A Basic Overview of

OCCUPATIONAL RADIATION EXPOSURE
Monitoring, Analysis & Reporting

Outreach & Awareness Series to Advance the DOE Mission

Office of Health, Safety and Security
U.S. Department of Energy

August 2010

Overview

The Department of Energy (DOE) is undergoing major changes in its operation and mission in response to the President's and Secretary's priorities to rapidly implement the economic recovery package, enhance energy security, restore leadership in science, reduce greenhouse emissions, and enhance the Nation's nuclear security. One of the priorities of the DOE is to ensure a safe and secure workplace by integrating safety and security into every element of the Department's mission to safeguard employees, contractors, and subcontractors.

This pamphlet is developed as part of the Office of Health, Safety and Security's (HSS) outreach and awareness campaign to proactively advance safe execution of the DOE mission. It is intended to provide a short summary of two specific HSS programs that aid in the oversight of radiation protection activities at DOE.

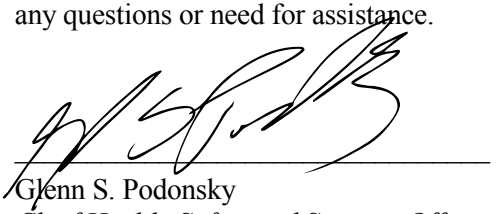
Title 10, Code of Federal Regulations (C.F.R.), Part 835, *Occupational Radiation Protection*, establishes radiation protection standards, limits, and program requirements for protecting individuals from radiation resulting from the conduct of DOE activities. Radiation protection programs within DOE cover a large range of diverse programs and activities. Two of these program areas are directly in support of 10 C.F.R. 835, namely: 1) the quality and accuracy of occupational radiation exposure monitoring, and 2) the recording, reporting, analysis, and dissemination of the monitoring results. Both areas are discussed in this pamphlet. These programs ensure that radiation exposure is within the applicable limits and "as low as reasonably achievable" (ALARA) requirements.

ALARA is an underlying principle for protecting nuclear workers from potential health outcomes related to occupational radiation exposure by utilizing all practical and cost-effective methods. ALARA is also a requirement for radiation protection activities in the United States.

The Department of Energy Laboratory Accreditation Program (DOELAP) is in place to ensure that radiation exposure monitoring at all DOE sites is precise and accurate, and conforms to national and international performance and quality assurance standards.

The DOE Radiation Exposure Monitoring Systems (REMS) program provides for the collection, analysis, and dissemination of occupational radiation exposure information. The annual REMS report is a valuable tool for managing radiological safety programs and for developing policies to protect individuals from occupational exposure to radiation. In tandem, these programs provide DOE management and workers an assurance that occupational radiation exposures are accurately measured, analyzed, and reported.

HSS strives to provide subject matter expertise and technical assistance related to occupational radiation exposure monitoring, analysis, and reporting. Please do not hesitate to contact us with any questions or need for assistance.



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Why are we concerned about exposure to radiation?

We are constantly exposed to radiation, whether from natural or man-made sources. Radiation consists of energy and particles that are given off by unstable atoms as part of a natural process to become stable. When we are exposed to radiation from the work we do, care is taken to protect against biological damage to the cells and DNA (genetic material) of our body, as well as risk of illness using engineered controls and by establishing regulatory controls. Fortunately, such risks are minimal at normal background radiation levels, at typical levels of medical exposure, and at occupational exposure levels allowed by regulations. HSS is responsible for establishing the regulatory requirements related to monitoring, assessing, reporting, and analyzing the radiation exposure to workers within the DOE Complex and to the public.

What are exposure limits?

Government agencies have established regulations that set limits for exposure to radiation based on extensive scientific research and recommendations from national and international scientific organizations. These limits are designed to protect individual workers, the public, and the environment, and are set at "acceptable" levels of risk similar to those for industrial activities (e.g., chemical, mining, transportation).

[1]The key U.S. limit for occupational exposure to radiation is 5 rem/year (50 mSv/year), while the exposure to minors and the general public is set at 100 mrem/year (0.1 rem/year), as specified in DOE O 5400.5.

[1] The "System International" of units (SI system) for radiation measurement uses the "sievert" (Sv) for equivalent dose. (1 Sv = 100 rem, 1 mSv = 100 mrem)

DOE radiation protection standards and exposure limits for workers are found in 10 C.F.R. 835, *Occupational Radiation Protection*, as shown in the table below.

