HSS
Office of Health, Safety and Security

DOE Occupational Radiation Exposure

2007 Report

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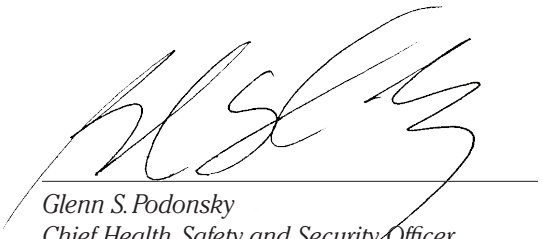
Foreword

One of the priorities of the U.S. Department of Energy (DOE) is to ensure the health, safety, and security of DOE employees, contractors, and subcontractors. The Office of Health, Safety and Security (HSS) provides the corporate-level leadership and strategic vision necessary to better coordinate and integrate health, safety, environment, security, enforcement, and independent oversight programs. One function that supports this mission is the DOE Corporate Operating Experience Program that provides collection, analysis, and dissemination of performance indicators, such as occupational radiation exposure information. This analysis supports corporate decision-making and synthesizes operational information to support continuous Environment, Safety and Health improvement across the DOE complex.

A key safety focus for DOE is to maintain radiation exposures of its workers below administrative control levels and DOE limits and to further reduce these exposures to levels that are "as low as reasonably achievable." The annual *DOE Occupational Radiation Exposure 2007 Report* provides an evaluation of DOE-wide performance regarding compliance with DOE Part 835 dose limits and ALARA process requirements and an overview of the status of radiation exposures of DOE work force. In addition, this report provides data to DOE organizations responsible for developing policies for protection of individuals from the effects of radiation. This report is intended to be a valuable tool for managing radiological safety programs, epidemiologists, researchers, and national and international agencies involved in developing policies to protect individuals from harmful effects of radiation. The overall radiation dose decreased from 2006 to 2007 in terms of collective dose. In addition, there were fewer individuals who received a measurable dose. The average measurable dose is calculated by dividing the collective dose by the number of individuals with measurable dose. Since the number of individuals with measurable dose decreased by a larger proportion than the collective dose, the resultant average measurable dose increased. In 2007, one individual received a dose in excess of the DOE regulatory limit.

One of the objectives of this report is to provide timely, useful, accurate, and complete information to the target audience. As part of a continuing improvement process, we would appreciate your response to the user survey included at the end of this report. The majority of respondents to the survey have indicated that timeliness of the report is important to them and all responders categorized the report as 'useful' or 'very useful'.



Glenn S. Podonsky
Chief Health, Safety and Security Officer
Office of Health, Safety and Security

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LIST OF EXHIBITS

LIST OF ACRONYMS

ACL	Administrative Control Level
AEDE	Annual Effective Dose Equivalent
AEC	Atomic Energy Commission
ALARA	As Low As Reasonably Achievable
CDE	Committed Dose Equivalent
CEDE	Committed Effective Dose Equivalent
CMR	Chemical and Metallurgy Research Facility
D&D	Decontamination and Decommissioning
DDE	Deep Dose Equivalent
DOE	U.S. Department of Energy
EM	Office of Environmental Management
EPA	U.S. Environmental Protection Agency
ETTP	East Tennessee Technology Park
HSS	Office of Health, Safety and Security
INTEC	Idaho Nuclear Technology and Engineering Center
LANL	Los Alamos National Laboratory
LDE	Lens (of the Eye) Dose Equivalent
LLNL	Lawrence Livermore National Laboratory
mSv	Millisievert
NE	Office of Nuclear Energy, Science and Technology
NNSA	National Nuclear Security Administration
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
PFP	Plutonium Finishing Plant
PSE	Planned Special Exposure
REMS	Radiation Exposure Monitoring System
SC	Office of Science
SDE-ME	Shallow Dose Equivalent to the Maximally Exposed Extremity
SDE-WB	Shallow Dose Equivalent to the Skin of the Whole Body
SRS	Savannah River Site
Sv	Sieverts
TEDE	Total Effective Dose Equivalent
TODE	Total Organ Dose Equivalent
TVA	Tennessee Valley Authority
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
WIPP	Waste Isolation Pilot Plant
Y-12	Y-12 National Security Complex

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Summary
Executive Summary

The U.S. Department of Energy (DOE) Office of Corporate Safety Analysis (HS-30) within the Office of Health, Safety and Security (HSS) publishes the annual *DOE Occupational Radiation Exposure Report* to provide an overview of the status of radiation protection practices at DOE.* The annual *DOE Occupational Radiation Exposure 2007 Report* provides an evaluation of DOE-wide performance regarding compliance with DOE Part 835 dose limits and ALARA process requirements. In addition the report provides data to DOE organizations responsible for developing policies for protection of individuals from the effects of radiation. This report provides a summary and an analysis of occupational radiation exposure information from the monitoring of individuals involved in DOE activities. The occupational radiation exposure information is analyzed in terms of aggregate data, dose to individuals, and dose by site over the past five years.

One of the report's features includes the collective total effective dose equivalent (TEDE)–an indicator of the overall amount of radiation dose received during the conduct of operations at DOE. The DOE collective TEDE decreased by 3% from 2006 to 2007, as shown in *Exhibit ES-1*. This is the fourth consecutive year that the collective TEDE has decreased. The decrease in 2007 is due primarily to decreases in the amount of work performed that directly involves radioactive materials. Three facilities ceased operations during 2006, which contributed to the decrease in the collective dose and the number of workers with measurable dose in 2007. Other sites that contributed to the decrease in the number of workers with measurable dose include Fermilab, Idaho, LANL, Sandia and SRS, while increases occurred at Hanford, ORP, and Y-12.

The TEDE is comprised of the external deep dose equivalent, which includes neutron and photon radiation, and the internal committed effective dose equivalent, which results from the intake of radioactive material into the body. While the photon component of the collective TEDE decreased by 3% from 2006 to 2007, the internal dose and neutron dose increased by 27% and 3%, respectively.

Another primary indicator of the level of radiation exposure covered in this report is the average measurable dose, which normalizes the collective dose over the population of workers who actually received a measurable dose. The average measurable TEDE increased by 13% from 2006 to 2007, as shown in *Exhibit ES-2*. The collective dose and number of individuals who received a measurable dose both decreased and the average measurable dose increased.

Exhibit ES-1:
Collective TEDE (person-rem), 2003–2007.

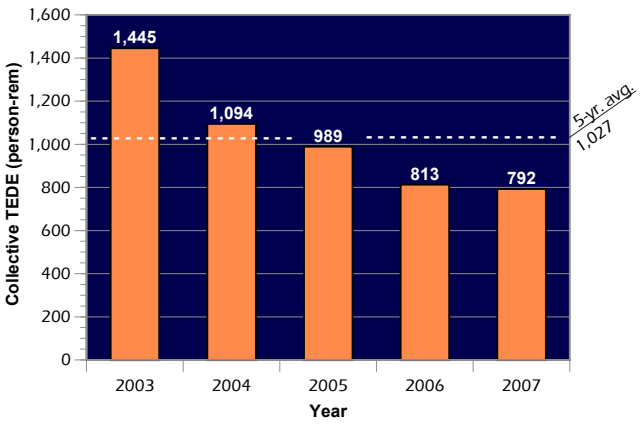
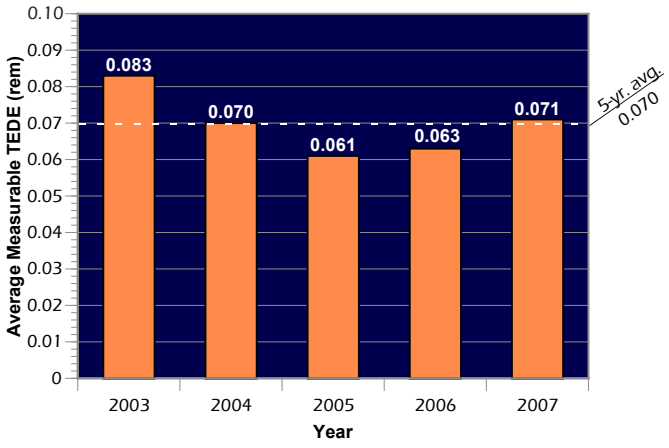


Exhibit ES-2:
Average Measurable TEDE (rem), 2003–2007.



* DOE is defined to include the National Nuclear Security Administration sites.

Additional analysis shows that the dose distribution in 2007 was similar to the distribution in 2006 with the exception of the one individual that exceeded the 5 rems (50 mSv) DOE regulatory limit. Most of the reduction in monitored individuals occurred in the number of individuals with no measurable dose and the number of individuals receiving less than 0.1 rem (1 mSv). The number of individuals receiving doses between 0.1 rem (1 mSv) and 2 rems (20 mSv) in 2007 remained within 0.2% of the number in 2006. The one individual that exceeded the 5 rems (50 mSv) DOE regulatory limit in 2007 received an internal dose of 7.530 rems (75.3 mSv) from a plutonium intake at Los Alamos National Laboratory.

In conclusion, the assessment of occupational radiation exposure for 2007 continues to show a declining trend in collective dose and the number of individuals with measurable dose, while the average measurable dose increased for the second year in a row. Primary factors in the decrease in collective dose for 2007 were a reduction in activities involving radiation at DOE sites, and the closure of several sites that are no longer in operation (Fernald, Mound, and Ashtabula). The increase in the average measurable dose was due to a decrease in the number of individuals with measurable dose (particularly measurable doses below 0.1 rem) and the one individual who received a dose above 5 rems (50 mSv). With the exception of one incident, in 2007, all DOE operations complied with DOE Part 835 dose limits and the DOE-wide dose constraints. Only a small fraction of the DOE workforce received measurable doses and the average measurable dose was less than 2% of the DOE limit.

From the trends observed during the past five years, it is anticipated that there will be a continued decrease in the number of individuals with measurable dose and the collective dose as DOE consolidates, remediates and rightsizes its radiological operations. The average measurable dose may increase as fewer individuals receive dose, but should remain low as radiation protection practices and ALARA principles continue to reduce dose to individuals.

To access this report and other information on occupational radiation exposure at DOE, visit DOE's HSS Web site at

http://www.hss.energy.gov

Select HSS Reporting Databases from the HSS Quick Reference, and then select the Radiation Exposure Monitoring System.

Section One Introduction

1

Introduction

The *DOE Occupational Radiation Exposure 2007 Report* analyzes occupational radiation exposures incurred by individuals at the U.S. Department of Energy (DOE) facilities during 2007. This report includes occupational radiation exposure information for all DOE employees, contractors, and subcontractors, as well as members of the public who are monitored for exposure to radiation. The 90 DOE organizations submitting radiation exposure reports for 2007 have been grouped into 29 sites across the complex. This information is analyzed and trended over time to provide a measure of DOE's performance in protecting its workers from radiation.

1.1 Report Organization

This report is organized into the five sections listed below. This year, in an effort to further streamline the printed report, most of the supporting technical information, tables of data, and additional items that were previously provided in the report and the appendices will be available on DOE's Web site for Information on Occupational Radiation Exposure.

A User Survey form is included at the end of this report and users are encouraged to provide feedback to improve this report. Of the responses received to date, all of the commentors categorized the overall report as "useful" or "very useful". The highest rated sections included the aggregate data analysis, and the discussion of individuals over 2 rem.

1.2 Report Availability

Requests for additional copies of this report, requests for access to the data files or individual dose records used to compile this report, and suggestions and comments should be directed to

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Visit the DOE Web site at **http://www.hss.energy.gov** for more information on occupational radiation exposure, such as the following:

- Annual occupational radiation exposure reports in pdf files since 1974
- Guidance on reporting radiation exposure information to the DOE Headquarters Radiation Exposure Monitoring System (REMS)
- Guidance on how to request a dose history for an individual
- Statistical data since 1987 for analysis
- Applicable DOE orders and manuals for the record keeping and reporting of occupational radiation exposure at DOE
- "As low as reasonably achievable" (ALARA) activities at DOE

Section One	Provides a description of the content and organization of this report.
Section Two	Provides a discussion of the radiation protection and dose reporting requirements.
Section Three	Presents the occupational radiation dose data from monitored individuals at DOE facilities for 2007. The data are analyzed to show trends over the past five years.
Section Four	Includes instructions to submit successful ALARA projects within the DOE complex.
Section Five	Presents conclusions based on the analysis contained in this report.
Appendices	In an effort to streamline this publication, the appendices are now offered in color on the DOE Radiation Exposure Web site. Please visit **http://www.hss.energy.gov** and select HSS Reports and Occupational Radiation Exposure Reports to review.

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Section Two
Standards and Requirements

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One of DOE's primary objectives is to provide a safe and healthy workplace for all employees and contractors. To meet this objective, DOE's Office of Health, Safety and Security (HSS) establishes comprehensive and integrated programs for the protection of workers from hazards in the workplace, including ionizing radiation. The basic DOE standards are radiation dose limits, which establish maximum permissible doses to workers and members of the public. In addition to the requirement that radiation doses not exceed the limits, contractors and subcontractors are required to maintain exposures ALARA.

This section discusses the radiation protection standards and requirements in effect for 2007. For more information on past requirements, visit DOE's Web site for DOE Directives, Regulations, and Standards at **http://www.hss.energy.gov**.

