted to the REMS database, which includes records for all DOE employees, contractors, subcontractors, and members of the public who were monitored while in controlled areas.

The REMS data, which can be accessed from an [online REMS query tool](#), is used to develop an Annual DOE Occupational Exposure Report, which analyzes and trends DOE radiation exposure data. It provides information on activities significantly contributing to changes in collective dose, shows historical trends, and links to activities that help meet ALARA principles within DOE operations.

Occupational radiation exposure data is used by radiation protection managers to evaluate DOE's radiation protection program activities. This data provides an opportunity to perform and report on corrective actions for incidents where radiation exposures were in excess of either Administrative Control Levels or regulatory limits.³

Annual Site Environmental Reporting (ASER)

DOE Order 231.1B requires each DOE site that conducts activities with, or in the presence of, radioactive material to provide detailed radiation safety performance information through the ASER Program.

The ASER data describe the site's annual environmental management performance, occurrences and responses, and compliance. ASER reports provide a detailed look into the site's environmental radiation protection programs and their effects on air, water, natural and cultural resources, and groundwater systems. ASER reports by location are available on the [DOE website](#).

² "Ionizing Radiation Exposure of the Population of the United States," National Council on Radiation Protection and Measurements.

³ Radiological Control, 211 Administrative Control Level, DOE-STD-1098-2017.



Worker and Individual Exposure

The REMS data demonstrates DOE's exposure safety performance across its radiation protection programs over time. For example, over the past 10-year period, for all measurable annual doses at DOE:

- 82% were below the DOE required monitoring threshold of 100 mrem;
- 17% had doses between the 100 mrem threshold and 500 mrem; and
- 1% received doses above 500 mrem.

Overall, out of the 809,835 annual dose records reported over the past 10 years, only one person received a dose exceeding the 5,000 mrem regulatory limit. The REMS data validates DOE's consistent efforts and commitment to protecting workers, contractors, and members of the public who visit a facility.

ASER Analysis of Doses to the Public

The ASER public receptor annual dose is the estimated potential dose to individuals within any area where members of the public have unrestricted access.

Current data indicate that the average dose to the most highly exposed public receptors across all sites was 99.3% lower than the regulatory limit of 100 mrem. Furthermore, out of the 87 site annual reports over the past three years, all public receptor doses were below 6 mrem. This means that even the sites with the highest off-site receptor doses were kept 94% below regulatory limits.

Conclusion

As a result of the protections DOE has in place and careful monitoring and tracking, the annual occupational exposure rate to workers from is less than that of the background radiation exposure to the average member of the public in daily life. DOE's efforts over the past decades have kept occupational radiation doses as low as reasonably achievable for DOE workers and those visiting or living near DOE sites.

References

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The Office of Environment, Health, Safety and Security, Office of ES&H Reporting and Analysis publishes the Operating Experience Summary to promote safety throughout the DOE complex by encouraging the exchange of lessons learned information among DOE facilities.

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