In 2007, DOE revised the dosimetric quantities and units to reflect more current international consensus values. Use of these quantities and units are required by July 2010.

DOE Dose Limits from 10 C.F.R. 835*

Personnel Category	Section of 10 C.F.R. 835	Type of Exposure	Acronym	Annual Limit
General employees	835.202	Total effective dose, which is the sum of the effective dose from external exposure and the committed effective dose from intakes.	TED (ED+CED)	5 rems
		Equivalent dose to the whole body from external exposures + committed equivalent dose to any organ or tissue (except for the skin and the lens of the eye). This is referred to as the total organ dose.	TOD (ED+CEqD)	50 rems
		Equivalent dose to the lens of the eye.	EqD-Eye	15 rems
		Equivalent dose to the skin or any extremity from external exposure + the committed equivalent dose to the skin or any extremity.	EqD (to the skin or any extremity) + CEqD (to the skin or any extremity)	50 rems
Declared pregnant workers**	835.206	Equivalent dose to the embryo/fetus from conception to birth.	EqD-Fetus	0.5 rem
Minors	835.207	Total effective dose.	TED	0.1 rem
Members of the public in a controlled area	835.208	Total effective dose.	TED	0.1 rem

* *As amended, 6/8/2007*
** *Limit applies to the embryo/fetus.*

For more information on 10 C.F.R. 835, visit the DOE HSS website at:

http://www.hss.energy.gov/HealthSafety/WSHP/radiation/rule.html

What are applicable requirements and standards?

- **10 C.F.R. 835**, *Occupational Radiation Protection*, establishes radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from the conduct of DOE activities. Subpart I, "Reports to Individuals," requires reporting of data to individuals monitored in accordance with 835.402.
- **10 C.F.R. 835.402 (b)** and **(d)**, "Individual Monitoring," requires implementing external and internal dose monitoring programs that are accredited, or excepted from accreditation, in accordance with the DOE Laboratory Accreditation Program.
- **DOE Order 231.1-1A**, *Environment, Safety and Health Reporting*, requires reporting of the individual occupational radiation exposure data to REMS repository.
- **DOE Manual 231.1-1A**, *Environment, Safety and Health Reporting Manual*, provides details about the data format and schedule for reporting (Chapter 3 and Appendix G).
- **The DOE Order 210.2**, *Corporate Operating Experience Program*, requires collection, analysis, and dissemination of performance indicators, such as occupational radiation exposure information.
- **DOE System of Records DOE–35**, *Personnel Radiation Exposure Records*, establishes requirements for routine use of the data.
- **DOE-STD-1111-98**, *DOE Laboratory Accreditation Program Administration*
- **DOE-STD-1095-95**, *DOE Laboratory Accreditation Program for Personal Dosimetry Systems*
- **DOE-STD-1112-98**, *DOE Laboratory Accreditation Program for Radiobioassay*

What is DOELAP?

DOELAP sets quality assurance and performance standards to ensure occupational exposure to radiation is measured accurately and consistently. DOELAP is part of the overall radiation protection program that assures workers that their work environments are safe and gives them confidence that their radiation exposures are accurately measured.

DOELAP consists of both an External Dosimetry Accreditation Program and a Radiobioassay Accreditation Program. The accreditation processes involve performance testing that is carried out by the Radiological and Environmental Sciences Laboratory (RESL), in Idaho, and onsite assessments of the DOE programs. Performance testing determines a program's ability to meet accuracy and precision requirements, while the onsite assessment evaluates a program's quality assurance processes.

DOELAP is made up of assessors, oversight boards, RESL, andthe DOELAP Administrator. Assessors are volunteers from the various DOE contractor dosimetry and radiobioassay programs who have been trained by RESL to perform these assessments. Oversight board members are also volunteers and are often the directors of DOE site programs or have had extensive dosimetry or radiobioassay experience. Performance test and assessment results are reviewed by the appropriate oversight board which then makes recommendations to the DOELAP Administrator regarding further accreditation. Finally, the DOELAP Administrator accredits those programs that successfully met all criteria.

DOELAP currently accredits external dosimetry programs at 20 DOE sites and radiobioassay programs at 17 of those sites. These programs monitor workforces that range from several dozen individuals to several thousand, and cover activities that include biological research, high-energy physics, nuclear weapon manufacturing, and the cleanup of former nuclear weapon production facilities.