2.1 Radiation Protection Requirements

DOE radiation protection standards in effect in 2007 are based on Federal guidance for protection against occupational radiation exposure promulgated by the U.S. Environmental Protection Agency (EPA) in 1987. [1] This guidance, initially implemented by DOE in 1989, is based on the 1977 recommendations of the International Commission on Radiological Protection (ICRP) [2] and the 1987 recommendations of the National Council on Radiation Protection and Measurements (NCRP). [3] This guidance recommends that internal organ dose be added to the external whole-body dose to determine the total effective dose equivalent (TEDE). Prior to this, the whole-body dose and internal organ dose were each limited separately.

In summary, the current laws and requirements for occupational radiation protection pertaining to the information collected and presented in this report are shown in *Exhibit 2-1*.

Exhibit 2-1:
Current Laws and Requirements Pertaining to This Report.

Title	Date	Description
10 CFR 835, "Occupational Radiation Protection." [4]	Issued 12/14/93. Amended 11/4/98. Amended 6/8/07.	Establishes radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation that results from the conduct of DOE activities.
DOE Order 231.1A [5]	Approved 8/19/03. Cancelled DOE Order 231.1.	Requires the annual reporting of occupational radiation exposure records to the DOE REMS repository.
DOE Manual 231.1-1A [6]	Approved 3/19/04. Cancelled DOE Manual 231.1-1.	Specifies the format and content of the reports required by DOE Order 231.1A. Readers should note that the revisions of this manual affect the content and reporting of radiation exposure records that were reported to the DOE REMS repository since March 2006.

2.2 Radiation Dose Limits

Radiation dose limits are codified in 10 CFR 835.202, 206,207, and 208 [4] and are summarized in *Exhibit 2-2*.

Under 10 CFR 835.204, planned special exposures (PSEs) may be authorized under certain conditions, allowing an individual to receive exposures in excess of the dose limits shown in Exhibit 2-2. With the appropriate prior authorization, the annual dose limit for an individual may be increased by an additional 5 rems (50 mSv) TEDE above the routine dose limit, as long as the individual does not exceed a cumulative lifetime TEDE of 25 rems (250 mSv) from other PSEs and doses above the limits. PSE doses are required to be recorded separately and are only intended to be used in exceptional situations where dose reduction alternatives are unavailable or impractical. No PSEs have occurred since the requirement became effective

2.3 Reporting Requirements

On August 19, 2003, DOE approved and issued the revised DOE Order 231.1A. [5] The DOE Manual 231.1-1A, [6] which details the format and content of reporting radiation exposure records to DOE, was approved on March 19, 2004. The revisions affected the content and reporting of radiation exposure records, beginning with the 2005 monitoring year. All of the 90 organizations that reported in 2007 reported under the revised Manual 231.1-1A.

Exhibit 2-2:
DOE Dose Limits from 10 CFR 835.

Personnel Category	Section of 10 CFR 835	Type of Exposure	Acronym	Annual Limit
General employees	835.202	Total effective dose equivalent.	TEDE	5 rems
		Deep dose equivalent + committed dose equivalent to any organ or tissue (except lens of the eye). This is often referred to as the total organ dose equivalent.	DDE+CDE (TODE)	50 rems
		Lens (of the eye) dose equivalent.	LDE	15 rems
		Shallow dose equivalent to the skin of the whole body or to any extremity.	SDE-WB and SDE-ME	50 rems
Declared pregnant workers*	835.206	Total effective dose equivalent.	TEDE	0.5 rem per gestation period
Minors	835.207	Total effective dose equivalent.	TEDE	0.1 rem
Members of the public in a controlled area	835.208	Total effective dose equivalent.	TEDE	0.1 rem

* Limit applies to the embryo/fetus.

2.4 Amendment to 10 CFR 835

In August 2006, DOE published a proposed amendment to 10 CFR 835 in the *Federal Register,* and, in June 2007, the final rule was published. The amendment

- Specified new dosimetric terminology and quantities based on ICRP 60/68 in place of ICRP 26/30
- Specified ICRP 60 *tissue weighting factors* in place of ICRP 26 *weighting factors*
- Specified ICRP 60 *radiation weighting factors* in place of ICRP 26 *quality factors*
- Amended other parts of the regulation that changed as a result of adopting ICRP 60 dosimetry system
- Used the ICRP 18 dose conversion factors to determine values for the derived air concentrations (DACs)

The rule became effective on July 9, 2007, and is required to be fully implemented by the DOE sites by July 9, 2010. Therefore the revisions were not applicable during this reporting period.

Several aspects of the amendment impact the record keeping and reporting of DOE occupational radiation exposure. A revision of the DOE Manual 231.1-1A will be issued in order to conform to the amended rule. The following is a summary of the changes that will affect the manual and the reporting of radiation exposure records:

- A change in dosimetric terms.
- A change in weighting factors to tissue weighting factors and a redefinition of the tissue weighting factor remainder.
- A change in quality factors to radiation weighting factors, most significantly this affects neutron dose assessment.
- Recording of internal dose is not required for any monitoring result estimated to correspond to an individual receiving less than 0.01 rem (0.1 mSv) committed effective dose.
- Added specific organ dose reporting for the colon, liver, stomach, esophagus, bladder, and skin.

When issued, the revised draft Manual 231.1-1A will be available for review and comment through the DOE RevCom process at **http://directives.doe.gov**.

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Occupational Radiation Dose at DOE

3.1 Analysis of the Data

Certain key indicators have been determined to be useful in evaluating the occupational radiation exposures received at DOE facilities. The key indicators are analyzed to identify and correlate parameters having an impact on radiation dose at DOE.

Key indicators for the analysis of aggregate data are

- number of records for monitored individuals
- individuals with measurable dose,
- collective dose,
- average measurable dose, and
- dose distribution.

Analysis of individual dose data includes an examination of

- doses exceeding 5 rems (50 mSv) DOE regulatory limits and
- doses exceeding the 2 rems (20 mSv) DOE administrative control level (ACL).

Additional information is provided in this report concerning activities at sites contributing to the majority of the collective dose.

3.2 Analysis of Aggregate Data

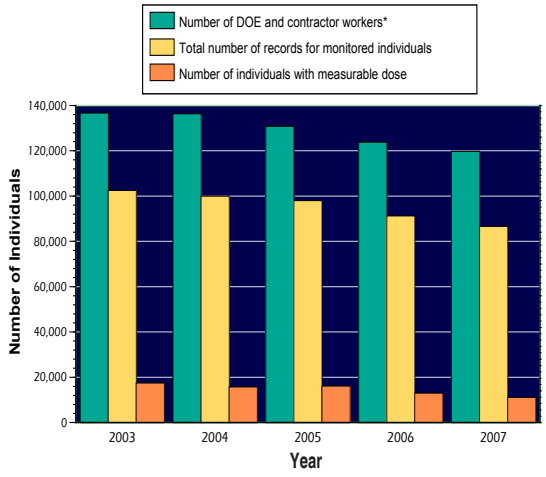
3.2.1 Number of Records for Monitored Individuals

The number of records for monitored individuals represents the size of the DOE worker population monitored for radiation dose. The number represents the sum of all records for monitored individuals, including all DOE employees, contractors, and subcontractors, as well as members of the public. The number of monitored individuals is the number of monitoring records submitted by each site. Because individuals may have more than one monitoring record, they may be counted more than once. Although an individual may be counted more than once, the overall effect on the numbers and analysis is minimal. The number of records for monitored individuals is an indication of the size of a dosimetry program, but it is not necessarily an indicator of the size of the exposed workforce. This is because of the conservative practice at some DOE facilities of providing radiation dose monitoring to individuals for reasons other than the potential for exposure to radiation and/or radioactive materials exceeding the monitoring thresholds. Many individuals are monitored for reasons such as security, administrative convenience, and legal liability. Some sites offer monitoring for any individual who requests monitoring, independent of the potential for exposure. For this reason, the number of records for workers who receive a measurable dose best represents the exposed workforce.

3.2.2 Number of Records for Individuals with Measurable Dose

DOE uses the number of individuals receiving measurable dose to represent the exposed workforce size. The number of individuals with measurable dose includes any individual with a reported TEDE greater than zero (individuals with a detectable dose).

Exhibit 3-1a:
Monitoring of the DOE Workforce, 2003–2007.



*The number of DOE and contractor workers was determined from the total annual work hours at DOE [7] converted to full-time equivalents.

For 2007, 72% of the DOE workforce was monitored for radiation dose, and 13% of monitored individuals received a measurable dose.

Exhibits 3-1a and *3-1b* show the number of DOE and contractor workers, the total number of workers monitored for radiation dose, the number of individuals with measurable dose, and the relative percentages for the past five years.

For 2007, 72% of the DOE workforce was monitored for radiation exposure. Thirteen percent of monitored individuals received a measurable dose. Over the past five years, the percentage of individuals monitored for radiation exposure has remained within 2% of the five-year average; the percentage of monitored individuals receiving any measurable radiation dose each year was within 2% of the five-year average.

Seventeen of the 29 reporting sites experienced decreases in the number of workers with measurable dose from 2006 to 2007. The largest decrease in total number of workers with measurable dose occurred at Los Alamos, which attributed part of the decrease to an operational pause in the fourth quarter of 2007 that was conducted in order to address criticality safety concerns. Fermilab also experienced a decrease in the number of workers with measurable dose due to a 10-week accelerator maintenance and improvement shutdown. Three facilities ceased operations during 2006 and therefore decreased the number of workers with measurable dose: Fernald, Mound, and the Ashtabula Closure Project (which previously reported under RMI Environmental Services). The largest increase in the number of workers receiving measurable dose occurred at the Hanford Site, which attributed the increase to the handling of materials at the Plutonium Finishing Plant and the removal of significant amounts of equipment and tooling from KE Basin in preparation for decontamination and decommissioning (D&D). A discussion of activities at the highest-dose facilities is included in Section 3.4.3.

3.2.3 Collective Dose

The collective dose is the sum of the dose received by all individuals with measurable dose and is measured in units of person-rem (person-Sv). The collective dose is an indicator of the overall radiation exposure at DOE facilities and includes the dose to all DOE employees, contractors, and subcontractors, as well as members of the public. DOE monitors the collective dose as one measure of the overall performance of radiation protection programs to keep individual exposures and collective exposures ALARA.

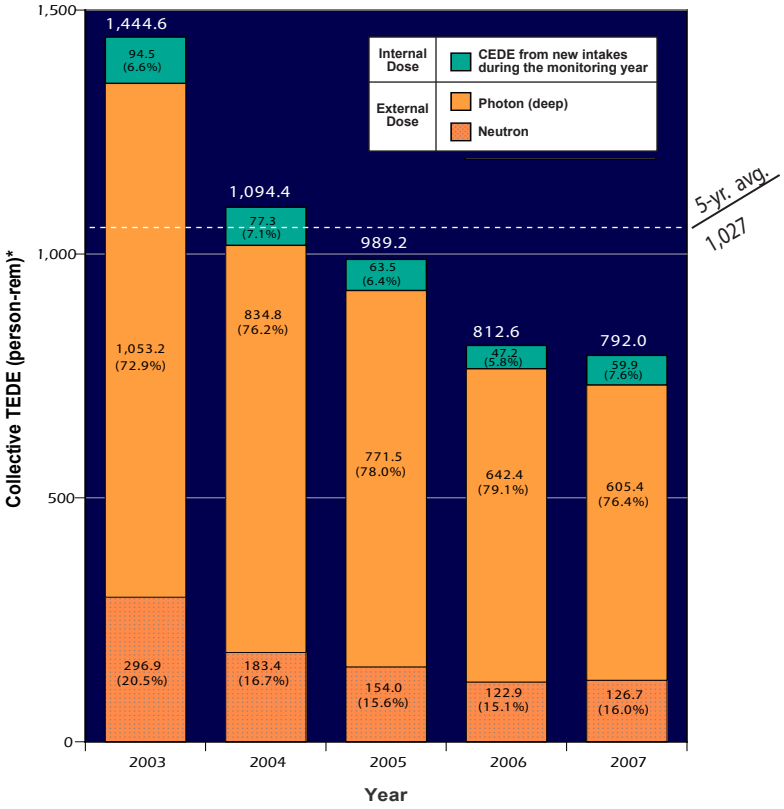
As shown in *Exhibit 3-2*, the collective TEDE decreased at DOE by 3% from 813 person-rems (8.13 person-Sv) in 2006 to 792 person-rems (7.92 person-Sv) in 2007. Thirty-eight percent of the DOE sites (11 out of 29 sites) reported increases in the collective TEDE from the 2006 values. The five sites that contributed to the majority of the DOE collective TEDE in 2007 are (in descending order of collective dose for 2007) Hanford, Los Alamos, Idaho, Savannah River, and Oak Ridge. Two out of these five sites reported decreases in the collective TEDE, while three sites reported increases.

Exhibit 3-1b:
Monitoring of the DOE Workforce, 2003–2007.

