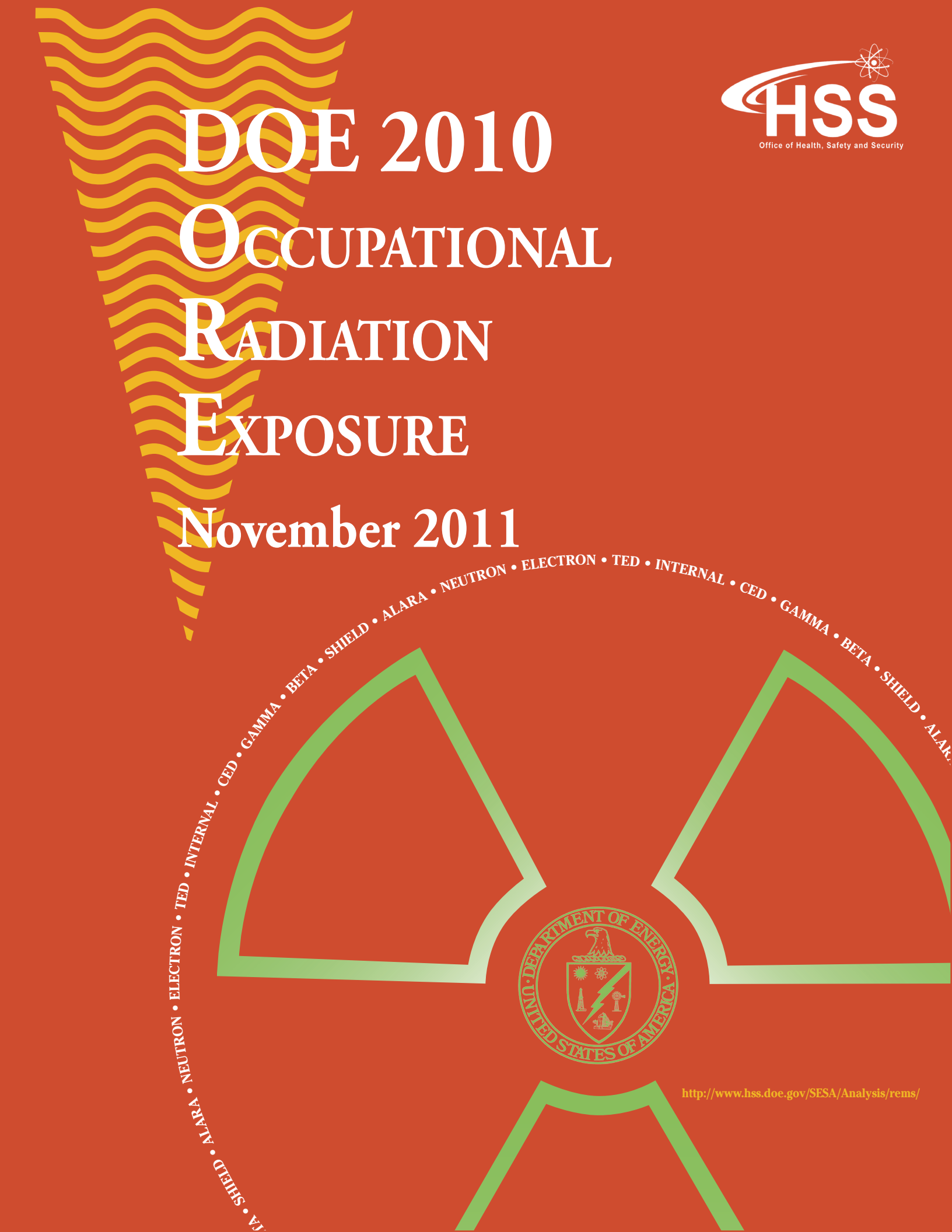
HSS
Office of Health, Safety and Security

DOE 2010 Occupational Radiation Exposure

November 2011



http://www.hss.doe.gov/SESA/Analysis/rems/

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REMS Program Web Site at:
http://www.hss.doe.gov/SESA/Analysis/rems/

Foreword

A core value of the U.S. Department of Energy (DOE) is to ensure the health and safety 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. In support of this mission, HSS's Office of Analysis provides for the collection, analysis, and dissemination of data and performance indicators, such as occupational radiation exposure information. This information supports corporate decisionmaking 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 worker radiation exposures below administrative control levels (ACL) and DOE limits and to further reduce these exposures to levels that are "as low as reasonably achievable (ALARA)." The annual *DOE 2010 Occupational Radiation Exposure Report* provides an evaluation of DOE-wide performance regarding compliance with Title 10, *Code of Federal Regulations* (C.F.R.) Part 835 Occupational Radiation Protection dose limits and ALARA process requirements and an overview of the status of radiation exposures of the DOE workforce. In addition, this report serves as a risk management tool for managing radiological safety programs and provides useful information to DOE organizations, epidemiologists, researchers, and national and international agencies involved in developing policies to protect individuals from harmful effects of radiation.

The Radiation Exposure Monitoring System (REMS) program remains a key component of HSS oversight and analysis to inform management and stakeholders of the continued vigilance and success of the DOE sites in minimizing radiation exposure to workers. One of the objectives of this report is to provide 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.

Glenn S. Podonsky
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Office of Health, Safety and Security

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LIST OF ACRONYMS

ACL	Administrative Control Level
AEC	Atomic Energy Commission
ALARA	As Low As Reasonably Achievable
ARRA	American Recovery and Reinvestment Act
BJC	Bechtel Jacobs Company LLC
CEqD	Committed Equivalent Dose
CED	Committed Effective Dose
D&D	Decontamination and Decommissioning
ED	Effective Dose
EqD	Equivalent Dose
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
ICP	Idaho Cleanup Project
ICRP	International Commission on Radiological Protection
INL	Idaho National Laboratory
LANL	Los Alamos National Laboratory
LANSCE	Los Alamos Neutron Science Center
LLNL	Lawrence Livermore National Laboratory
mSv	Millisievert
NE	Office of Nuclear Energy
NNSA	National Nuclear Security Administration
NNSS	Nevada National Security Site
NRC	U.S. Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
PFP	Plutonium Finishing Plant
RCS	Radiological Control Standard
REMS	Radiation Exposure Monitoring System
SLAC	SLAC National Accelerator Laboratory
SNL	Sandia National Laboratories
SRNS	Savannah River Nuclear Solutions
SRR	Savannah River Remediation
SRS	Savannah River Site
Sv	Sieverts
TED	Total Effective Dose
TRU	Transuranic
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 Analysis 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 *DOE 2010 Occupational Radiation Exposure Report* provides an evaluation of DOE-wide performance regarding compliance with DOE Part 835 dose limits and as low as reasonably achievable (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. The 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 5 years.

It should be noted that while Title 10, *Code of Federal Regulations* (C.F.R.) 835 was revised as of June 2007, full implementation was not required until July 2010. All sites have now transitioned and therefore this report reflects the changes in dose terminology required by the revision to 10 C.F.R. 835.

One of the report's features includes the collective total effective dose (TED) - an indicator of the overall amount of radiation dose received during the conduct of operations at DOE. Over the past 10-year period, 99.99% of the individuals receiving measurable dose have received doses below the 2 rems (20 millisievert [mSv]) TED administrative control level (ACL), which is well below the DOE regulatory limit of 5 rems (50 mSv) TED.

However, the DOE collective TED increased by 30% from 2009 to 2010, as shown in *Exhibit ES-1*. This is the second consecutive year that the collective TED has increased. The collective TED increased at all five of the sites with the largest collective TED in 2010. For these five sites, the increase in collective TED in 2010 was attributed to: waste processing, including higher dose waste drums and decommissioning at Savannah River Site (SRS), isotope processing and cleanup and waste disposal at Oak Ridge, increased decontamination and decommissioning (D&D) at Idaho, and increased manufacturing and related weapons work, processing and shipping solid waste, and maintenance activities at Los Alamos National Laboratory (LANL). These sites attributed much of the increase in collective dose to increases in funding for cleanup and environmental efforts under the American Recovery and Reinvestment Act (ARRA) of 2009.

Exhibit ES-1:
Collective TED (person-rem), 2006–2010.

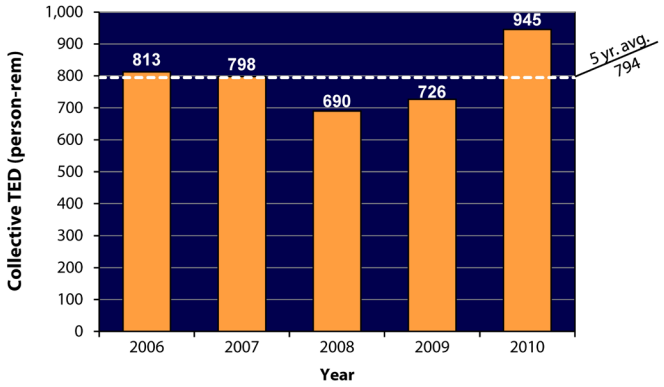
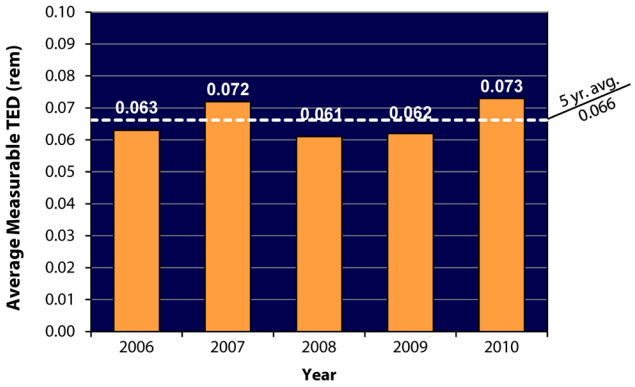


Exhibit ES-2:
Average Measurable TED (rem), 2006–2010.



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

Sites that contributed to the increase in the number of workers with measurable dose include SRS, Hanford Site, Oak Ridge National Laboratory (ORNL), and Idaho National Laboratory (INL). Overall from 2009 to 2010, there was an 11% increase in the number of workers with measurable dose. However, due to the increases in the DOE work force and monitored workers, the ratio of workers with measurable doses to monitored workers remained about the same (approximately 14%).

The TED is comprised of the effective dose (ED) from external sources, which includes neutron and photon radiation, and the internal committed effective dose (CED), which results from the intake of radioactive material into the body. The collective dose from photon exposure increased by 28%, while the neutron dose and internal dose components of the collective TED increased by 18% and 86%, 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 TED increased by 18% from 2009 to 2010, as shown in *Exhibit ES-2*. The number of individuals who received a measurable dose also increased.

Additional analyses show that the dose distribution in 2010 was similar to the distribution in 2009. However, as a result of an incident involving plutonium, an individual at SRS received a TED of 31.589 rems and received a CEqD to the bone surface of 1,040 rems. These doses exceed the regulatory limit of 5 rems TED and the 50 rems committed equivalent dose (CEqD) to an organ or tissue.

In 2010, only 14% of the monitored workers received a measurable dose and the average measurable dose was less than 2% of the DOE limit. From 2009 to 2010, the collective dose and the number of individuals with measurable dose increased by 30% and 11%, respectively. These increases in the dose and number of individuals were the result of increased activities involving radioactive materials, particularly at the DOE sites that comprise the majority of DOE collective dose. It should be noted that the individual dose in excess of the DOE limits at SRS was a significant contributor to the increase in collective dose in 2010.

Over the past 10 years, the collective dose and the size of the monitored workforce have remained at fairly stable levels. For the past 3 years, there has been an increase in collective dose and the number of individuals with measurable dose as activities have increased in decommissioning and waste processing at several of the larger DOE sites.

To access this report and other information on occupational radiation exposure at DOE, visit the DOE HSS web site at:

http://www.hss.doe.gov/SESA/Analysis/rems/

Section One Introduction

1

Introduction

The *DOE 2010 Occupational Radiation Exposure Report* analyzes occupational radiation exposures at U.S. Department of Energy (DOE) facilities during 2010. This report includes occupational radiation exposure information for all DOE employees, contractors, and subcontractors, as well as members of the public in controlled areas who are monitored for exposure to radiation. The 101 DOE organizations submitting radiation exposure reports for 2010 have been grouped into 32 sites across the complex. This information has been 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. Additional supporting technical information, tables of data, and additional items are available on the DOE 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.

1.2 Report Availability

This report is available online and may be downloaded from:

http://www.hss.doe.gov/SESA/Analysis/rems/

Requests for additional copies of this report, 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 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 recordkeeping and reporting of occupational radiation exposure at DOE; and
- ALARA activities at DOE.