Not all DOE sites conduct work that has the potential for breathing in or the ingestion of radioactive material. The three DOE sites that do not have radiobioassay programs are dedicated to particle accelerator research.

DOELAP also provides calibration sources, through its phantom library, to programs that use relatively large radiation detectors to identify and measure the amount of certain radioactive materials that may have been incorporated in an individual's body. The library, currently maintained and operated by RESL, has human body-like phantoms for loan to DOE sites, U.S. Nuclear Regulatory Commission licensees, and state emergency response organizations. The phantoms are loaned at no cost other than shipping and insurance.

What are the basic elements of DOELAP?

1. Performance testing
2. Onsite assessment
3. Accreditation certification
4. Assessor training
5. Program development
6. Applied research in areas where technological shortfalls exist

What is the REMS program?

The DOE REMS program establishes a database for collection, analysis, and dissemination of data on occupational radiation exposures received at DOE sites. DOE and the U.S. Nuclear Regulatory Commission (NRC) have a Protective Agreement (PA) to share radiation exposure data to allow both agencies to collect and maintain dose records of monitored individuals. Requests for prior dose records often pertain to worker exposures at both NRC and DOE facilities. For this reason, both agency databases are managed by Oak Ridge Associated Universities (ORAU) in Oak Ridge, Tennessee.

The REMS database serves as the central repository of radiation exposure information for DOE. The database consists of individual occupational radiation exposure records for DOE workers from 1987 to the present. From 1969 to 1987, facilities were required to report only career radiation exposure records when the individual terminated employment. As part of a historical data collection effort, 13 major DOE sites voluntarily provided historical exposure data (about 4 million dose records) to the REMS database.

An annual analysis and explanation of observed trends in occupational exposure across DOE are provided in the *DOE Occupational Radiation Exposure Report*. Reports since 1974 are available at http://www.hss.energy.gov/csa/analysis/rems/annual.htm.

What are the basic elements of the REMS program?

1. Data collection and management
2. Publish the annual Occupational Radiation Exposure Report
3. Data dissemination and guidance

What DOELAP and REMS resources are available?

Additional information on DOELAP is located at:

http://www.hss.energy.gov/csa/csp/doelap

1. DOELAP Regulatory Basis
2. DOELAP Program Administration
3. Phantom library
4. Application for accreditation

Additional information on REMS is located at:

http://www.hss.energy.gov/csa/analysis/rems

1. Annual Occupational Radiation Exposure Reports since 1974
2. Statistical data since 1984
3. Applicable DOE Orders and manuals for the recordkeeping and reporting of occupational radiation exposure at DOE
4. Guidance on how to request dose data from DOE and other federal agencies
5. Guidance on how to report data to the REMS repository

What is the trend in DOE radiation exposures?

[2]Exposure data for the previous calendar year is submitted to REMs by May of each year. Radiation protection performance is currently evaluated by measures such as collective dose (the sum of all doses to all individuals at the DOE Complex) and average measurable dose.

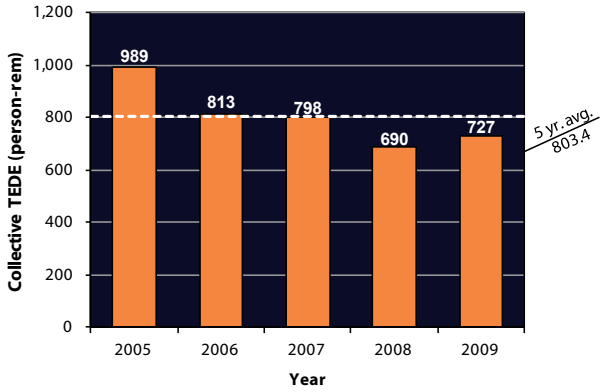
Based on the latest available data (2005–2009), DOE has:

- Reduced number of individuals with a measurable dose since 2005;
- Significantly reduced the collective dose since 2005; and
- Found that, for 2009, 69% of the DOE workforce was monitored for radiation dose, and 14% of the monitored individuals received a measurable dose.

The following chart shows collective Total Effective Dose Equivalent (TEDE) decreasing over the past 5 years. TEDE is comprised of the external deep dose equivalent, which includes neutron and photon radiation, plus the committed effective dose equivalent, which results from the intake of radioactive material into the body. The collective TEDE represents the occupational radiation dose received by the entire DOE workforce.