Year	DOE & Contractor Workforce	Number of Workers Monitored	Percent of Workers Monitored*	Number Monitored w/Measurable Dose	Percent Monitored w/Measurable Dose*
2003	136,710	102,509	75% ▼	17,484	17%
2004	136,353	100,011	73% ▼	15,739	16% ▼
2005	130,795	98,040	75% ▲	16,136	16%
2006	123,768	91,280	74% ▼	12,953	14% ▼
2007	119,776	86,630	72% ▼	11,077	13% ▼
5-Year Average	**129,480**	**95,694**	**74%**	**14,678**	**15%**

*Up arrows indicate an increase from the previous year's value. Down arrows indicate a decrease from the previous year's value.

Exhibit 3-2:
Components of TEDE, 2003–2007.



* The percentages in parentheses represent the percentage of each dose component to the collective TEDE.

The collective TEDE decreased by 3% at DOE from 2006 to 2007.

The collective internal dose increased by 27% from 2006 to 2007.

Neutron dose increased by 3% from 2006 to 2007.

Photon dose decreased by 6% from 2006 to 2007.

Photon dose (deep)—the component of external dose from gamma or X-ray electromagnetic radiation (also includes energetic betas)

Neutron dose—the component of external dose from neutrons ejected from the nucleus of an atom during nuclear reactions

Internal dose—radiation dose resulting from radioactive material taken into the body

The two sites that reported decreases in the collective dose attributed the decreases to the following:

- Some planned activities for programs at Los Alamos National Laboratory (LANL) were not performed, thereby reducing exposure. Additionally, there was a significant reduction in work throughout the facility during a pause in operations in the fourth quarter of 2007 due to criticality safety concerns.
- ALARA initiatives that increased awareness of containers and areas with elevated dose rates at the Advanced Mixed Waste Treatment Project, a cessation of work at the Space Battery assembly, and a shutdown of the Fuel Conditioning Facility at the Idaho National Laboratory.

The three sites that reported increases in the collective dose attributed the increases to the following:

- Handling of materials at the Plutonium Finishing Plant for shipping off site, removal of significant amounts of equipment and tooling from KE Basin in preparation for D&D, and exposure related to S-102 cleanup activities at Hanford.
- Expanded activities, including a high activity drain replacement in the central laboratory facility, increased effort for the Tank 37 high level waste transfer line replacement and drum re-packaging of higher dose transuranic wastes in multiple facilities at Savannah River Site (SRS).
- Waste operations tasks at Oak Ridge National Laboratory (ORNL).

In addition to these increases at the DOE sites with the highest collective dose, West Valley collective TEDE increased by 177% from 16.1 person-rems (161 person-mSv) in 2006 to 44.5 person-rems (445 person-mSv) in 2007. West Valley attributed the increase to an increase in activities involving radiation exposure for the Waste Management Project and the Deactivation, Decontamination, Decommissioning and Demolition (D4) Closure Project. Activities included the completion

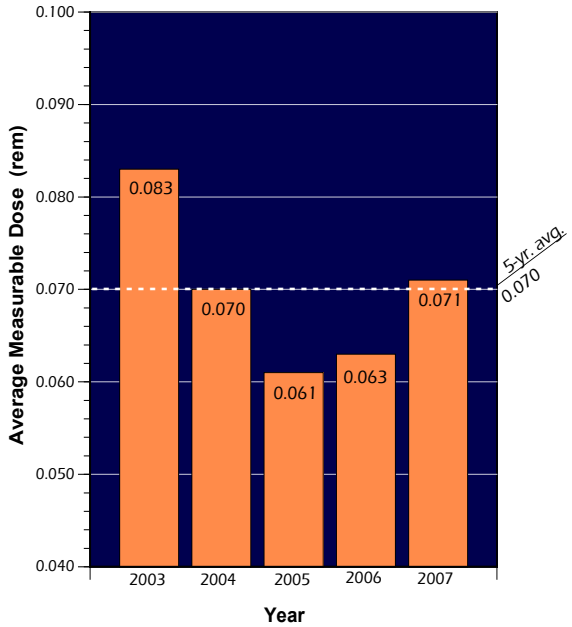
of emptying the drum cell and shipping all retrieved waste drums to the Nevada Test Site; decommissioning the fuel receiving and storage area water treatment area; and low level waste processing. In addition, the Remote Handle Waste Facility continued to operate by sorting and processing radioactive waste.

It is important to note that the collective TEDE includes the components of external dose and internal dose. *Exhibit 3-2* shows the types of radiation and their contribution to the collective TEDE. Internal dose, photon, and neutron components are shown.

It should be noted that the internal dose shown in *Exhibit 3-2* for 2003 through 2007 is based on the 50-year committed effective dose equivalent (CEDE) methodology, which assigns the projected dose delivered to the individual over the next 50 years to the year when the intake occurred. The internal dose component increased by 27% from 47 person-rems (470 person-mSv) in 2006 to 60 person-rems (600 person-mSv) in 2007. The collective internal dose can vary from year to year due to the relatively small number of intakes of radioactive material. The collective photon dose decreased by 6% from 642 person-rems (6.42 person-Sv) in 2006 to 605 person-rems (6.05 person-Sv) in 2007.

The neutron component of the TEDE increased by 3% from 123 person-rems (1.23 person-Sv) in 2006 to 127 person-rems (1.27 person-Sv) in 2007. This is due primarily to increases in the neutron dose at the SRS and Hanford. Hanford and SRS process plutonium, which can result in a neutron dose from the alpha/neutron reaction and from spontaneous fission of the plutonium.

Exhibit 3-3:
Average Measurable TEDE, 2003–2007.



3.2.4 Average Measurable Dose

The average measurable dose to DOE workers presented in this report for TEDE and CEDE is determined by dividing the collective dose (i.e. TEDE or CEDE) by the number of individuals with measurable dose for each dose type. This is one of the key indicators of the overall level of radiation dose received by DOE workers.

The average measurable TEDE is shown in *Exhibit 3-3*. The average measurable TEDE increased by 13% from 0.063 rem (0.63 mSv) in 2006 to 0.071 rem (0.71 mSv) in 2007. The increase in the average measurable TEDE was due to a decrease in the number of individuals with measurable TEDE. While the collective dose and average measurable dose serve as measures of the magnitude of the dose accrued by DOE workers, they do not indicate the distribution of doses among the worker population.

3.2.5 Dose Distribution

Exposure data are commonly analyzed in terms of dose intervals to depict the dose distribution among the worker population. *Exhibit 3-4* shows the number of individuals in each of 18 different dose ranges. The number of individuals receiving doses above 0.1 rem (1 mSv) is included to show the number of individuals with doses above the monitoring threshold specified in 10 CFR 835.402(a) and (c). [4]

Exhibit 3-4 shows a decrease in the number of individuals in most dose ranges except for the 0.5–0.75 rem (5–7.5 mSv) range and above 1 rem (10 mSv). Ninety-nine percent of the individuals monitored had doses less than 0.25 rem (2.5 mSv). It also shows that the collective TEDE has decreased each year from 2003 to 2007. For the first time in the past four years, one individual received a TEDE above 5 rems (50 mSv) from an internal dose at LANL (see section 3.3.1). Another way to examine the dose distribution is to analyze the percentage of the dose received above a certain dose value as compared to the total collective dose.

The United Nations' *Sources and Effects of Ionizing Radiation, United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2000 Report to the General Assembly, with Scientific Annexes, Volume I*, [8] recommends the calculation of a parameter "SR"

Exhibit 3-4:
Distribution of TEDE by Dose Range, 2003–2007.

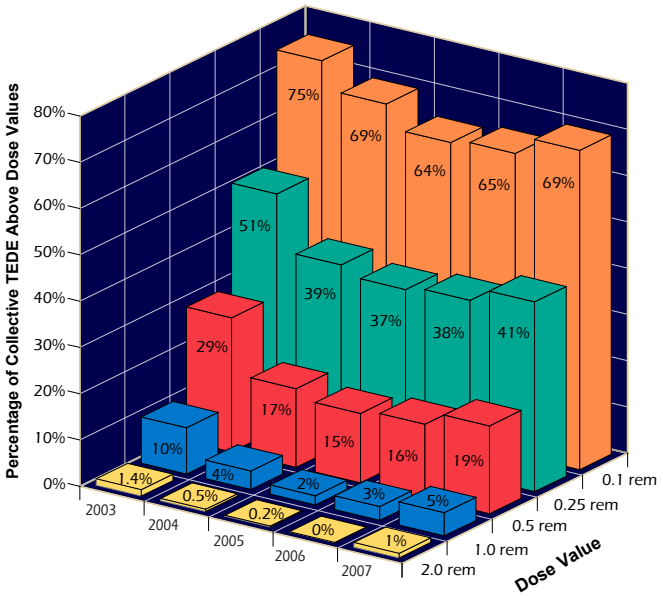
TEDE Range (rem)		2003	2004	2005	2006	2007
Number of Individuals in Each Dose Range*	Less than measurable	85,025	84,272	81,904	78,327	75,553
	measurable <0.1	13,865	12,700	13,537	10,815	8,943
	0.10–0.25	2,205	2,086	1,753	1,441	1,421
	0.25–0.5	910	703	644	520	511
	0.5–0.75	287	157	141	120	146
	0.75–1.0	117	63	42	36	33
	1–2	97	28	18	21	22
	2–3	1	1	1		
	3–4		1			
	4–5					
	5–6					
	6–7					
	7–8					1
	8–9	1				
	9–10					
	10–11	1				
	11–12					
	>12					
Total number of records for monitored Individuals		102,509	100,011	98,040	91,280	86,630
Number with measurable dose		17,484	15,739	16,136	12,953	11,077
Number with dose >0.1 rem		3,619	3,039	2,599	2,138	2,134
% of individuals with measurable dose		17%	16%	16%	14%	13%
Collective TEDE (person-rems)		1,444.6	1,094.4	989.2	812.6	792.0
Average measurable TEDE (rem)		0.083	0.070	0.061	0.063	0.071

* Individuals with doses equal to the dose value separating the dose ranges are included in the next higher dose range.

(previously referred to as CR) to aid in the examination of the distribution of radiation exposure among workers. The parameter SR is defined to be the ratio of the annual collective dose incurred by workers whose annual doses exceed 1.5 rems (15 mSv) to the total annual collective dose. The UNSCEAR report notes that a dose level of 1.5 rems (15 mSv) may not be useful where doses are consistently lower than this level, and it is recommended that research organizations report SR values lower than 1.5 rems (15 mSv) where appropriate. For this reason, DOE calculates and tracks the SR at dose levels of 0.100 rem (1 mSv), 0.250 rem (2.5 mSv), 0.500 rem (5 mSv), 1.0 rem (10 mSv), and 2.0 rems (20 mSv). The SR values shown in *Exhibit 3-5* were calculated by summing the TEDE to each individual who received a TEDE greater than or equal to the specified dose level divided by the total collective TEDE. This ratio is presented as a percentage rather than a decimal fraction.

Exhibit 3-5 shows the dose distribution given by percentage of collective TEDE above each of five dose

Exhibit 3-5:
Percentage of Collective TEDE Above Dose Values During 2003–2007.

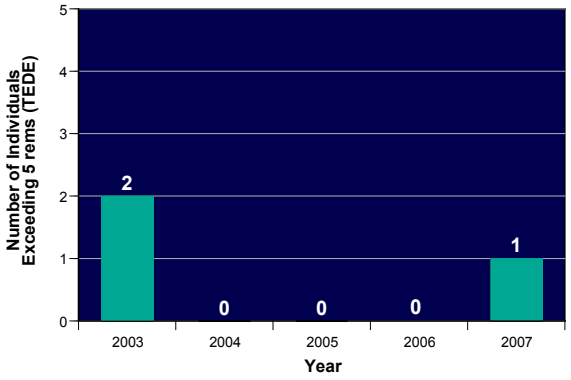


values, from 0.1 rem (1 mSv) to 2 rems (20 mSv). This graph facilitates the examination of a property described above that may be used as an indication of effective ALARA programs at DOE: a relatively small percentage of the collective dose accrued in the higher dose ranges. *Exhibit 3-5* also shows that each successively higher dose range is responsible for a lower percentage of the collective dose. The decrease in the values shown in the dose distribution indicate that, in addition to a decrease in the collective dose, most individuals received doses at lower dose values from 2003 to 2006. In 2007, the percentage in each dose range increased slightly. The percentages above 0.5 rem (5 mSv) increased primarily due to the individual who received a TEDE above 5 rems (50 mSv).

3.3 Analysis of Individual Dose Data

The previous analysis is based on aggregate data for DOE. From an individual worker perspective, as well as a regulatory perspective, it is important to closely examine the doses received by individuals in the elevated dose ranges to thoroughly understand the circumstances leading to these doses in the workplace and to better manage and avoid these doses in the future. The following analysis focuses on doses received by individuals that were in excess of the DOE limit (5 rems [50 mSv] TEDE) and the DOE recommended ACL (2 rems [20 mSv] TEDE).

Exhibit 3-6:
Number of Individuals Exceeding 5 rems (TEDE), 2003–2007.