Section One	Describes the content and organization of this report.
Section Two	Discusses the radiation protection and dose reporting requirements.
Section Three	Presents the 2010 occupational radiation dose data trended over the past 5 years.
Section Four	Includes instructions to submit successful ALARA projects.
Section Five	Conclusions.
Appendices	The appendices are now offered in color on the DOE Radiation Exposure web site. Please visit **http://www.hss.doe.gov/SESA/Analysis/rems/** and select Annual Reports to review.

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Section Two
Standards and Requirements

2

Standards and Requirements

One of DOE's primary objectives is to provide a safe and healthy workplace for all employees and contractors. To meet this objective, the DOE 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 for occupational radiation protection include radiation dose limits, which establish maximum permissible doses to workers. 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 2010. For more information on past requirements, visit the DOE web site for DOE Directives, Regulations, and Standards.

2.1 Radiation Protection Requirements

DOE radiation protection standards in effect at the beginning of 2010 were 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) 26 [2] and the 1987 recommendations of the National Council on Radiation Protection and Measurements (NCRP) 91 [3]. This guidance recommends that internal dose be added to the external whole-body dose to determine the total effective dose equivalent (TEDE). Prior to this guidance, the external dose and internal dose were each limited separately. It should be noted that 10 C.F.R. 835 was revised in June 2007, with full implementation required by July 2010. The revision adopted ICRP 60 [4] and 68 [5] dosimetric quantities and units. See section 2.4. The laws and requirements for occupational radiation protection pertaining to the information collected and presented in this report are summarized in *Exhibit 2-1*.

2.2 Radiation Dose Limits

Radiation dose limits are codified in 10 C.F.R. 835.202, 206, 207, and 208 [6] and are summarized in *Exhibit 2-2*.

2.3 Reporting Requirements

On August 19, 2003, DOE approved and issued the revised DOE O 231.1A [7]. DOE M 231.1-1A [8], 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 and ending with the monitoring year 2009. For the monitoring year 2010, the sites were required to

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

Title	Date	Description
10 C.F.R. 835, "Occupational Radiation Protection." [6]	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, "Environment, Safety and Health Reporting." [7]	Approved 8/19/03.	Requires the annual reporting of occupational radiation exposure records to the DOE REMs repository.
DOE Manual 231.1-1A, "Environment, Safety and Health Reporting Manual." [8]	Approved 3/19/04.	Specifies the current format and content of the reports required by DOE Order 231.1A.

Exhibit 2-2:
DOE Dose Limits from 10 C.F.R. 835.

Personnel Category	Section of 10 C.F.R. 835	Type of Exposure	Acronym	Annual Limit
General employees	835.202	Total effective dose.	TED	5 rems
		The sum of the effective dose to the whole body for external exposures and the committed equivalent dose to the maximally exposed organ or tissue other than the skin or the lens of the eye. (Total Organ Dose)	ED+CEqD (TOD)	50 rems
		Equivalent Dose to the Lens of the Eye.	EqD-Eye	15 rems
		The sum of the equivalent dose to the skin or to any extremity for external exposures and the committed equivalent dose to the skin or to any extremity.	EqD-SkWB + CEqD-SK and EqD to the maximally exposed extremity + CEqD-SK	50 rems
Declared pregnant workers*	835.206	Total effective dose.	TED	0.5 rem per gestation period
Minors	835.207	Total effective dose.	TED	0.1 rem
Members of the public in a controlled area	835.208	Total effective dose.	TED	0.1 rem

*Limit applies to the embryo/fetus.

implement the changes required by the Amendment to 10 C.F.R. 835.

As of June 27, 2011, DOE O 231.1A has been updated and reissued as DOE O 231.1B. DOE M 231.1-1A, has been cancelled and the reporting requirements from the manual have been moved to the online REMS Reporting Guide at http://www.hss.doe.gov/sesa/Analysis/rems/index.htm.

2.4 Amendment to 10 C.F.R. 835

In August 2006, DOE published a proposed amendment to 10 C.F.R. 835 in the *Federal Register*, and in June 2007, the final amended 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 68 dose conversion factors to determine values for the derived air concentrations (DACs); and
- Adopted other changes intended to enhance radiation protection.

The rule became effective on July 9, 2007, and was required to be fully implemented by DOE sites by July 9, 2010. Therefore, all sites began complying with the new requirements during 2010. The monitoring year 2010 is the first year where all sites are required to report under the Amendment to 10 C.F.R. 835 and therefore all terminology in this annual report has been changed in accordance with the Amendment.

Section Three
Occupational Radiation Dose at DOE

3

3.1 Analysis of the Data

Certain key indicators have been determined useful when evaluating 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 the 5 rems (50 millisievert [mSv]) DOE regulatory limit; and
- doses exceeding the 2 rems (20 mSv) DOE administrative control level (ACL), as specified in DOE STD 1098-2008 Radiological Control.

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 indication 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 specified in10 C.F.R. 835.402. 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.

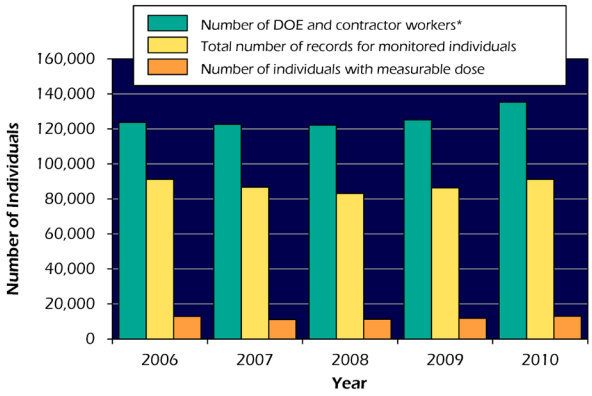
3.2.2 Number of Records for Individuals with Measurable Dose

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

Over the past 10-year period, 99.99% of the individuals receiving measurable dose have received doses below the 2 rems (20 mSv) TED ACL, which is well below the DOE regulatory limit of 5 rems (50 mSv) TED.

Exhibits 3-1a and *3-1b* show the number of DOE and contractor workers, the total number of workers

Exhibit 3-1a:
Monitoring of the DOE Workforce, 2006–2010.



*The number of DOE and contractor workers was determined from the total annual work hours at DOE [9] converted to full-time equivalents.

For 2010, 67% of the DOE workforce was monitored for radiation dose, and 14% of monitored individuals received a measurable dose.

Exhibit 3-1b:
Monitoring of the DOE Workforce, 2006–2010.

Year	DOE & Contractor Workforce	Number of Workers Monitored	Percent of Workers Monitored*	Number Monitored w/Measurable Dose	Percent Monitored w/Measurable Dose*
2006	123,768	91,280	74%▼	12,953	14%▼
2007	122,660	86,651	71%▼	11,102	13%▼
2008	122,139	83,208	68%▼	11,287	14%▲
2009	125,272	86,371	69%▲	11,721	14%
2010	135,266	91,229	67%▼	13,004	14%
5-Year Average	**125,821**	**87,748**	**70%**	**12,013**	**14%**

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

monitored for radiation dose, the number of individuals with a measurable dose, and the relative percentages for the past 5 years.

Over the past 5 years, the percentage of individuals monitored for radiation exposure has remained within 4% of the 5-year average; the percentage of monitored individuals receiving any measurable radiation dose each year has been within 1% of the 5-year average.

Eleven of the reporting sites experienced decreases in the number of workers with a measurable dose from 2009 to 2010. The largest decrease in total number of workers with a measurable dose occurred at the Fermi National Accelerator Laboratory. Eighteen of the reporting sites experienced increases in the number of workers with a measurable dose from 2009 to 2010. The largest increase in the number of workers receiving a measurable dose occurred at the Savannah River Site (SRS) (which includes Savannah River Nuclear Solutions [SRNS] and Savannah River Remediation [SRR]). 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 a measurable dose and is measured in units of person-rem (person-sievert [Sv]). As used in this report, the collective dose is a measure of the overall occupational radiation exposure at DOE facilities and includes the dose to all DOE employees, contractors, and subcontractors, as well as members of the public who are monitored during a visit to a DOE facility. DOE monitors the collective dose as one measure of the overall performance of radiation protection programs to keep individual exposures and collective exposures ALARA.

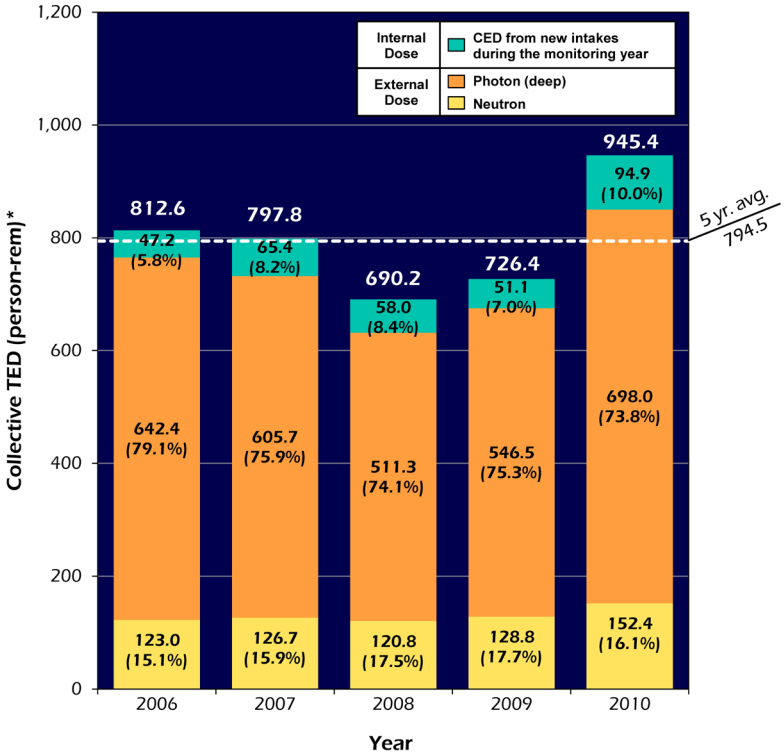
As shown in *Exhibit 3-2*, the collective TED increased at DOE by 30% from 726 person-rems (7.26 person-Sv) in 2009 to 945 person-rems (9.45 person-Sv) in 2010.

The internal dose is based on the 50-year Committed Effective Dose (CED) methodology. Under this methodology, the cumulative dose received from the intake of radioactive material over the next 50 years is assigned to the individual as a one-time dose in the year of intake.

The internal dose component of the collective TED increased by 86% from 51.1 person-rems (511 person-mSv) in 2009 to 94.9 person-rems (949 person-mSv) in 2010. The collective photon dose increased by 28% from 547 person-rems (5.47 person-Sv) in 2009 to 698 person-rems (6.98 person-Sv) in 2010.

The neutron component of the TED increased by 18% from 129 person-rems (1.29 person-Sv) in 2009 to 152 person-rems (1.52 person-Sv) in 2010. This is due primarily to the 167% increase in neutron dose at Hanford and the 54% increase in neutron dose at SRNS. Hanford attributed the increase in neutron dose primarily to the clean-out and removal of glove boxes at the Plutonium Finishing Plant (PFP). The increase in work was a result of an increase in ARRA funds for this effort. SRNS attributes approximately 40% of the increase in neutron dose to the change in radiation weighting factors for neutrons as a result of the implementation of the amendment to 10 C.F.R. 835.

Exhibit 3-2:
Components of TED, 2006–2010.



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

The collective TED increased by 30% at DOE from 2009 to 2010.

The collective internal dose increased by 86% from 2009 to 2010.

Neutron dose increased by 18% from 2009 to 2010.

Photon dose increased by 28% from 2009 to 2010.