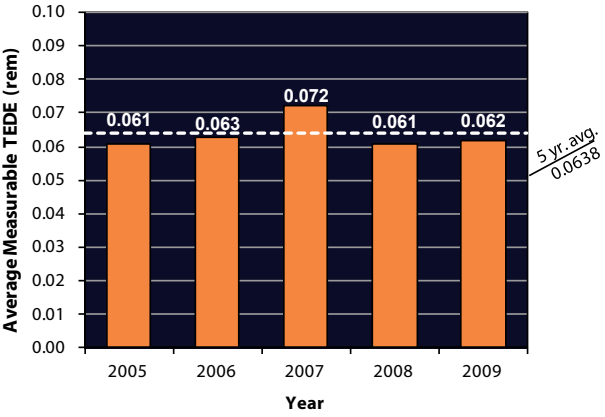
[2] At DOE sites, radiation dose is measured and reported in units called *rem*.

Collective TEDE (person-rem), 2005-2009



Another primary indicator of the level of radiation exposure is the average measurable dose, which normalizes the collective dose over the population of workers who actually received a measurable dose, as shown in the chart below.

Average Measurable TEDE (rem), 2005-2009



For additional and updated information on DOE occupational radiological exposures and trends, visit the DOE HSS web site at:

http://www.hss.energy.gov/csa/analysis/rems

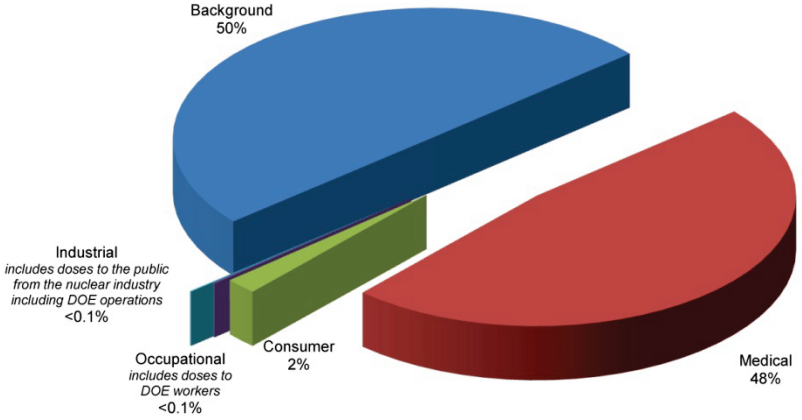
DOE radiation exposure in context

Comparing the DOE radiation exposure with other sources of radiation that we are exposed to in our daily lives provides an understanding of the radiation exposures to DOE workforce. In March 2009, the National Council on Radiation Protection and Measurements (NCRP) published report No. 160, *Ionizing Radiation Exposure of the Population of the United States*, which describes the doses to the U.S. population from all sources of ionizing radiation for 2006 (the most recent data available at the time the report was written). It also provides information on the variability of those doses from one individual to another. The NCRP reports the relative contributions to the U.S. population dose from naturally occurring sources (natural background), such as cosmic radiation from space; terrestrial radiation from radioactive materials in the earth; naturally radioactive materials in the food people eat and the air people breathe; medical sources from the diagnosis and treatment of health disorders using radioactive pharmaceuticals and radiation-producing equipment; consumer products; and industrial, security, educational, and research activities. Both occupational and non-occupational doses are addressed.

The pie chart on the following page illustrates the relative contributions of these sources to the total radiation dose to the U.S. population. Effective dose per individual in the U.S. population is 620 mrem for 2006. Doses to the public from industrial uses include nuclear power generation as well as DOE operations; doses to DOE workers from DOE operations are included in the category of occupational dose and significantly below 5 rem regulatory occupational dose limit.

Doses to the general public from DOE operations are insignificant, being less than 0.1% of the total radiation dose to the U.S. population. Average measurable dose received by a DOE nuclear worker (62 mrem in 2009) is less than the DOE limit for a member of the public (100 mrem).

Percent contribution of various sources of exposure to the total collective effective dose and the total effective dose per individual in the U.S. population for 2006.



Credit: Modification to image courtesy of National Council on Radiation Protection and Measurements

Who should I contact if I have a question?

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