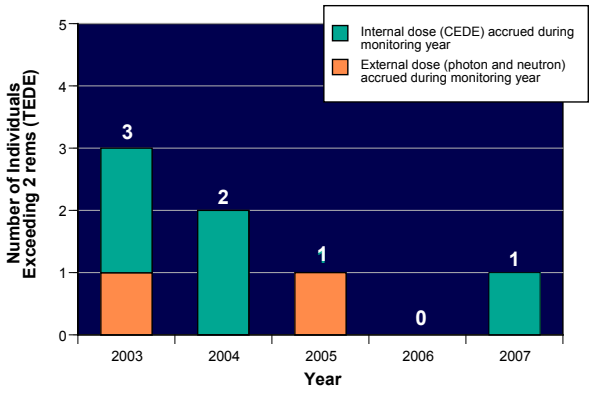


In 2007, one individual received a dose in excess of the 5 rems (50 mSv) TEDE limit.

3.3.1 Doses in Excess of DOE Limit

Exhibit 3-6 shows the number of doses in excess of the TEDE regulatory limit (5 rems [50 mSv]) from 2003 through 2007. There were no individuals that exceeded 5 rems (50 mSv) TEDE from 2004 to 2006, but one individual received a TEDE in excess of 5 rems (50 mSv) in 2007.

Exhibit 3-7:
Number of Doses in Excess of the DOE 2 rems ACL, 2003–2007.



The individual received a CEDE of 7.530 rems from a plutonium intake at LANL. In January 2007, a metallographic glove box worker sustained an injury to the left index finger due to a puncture by a screwdriver while working at a glove box at the Chemical & Metallurgy Research (CMR) facility. The wound count was positive for radiological contamination, the isotope being plutonium 239 (Pu-239). (See ORPS report NA–LASO-LANL-CMR-2007-0002.)

3.3.2 Doses in Excess of Administrative Control Level

The Radiological Control Standard (RCS) recommends a 2 rems (20 mSv) ACL for TEDE, which should not be exceeded without prior DOE approval. The RCS recommends that each DOE site establish its own more restrictive ACL that would require contractor management approval to be exceeded. The number of individuals receiving doses in excess of the 2 rems (20 mSv) ACL is a measure of the effectiveness of DOE's radiation protection program.

As shown in *Exhibit 3-7*, there was one individual who received a TEDE above 2 rems (20 mSv) during 2007. This individual also exceed the 5 rems (50 mSv) TEDE limit as described in the previous section.

Exhibit 3-8:
Doses in Excess of DOE Limits, 2003–2007.

Year	TEDE (rem)	DDE (rem)	CEDE (rem)	Intake Nuclides	Facility Types	Site
2003	8.170	0.949	7.221	Pu-238	Other	LANL
	10.197	0.609	9.588	Pu-238	Waste Processing	LANL
2004	None reported					
2005	None reported					
2006	None reported					
2007	7.530	0	7.530	Pu-238, Pu-239	Research, General	LANL

3.3.3 Internal Depositions of Radioactive Material

As shown in *Exhibit 3-8*, some of the highest doses to individuals have been the result of intakes of radioactive material. For this reason, DOE emphasizes the need to avoid intakes and tracks the number of intakes as a performance measure.

The number of internal depositions of radioactive material (an indicator of worker intakes), collective committed effective dose equivalent (CEDE), and average measurable CEDE for 2003–2007 are shown in *Exhibit 3-9*. The number of internal depositions decreased by 4% from 1,260 in 2006 to 1,211 in 2007, while the collective CEDE increased by 27%. As a result, the average measurable CEDE increased from 0.037 rem (0.37 mSv) in 2006 to 0.049 rem (0.49 mSv) in 2007.

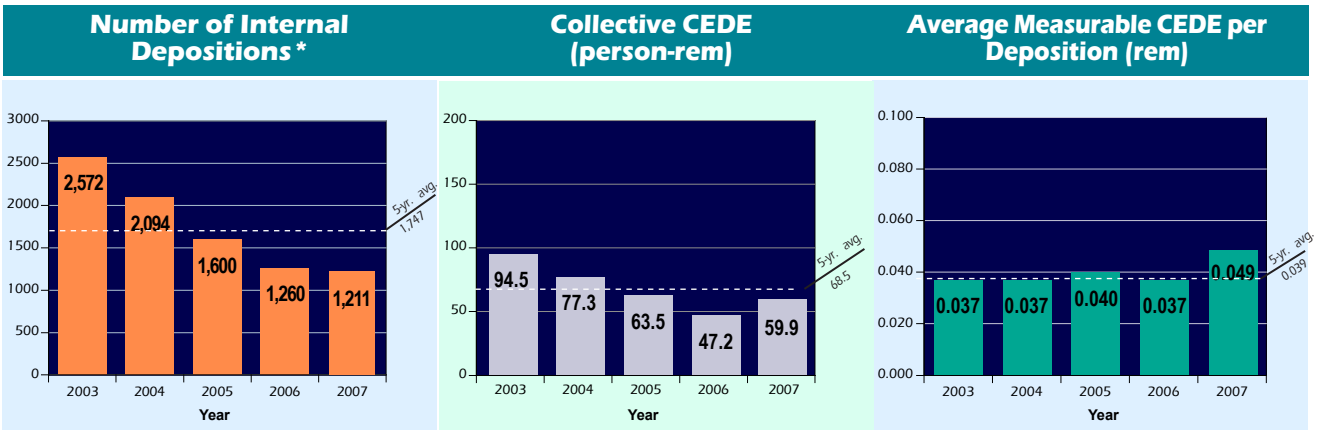
During the past five years, there have been five intakes from plutonium in excess of 2 rems (20mSv) and three of the five doses were also in excess of 5 rems (50 mSv).

While the numbers of internal depositions above 5 rems (50 mSv) have been few, they contributed significantly to the collective internal dose in 2003. In 2007, one individual received an internal dose from plutonium above 5 rems (50 mSv) as described in section 3.3.1.

A majority (83%) of the collective CEDE was from uranium intakes at the Oak Ridge Y-12 National Security Complex during the operation and management of Enriched Uranium Operations facilities at the site. Compared to external dose, relatively few workers receive measurable internal dose so that fluctuations in the number of workers and collective CEDE can occur from year to year. While trend analysis is statistically limited, these values have exhibited an overall decreasing trend over the past five years.

Exhibit 3-10 shows the distribution of the internal dose from 2003 to 2007. The total number of individuals with intakes in each dose range is the sum of all records of intake in the subject dose range. Individuals with multiple intakes during the year may be counted more than once.

Exhibit 3-9:
Number of Internal Depositions, Collective CEDE, and Average Measurable CEDE, 2003–2007.



* The number of internal depositions represents the number of internal dose records with positive results reported for each individual. Individuals may have multiple intakes in a year and, therefore, may be counted more than once.

Exhibit 3-10:
Internal Dose Distribution from Intakes, 2003–2007.

Year	Number of Individuals with CEDE in the Ranges (rem)*											Total No. of Indiv.**	Total Collective CEDE (person-rem)
	Meas. <0.020	0.020-0.100	0.100-0.250	0.250-0.500	0.500-0.750	0.750-1.000	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	>5.0		
2003	1,622	763	163	18	3		1				2	2,572	94.5
2004	1,364	521	184	12	7	3	1	1	1			2,094	77.3
2005	858	562	156	22	1	1						1,600	63.5
2006	664	474	106	15	1							1,260	47.2
2007	626	425	139	18	2						1	1,211	59.9

*Individuals with doses equal to the dose value separating the dose ranges are included in the next higher dose range.
**Individuals may have multiple intakes in a year and, therefore, may be counted more than once.

Doses below 0.020 rem (0.20 mSv) are shown as a separate dose range to show the large number of doses in this low-dose range. There was one internal dose above 5 rems (50 mSv) in 2007.

The internal dose records indicate that the majority of the intakes result in very low doses. In 2007, 52% of the internal dose records were for doses below 0.020 rem (0.20 mSv). Over the five-year period, internal doses from intakes accounted for 7% of the collective TEDE, and 10% of the individuals who received internal doses were above the monitoring threshold specified (100 mrem [1 mSv]) in 10 CFR 835.402(c). [4]

3.3.4 Bioassay and Intake Summary Information

The revised DOE Manual 231.1-1A [6] was issued on March 19, 2004. Reporting of bioassay and intake summary data under the revised DOE Manual 231.1-1A occurred for the first time in 2005. During the past three years, urinalysis has been reported as the most common method of bioassay measurement used to determine internal doses to the individuals. *Exhibit 3-11* shows the breakdown of bioassay measurements by measurement type. The measurements reported under 'in vivo' include measurements taken while the radioactive material is in the body of the monitored person. Examples of in vivo measurements include whole body counts and lung or thyroid counts. The measurements reported under 'other' were for air samples taken in the workplace that are used to calculate the amount of airborne radioactive material taken into the body and the resultant internal dose. Note that the numbers shown are

Exhibit 3-11:
Bioassay Measurements, 2005-2007.

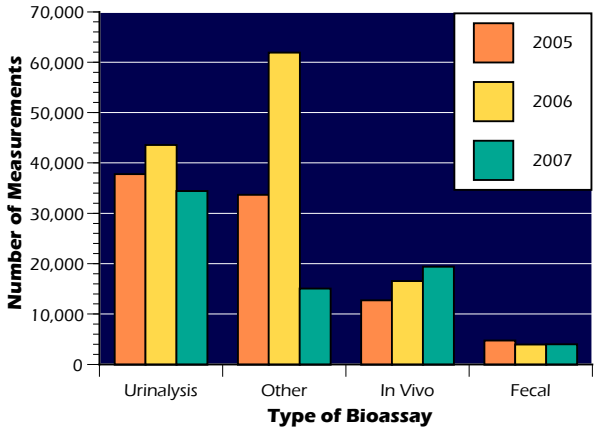
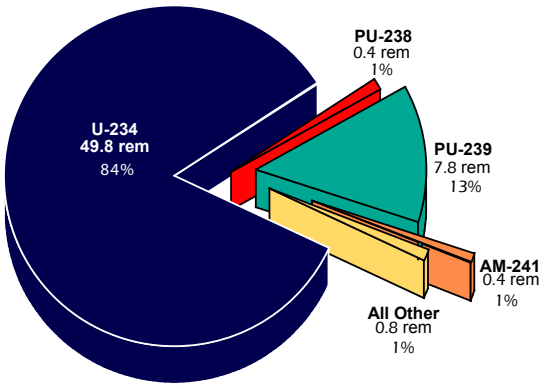


Exhibit 3-12:
Collective CEDE by Radionuclide, 2007.



based on the number of measurements taken, not the number of individuals monitored. Individuals may have measurements taken more than once during the year.

Seventy-one percent of the urinalysis measurements were performed at four sites: Oak Ridge Y-12, SRS, LANL, and Hanford. All of the bioassay measurements reported as "other" were from air sampling reported by Fernald, Hanford, Mound, SRS, and Pantex. In 2006, the majority of air samples (66%) were reported by Fernald. The large number of air samples taken at Fernald was due to the fact that they provided air sampling for every worker who entered an area where thorium may have been present. Work at Fernald in these areas was completed in 2006, resulting in a 76% decrease in the number of air sample measurements taken and reported in the "other" category in 2007.

Exhibit 3-12 shows the breakdown of the collective CEDE by radionuclide for 2007. Uranium-234 accounts for the largest percentage of the collective dose, with over 99% of this dose accrued at the Oak Ridge Y-12.

3.4 Analysis of Site Data

3.4.1 Collective TEDE by Site and Other Facilities

The collective TEDE for 2005 through 2007 for the major DOE sites and operations/field offices is shown graphically in *Exhibit 3-13*. A list of the collective TEDE and number of individuals with measurable TEDE by DOE sites is shown in *Exhibit 3-14*. The collective TEDE decreased by 3% from 813 person-rems (8.13 person-Sv) in 2006 to 792 person-rems (7.92 person-Sv) in 2007, with LANL, Idaho, Hanford (including the Hanford Site, ORP, and PNNL), SRS, and the Oak Ridge sites (including ETTP, Y-12, ORNL, and ORISE) contributing 83% of the total DOE collective TEDE.

3.4.2 Changes by Site from 2006 to 2007

Exhibit 3-15 shows the collective TEDE, the number with measurable dose, the average measurable TEDE, and the percentage of the collective TEDE delivered above 0.500 rem by site for 2007, as well as the percentage change

Exhibit 3-13:
Collective TEDE by DOE Site for 2005–2007.