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

Effective dose from neutrons—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

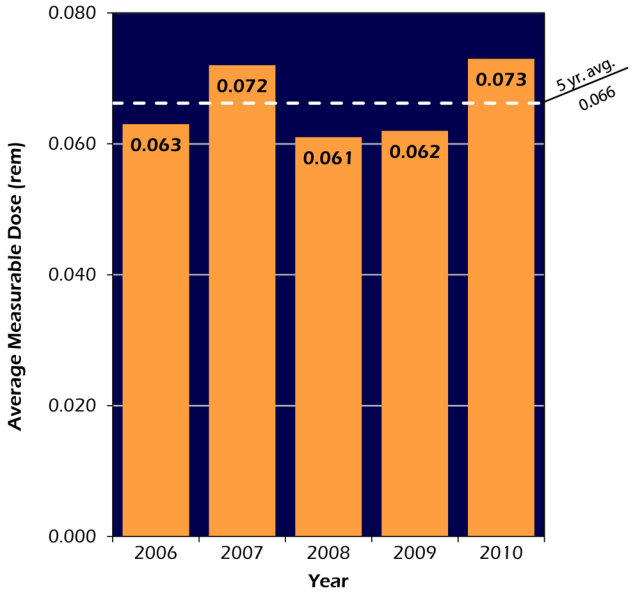
Nine of the DOE sites reported decreases in the collective TED from the 2009 values, while 21 of the DOE sites reported increases. The five sites that contributed most (79%) of the DOE collective TED in 2010 were (in descending order of collective dose for 2010) Savannah River - 19% (including SRNS and SRR), Hanford - 18% (including the Hanford Site, Pacific Northwest National Laboratory, and the Office of River Protection), Oak Ridge sites - 15% (including East Tennessee Technology Park [ETTP], Y-12, Oak Ridge National Laboratory [ORNL], and Oak Ridge Institute for Science and Education), Idaho - 14% (including Idaho National Laboratory and Idaho Cleanup Project), and Los Alamos National Laboratory (LANL) - 13%. All five sites reported increases in the collective TED in 2010 over 2009.

3.2.4 Average Measurable Dose

The average measurable dose to DOE workers, a key radiation dose indicator, is calculated by dividing the collective dose (i.e., TED or CED) by the number of individuals with a measurable dose for each dose type.

The average measurable TED is shown in *Exhibit 3-3*. The average measurable TED increased by 18% from

Exhibit 3-3:
Average Measurable TED, 2006–2010



0.062 rem (0.62 mSv) in 2009 to 0.073 rem (0.73 mSv) in 2010 and is above the 5-year average for the first time since 2007. 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 C.F.R. 835.402(a) and (c) [6].

Exhibit 3-4 shows that the dose distribution for 2010 was slightly higher in all but two ranges to the 2009 data. Ninety-nine percent of the individuals monitored had doses less than 0.25 rem (2.5 mSv). It also shows that the collective TED has increased each year from 2008 to 2010, with a significant increase (30%) for 2010. In 2010, it can be seen that the distribution of doses above 0.5 rem (5 mSv) remained comparable with the 2009 distribution with the exception of one over exposure. 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 with the total collective dose.

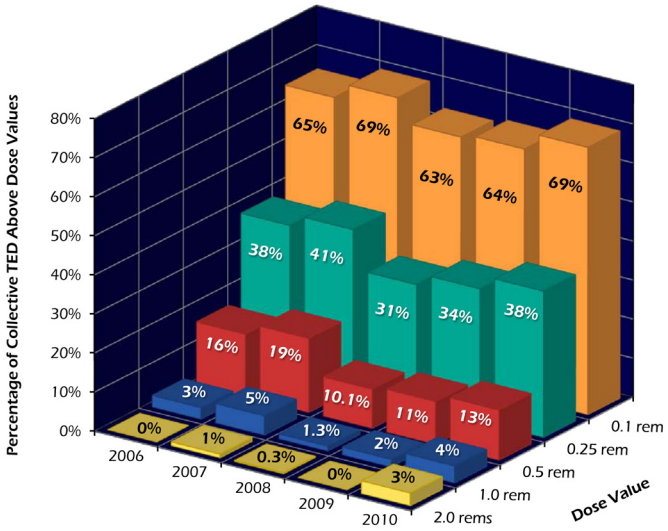
The United Nations' *Sources and Effects of Ionizing Radiation, United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2000 Report to the General Assembly, with Scientific Annexes, Volume I* [10], recommends the calculation of a parameter "SR" to aid in the examination of the 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,

Exhibit 3-4:
Distribution of TED by Dose Range, 2006–2010.

TED Range (rem)		2006	2007	2008	2009	2010
Number of Individuals in Each Dose Range*	Less than measurable	78,327	75,549	71,921	74,650	78,225
	Measurable to 0.1	10,815	8,951	9,341	9,723	10,318
	0.10–0.25	1,441	1,428	1,425	1,398	1,860
	0.25–0.5	520	519	421	491	692
	0.5–0.75	120	147	73	71	101
	0.75–1.0	36	34	20	28	24
	1–2	21	22	6	10	8
	2–3			1		
	3–4					
	4–5					
	5–6					
	6–7					
	7–8		1			
	8–9					
	9–10					
	10–11					
	11–12					
	>12					1
Total number of records for monitored individuals		91,280	86,651	83,208	86,371	91,229
Number with measurable dose		12,953	11,102	11,287	11,721	13,004
Number with dose >0.1 rem		2,138	2,151	1,946	1,998	2,686
% of individuals with measurable dose		14%	13%	14%	14%	14%
Collective TED (person-rems)		812.6	797.8	690.2	726.4	945.4
Average measurable TED (rem)		0.063	0.072	0.061	0.062	0.073

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

Exhibit 3-5:
Percentage of Collective TED Above Dose Values During 2006–2010



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 TED to each individual who received a TED greater than or equal to the specified dose level divided by the total collective TED. This ratio is presented as a percentage rather than a decimal fraction.

Exhibit 3-5 shows the dose distribution given by percentage of collective TED above each of five dose 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 values for 2007 were elevated primarily from the one individual who received a TED above 5 rems (50 mSv) from an intake of plutonium at LANL. In 2010, the values for each dose range increased significantly above the values for 2009. This was due primarily to the one exposure in excess of the 5 rems TED limit at SRS. As in 2007, an individual receiving a dose of this magnitude will increase the percentages across all dose ranges. Apart from the exposure in excess of limits, the values for 2010 remained the same as in 2009.

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 sections focus on doses received by individuals that were in excess of the DOE limit (5 rems [50 mSv] TED) and the DOE recommended ACL (2 rems [20 mSv] TED).

3.3.1 Doses in Excess of DOE Limit

Exhibit 3-6 shows the number of doses in excess of the TED regulatory limit (5 rems [50 mSv]) from 2006 through 2010. One individual received a TED in excess of 5 rems (50 mSv) in 2007 from an intake of plutonium at LANL.

In 2010, one individual received a TED in excess of 5 rems (50 mSv). An event occurred in June 2010 at SRS that led to an exposure in excess of DOE annual limits.

A technician received a puncture wound in a glovebox while performing remediation work. The technician was placing a flag indicator in a waste can and accidentally punctured his protective gloves, resulting in an internal contamination of Pu-238 and Am-241. Transuranics such as plutonium require numerous bioassay measurements taken over a long period of time to accurately determine dose. In October 2011,

Exhibit 3-6:
Number of Individuals Exceeding 2 rems ACL and the 5 rems Annual Limit, 2006–2010.

Year	>2 rems	>5 rems
2006		
2007		1
2008	1	
2009		
2010		1

In 2010, one individual received a TED in excess of 5 rems (50 mSv).

Exhibit 3-7:
Doses in Excess of DOE Limit, 2006–2010.

Year	Total Effective Dose (TED) (external + internal dose) (rem)	Effective Dose (ED) from external sources (rem)	Committed Effective Dose (CED) from intakes (rem)	Committed Equivalent Dose (CEqD) from intakes (rem)	Intake Nuclides	Facility Types	Site
2006	None reported						
2007	7.530	0	7.530	130	Pu-238, Pu-239	Research, General	LANL
2008	2.106	0.286	1.820	60	Pu-238, Pu-239	TA-55 Facility	LANL
2009	None reported						
2010	31.618	0.029	31.589	1,043.190	Pu-238	TRU Waste Remediation Facility	SRS

the final dose was determined to be of 31.589 rems CED, and a CEqD to the bone surface of 1,043.190 rems. For more information on this event, see the Type B Accident Investigation Board Report "Employee Puncture Wound at the F-TRU Waste Remediation Facility", June 14, 2010 and the Preliminary Notice of Violation, NEA-2011-02, issued to SRNS July 22, 2011.

3.3.2 Doses in Excess of Administrative Control Level

The Radiological Control Standard (RCS) [11] recommends a 2 rems (20 mSv) ACL for TED, 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.

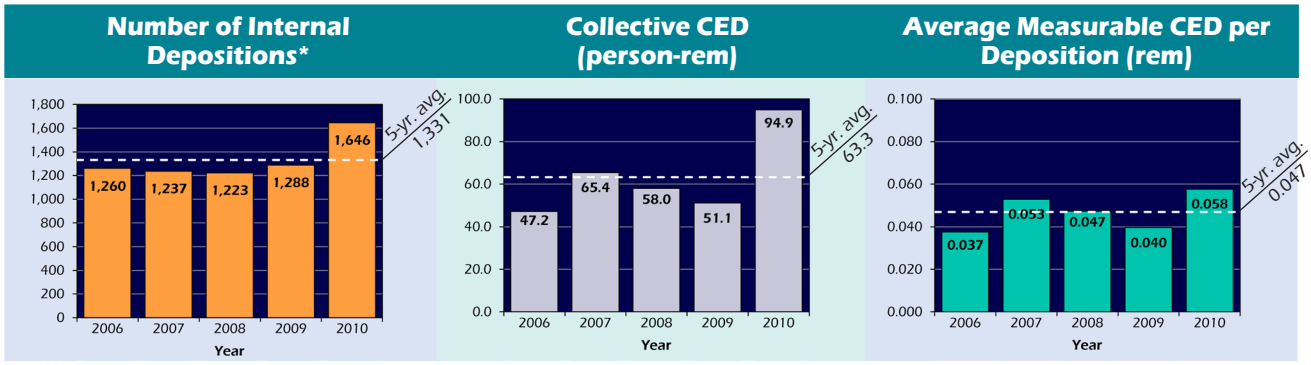
As shown in *Exhibit 3-6*, three individuals have exceeded the 2 rems (20 mSv) ACL in the past 5 years. Two of the three individuals also exceeded the 5 rems (50 mSv) annual limit.

3.3.3 Internal Depositions of Radioactive Material

As shown in *Exhibit 3-7*, some of the highest doses to individuals have been the result of intakes of radioactive material. For this reason DOE tracks the number of intakes as a performance measure in this report. DOE emphasizes the importance of taking measures to avoid intakes and maintain doses as low as reasonably achievable.

Exhibit 3-8 shows the number of internal depositions of radioactive material (an indicator of worker intakes),

Exhibit 3-8:
Number of Internal Depositions, Collective CED, and Average Measurable CED, 2006–2010.



* 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 3-9:
Internal Dose Distribution from Intakes, 2006–2010.

Year	Number of Individuals with CED in the Ranges (rem)*											Total No. of Indiv.**	Total Collective CED (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		
2006	664	474	106	15	1							1,260	47.200
2007	623	436	151	22	3	1					1	1,237	65.400
2008	602	460	131	25	2	2	1					1,223	58.000
2009	701	449	117	16	4	1						1,288	51.100
2010	890	600	133	19	1	1	1				1	1,646	94.895

* 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.

collective CED, and average measurable CED for 2006 to 2010. The number of internal depositions increased by 28% from 1,288 in 2009 to 1,646 in 2010, while the collective CED increased by 86%. The average measurable CED increased from 0.040 rem (0.40 mSv) in 2009 to 0.058 rem (0.58 mSv) in 2010.

Over half (60%) of the collective CED in 2010 was from uranium intakes at the Y-12 National Security Complex (Y-12) during the operation and management of Enriched Uranium Operations facilities at the site. Compared with external dose, relatively few workers receive measurable internal dose, so larger fluctuations in the number of workers and collective CED, than for other components of TED, may occur from year to year.

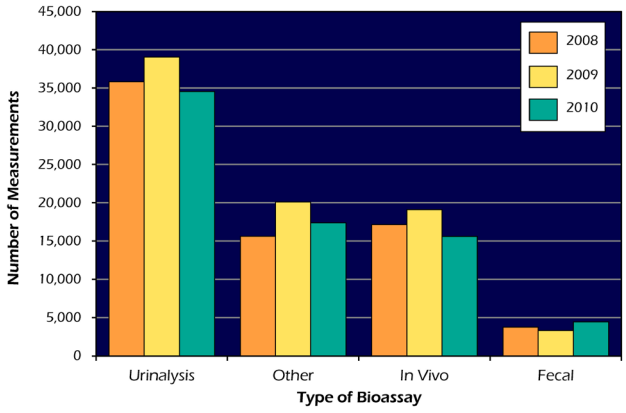
Exhibit 3-9 shows the distribution of the internal dose from 2006 to 2010. The total number of individuals with intakes in each dose range is the sum of all records of intake in the subject dose range. Individuals with multiple intakes during the year may be counted more than once. Doses below 0.020 rem (0.20 mSv) are shown as a separate dose range, which shows the large number of doses in this low dose range. The increase in the number of individuals with measurable CED in 2010 is primarily due to the increase of individuals receiving less than 0.100 rem (1 mSv). There was one internal dose above 5 rems (50 mSv) CED in 2010.