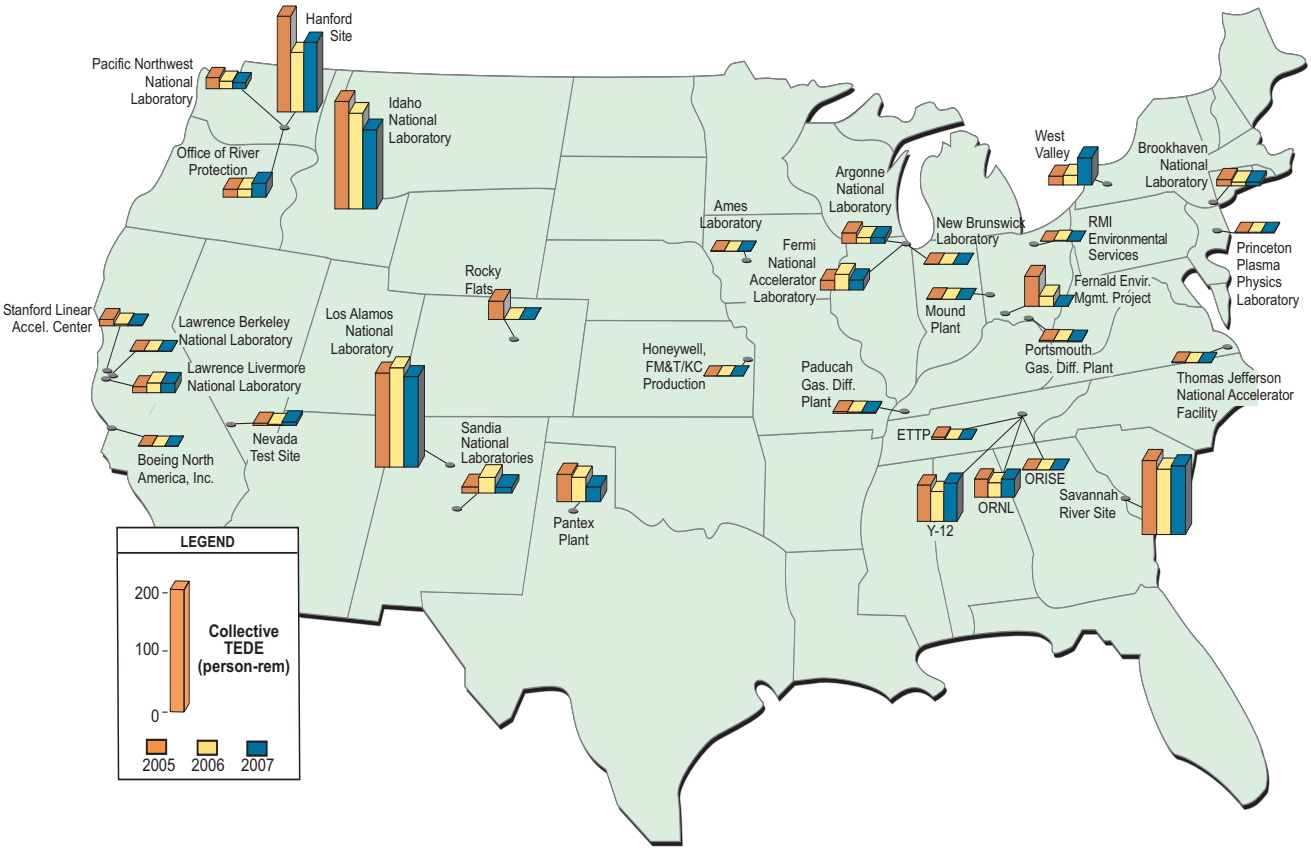


Exhibit 3-14:
Collective TEDE and Number of Individuals with Measurable TEDE by DOE Site, 2005–2007.

Site	2005		2006		2007	
	Collective TEDE (person-rem)	Number with Meas. TEDE	Collective TEDE (person-rem)	Number with Meas. TEDE	Collective TEDE (person-rem)	Number with Meas. TEDE
Ames Laboratory	0.3	14	0.2	8	0.2	6
Argonne National Laboratory	17.0	267	9.5	158	9.2	146
Boeing North America, Inc.–Research	1.1	29	0.0	5	0.2	14
Brookhaven National Laboratory	10.2	216	6.1	147	6.3	191
Fermi National Accelerator Laboratory	16.1	425	25.7	776	16.6	213
Fernald Environmental Management Project*	48.8	846	16.8	462	–	–
Hanford:						
Hanford Site	170.8	1,828	106.1	1,451	124.2	1,650
Office of River Protection	13.2	272	13.5	278	22.8	397
Pacific Northwest National Laboratory	20.1	194	13.3	182	11.0	181
Honeywell, FM&T/KC Production	0.1	24	0.2	26	0.1	22
Idaho National Laboratory	**181.6**	2,054	161.7	2,023	133.7	1,871
Lawrence Berkeley National Laboratory	1.2	22	0.9	16	0.8	17
Lawrence Livermore National Laboratory	10.0	185	16.4	134	15.5	137
Los Alamos National Laboratory	155.4	2,168	**164.0**	1,985	**149.6**	1,392
Mound Plant*	1.0	119	0.2	15	–	–
Nevada Test Site	3.6	71	1.8	39	5.7	70
New Brunswick Laboratory	0.2	4	0.1	2	0.0	2
Oak Ridge:						
East Tennessee Technology Park	4.4	161	0.5	22	0.2	15
Oak Ridge Institute for Science and Education	0.3	36	0.0	8	0.1	35
Oak Ridge National Laboratory	32.2	547	25.6	416	31.8	424
Y-12 National Security Complex	64.8	1,277	53.3	1,171	68.4	1,233
Paducah Gaseous Diffusion Plant	2.8	45	2.2	25	1.7	29
Pantex Plant	44.2	334	39.7	327	23.9	293
Portsmouth Gaseous Diffusion Plant	2.6	45	2.2	40	1.5	18
Princeton Plasma Physics Laboratory	1.2	136	1.5	155	1.4	153
RMI Environmental Services*	0.0	1	1.5	66	–	–
Rocky Flats Environmental Technology*	28.3	1,507	–	–	–	–
Sandia National Laboratories	8.5	222	22.0	268	7.8	175
Savannah River Site	121.3	**2,360**	107.2	**2,387**	112.4	**2,135**
Stanford Linear Accelerator Center	10.4	359	3.0	102	1.5	41
Thomas Jefferson National Accelerator Facility	1.5	72	0.5	29	0.8	19
West Valley	14.5	210	16.1	189	44.5	188
Site Office Personnel**	1.3	85	0.7	41	0.3	10
Totals* **	**989.2**	**16,135**	**812.6**	**12,953**	**792.0**	**11,077**

* In 2006, Fernald, Mound Plant, and RMI Environmental Services ceased operations. In addition, in 2005, Rocky Flats completed the cleanup operation. These four facilities are no longer required to report and are not included in 2007.

** Includes site office personnel from Albuquerque, Chicago, Oak Ridge, and Ohio in addition to several smaller facilities not associated with a DOE site. Note: Bold values indicate the greatest value in each column.

*** The collective TEDE totals are calculated from the dose records that are reported in millirem while the values shown are rounded to the nearest tenth of a rem.

Exhibit 3-15:
Site Dose Data, 2007.

Site	2007							
	Collective TEDE (person-rem)	Percent Change from 2006	Number with Meas. Dose	Percent Change from 2006	Avg. Meas. TEDE (rem)	Percent Change from 2006	Percentage of Coll. TEDE above 0.500 rem	Percent Change from 2006
Ames Laboratory	0.2	-13% ▼	6	-25% ▼	0.026	16% ▲		
Argonne National Laboratory	9.2	-3% ▼	146	-8% ▼	0.063	5% ▲	12%	53% ▲
Boeing North America, Inc.–Research	0.2	**363%** ▲	14	180% ▲	0.012	65% ▲		
Brookhaven National Laboratory	6.3	3% ▲	191	30% ▲	0.033	-21% ▼		
Fermi National Accelerator Laboratory	16.6	-36% ▼	213	-73% ▼	0.078	134% ▲	3%	71% ▲
Fernald Environmental Management Project*	–	–	–	–	–	–	–	–
Hanford:								
Hanford Site	124.2	17% ▲	1,650	14% ▲	0.075	3% ▲	18%	25% ▲
Office of River Protection	22.8	69% ▲	397	43% ▲	0.057	18% ▲		
Pacific Northwest National Laboratory	11.0	-17% ▼	181	-1% ▼	0.061	-17% ▼		
Honeywell, FM&T/KC Production	0.1	-35% ▼	22	-15% ▼	0.004	-23% ▼		
Idaho National Laboratory	133.7	-17% ▼	1,871	-8% ▼	0.071	-11% ▼	7%	-59% ▼
Lawrence Berkeley National Laboratory	0.8	-18% ▼	17	6% ▲	0.045	-23% ▼		
Lawrence Livermore National Laboratory	15.5	-5% ▼	137	2% ▲	0.113	-7% ▼	40%	-3% ▼
Los Alamos National Laboratory	**149.6**	-9% ▼	1,392	-30% ▼	0.107	30% ▲	**45%**	33% ▲
Mound Plant*	–	–	–	–	–	–		
Nevada Test Site	5.7	219% ▲	70	79% ▲	0.082	78% ▲		
New Brunswick Laboratory	0.0	-68% ▼	2	0% ▲	0.014	-68% ▼		
Oak Ridge:								
East Tennessee Technology Park	0.2	-54% ▼	15	-32% ▼	0.014	-33% ▼		
Oak Ridge Institute for Science and Education	0.1	202% ▲	35	**338%** ▲	0.004	-31% ▼		
Oak Ridge National Laboratory	31.8	24% ▲	424	2% ▲	0.075	22% ▲	19%	116% ▲
Y-12 National Security Complex	68.4	29% ▲	1,233	5% ▲	0.055	22% ▲	3%	-74% ▼
Paducah Gaseous Diffusion Plant	1.7	-25% ▼	29	16% ▲	0.057	-35% ▼		
Pantex Plant	23.9	-40% ▼	293	-10% ▼	0.082	-33% ▼	22%	100% ▲
Portsmouth Gaseous Diffusion Plant	1.5	-35% ▼	18	-55% ▼	0.081	44% ▲		
Princeton Plasma Physics Laboratory	1.4	-11% ▼	153	-1% ▼	0.009	-9% ▼		
RMI Environmental Services*	–	–	–	–	–	–		
Rocky Flats Environmental Technology*	–	–	–	–	–	–		
Sandia National Laboratories	7.8	-64% ▼	175	-35% ▼	0.045	-46% ▼		
Savannah River Site	112.4	5% ▲	**2,135**	-11% ▼	0.053	17% ▲	7%	**971%** ▲
Stanford Linear Accelerator Center	1.5	-52% ▼	41	-60% ▼	0.035	19% ▲		
Thomas Jefferson National Accelerator Facility	0.8	44% ▲	19	-34% ▼	0.041	120% ▲		
West Valley	44.5	177% ▲	188	-1% ▼	**0.237**	**179%** ▲	41%	100% ▲
Site Office Personnel**	0.3	-65% ▼	10	-76% ▼	0.025	42% ▲		
Totals* **	**792.0**	**-3%** ▼	**11,077**	**-14%** ▼	**0.071**	**13%** ▲	**19%**	**19%** ▲

* In 2006, Fernald, Mound Plant, and RMI Environmental Services ceased operations. In addition, in 2005, Rocky Flats completed the cleanup operation. These four facilities are no longer required to report and are not included in 2007.

** Includes site office personnel from Albuquerque, Chicago, Oak Ridge, and Ohio in addition to several smaller facilities not associated with a DOE site.
Note: Bold values indicate the greatest value in each column.

*** The collective TEDE totals are calculated from the dose records that are reported in millirem while the values shown are rounded to the nearest tenth of a rem.

in these values from the previous year. Some of the largest percentages of change occur at relatively small facilities where conditions may fluctuate from year to year. The changes that have the most impact in the overall values at DOE occur at sites with a relatively large collective dose in addition to a large percentage change, such as Oak Ridge, Idaho, and Hanford in 2007.

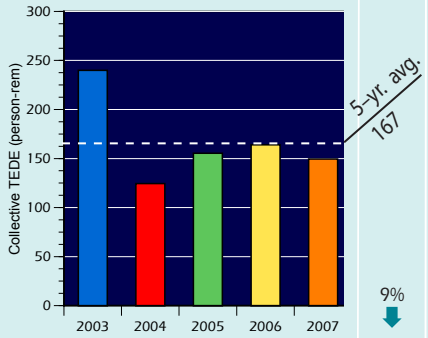
The percentage of the collective TEDE above 0.500 rem is an indicator of the distribution of dose to individuals. A greater fraction of the monitored population is receiving doses above 0.5 rem . See section 3.2.5 for more information on the characteristics of the distribution of doses to individuals above a certain dose value.

3.4.3 Activities Significantly Contributing to Collective Dose in 2007

In an effort to identify the reasons for changes in the collective dose at DOE, several of the larger sites were contacted to provide information on activities that significantly contributed to the collective dose for 2007. These sites (Los Alamos, Idaho, Hanford, Savannah River, and Oak Ridge) had a collective dose near 100 person-rem and were the top contributors to the collective TEDE in 2007. These sites comprised 83% of the total collective TEDE at DOE. Two of the sites reported decreases in the collective TEDE, which contributed to a 3% decrease in the DOE collective TEDE from 813 person-rems (8.13 person-Sv) in 2006 to 792 person-rems (7.92 person-Sv) in 2007. The sites significantly contributing to the collective TEDE in 2007 are shown in *Exhibit 3-16*, including a description of activities that affected the collective TEDE.