The internal dose records indicate that the majority of the intakes result in very low doses. In 2010, 54% of the internal dose records were for doses below 0.020 rem (0.20 mSv). Over the 5-year period, internal doses from intakes accounted for 8% of the collective TED, and 10% of the individuals who received internal doses were above the monitoring threshold (0.1 person-rem [1 mSv]) specified in 10 C.F.R. 835.402(c) [6]. It should be noted that the one individual who received a dose of 31.589 rems in 2010 contributed to 33% of the collective CED in 2010 (see Section 3.3.1).

3.3.4 Bioassay and Intake Summary Information

For the monitoring year 2010, bioassay and intake summary information was required to be reported under DOE M 231.1-1A [8]. During the past 3 years, urinalysis has been reported as the most common method of bioassay measurement used to determine internal doses to the individuals. *Exhibit 3-10* shows the breakdown of bioassay measurements by measurement type. The measurements reported under "in vivo" include direct measurements of the radioactive material in the body of the monitored person. Examples of in vivo measurements include whole body counts and lung or thyroid counts. The measurements reported in "Other"

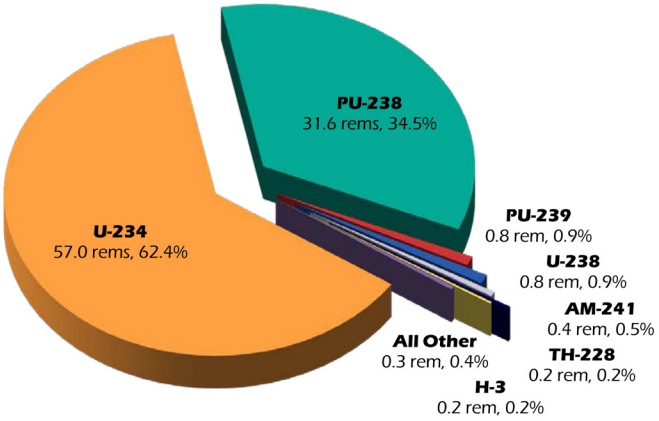
Exhibit 3-10:
Bioassay and Air Sampling Measurements, 2008-2010.



are 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 based on the number of measurements taken, not the number of individuals monitored. Individuals may have measurements taken more than once during the year. Sixty-four percent of the urinalysis measurements in 2010 were performed at three sites: LANL, Y-12, and Hanford. The majority of the bioassay measurements reported as "Other" were from air sampling and account for 24% of the measurements. Ninety-one percent of the measurements reported as "Other" were performed at SRS. Over half of the in vivo measurements were from Hanford. Y-12 performs the largest number of bioassay measurements overall, comprising 18% of the total measurements taken.

Exhibit 3-11 shows the breakdown of the collective CED by radionuclide for 2010. Uranium-234 accounts for the largest percentage of the collective dose, with over 99% of this dose accrued at Y-12. Essentially all of the dose from plutonium-238 was a result of the individual who exceeded the DOE dose limit at SRS (see Section 3.3.1).

Exhibit 3-11:
Collective CED by Radionuclide, 2010.



3.4 Analysis of Site Data

3.4.1 Collective TEDE by Site and Other Facilities

The collective TED for 2008 through 2010 for the major DOE sites and operations/field offices is shown graphically in *Exhibit 3-12*. A list of the collective TED and number of individuals with measurable TED by DOE sites is shown in *Exhibit 3-13*. The collective TED increased by 30% from 726 person-rems (7.26 person-Sv) in 2009 to 945 person-rems (9.45 person-Sv) in 2010, with Savannah River (including SRNS and SRR), Hanford (including the Hanford Site, Pacific Northwest National Laboratory, and the Office of River Protection), Oak Ridge sites (including East Tennessee Technology Park [ETTP], Y-12, Oak Ridge National Laboratory [ORNL], and Oak Ridge Institute for Science and Education), INL (including Idaho National Laboratory and Idaho Cleanup Project), and LANL contributing 79% of the total DOE collective TED.

3.4.2 Changes by Site from 2009 to 2010

Exhibit 3-14 shows the collective TED, the number with a measurable dose, the average measurable TED, and the percentage of the collective TED delivered above 0.500 rem by site for 2010, as well as the percentage change 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 Hanford in 2010.

The percentage of the collective TED above 0.500 rem is an indicator of the distribution of dose to individuals. A smaller fraction of the monitored population received doses above 0.5 rem in 2010. 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 2010

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 2010. These sites (Savannah River, Hanford, Oak Ridge, INL, and LANL) had a collective dose over 100 person-rems and were the top contributors to the collective TED in 2010. These sites comprised 79% of the total collective TED at DOE. All sites reported increases in the collective TED, which contributed to a 30% increase in the DOE collective TED from 726 person-rems (7.26 person-Sv) in 2009 to 945 person-rems (9.45 person-Sv) in 2010. The sites significantly contributing to the collective TED in 2010 are shown in *Exhibit 3-15*, including a description of activities that affected the collective TED.

Exhibit 3-12:
Collective TED by DOE Site for 2008–2010.

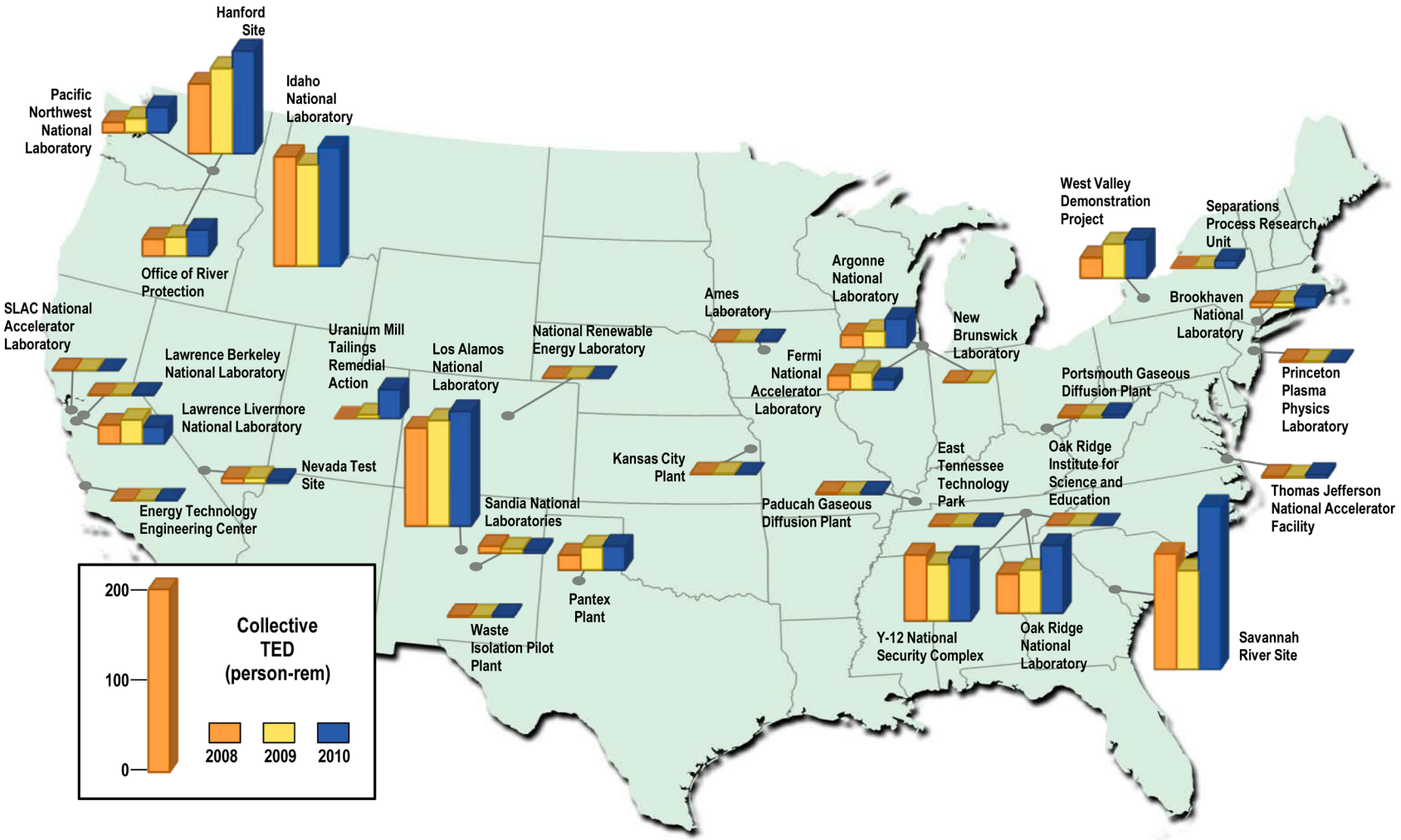


Exhibit 3-13:
Collective TED and Number of Individuals with Measurable TED by DOE Site, 2008–2010.

Site	2008		2009		2010	
	Collective TED (person-rem)	Number with Meas. TED	Collective TED (person-rem)	Number with Meas. TED	Collective TED (person-rem)	Number with Meas. TED
Ames Laboratory	0.5	30	0.7	31	0.9	32
Argonne National Laboratory	13.2	128	17.6	137	30.8	173
Brookhaven National Laboratory	5.4	149	5.2	180	11.5	214
Energy Technology Engineering Center	0.1	15	0.1	43	0.3	54
Fermi National Accelerator Laboratory	15.4	166	18.8	243	11.2	169
Hanford:						
Hanford Site	76.5	1,778	93.4	1,634	112.5	1,673
Office of River Protection	18.3	372	20.6	346	28.5	535
Pacific Northwest National Laboratory	11.1	226	15.3	242	27.5	280
Idaho National Laboratory	120.4	1,956	111.3	1,808	129.9	1,889
Kansas City Plant	0.1	39	0.5	10	0.0	10
Lawrence Berkeley National Laboratory	0.4	8	0.6	14	1.1	16
Lawrence Livermore National Laboratory	20.4	129	26.1	182	18.3	146
Los Alamos National Laboratory	107.3	1,219	**115.7**	1,392	125.4	1,335
National Renewable Energy Laboratory	0.0	3	0.0	5	0.0	3
Nevada National Security Site	5.2	75	5.5	86	3.0	73
New Brunswick Laboratory	0.1	8	0.1	3		
Oak Ridge:						
East Tennessee Technology Park	0.4	23	1.1	37	1.2	43
Oak Ridge Institute for Science and Education	0.2	53	0.2	62	0.1	56
Oak Ridge National Laboratory	42.7	492	46.9	659	74.0	739
Y-12 National Security Complex	72.1	1,301	61.9	1,379	69.4	1,634
Paducah Gaseous Diffusion Plant	1.3	44	1.2	79	1.3	71
Pantex Plant	16.5	287	25.2	302	26.1	303
Portsmouth Gaseous Diffusion Plant	1.4	36	1.5	32	3.0	63
Princeton Plasma Physics Laboratory	1.3	123	0.8	101	0.7	79
Sandia National Laboratories	7.2	160	4.1	88	2.9	59
Savannah River Site	**127.1**	**2,151**	108.8	**2,183**	**179.6**	**2,587**
Separations Process Research Unit			0.3	10	7.9	74
SLAC National Accelerator Laboratory	0.6	25	0.2	6	0.1	4
Thomas Jefferson National Accelerator Facility	1.5	51	0.7	27	3.1	67
Uranium Mill Tailings Remediation Action Project	0.1	7	3.6	92	31.5	237
Waste Isolation Pilot Plant	1.1	63	0.9	68	1.2	62
West Valley Demonstration Project	22.2	157	37.0	230	41.9	308
Service Center Personnel*	0.5	14	0.5	10	0.4	16
Totals**	**690.5**	**11,288**	**726.4**	**11,721**	**945.4**	**13,004**

Note: Bold values indicate the greatest value in each column.

* Includes service center personnel from Albuquerque and Oak Ridge in addition to several smaller facilities not associated with a DOE site.

** The collective TED 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.

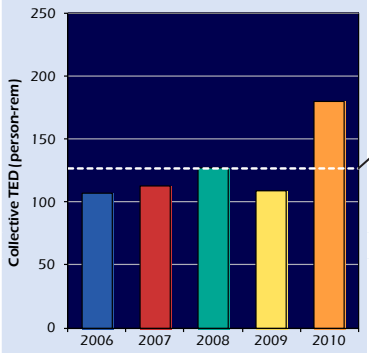
Exhibit 3-14:
Site Dose Data, 2010.

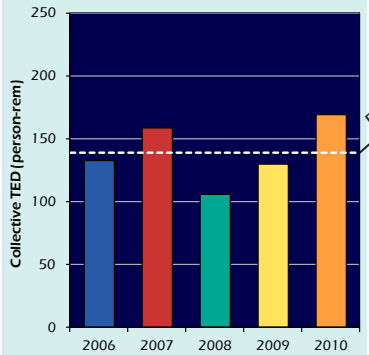
Site	2010							
	Collective TED (person-rem)	Percent Change from 2009	Number with Meas. Dose	Percent Change from 2009	Avg. Meas. TED (rem)	Percent Change from 2009	Percentage of Coll. TED above 0.500 rem	Percent Change from 2009
Ames Laboratory	0.907	26% ▲	32	3% ▲	0.028	23% ▲		
Argonne National Laboratory	30.799	76% ▲	173	28% ▲	**0.178**	37% ▲	**52%**	58% ▲
Brookhaven National Laboratory	11.529	122% ▲	214	19% ▲	0.054	87% ▲	6%	
Energy Technology Engineering Center	0.292	134% ▲	54	26% ▲	0.005	86% ▲		
Fermi National Accelerator Laboratory	11.220	-40% ▼	169	-30% ▼	0.066	-14% ▼		
Hanford:								
Hanford Site	112.522	21% ▲	1,673	2% ▲	0.067	18% ▲	1%	-92% ▼
Office of River Protection	28.522	38% ▲	535	55% ▲	0.053	-11% ▼		
Pacific Northwest National Laboratory	27.500	79% ▲	280	16% ▲	0.098	55% ▲	45%	320% ▲
Idaho National Laboratory	129.945	17% ▲	1,889	4% ▲	0.069	12% ▲	5%	406% ▲
Kansas City Plant	0.046	-91% ▼	10		0.005	-91% ▼		
Lawrence Berkeley National Laboratory	1.097	79% ▲	16	14% ▲	0.069	57% ▲		
Lawrence Livermore National Laboratory	18.349	-30% ▼	146	-20% ▼	0.126	-12% ▼	45%	-32% ▼
Los Alamos National Laboratory	125.389	8% ▲	1,335	-4% ▼	0.094	13% ▲	24%	6% ▲
National Renewable Energy Laboratory	0.022		3		0.007			
Nevada National Security Site	2.999	-46% ▼	73	-15% ▼	0.041	-36% ▼		
New Brunswick Laboratory								
Oak Ridge:								
East Tennessee Technology Park	1.187	6% ▲	43	16% ▲	0.028	-9% ▼		
Oak Ridge Institute for Science and Education	0.114	-51% ▼	56	-10% ▼	0.002	-45% ▼		
Oak Ridge National Laboratory	74.013	58% ▲	739	12% ▲	0.100	41% ▲	10%	74% ▲
Y-12 National Security Complex	69.430	13% ▲	1,634	18% ▲	0.042	-5% ▼	5%	-31% ▼
Paducah Gaseous Diffusion Plant	1.330	16% ▲	71	-10% ▼	0.019	29% ▲		
Pantex Plant	26.131	4% ▲	303		0.086	4% ▲		
Portsmouth Gaseous Diffusion Plant	2.960	92% ▲	63	97% ▲	0.047	-2% ▼		
Princeton Plasma Physics Laboratory	0.663	-16% ▼	79	-22% ▼	0.008	8% ▲		
Sandia National Laboratories	2.885	-30% ▼	59	-33% ▼	0.049	4% ▲		
Savannah River Site	**179.572**	65% ▲	**2,587**	19% ▲	0.069	39% ▲	18%	**793%** ▲
Separations Process Research Unit	7.850		74		0.106		28%	
SLAC National Accelerator Laboratory	0.053	-69% ▼	4	-33% ▼	0.013	-53% ▼		
Thomas Jefferson National Accelerator Facility	3.111	351% ▲	67	148% ▲	0.04 6	82% ▲		
Uranium Mill Tailings Remediation Action Project	31.497	**769%** ▲	237	**158%** ▲	0.133	**237%** ▲		
Waste Isolation Pilot Plant	1.199	32% ▲	62	-9% ▼	0.019	45% ▲		
West Valley Demonstration Project	41.873	13% ▲	308	34% ▲	0.136	-15% ▼	7%	-71% ▼
Service Center Personnel*	0.363	-29% ▼	16	7% ▲	0.023	-33% ▼		
Totals	**945.369**	**30%** ▲	**13,004**	**11%** ▲	**0.073**	**18%** ▲	**13%**	**19%** ▲

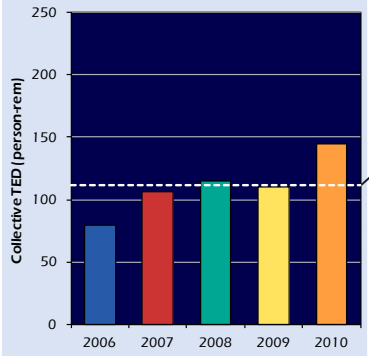
Note: Bold and boxed values indicate the greatest value in each column. Please see section 3.4.3.1 for more information.

* Includes service center personnel from Albuquerque and Oak Ridge in addition to several smaller facilities not associated with a DOE site.

Exhibit 3-15 :
Activities Significantly Contributing to Collective TED in 2010.

Savannah River Site	Percent Change* 2009-2010 (last yr.)	2008-2010 (3 yr.)	2006-2010 (5 yr.)	Description of Activities at the Site
	↑ 65.1%	↑ 41.3%	↑ 67.5%	For calendar year 2010, Savannah River Site (SRS) cumulative radiation exposure totals were over 65% higher than 2009. SRS includes Savannah River Nuclear Solutions (SRNS) and Savannah River Remediation (SRR). For SRNS, the increase was the result of handling higher dose rate transuranic (TRU) drums, the Solid Waste Pad 16 spill, a new method for culvert mining in Solid Waste, and continued decommissioning work in Area Completion under the American Recovery and Reinvestment Act (ARRA). SRR realized an increase from continued bulk waste removal in F and H Tank Farms, salt processing at Saltstone, and tank closure activities at the Modular Caustic Extraction Unit. The internal dose methods of ICRP 60 were implemented at the beginning of 2006 by formal exemption to the previous rule, with a net effect of reducing calculated doses for TRU materials. However, the neutron dose methods were implemented 1/1/2010. The latter changes resulted in a 39% increase at SRS in dose assigned from given neutron exposure. In addition, an individual received an internal dose of 31.589 rems (CED) from an intake of plutonium that contributed to 18% of the collective TED in 2010.

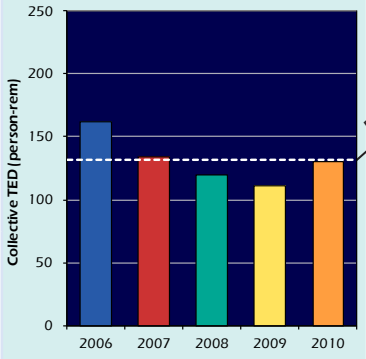
Hanford	Percent Change* 2009-2010 (last yr.)	2008-2010 (3 yr.)	2006-2010 (5 yr.)	Description of Activities at the Site
	↑ 30.3%	↑ 59.1%	↑ 26.8%	The collective TED at Hanford (which includes Richland Operations Office, Office of River Protection, and the Pacific Northwest Site Office [PNSO]) increased by 30% from 2009 to 2010. The increase in collective dose was due to increased Decontamination and Decommissioning (D&D) activities at Plutonium Finishing Plant (PFP) and increased retrieval and processing of TRU waste. The neutron dose increased as a result of cleanout and removal of glove boxes at PFP. The increase in work was a result of an increase in ARRA funds for this effort. CED at the Hanford site was low, 0.162 person-rem, but was an increase from 2009.

Oak Ridge	Percent Change* 2009-2010 (last yr.)	2008-2010 (3 yr.)	2006-2010 (5 yr.)	Description of Activities at the Site
	↑ 31.6%	↑ 25.4%	↑ 82.0%	**Y-12 National Security Complex (Y-12) – Babcock & Wilcox (B&W)** At Y-12, the collective TED increased 12% from 61.856 person-rems in 2009 to 69.430 person-rems in 2010. The total persons monitored increased by nearly 18% from 5,791 to 6,830. While the total collective exposure at Y-12 increased in 2010 as compared to 2009, on average exposures decreased. An additional 1,041 individuals were monitored, including 382 additional people monitored for internal exposure. Most of the additional people monitored were a part of the ARRA projects being conducted at Y-12. Utilizing the resources provided by the ARRA, Y-12 was able to rid the site of unnecessary legacy material and to perform demolition of excess buildings thereby reducing future dose to workers. The organization with the largest contribution to Y-12's collective dose is the Production organization. This organization accounts for 46% of the site's overall dose. Despite increased workloads in many areas within

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

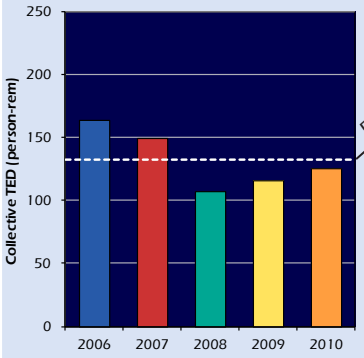
Exhibit 3-15 (Continued):
Activities Significantly Contributing to Collective TED in 2010.

Oak Ridge	Percent Change*			Description of Activities at the Site
	2009-2010 (last yr.)	2008-2010 (3 yr.)	2006-2010 (5 yr.)	
				production, the average dose to production personnel remained essentially the same as in 2009, with a slight reduction in the average internal exposure. Production also accounts for most of the internal exposure received at the plant. The average internal exposure in this group is 47 millirem with the next highest group averaging only 18 millirem (internal). The Facilities, Infrastructure and Services organization makes the second largest contribution (15% of the total). Its average exposures increased in 2010 by 3 millirem primarily due to additional workload in the production areas. The 2010 collective CED increased 16.1% from 49.2 person-rems in 2009 to 57.1 person-rems in 2010; however, the average CED increased only 0.6% from 0.019 rem in 2009 to 0.020 rem in 2010 per monitored individual. There were an additional 382 workers monitored for internal exposure. There were 148 workers who received an internal dose equal to or in excess of 0.100 person-rem (CED). **East Tennessee Technology Park (ETTP) – Bechtel Jacobs Company LLC (BJC)** There were a total of 2,582 individuals monitored by BJC in 2010, resulting in a collective TED of 4.27 person-rems and a total CED of 0.164 person-rem for all BJC sites. The increase in TED and total neutron dose for 2010 as compared with 2009 is attributed to an increase in waste operations tasks at ORNL. The increase in CED for 2010 as compared to 2009 is due to seven individuals that had a CED in excess of 0.010 person-rem. Individual CED was primarily from routine bioassay measurements and not the result of any specific radiological event. Most of the individuals had positive bioassay samples during a period of work in areas with elevated air monitoring results. Most of the individuals were associated with process equipment segmentation work at the K-25 Building D&D project. There were no unusual events related to occupational radiation exposure at BJC facilities for 2010. **ORNL-UT Battelle** The reported TED for ORNL during 2010 is about 17.5% higher than the 2009 reported TED. During 2010, ORNL saw an increase in isotope processing and cleanup and waste disposal activities which attributed to this increase. The waste disposal activities were due to tasks performed during isotope processing.

Idaho National Laboratory	Percent Change*			Description of Activities at the Site
	2009-2010 (last yr.)	2008-2010 (3 yr.)	2006-2010 (5 yr.)	
	↑ 16.7%	↑ 8.2%	↓ 19.6%	At the Idaho site, the collective TED increased by 17% from 2009 to 2010. D&D Reactor Testing Complex activities included Voluntary Consent Order (VCO) activities relating to TRA-613, 713, 630, 730 and associated underground piping systems. D&D of TRA-604; D&D at TRA-603, including Material Test Reactor (MTR) monolith demolition; and the lifting of the Reactor in preparation for transport to ICDF was performed, as well as the cleanout and characterization of the TRA-632 hot cell facility. D&D work at Reactor Testing Complex (RTC) including the underground VCO piping and the MTR reactor work contributed to increased dose. At the Materials Test Complex (MTC), the work involved high doses during lead removal necessary to complete asbestos removal on process piping, as well as reactor internals demolition. INTEC D&D work on sample blisters and remaining cell pregrouting evolutions also added to increased dose.