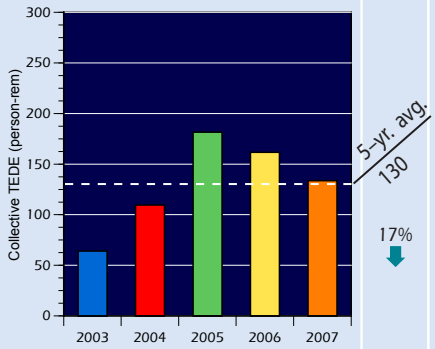
Another impact on the collective dose at DOE is the cessation of activities at certain facilities that results in a decrease in collective dose since the site is no longer required to report radiation exposure. Rocky Flats ceased operations in 2005, resulting in a 16% decrease in the collective dose from 2005 to 2006. In 2006, three facilities ceased operation involving radioactive material and therefore did not contribute to occupational radiation exposure during 2007: Fernald, Mound, and the Ashtabula Closure Project (which previously reported under RMI Environmental Services). Of these three facilities, Fernald was the only site that contributed significantly in 2006

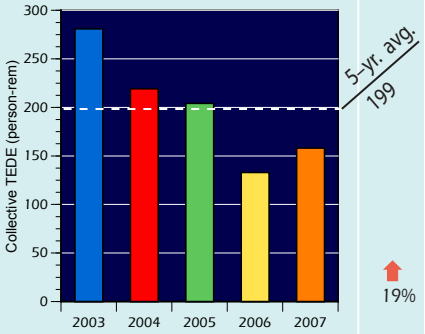
Exhibit 3-16:
Activities Significantly Contributing to Collective TEDE in 2007.

Los Alamos National Laboratory	Percent Change*			Description of Activities at the Site
	2006-2007 (last yr.)	2005-2007 (3 yr.)	2003-2007 (5 yr.)	
	9% ⬇	4% ⬇	38% ⬇	The collective TEDE at LANL decreased by 9% from 2006 to 2007. Plutonium facility operations account for the majority of occupational dose at LANL. The 2007 doses at this facility were not as high as anticipated at the beginning of the year and significantly lower than 2006 doses. For various reasons, programmatic work was not executed as expected. Additionally, there was a significant reduction in work throughout the facility during a pause in operations in the fourth quarter of 2007 due to criticality safety concerns. This resulted in a 13% decrease in external dose. In addition to plutonium facility operations, significant portions of LANL external dose were accrued by workers performing maintenance at TA-53 (the linear accelerator) and those supporting retrieval, repackaging, and shipping radioactive solid waste to the Waste Isolation Pilot Plant. The total internal dose increase of 6.6 rems from 2006 to 2007 reflects several radiological material intake events, including one LANL individual receiving a TEDE in excess of 5 rems from an incident on January 8, 2007, involving a wound sustained during glove-box work. This event is documented in ORPS report NA–LASO-LANL-CMR-2007-00012. LANL extremity dose increased by 225 person-rems, which resulted from an increase in hands-on work at the plutonium facility, and a glove-box event involving unusual quantities of Am-241 (see ORPS report NA–LASOLANL-TA55-2007-0040).

* Up arrows indicate an increase in change. Down arrows indicate a decrease in change.

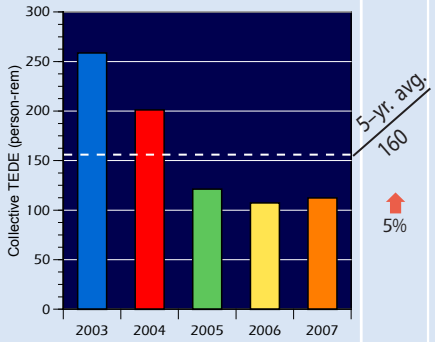
Exhibit 3-16 (Continued):
Activities Significantly Contributing to Collective TEDE in 2007.

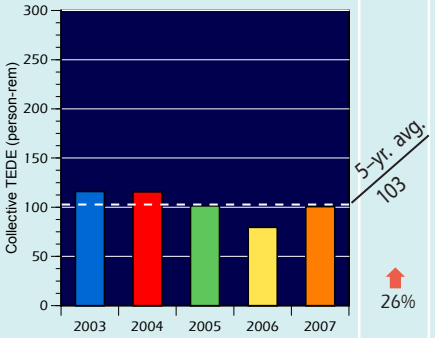
Idaho National Laboratory	Percent Change*			Description of Activities at the Site
	2006-2007 (last yr.)	2005-2007 (3 yr.)	2003-2007 (5 yr.)	
	17% ↓	26% ↓	109% ↑	The collective TEDE at the Idaho National Laboratory decreased by 17% from 2006 to 2007. The primary Idaho Cleanup Project activities, performed by CH2M-WG Idaho, LLC, during 2007, leading to radiation exposure, included deactivation and grouting activities at the CPP-603 fuel storage basins; D&D activities at Test Area North (TAN) including the demolition of the TAN-607 Hot Shop and Fuel Storage Basin; VCO and D&D activities at Reactor Technology Complex, including decontamination and demolition of the Engineering Test Reactor (ETR) primary/secondary cubicles and removal of the ETR reactor vessel; retrieval, packaging, and shipment of targeted Rocky Flats waste at the Accelerated Retrieval Project; and activities in support of grouting and closure of several high level waste tank farm vessels at INTEC. The radiation exposure activities, performed by Battelle Energy Alliance during 2007 at the Idaho National Laboratory, included reactor power operations and maintenance, (i.e., loop maintenance and primary heat exchanger inspections and repair); research and development activities; hot cell and laboratory operations; and homeland security training and exercises. The majority of the decrease in dose from 2006 to 2007 was due to efficiencies in performing these activities as well as work that was not continued in 2007 from the previous year, and the shutdown of the Fuel Conditioning Facility. The Advanced Mixed Waste Treatment Project (AMWTP) work activities,performed by Bechtel BWXT Idaho in 2007 continued the direct support of the 1995 Idaho/U.S. Navy/U.S. DOE Settlement Agreement requiring the removal of transuranic waste from DOE's Idaho operation areas. The primary work activities at the AMWTP that contributed to workforce dose included transuranic waste retrieval from burial, waste characterization, and waste handling operations in support of shipment of transuranic and by-product waste materials from Idaho to DOE's Waste Isolation Security Complex facility and other commercial disposal sites. Significant dose reductions were realized as a direct result of ALARA initiatives that increased personnel awareness of containers and areas with elevated dose rates. The awareness campaign included bright visual cues for containers measuring more than 40 mR/hr on contact, the use of electronic chirpers sensitive enough to alert operators of chronic low dose rate fields (e.g., 1 mR/hr), and operator training to arrange containers such that lower dose rate containers shielded the higher dose rate containers.

Hanford Site	Percent Change*			Description of Activities at the Site
	2006-2007 (last yr.)	2005-2007 (3 yr.)	Since 2003 (5 yr.)	
	19% ↑	23% ↓	44% ↓	The collective TEDE at Hanford (which includes the dose from the Hanford Site, the Office of River Protection, and PNNL) increased by 19% from 2006 to 2007. The largest contributors to the collective TEDE at Hanford were the K Basins Closure Project (removal of contaminated equipment from the basins and retrieval of sludge) (34%), Waste Stabilization and Disposal Project (retrieval, processing, and shipment of transuranic waste)(22%), tank farm activities (14%), the Plutonium Finishing Plant (PFP) Closure Project (D&D of PFP facilities)(12%), Pacific Northwest National Laboratories activities (7%), and other D&D projects (7%). The increase in collective dose was due to handling of materials at PFP for shipping off site, removal of significant amounts of equipment and tooling from KE Basin in preparation for D&D, and exposure related to S-102 cleanup activities (see ORPS report EM-RP–CHG-TANKFARM-2007-0009). Neutron dose increased 41% due to handling of materials at PFP for shipping off site. Extremity dose increased 12% in conjunction with the increase in TEDE. CEDE at the Hanford site was low, 540 mrem, but increased by 35% from 2006. The majority of the CEDE was due to uptakes by three workers caused by a leaking Pu-238 instrument check source (see ORPS report SC–PNSO-PNNL-PNNLBOPER-2007-0006, Personnel and Offsite Contamination from Leaking Source, for details).

* Up arrows indicate an increase in change. Down arrows indicate a decrease in change.

Exhibit 3-16 (Continued):
Activities Significantly Contributing to Collective TEDE in 2007.

Savannah River Site	Percent Change*			Description of Activities at the Site
	2006-2007 (last yr.)	2005-2007 (3 yr.)	Since 2003 (5 yr.)	
	⬆ 5%	⬇ 7%	⬇ 57%	The collective TEDE at SRS increased by 5% from 2006 to 2007. SRS continued aggressive ALARA controls for ongoing work such as deactivation of facilities, plutonium storage and surveillance, the Tank 37 high-level waste transfer line replacement and handling higher dose transuranic waste drums. However, new and expanded work activities resulted in higher total doses. Examples of the expanded activities include a high activity drain replacement in the central laboratory facility, more time than anticipated for the Tank 37 high level waste transfer line replacement and drum repackaging of higher dose transuranic wastes in multiple facilities. Continued reductions in worker dose in many areas were offset by the increase in higher dose work.

Oak Ridge Reservation	Percent Change*			Description of Activities at the Site
	2006-2007 (last yr.)	2005-2007 (3 yr.)	Since 2003 (5 yr.)	
	⬆ 26%	⬇ 1%	⬇ 13%	The collective TEDE at the Oak Ridge Reservation (which includes ORNL, ETTP, ORISE, and Y-12) increased by 26% from 2006 to 2007. ORNL, ETTP, Y-12 There were a total of 2,698 individuals monitored by Bechtel Jacobs Company, LLC (BJC) in 2007 who received a collective TEDE of 10.366 person-rems and a total CEDE of 0.017 person-rem. BJC performs work at the ETTP site, ORNL site, and the Y-12 site. The major activities performed at BJC sites consisted of environmental restoration work, removal or stabilization of buried hazardous wastes, decontamination of facilities, surveillance and maintenance tasks, stabilization of inactive facilities, and demolition of surplus facilities. The increase in TEDE for 2007 as compared to 2006 is attributed to waste operations tasks at ORNL. The increases in total neutron dose and total extremity dose for 2007 compared to 2006 were also due to the waste operations work at ORNL. There were no unusual events related to occupational radiation exposure at BJC facilities for 2007. Y-12 The 2007 collective DDE for the Y-12 Complex decreased by 11.3% from 21.5 person-rems in 2006 to 19.1 person-rems in 2007. This decrease is a result of a midyear stand-down of the Tennessee Valley Authority Off-Spec Project. Average DDE remained the same at 0.004 rem in 2006 and 0.004 rem in 2007. Collective CEDE increased 11.3% from 44.3 person-rems in 2006 to 49.4 person-rems in 2007, while the average CEDE increased 11.1% from 0.018 rem in 2006 to 0.020 rem in 2007. There were 152 workers who received an internal dose in excess of 100 mrem (CEDE). There was an increase in work activity in most of the process areas within Y-12 involving potential for internal exposure. Collective TEDE increased 4.0% from 2006 (65.8 person-rems) to 2007 (68.4 person-rems), while the total persons monitored decreased by 3.3% from 5,007 to 4,842. There was a slight increase in the average TEDE from 0.013 rem in 2006 to 0.014 rem in 2007. Maximum TEDE increased 3.9% from 0.587 rem in 2006 to 0.610 rem in 2007.

* Up arrows indicate an increase in change. Down arrows indicate a decrease in change.

(16.8 person-rems) and therefore contributed significantly to the decrease in the collective dose in 2007.

3.4.4 Summary by Program Office

DOE has divided the responsibility of managing its missions among specific program offices. The various DOE sites support different functions and therefore fall under the authority and management of separate program offices. *Exhibit 3-17* shows the number of individuals with measurable dose, the collective TEDE, and the average measurable TEDE by DOE program office. The Office of Environmental Management (EM) and the National Nuclear Security Administration (NNSA) account for the largest percentages of the collective dose (45% and 34%, respectively). EM works to mitigate the risks and hazards posed by the legacy of nuclear weapons production and research. NNSA is responsible for the management and security of the nation's nuclear weapons, nuclear nonproliferation, and naval reactor programs, as well as responding to radiological emergencies and the transportation of nuclear weapons and special nuclear materials. In general, the missions of EM and NNSA require more interaction and activities involving radioactive materials. These offices account for nearly 80% of the collective dose at DOE.

The primary sites contributing to the collective TEDE at EM are Hanford, SRS, Idaho, West Valley, and the Office of River Protection. For NNSA, the primary contributors are LANL, Y-12, Pantex, and Lawrence Livermore. For the Office of Nuclear Energy, Science and Technology (NE), the primary contributor is Idaho, and, for the Office of Science (SC), the primary contributors are ORNL, Fermilab, and Pacific Northwest National Laboratory.

3.5 Transient Individuals

Transient individuals, or transients, are defined as individuals who are monitored at more than one DOE site during the calendar year. For the purpose of this report, a DOE site is defined as a geographic location. During the year, some individuals performed work at multiple

Exhibit 3-17: Program Offices.