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

Exhibit 3-15 (Continued):
Activities Significantly Contributing to Collective TED in 2010.

Los Alamos National Laboratory	Percent Change*			Description of Activities at the Site
	2009-2010 (last yr.)	2008-2010 (3 yr.)	2006-2010 (5 yr.)	
	↑ 8.4%	↑ 16.9%	↓ 23.5%	The collective TED at LANL increased by 8% from 2009 to 2010. TA-55 Plutonium Facility operations accounted for the majority of occupational dose at LANL in calendar year 2010— historically consistent for LANL. Occupational dose was accrued from manufacturing and related weapons work, Pu-238 work, repackaging materials, and providing radiological control technicians and other infrastructure support for radiological work and facility maintenance at TA-55. In addition to TA-55 operations, significant portions of LANL dose were accrued by workers performing retrieval, repackaging, and shipping of radioactive solid waste at LANL waste facilities at TA-50 and TA-54 and workers performing programmatic and maintenance work at the TA-53 Los Alamos Neutron Science Center (LANSCE).

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

3.4.3.1 Further Detail on Activities Significantly Contributing to Collective Dose in 2010

In addition to the information provided in *Exhibit 3-15*, several of the DOE sites provided further information on operations conducted during the monitoring year. DOE M 231.1-1A, Appendix G, Section 1, specifies that the sites should provide a description of activities conducted at the site as it relates to the collective radiation exposure received. The following descriptions are excerpts from the transmittal letters from DOE sites in 2010.

Argonne National Laboratory

The collective dose (TED) for the monitoring year 2010 at Argonne is approximately 31 person-rems, up from approximately 18 person-rems the previous year. The increase from 2009 was approximately 75%. No individuals exceeded 2 rems TED this monitoring year. The Alpha Gamma Hot Cell Facility (AGHCF) was the primary dose contributor in 2010. There were five AGHCF workers with an annual individual dose (TED) exceeding 1.0 person-rem. Their doses were between 1.0 person-rem and 1.3 person-rems. The doses at AGHCF were accrued mainly during campaigns to remove radioactive waste from the hot cell. The number of waste removal campaigns continued to increase significantly this year as more funding became available and the AGHCF team became more proficient. Another major contributor was site waste management operations. The radiological safety organization accrued considerable dose in monitoring these activities.

Brookhaven National Laboratory

The collective total effective dose (TED) at Brookhaven National Laboratory (BNL) increased by 122%, from 5.2 person-rems in 2009 to 11.5 person-rems in 2010. All exposures were from Equivalent Dose (EqD). The increase in total dose is primarily due to the increase in remediation activities at the Brookhaven Graphite Research Reactor Project. The highest individual dose was 0.651 rem, so no individual exceeded 2 rems TED or exceeded any DOE occupational dose limit.

Fermi National Accelerator Laboratory

The collective TED at Fermi National Accelerator Laboratory (Fermilab) for 2010 was 11.22 person-rems.

During 2010, there was one major shutdown of the accelerators that lasted approximately 1 month and began on July 19. The shutdown was necessary to perform accelerator maintenance and improvements. The majority of the work performed during these shutdown periods involved Accelerator Division personnel, although personnel from other divisions/sections/centers assisted as necessary. The shutdown involved several major projects, involving component replacement and upgrades of several machines within the accelerator complex. All of the shutdown tasks were necessary to achieve the challenging goals of the physics research program, while at the same time were aimed at reducing beam losses, which is an essential ingredient in improving performance and increasing deliverable proton intensities. Reducing beam losses also reduces

radioactivation of beam line components and potential radiation dose to personnel who must maintain the accelerators in the future.

While Fermilab continues to diligently manage a Radiation Protection Program, under 10 C.F.R. 835, as part of integrated safety management (ISM) to control radiation doses to personnel and keep exposures as low as is reasonably achievable (ALARA), it has been shown for many years now that these necessary shutdowns of the accelerators for upgrades, maintenance, and repair work do lead to an increase in the TED. The TED for 2010 is within the expected range for a year in which a 1-month shutdown occurred.

Kansas City Plant

The Kansas City Plant (KCP) collective TED for these individuals was 0.046 person-rem. This represents a 91% decrease from last year's monitoring period. However, last year's collective TED was abnormally high due to an individual's dose reading of 0.499 rem. Excluding that dose, collective doses from all 5 years were similar and hence, does not reflect any systemic problem or negative trend at the site. The 2010 collective TED more accurately reflects the routine activities at the KCP and there were no special projects contributing to these doses.

Lawrence Berkeley National Laboratory

The collective TED at Lawrence Berkeley National Laboratory (LBNL) increased from 0.613 person-rem in 2009 to 1.075 person-rem in 2010. Ninety two percent of the collective TED is the result of radiological activities at the Center for Functional Imaging (CFI), specifically those activities associated with new radiopharmaceutical (F-18/C-11) development.

Lawrence Livermore National Laboratory

The Lawrence Livermore National Laboratory (LLNL) 2010 collective TED of 18.017 person-rems reflects a decrease from the 2009 collective TED of 25.834 person-rems and represents decreased operations in the Plutonium Facility and at LLNL. Doses for 2010 are as expected. The LLNL – Nevada National Security Site (NNSS) 2010 collective TED of 0.332 person-rem reflects an increase from the 2009 collective TED of 0.265 person-rem.

Pantex Plant

The DOE/National Nuclear Security Administration (NNSA) Pantex Plant is the nation's only facility for assembly and disassembly of nuclear explosives. The operations that contribute the majority of the dose to Pantex Plant workers are operations that expose them to large numbers of bare weapon pits (the pits contain significant quantities of Special Nuclear Materials). These operations include nuclear explosive assembly/disassembly operations, weapon dismantlement programs, life-extension programs, Special Nuclear Material Component Re-qualification, and Special Nuclear Material staging.

The total population dose to Pantex Plant workers increased by 35% in 2010 compared with 2009. The increase was due to variations in the specific types and quantities of production work performed by B&W Pantex.

Sandia National Laboratories

The site collective dose at Sandia National Laboratories (SNL) for 2010 is 2.9 person-rems, a 1.5% decrease from last year. SNL radiological operations remain consistent with recent years' activities and currently include operation of a research reactor, gamma irradiation facility, hot cell facility, several pulsed-power accelerators, light laboratory work involving X-ray machines and use of tracer radionuclides, neutron generator production, and waste operations. Approximately 2,500 individuals received dosimetry monitoring in 2010.

Separations Process Research Unit

The Separation Process Research Unit Disposition Project (SPRU – NY) collective TED for 2010 is 7.887 person-rems. No individual exceeded 2 rems TED.

The project activities in 2010 of dose concern were the continued characterization of facility radiological conditions, demolition preparation activities that included the decontamination and asbestos abatement activities of the SPRU facilities in Buildings G2, H2, and the E1/G1 Tunnels. Also included in 2010 is the commencement of G2 and H2 Facility demolition and activities at the SPRU waste tanks that contributed to personnel dose.

The Separation Process Research Unit Disposition Project (SPRU – LA) collective TED for 2010 is 0 person-rem.

The SPRU-LA project concluded remediation activities in 2010. Approximately 15,000 cubic yards of material, removed from approximately a 15-acre site, was excavated, packaged, and shipped off site for disposal.

This was accomplished under approximately 39,000 RWP-man-hours. As this was the last year of the project and all individual doses were zero for the year, there is no change in cumulative TED.

SLAC National Accelerator Laboratory

The 2010 collective TED (0.053 person-rem) at SLAC is about 31% of the 2009 collective TED (0.169 person-rem). These low values in collective TEDs for both years are mainly associated with no operational activities for high energy physics researchers compared with previous years. In particular, the beams from the linear accelerator at Sectors 0-19, including associated klystrons have been maintained inactive since 2008. A review of the Radiological Work Permit (RWP) program in 2010 also shows no significant works involving elevated personal exposures. Thus, the collective dose reduction in 2010 was in line with less work activities conducted in Radiological Areas, especially in High Radiation Areas and Contamination Areas during 2010. No individuals exceeded 2 rems (20 mSv) TED or any DOE occupational dose limit during 2010 at SLAC.

Thomas Jefferson National Accelerator Facility

The collective TED at Thomas Jefferson National Accelerator Facility increased approximately 350%, from 0.690 person-rem in 2009 to 3.111 person-rems in 2010. This collective dose is attributed to maintenance, modification and repair of activated components associated with the Continuous Electron Beam Accelerator Facility as part of operating and upgrading these facilities, as well as ancillary activities such as transport, storage and disposal of radioactive materials. No individuals exceeded 2 rems (20 mSv) TED.

Uranium Mill Tailings Remediation Action Project – Moab

In April 2009, DOE began removing the 16 million tons of uranium mill tailings from the Moab site and relocating them by rail to the permanent disposal cell constructed at Crescent Junction. The employees' 2010 radiological exposures occurred in the mill tailings excavation and conditioning, which took place directly on top of the mill tailing pile. The mill tailings were then placed in steel containers with locking lids for transportation to the disposal cell at Crescent Junction. In calendar year 2010, two train shipments were made daily Monday through Friday.

The Moab UMTRA Project accomplished the two shipments daily, with the assistance of funding from the ARRA. Approximately one-third of the 2010 radiological dose would be assigned to those workers who were hired in support of ARRA program.

West Valley Demonstration Project

Two major projects of dose concern continue to be D&D Projects and Waste Management. D&D work in extraction cells and support cells included removing and packaging contaminated tanks, piping, and components in preparation for being declared "Demolition-Ready." Waste Management activities included waste processing and shipping for disposal. Waste Management is also involved in modifying facilities to accommodate the remaining waste to be processed.

The 2010 TED of 41.873 person-rems is approximately 13% higher than the 2009 TED of 36.985 person-rems. This increase was due primarily to an increased level of effort in D&D and Waste Management. No individual exceeded 2 rems TED.

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. It should be noted that several of the DOE sites undertake work supporting multiple program offices. However, those sites have a lead program office and are not required to report radiation exposure by program office, so the exact contribution from each program office cannot be determined. In these instances, the site is shown under one program office but may have significant portions of the dose from work done in support of other program offices. *Exhibit 3-16* shows the number of individuals with measurable dose, the collective TED, and the average measurable TED by DOE program office. The Office of Environmental Management (EM) and the NNSA account for the largest percentages of the collective dose (56% and 26%, respectively). The mission of the Office of Environmental Management (EM) is to complete the safe cleanup of the environmental legacy brought about from five decades of nuclear weapons development and government-sponsored nuclear energy 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 82% of the collective dose at DOE.

Exhibit 3-16:
Program Office Dose Data, 2010.

Program Office	Collective TED (person-rem)	Percent Change from 2009	Number with Meas. Dose	Percent Change from 2009	Avg. Meas. TED (rem)	Percent Change from 2009
Office of Energy Efficiency and Renewable Energy (EE)						
National Renewable Energy Laboratory	0.0	-24% ▼	3	-40% ▼	0.007	26% ▲
EE Totals*	**0.0**	**-24% ▼**	**3**	**-40% ▼**	**0.007**	**26% ▲**
Office of Environmental Management (EM)						
East Tennessee Technology Park	1.2		43		0.028	
Energy Technology Engineering Center	0.3		54		0.005	
Hanford Site	112.5	21% ▲	1,673	2% ▲	0.067	18% ▲
Idaho National Laboratory	85.5	30% ▲	1,114	-2% ▼	0.077	32% ▲
Oak Ridge National Laboratory	38.1	95% ▲	277	8% ▲	**0.138**	81% ▲
Office of River Protection	28.5	38% ▲	535	55% ▲	0.053	-11% ▼
Paducah Gaseous Diffusion Plant	1.3	16% ▲	71	-10% ▼	0.019	29% ▲
Portsmouth Gaseous Diffusion Plant	3.0	92% ▲	63	97% ▲	0.047	-2% ▼
Savannah River Site	**179.6**	65% ▲	**2,587**	19% ▲	0.069	39% ▲
Separations Process Research Unit	7.9		74		0.106	
Service Center Personnel	0.0		4		0.010	
Uranium Mill Tailings Remedial Action Project	31.5	**769%** ▲	237	**158%** ▲	0.133	**237%** ▲
Waste Isolation Pilot Plant	1.2	32% ▲	62	-9% ▼	0.019	45% ▲
West Valley Demonstration Project	41.9	13% ▲	308	34% ▲	0.136	-15% ▼
EM Totals*	**532.4**	**50% ▲**	**7,102**	**15% ▲**	**0.075**	**30% ▲**
National Nuclear Security Administration (NNSA)						
Kansas City Plant	0.0	-91% ▼	10		0.005	-91% ▼
Lawrence Livermore National Laboratory	18.3	-30% ▼	146	-20% ▼	**0.126**	-12% ▼
Los Alamos National Laboratory	**125.4**	8% ▲	1,335	-4% ▼	0.094	**13%** ▲
Nevada National Security Site	3.0	-46% ▼	73	-15% ▼	0.041	-36% ▼
Pantex Plant	26.1	4% ▲	303		0.086	4% ▲
Sandia National Laboratories	2.9	-30% ▼	59	-33% ▼	0.049	4% ▲
Service Center Personnel	0.3		11		0.026	
Y-12 National Security Complex	69.4	**13%** ▲	**1,634**	**18%** ▲	0.042	-5% ▼
NNSA Totals*	**245.5**	**3% ▲**	**3,571**	**4% ▲**	**0.069**	**-1% ▼**
Office of Nuclear Energy (NE)						
Idaho National Laboratory	44.5	-2% ▼	775	15% ▲	0.057	-15% ▼
NE Totals*	**44.5**	**-2% ▼**	**775**	**15% ▲**	**0.057**	**-15% ▼**
Office of Science (SC)						
Ames Laboratory	0.9	26% ▲	32	3% ▲	0.028	23% ▲
Argonne National Laboratory	30.8	76% ▲	173	28% ▲	**0.178**	37% ▲
Brookhaven National Laboratory	11.5	122% ▲	214	19% ▲	0.054	**87%** ▲
Fermi National Accelerator Laboratory	11.2	-40% ▼	169	-30% ▼	0.066	-14% ▼
Lawrence Berkeley National Laboratory	1.1	75% ▲	16	14% ▲	0.067	53% ▲
New Brunswick Laboratory						
Oak Ridge Institute for Science and Education	0.1	-51% ▼	56	-10% ▼	0.002	-45% ▼
Oak Ridge National Laboratory	**35.9**	31% ▲	**462**	15% ▲	0.078	14% ▲
Pacific Northwest National Laboratory	27.5	79% ▲	280	16% ▲	0.098	55% ▲
Princeton Plasma Physics Laboratory	0.7	-16% ▼	79	-22% ▼	0.008	8% ▲
Service Center Personnel	0.0	-92% ▼	1	-80% ▼	0.034	-58% ▼
SLAC National Accelerator Laboratory	0.1	-69% ▼	4	-33% ▼	0.013	-53% ▼
Thomas Jefferson National Accelerator Facility	3.1	**351%** ▲	67	**148%** ▲	0.046	82% ▲
SC Totals*	**122.9**	**40% ▲**	**1,553**	**7% ▲**	**0.079**	**31% ▲**

Note: Bold and boxed values indicate the greatest value in each column. The percentage change from the previous year is not shown because it is not meaningful when the site collective dose is less than 1 person-rem (10 person-mSv). Please see section 3.4.3.1 for more information.

* The collective TED 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.

The primary sites contributing to the collective TED at EM are SRS, Hanford, and INL. For NNSA, the primary contributors are LLNL and Y-12. For the Office of Nuclear Energy, the primary contributor is INL. ORNL is the main contributor under the Office of Science.

A more detailed breakdown of the exposure information by site, program office, and contractor is available at http://www.hss.doe.gov/SESA/Analysis/rems/ in the Appendices section of the Annual Report.

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 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 doses received by these individuals. *Exhibit 3-17* shows the dose distribution and total number of transient individuals from 2006 to 2010. Over the past 5 years, the records of transient individuals have averaged 3% of the total records for all monitored individuals at DOE. These individuals received, on an average, 4% of the collective dose. The collective dose for transients increased by 21% from 31.1 person-rems (311 person-mSv) in 2009 to 37.7 person-rems (377 person-mSv) in 2010. The average measurable TED increased 23% from 0.052 rem (0.52 mSv) in 2009 to 0.064 rem (0.64 mSv) in 2010. These increases are consistent with the overall increases observed across the DOE complex from 2009 to 2010 and represent an increase in work performed involving radiation exposure. Since 1993, the percentages have remained relatively constant, even though DOE has become extensively involved in D&D activities and other types of operations.

The tracking and analysis of transient workers is an important aspect of the HSS REMS project. While each site is responsible for monitoring individuals during their work at that site, the REMS project collects dose records from all sites and verifies that individuals do not exceed regulatory limits by accruing dose at multiple facilities. Although the number of transient individuals and average dose has been relatively low, the examination of these records remains an important function of HSS in ensuring worker health and safety.

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 5 years as presented in this report. For this reason, *Exhibits 3-18* and *3-19* are presented to show a summary

Exhibit 3-17:
Dose Distribution of Transient Workers, 2006–2010.

	Dose Ranges (TED in rem)	2006	2007	2008	2009	2010
Transients	Less than measurable	1,888	2,182	2,085	2,052	2,328
	measurable <0.1	412	388	430	522	486
	0.10–0.25	24	51	43	51	74
	0.25–0.5	9	8	9	20	23
	0.5–0.75	4				5
	0.75–1.0	3			3	2
	1.0–2.0	2		1		
	Total number of individuals monitored*	2,342	2,629	2,568	2,648	2,918
	Number with measurable dose	454	447	483	596	590
	% with measurable dose	19%	17%	19%	23%	20%
	Collective TED (person-rem)	25.532	22.111	21.410	31.112	37.722
	Average measurable TED (rem)	0.056	0.049	0.044	0.052	0.064
All DOE	Total number of records for monitored individuals	91,280	86,651	83,208	86,371	91,229
	Number with measurable dose	12,953	11,102	11,287	11,721	13,004
	% of total monitored who are transient	2.6%	3.0%	3.1%	3.1%	3.2%
	% of the number with measurable dose who are transient	3.5%	4.0%	4.3%	5.1%	4.5%

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

Exhibit 3-18:
Collective Dose and Average Measurable Dose, 1974–2010.

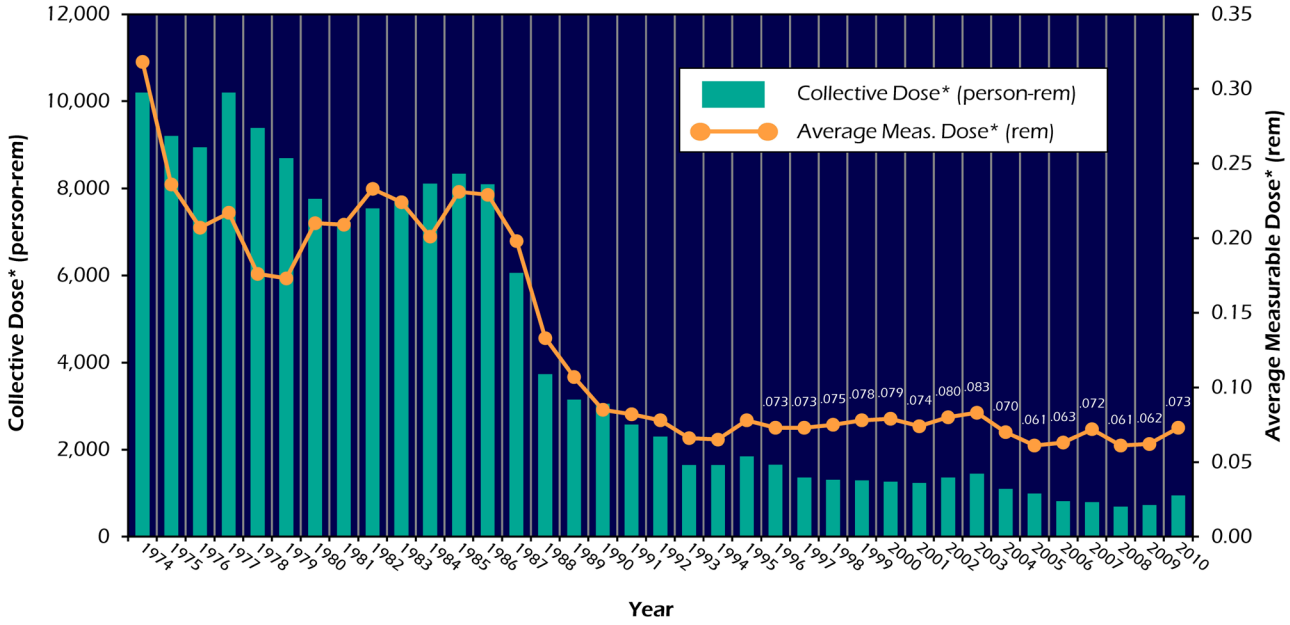
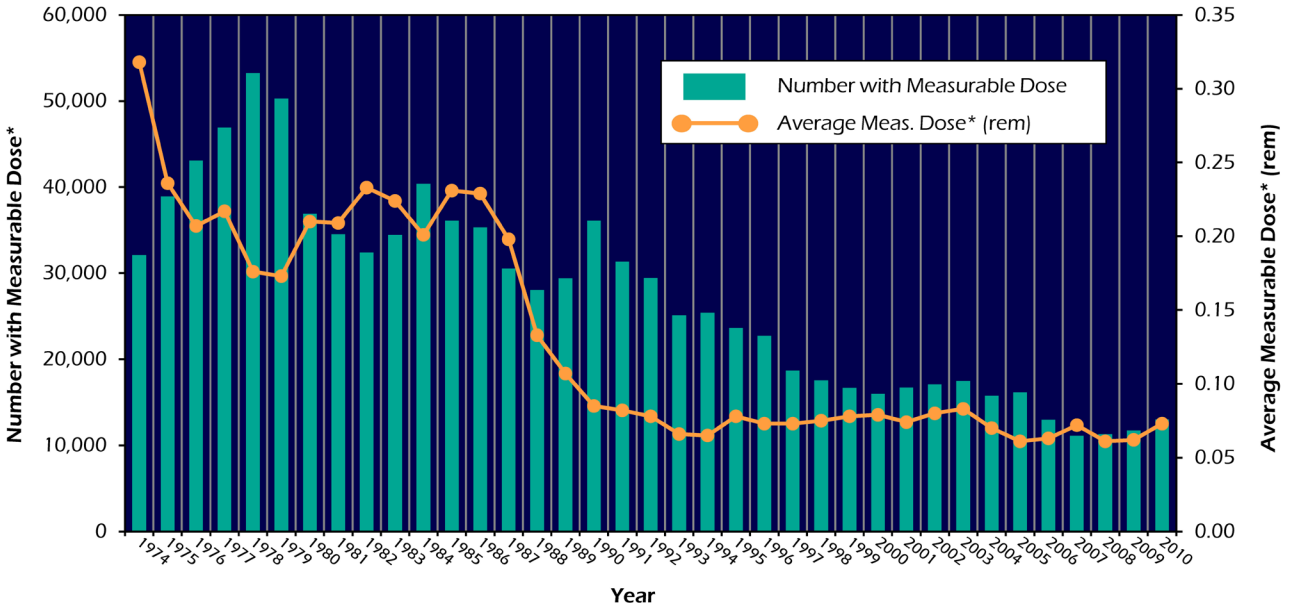


Exhibit 3-19:
Number of Workers with Measurable Dose and Average Measurable Dose, 1974–2010.



* 1974–1989 collective dose = DDE
1990–1992 collective dose = DDE + AEDE
1993–2010 collective dose = DDE + CEDE
2010 collective dose = ED + CED

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

of occupational exposures back to 1974, when the Atomic Energy Commission (AEC) split into the U.S. Nuclear Regulatory Commission (NRC) and the Energy Research and Development Administration (ERDA), which subsequently became DOE. *Exhibits 3-18* and *3-19* show the collective dose, average measurable dose, and number of workers with a measurable dose from 1974 to 2010. 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 historical data that had been collected to date. Sites were requested by DOE to voluntarily provide historical exposure data, and many sites have subsequently responded. No additional sites have reported historical data during the year 2010.

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 request to voluntarily report historical data (records prior to 1987) that are available in electronic form or 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;
- Idaho National Laboratory;
- Kansas City Plant;
- Lawrence Berkeley National Laboratory;
- Lawrence Livermore National Laboratory;
- Nevada National Security Site;
- Oak Ridge K-25 Site;
- Pantex Plant;
- Portsmouth Gaseous Diffusion Plant;
- Rocky Flats Environmental Technology Site;
- Sandia National Laboratories; and
- Savannah River Site.