Program Office			Number with Meas. TEDE	Coll. TEDE (person-rem)	Avg. Meas. TEDE (rem)
Office of Environmental Management (EM)			5,131	354.9	0.069
Boeing N America	ORNL	Portsmouth			
ETTP	ORP	Savannah River			
Hanford Site	Paducah	West Valley			
Idaho	Pantex				
National Nuclear Security Administration (NNSA)			3,324	271.1	0.082
Honeywell, FM&T	NTS	Y-12			
LANL	Pantex				
LLNL	SNL				
Office of Nuclear Energy, Science and Technology (NE)			1,201	86.4	0.072
Idaho					
Office of Science (SC)			1,364	76.2	0.056
Ames	LBNL	PPPL			
ANL	ORISE	SLAC			
BNL	ORNL	TJ Nat'l Accel			
Fermi	PNNL				
Other			57	3.3	0.059
New Brunswick					
Totals			**11,077**	**792.0**	**0.071**

sites and, therefore, had more than one monitoring record reported to the repository. In addition, some individuals transferred from one site to another. This section presents information on transient individuals to determine the extent to which individuals traveled from site to site and to examine the dose received by these individuals.

Exhibit 3-18 shows the dose distribution and total number of transient individuals from 2003 to 2007. Over the past five years, the records of transient individuals have averaged 2.7% of the total records for all monitored individuals at DOE, who received, on an average, 3% of the collective dose. The collective dose for transients decreased by 13% from 25.5 person-rems (255 person-mSv) in 2006 to 22.1 person-rems (221 person-mSv) in 2007. The decrease was due primarily to decreases in dose to transient workers at Lawrence Livermore National Laboratory (LLNL), Sandia, and Fermilab and the cessation of activities at Fernald. The average measurable TEDE decreased from 0.056 rem (0.56 mSv) in 2006 to 0.049 rem (0.49 mSv) in 2007. Since 1993, these parameters have remained relatively constant, even though DOE has become extensively involved in D&D activities and other types of operations.

3.6 Historical Data

3.6.1 Prior Years

In order to analyze recent radiation exposure data in the context of the history of radiation exposure at DOE, it is useful to include information prior to the past five years as presented in this report. For this reason, *Exhibits 3-19* and *3-20* are presented to show a summary of occupational exposure back to 1974, when the Atomic Energy Commission (AEC) split into the Nuclear Regulatory Commission and the Energy Research and Development Administration (ERDA), which subsequently became DOE.

Exhibits 3-19 and *3-20* show the collective dose, average measurable dose, and number of workers with measurable dose from 1974 to 2007. As can be seen from the graphs, all three parameters decreased dramatically between 1986 and 1993. The main reasons for this large decrease were the shutdown of facilities within the weapons complex and the end of the Cold War era, which shifted the DOE mission from weapons production to shutdown, stabilization, and D&D activities.

3.6.2 Historical Data Collection

In section 3.7 of the 2000 and 2001 annual reports on occupational exposure, information was presented on

Exhibit 3-18:
Dose Distribution of Transient Workers, 2003–2007.

	Dose Ranges (TEDE in rem)	2003	2004	2005	2006	2007
Transients	Less than measurable dose	2,063	1,917	2,067	1,888	2,182
	Measurable <0.1	492	439	715	412	388
	0.10–0.25	59	52	79	24	51
	0.25–0.5	23	9	13	9	8
	0.5–0.75	9	4	3	4	
	0.75–1.0	7		2	3	
	1.0–2.0	12	1	1	2	
	Total number of individuals monitored *	2,665	2,422	2,880	2,342	2,629
	Number with measurable dose	602	505	813	454	447
	% with measurable dose	23%	21%	28%	19%	17%
	Collective TEDE (person-rem)	56.141	25.609	39.757	25.532	22.111
	Average measurable TEDE (rem)	0.093	0.051	0.049	0.056	0.049
All DOE	Total number of records for monitored individuals	102,509	100,011	98,040	91,280	86,630
	Number with measurable dose	17,484	15,739	16,136	12,953	11,077
	% of total monitored who are transient	2.6%	2.4%	2.9%	2.6%	3.0%
	% of the number with measurable dose who are transient	3.4%	3.2%	5.0%	3.5%	4.0%

* Total number of individuals represents the number of individuals monitored and not the number of records.

Exhibit 3-19:
Collective Dose and Average Measurable Dose, 1974–2007.

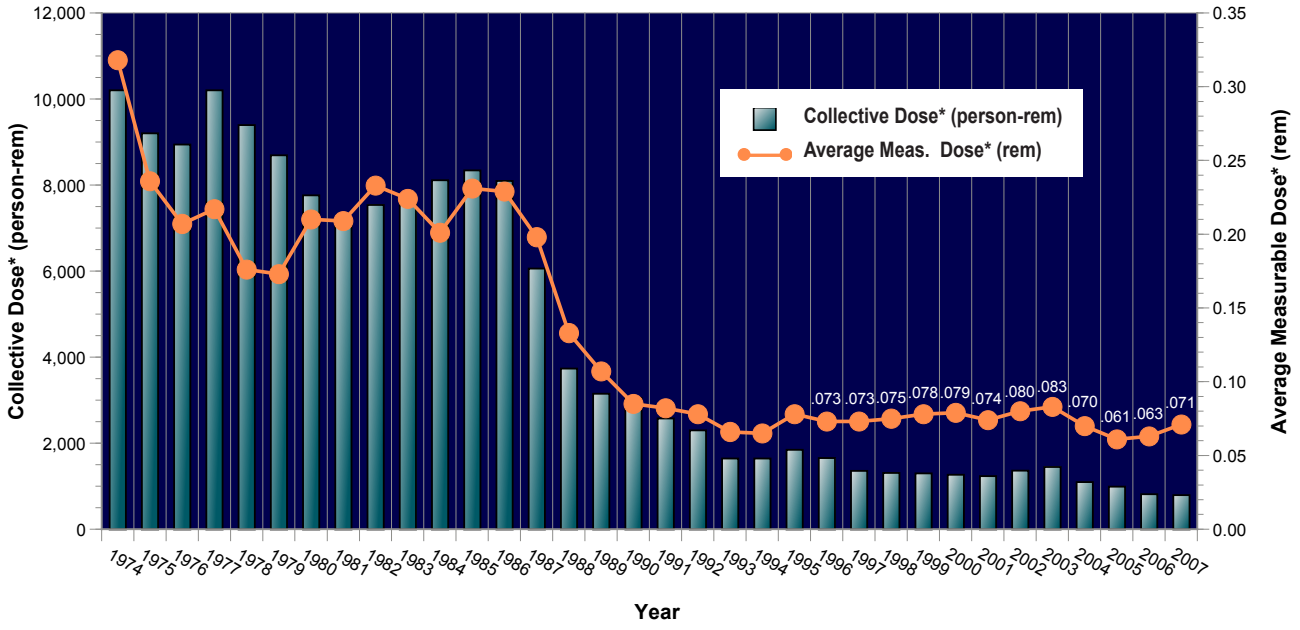
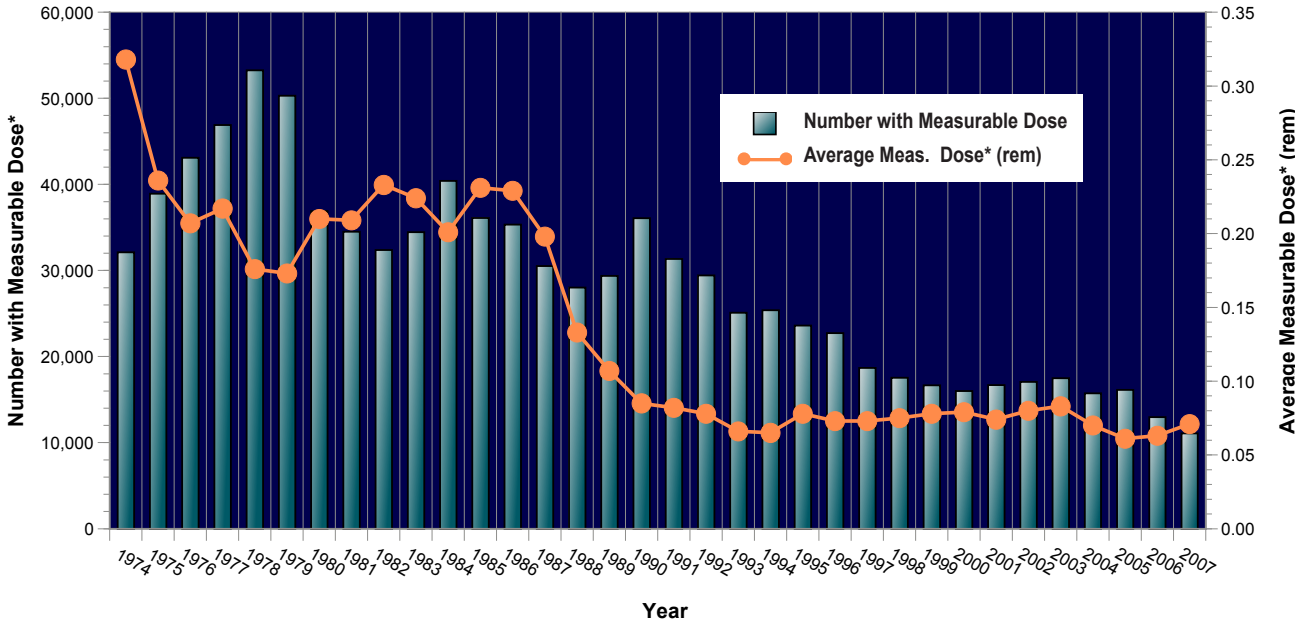


Exhibit 3–20:
Number of Workers with Measurable Dose and Average Measurable Dose, 1974–2007.



* 1974–1989 collective dose = DDE
1990–1992 collective dose = DDE + AEDE
1993–2007 collective dose = DDE + CEDE

1946–1974	Atomic Energy Commission (AEC)
1974–1977	Energy Research and Development Administration (ERDA)
1977–Present	Department of Energy (DOE)

historical data that had been collected to date. Sites were requested by DOE to voluntarily provide historical exposure data. No additional sites have reported historical data during the year 2007.

Sites that have not yet reported historical dose records are encouraged to contact Ms. Nirmala Rao at DOE (see section 1.2) to obtain further information on reporting these records. This is a voluntary request to report historical data (records prior to 1987) that are available in electronic form in whatever format that is most convenient for the site. The data will be stored as reported in REMS, and, wherever possible, data will be extracted and loaded into the REMS database for analysis and retrieval. For detailed analysis, read section 3.7 of the 2000 report.

Sites that have voluntarily reported historical data are as follows:

- Fernald Environmental Management Project
- Hanford Site
- Idaho National Laboratory
- Kansas City Plant
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- Nevada Test Site
- Oak Ridge K-25 Site
- Pantex Plant
- Portsmouth Gaseous Diffusion Plant
- Rocky Flats Environmental Technology Site
- Sandia National Laboratories
- Savannah River Site

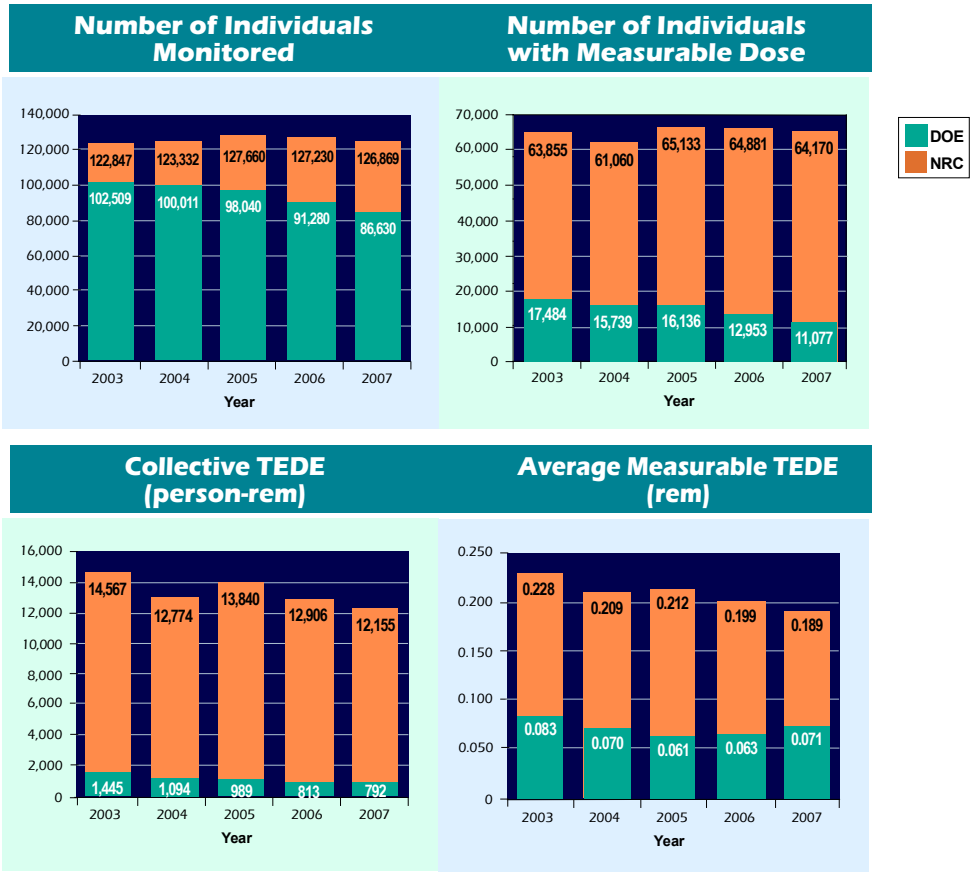
3.7 Comparison of DOE Dose to Other Activities

3.7.1 Comparison with Activities Regulated by the Nuclear Regulatory Commission

In the 1994 DOE Occupational Radiation Exposure report, a comparison of DOE radiation exposure to other industrial and governmental endeavors was included in order to gain an understanding of the relative scale of the radiation exposure at DOE operations to other activities. The 2007 report includes a comparison of DOE exposures to that of activities regulated by the U.S. Nuclear Regulatory Commission (NRC). It should be noted that this comparison is simply to put the DOE radiation exposure in context with other endeavors that involve radiation exposure. The comparison is limited due to the vast difference in mission of the DOE and NRC. While the mission of the DOE is broad in scope and includes activities from energy research to national defense, NRC-licensed activities are dominated by radiation exposure received during commercial nuclear power production. Reactor operations account for approximately 95% of the collective dose while industrial radiographers, manufacturers and distributors of radiopharmaceuticals, independent spent fuel storage installations (ISFSI), and fuel cycle licensees comprise the remainder.

The DOE and NRC occupational exposure data shown in *Exhibit 3-21* cover the past 5 years (2003-2007). While the number of workers monitored at NRC and DOE are relatively comparable over the past five years, the number of individuals with measurable dose at DOE was 23% of the NRC total for this time period. The percentage of the collective dose and average measurable dose were 8% and 34% respectively.

Exhibit 3–21:
Comparison of Occupational Exposure for DOE and NRC, 2003 –2007.



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Section Four

4 ALARA Activities at DOE

In past years, the published annual report has included descriptions of ALARA activities at DOE for the purposes of sharing strategies and techniques that have shown promise in the reduction of radiation exposure.

These ALARA activity descriptions are now provided on the HSS Web site to facilitate the dissemination among DOE radiation protection managers and others interested in these project descriptions. Readers should be aware that the project descriptions are voluntarily submitted from the sites and are not independently verified or endorsed by DOE. Program and site offices and contractors who are interested in benchmarks of success and continuous improvement in the context of integrated safety management and quality are encouraged to provide input.

4.1 Submitting ALARA Project Descriptions for Future Annual Reports

Individual project descriptions may be submitted to the DOE Office of Corporate Safety Analysis through the REMS Web site. The submittals should describe the process in sufficient detail to provide a basic understanding of the project, the radiological concerns, and the activities initiated to reduce dose. The Web site provides a form to collect the following information about the project:

- Mission statement
- Project description
- Radiological concerns
- Total collective dose for the project
- Dose rate to exposed workers before and after exposure controls were implemented
- Information on how the process implemented ALARA techniques in an innovative or unique manner
- Estimated dose avoided
- Project staff involved
- Approximate cost of the ALARA effort
- Impact on work processes, in person-hours if possible (may be negative or positive)
- Figures and/or photos of the project or equipment (electronic images if available)
- Point of contact for follow-up by interested professionals

The REMS Web page for the ALARA project descriptions can be accessed on the Internet at

http://www.hss.energy.gov/CSA/analysis/rems/rems/ALARA.cfm

4.2 Lessons-Learned Process

DOE has a mature lessons-learned process that was initially developed in 1994. The current DOE lessons-learned process is described in DOE-STD-7501-99. [9] The purpose of the DOE lessons-learned process is to facilitate the identification, documentation, sharing, and utilization of lessons learned from a review of actual operating experiences throughout the DOE complex. This is accomplished by sharing lessons among DOE sites through a common corporate database. A recent review of the lessons-learned process has led to a redesign of the process to add a more corporate component. This new corporate component, modeled after the Institute of Nuclear Power Operations Significant Event Evaluation and Information Network program, has introduced an additional corporate role in the review of DOE site performance and crosscutting operating experience and has started to provide additional lessons-learned information to the DOE community in addition to that already provided by DOE field sites.

The collected information is currently located on a Web site. This system allows for shared access to lessons learned across the DOE complex. The information available on the system complements existing reporting systems presently used within DOE, which is taking this approach to enhance those existing systems by providing a method to quickly share information among the field elements. Also, this approach goes beyond the typical occurrence reporting to identify good lessons learned. DOE uses the Web site to openly disseminate such information so that not only DOE but also other entities will have a source of information to improve the health and safety aspects of operations at and within their facilities. Additional benefits include enhancing the

workplace environment and reducing the number of accidents and injuries.

The Web site contains several items that are related to health physics. Items range from off-normal occurrences to procedural and training issues. Documentation of occurrences includes the description of events, root-cause analysis, and corrective measures. Several of the larger sites have systems that are connected through this system. DOE organizations are encouraged to participate in this valuable effort.

The specific Web-site address may be subject to change. Information services can be accessed through the HSS Web site as follows:

http://www.hss.energy.gov

Section Five
Conclusions

5

Conclusions

The occupational radiation exposure records show that in 2007, with only one exception, DOE facilities continued to comply with DOE dose limits and administrative control levels and worked to minimize exposure to individuals. Only 13% of the monitored workers received a measurable dose and the average measurable dose was less than 2% of the DOE limit. Both the collective dose and the number of individuals with measurable dose decreased.

Over the past 10 years, the collective dose and exposed workforce size have remained at fairly stable levels. For the past five years, there has been a decrease in collective dose and the number of individuals with measurable dose. Most of this decrease has been attributed to the completion of cleanup activities at various facilities. The closure of Rocky Flats in 2005 contributed to reductions in the collective dose for 2005 and 2006. The closure of Fernald and Mound and the completion of the Ashtabula Closure Project contributed to the decrease from 2006 to 2007.

The collective dose at DOE facilities has experienced a dramatic (90%) decrease since 1986. This decrease coincides with the end of the Cold War era, which shifted the DOE mission from weapons production to stabilization, waste management, and environmental remediation activities along with the rightsizing of facilities across the complex to meet the new mission. Also during this time period, regulations have improved with an increased focus on ALARA practices and risk reduction.

Exhibit 5-1:
2007 Radiation Exposure Summary.

- There was one exposure in excess of the DOE 5 rems (50 mSv) annual TEDE limit where an individual at LANL received an intake of plutonium from a puncture wound during glove-box work.
- There were no additional exposures in excess of the DOE ACL of 2 rems (20 mSv) TEDE other than the one individual who exceeded the 5 rems (50 mSv) DOE regulatory limit.
- The collective TEDE decreased 3% from 813 person-rems (8.13 person-Sv) in 2006 to 792 person-rems (7.92 person-Sv) in 2007.
- Sites contributing significantly to collective dose were (in descending order of collective dose) Hanford, LANL, Idaho, SRS, and Oak Ridge. These sites accounted for 83% of the collective dose at DOE in 2007.
- Decreases in collective dose at two of the highest dose sites were attributed to a reduction in exposure for some planned activities at LANL that were not performed and a significant reduction in work throughout LANL during a pause in operations in the fourth quarter of 2007 due to criticality safety concerns. ALARA initiatives that increased awareness of containers and areas with elevated dose rates at the Advanced Mixed Waste Treatment Project, a cessation of work at the Space Battery assembly, and a shutdown of the Fuel Conditioning Facility at the Idaho National Laboratory.
- The collective internal dose (CEDE) increased by 27% between 2006 and 2007 primarily due to the intake of plutonium at LANL and increased internal dose from uranium at the Oak Ridge Y-12.
- Eighty three percent of the collective CEDE at DOE is due to U-234, and over 99% of the CEDE at DOE from U-234 was accrued at Y-12.
- The collective dose for transient workers decreased by 13% from 25.5 person-rems (255 mSv) in 2006 to 22.1 person-rems (221 mSv) in 2007. The decrease was due primarily to decreases in dose to transient workers at LLNL, Sandia, and Fermilab and the cessation of activities at Fernald.
- The total number of bioassay measurements performed decreased by 42% from 125,981 in 2006 to 72,861 in 2007. The largest portion of this decrease was due to the completion of work at Fernald, which in previous years had reported the majority of the measurements in the "other" category. These measurements were air samples taken to monitor thorium. Urinalysis measurements decreased by 21% from 2006 to 2007.

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Glossary

administrative control level (ACL)
A dose level that is established below the DOE dose limit in order to administratively control exposures. ACLs are multitiered, with increasing levels of authority required to approve a higher level of exposure.

ALARA
Acronym for "as low as reasonably achievable," which is the approach to radiation protection to manage and control exposures (both individual and collective) to the workforce and the general public to as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. ALARA is not a dose limit but a process with the objective of attaining doses as far below the applicable limits as is reasonably achievable.

annual effective dose equivalent (AEDE)
The summation for all tissues and organs of the products of the dose equivalent calculated to be received by each tissue or organ during the specified year from all internal depositions multiplied by the appropriate weighting factor. AEDE is expressed in units of rem.

average measurable dose
Dose obtained by dividing the collective dose by the number of individuals who received a measurable dose. This is the average most commonly used in this and other reports when examining trends and comparing doses received by workers, because it reflects the exclusion of those individuals receiving a less than measurable dose. Average measurable dose is calculated for TEDE, DDE, neutron dose, extremity dose, and other types of dose.

collective dose
The sum of the total annual effective dose equivalent or total effective dose equivalent values for all individuals in a specified population. Collective dose is expressed in units of person-rem.

committed dose equivalent (CDE) (H_T,50)
The dose equivalent calculated to be received by a tissue or organ over a 50-year period after the intake of a radionuclide into the body. It does not include contributions from radiation sources external to the body. CDE is expressed in units of rem.

committed effective dose equivalent (CEDE) (H_E,50)
The sum of the committed dose equivalents to various tissues in the body (H_T,50), each multiplied by the appropriate weighting factor (w_T) (i.e., H_E,50 = $w_T H_T$,50). CEDE is expressed in units of rem.

CR
See SR.

deep dose equivalent (DDE)
The dose equivalent derived from external radiation at a depth of 1 cm in tissue.

DOE site
A geographic location operated under the authority of the Department of Energy (DOE).

effective dose equivalent (H_E)
The summation of the products of the dose equivalent received by specified tissues of the body (H_T) and the appropriate weighting factor (w_T)(i.e., $H_E = w_T H_T$). It includes the dose from radiation sources internal and/or external to the body. The effective dose equivalent is expressed in units of rem.

exposure
As used in this report, exposure refers to individuals subjected to, or in the presence of, radioactive materials that may or may not result in occupational radiation dose.

lens (of the eye) dose equivalent (LDE)
The radiation dose for the lens of the eye is taken as the external equivalent at a tissue depth of 0.3 cm.

members of the public
Individuals who are not occupationally exposed to radiation or radioactive material. This includes visitors and visiting dignitaries.

number of individuals with measurable dose
The subset of all monitored individuals who receive a measurable dose (greater than the limit of detection for the monitoring system). Many personnel are monitored as a matter of prudence and may not receive a measurable dose. For this reason, the number of individuals with measurable dose is presented in this report as a more accurate indicator of the exposed workforce. The number of individuals represents the number of dose records reported. Some individuals may be counted more than once if multiple dose records are reported for the individual during the year.

occupational dose
An individual's ionizing radiation dose (external and internal) as a result of that individual's work assignment. Occupational dose does not include doses received as a medical patient or doses resulting from background radiation or participation as a subject in medical research programs.

shallow dose equivalent (SDE)
The dose equivalent deriving from external radiation at a depth of 0.007 cm in tissue.

SR (formerly CR)
SR is defined by United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) as the ratio of the annual collective dose delivered at individual doses exceeding a specified dose value to the collective dose. UNSCEAR uses a subscript to denote the dose value (in mSv) used in the calculation of the ratio. Therefore, SR_{15} would be the ratio of the annual collective dose delivered at individual doses exceeding 1.5 rem (15 mSv) to the total annual collective dose.

total effective dose equivalent (TEDE)
The sum of the effective dose equivalent for external exposures and the committed effective dose equivalent (CEDE) for internal exposures. Deep dose equivalent to the whole body is typically used as effective dose equivalent for external exposures. The internal dose component of TEDE changed from the annual effective dose equivalent (AEDE) to the CEDE in 1993.

total number of records for monitored individuals
All individuals who are monitored and reported to the DOE Headquarters database system. This includes DOE employees, contractors, subcontractors, and members of the public monitored during a visit to a DOE site. The number of individuals represents the number of dose records reported. Some individuals may be counted more than once if multiple dose records are reported for the individual during the year.

transient individual
An individual who is monitored at more than one DOE site during the calendar year.

urinalysis
The technique of determining the radiation dose received by an individual from an intake by the measurement of the amount of radioactive material in the urine excreted from the body.

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User Survey

DOE Occupational Radiation Exposure Report

User Survey

DOE, striving to meet the needs of its stakeholders, is looking for suggestions on ways to improve the DOE Occupational Radiation Exposure Report. **Your feedback is important.** Constructive feedback will ensure the report can continue to meet user needs. Please fill out the attached survey form and return it to

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Questions concerning this survey should be directed to Ms. Rao at (301) 903-2297.

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Analysis of Individual Dose Data	1	2	3	4	5
Doses above 2 rems ACL	1	2	3	4	5
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Analysis of Site Data	1	2	3	4	5
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