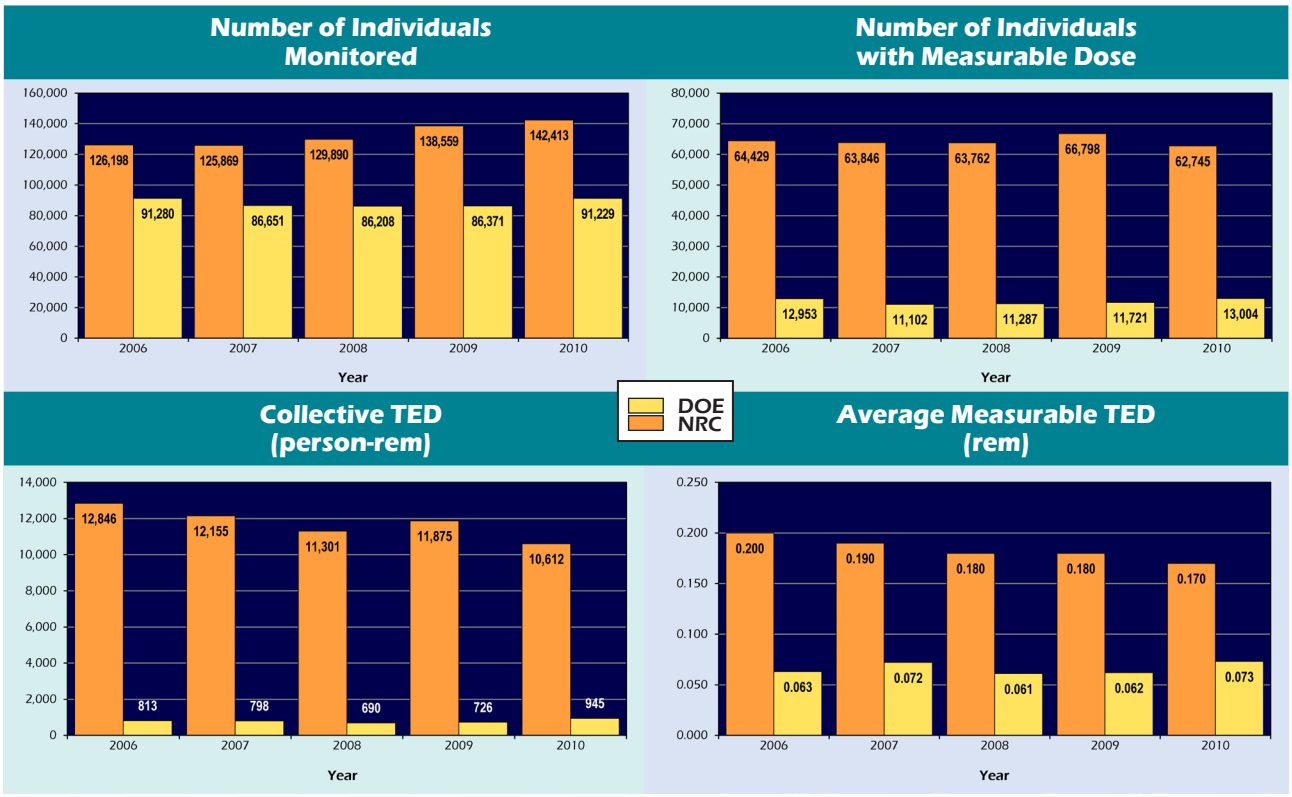
3.7 DOE Occupational Dose in Relation to Other Activities

3.7.1 Activities Regulated by the U.S. Nuclear Regulatory Commission

In the *DOE Occupational Radiation Exposure Report 1992-1994*, DOE occupational radiation exposure was shown in relation to other industrial and governmental endeavors in order to gain an understanding of the relative scale of the radiation exposure at DOE operations to other activities. The 2010 report includes the DOE occupational exposure in relation to activities regulated by the NRC. It should be noted that the purpose of this information is simply to put the DOE radiation exposure in context with other endeavors that involve radiation exposure. A direct comparison is not appropriate due to the differences in the missions of DOE and NRC. While the mission of DOE is broad in scope and includes activities from energy research to national defense, NRC licensed activities are dominated by radiation exposure received at commercial nuclear power plants. Reactor operations account for approximately 91% of the collective dose, while industrial radiographers, manufacturers, and distributors of radiopharmaceuticals, independent spent fuel storage installations, and fuel cycle licensees comprise the remainder.

The DOE and NRC occupational exposure data shown in *Exhibit 3-20* cover the past 5 years (2006 to 2010). While the number of workers monitored at NRC and DOE are relatively comparable over the past 5 years, the number of individuals with a measurable dose at DOE was 21% of the NRC total for this time period. The percentages of DOE's collective dose (TED) and average measurable dose (TED) were 9% and 43% of the NRC totals, respectively.

Exhibit 3-20:
Comparison of Occupational Exposure for DOE and NRC, 2006 –2010 .



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Section Four
ALARA Activities at DOE

4

Descriptions of ALARA activities at DOE are provided on the HSS web site for the purposes of sharing strategies and techniques that have shown promise in the reduction of radiation exposure and 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 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); and
- Point of contact for follow-up by interested professionals.

The REMS web page for submitting ALARA project descriptions can be accessed on the Internet at:

http://www.hss.doe.gov/SESA/Analysis/rems/rems/ALARA.cfm

4.2 Operating Experience Program

DOE has a mature operating experience program, which has been enhanced from the lessons learned program that was initially developed in 1994. The current DOE operating experience program is described in DOE O 210.2A, *DOE Corporate Operating Experience Program* [12]. The objective is to institute a DOE-wide program for the management of operating experience to prevent adverse operating incidents and to expand the sharing of good work practices among DOE sites. The purpose is to provide a systematic review, identification, collection, screening, evaluation, and dissemination of operating experience from U.S. and foreign government agencies and industry, professional societies, trade associations, national academies, universities, and DOE and its contractors. The Headquarters corporate responsibility for identifying, analyzing, and sharing operating experience information, combined with the operating experience/lessons learned provided by DOE field sites, optimizes the knowledge gained and shared with others through various products, including a corporate database.

DOE posts operating experience information and links to other operating experience resources on the Internet. DOE uses the Internet to openly disseminate such information so that not only DOE but also other external entities will have a source of information to improve the health and safety aspects of operations within their facilities, including reducing the number of accidents and injuries.

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

http://www.hss.doe.gov/SESA/Analysis/II/

1000 Independence Avenue, SW

Washington, D.C. 20585-1290

E-mail: nimi.rao@hq.doe.gov

Section Five
Conclusions

5

Conclusions

The occupational radiation exposure records show that in 2010, DOE facilities continued to comply with DOE dose limits and ACLs and worked to minimize exposure to individuals. Only 14% of the monitored workers received a measurable dose and the average measurable dose was less than 2% of the DOE limit. In 2010, the collective dose and the number of individuals with measurable dose increased by 30% and 11%, respectively. These increases in the dose and number of individuals were the result of increased activities involving radioactive materials, particularly at the DOE sites that comprise the majority of DOE collective dose. See *Exhibit 5-1* below for summary data.

Over the past 10 years, the collective dose and the size of the monitored workforce have remained at fairly stable levels. For the past 3 years, there has been an increase in collective dose and the number of individuals with measurable dose as activities have increased in decommissioning and waste processing at several of the larger DOE sites.

The collective dose at DOE facilities has experienced a dramatic (89%) 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 consolidation and remediation of facilities across the complex to meet the new mission. It is notable, that as DOE has become more involved in the new mission, collective and average doses have been relatively low. Also during this time period, regulations have improved with an increased focus on ALARA practices and risk reduction.

Exhibit 5-1:
2010 Radiation Exposure Summary.

- In 2010, one individual was reported to have received a TED in excess of 5 rems (50 mSv). The final dose was determined to be 31.589 rems CED from an intake of plutonium at SRS. The individual also exceeded the 50 rems CEqD limit for an organ or tissue.
- The collective TED increased 30% from 726 person-rems (7.26 person-Sv) in 2009 to 945 person-rems (9.45 person-Sv) in 2010.
- Sites contributing significantly to collective dose were (in descending order of collective dose) Savannah River, Hanford, Oak Ridge, Idaho, and Los Alamos. These sites accounted for 79% of the collective dose at DOE in 2010.
- At these sites, the increase in collective TED was attributed to: increased D&D activities at PFP and increased retrieval and processing TRU waste at Hanford, waste processing including higher dose waste drums and decommissioning at Savannah River Site, isotope processing and cleanup and waste disposal at Oak Ridge, increased decommissioning and decontamination at Idaho, increased manufacturing and related weapons work, processing and shipping solid waste, and maintenance activities at LANL.
- Sites attributed much of the increase in collective dose to increases in funding for cleanup and environmental efforts under the American Recovery and Reinvestment Act (ARRA) of 2009.
- The collective internal dose (CED) increased by 86% between 2009 and 2010.
- Uranium-234 accounted for the largest percentage of the collective CED, with over 99% of this dose accrued at Y-12.
- The collective dose for transient workers increased by 21% from 31.1 person-rems (311 person-mSv) in 2009 to 37.7 person-rems (377 person-mSv) in 2010, but did not exceed the highest value within the past 5 years.
- The total number of bioassay measurements decreased by 12% from 81,532 in 2009 to 71,924 in 2010.

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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 multi-tiered, 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.

ARRA
The American Recovery and Reinvestment Act of 2009 is an economic stimulus package signed into law on February 27, 2009.

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 TED, ED, neutron dose, extremity dose, and other types of dose.

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

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

committed equivalent dose (CEqD) (H_T,50)
The equivalent dose 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. CEqD is expressed in units of rem.

CR
See SR.

effective dose (*ED*)
The summation of the products of the equivalent dose received by specified tissues or organs of the body (H_T) and the appropriate tissue weighting factor (w_T)—that is, $E = \Sigma w_T H_T$. It includes the dose from radiation sources internal and/or external to the body.

Equivalent dose (EqD)
The product of average absorbed dose ($D_{T,R}$) in rad (or gray) in a tissue or organ (T) and a radiation (R) weighting factor (w_R). For external dose, the: equivalent dose to the whole body is assessed at a depth of 1 cm in tissue; the equivalent dose to the lens of the eye is assessed at a depth of 0.3 cm in tissue, and the equivalent dose to the extremity and skin is assessed at a depth of 0.007 cm in tissue. The mathematical term is H_T, while the abbreviation EqD is used in this report and in the REMS reporting requirements for this data element. Equivalent dose is expressed in units of rem (or Sv).

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

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.

Hanford
This term is used to describe the entire reservation and all activities at this geographic location. It includes all cleanup activities at the reactors at the "Hanford Site," Office of River Protection, and Pacific Northwest National Laboratory. This term is used when we are including Hanford Site, Office of River Protection, and Pacific Northwest National Laboratory.

Hanford Site
All activities at, and clean up of, the reactors and 100 – 400 areas at the reservation. Does not include Office of River Protection and Pacific Northwest National Laboratory.

Office of River Protection
Tank farm and liquid waste cleanup to protect the Columbia River.

Pacific Northwest National Laboratory
The national laboratory involved in a broad range of scientific research.

members of the public
Individuals who are not occupationally exposed to radiation or radioactive material.

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.

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 rems (15 mSv) to the total annual collective dose.

total effective dose (TED)
The sum of the effective dose (ED) from external sources and the committed effective dose (CED) from intakes of radionuclides during the monitoring period.The internal dose component of TED changed from the annual effective dose equivalent (AEDE) to the CEDE in 1993 and from CEDE to CED in 2007.

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.

total organ dose (TOD)
The sum of the effective dose to the whole body for external exposures and the committed equivalent dose to the maximally exposed organ or tissue other than the skin or the lens of the eye.

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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References

References

1. EPA (U.S. Environmental Protection Agency), 1987. "Radiation Protection Guidance to Federal Agencies for Occupational Exposure," *Federal Register* 52, No. 17, 2822; with corrections published in the *Federal Registers* of Friday, January 30, and Wednesday, February 4, 1987.

2. ICRP (International Commission on Radiological Protection), 1977. "Recommendations of the International Commission on Radiological Protection," ICRP Publication 26, Annals of the ICRP, Vol. 1, No. 3 (Pergamon Press, New York).

3. NCRP (National Council on Radiation Protection and Measurements), 1987. "Recommendations on Limits for Exposure to Ionizing Radiation," NCRP 91; superseded by NCRP Report No. 116.

4. ICRP (International Commission on Radiological Protection), 1991. "1990 Recommendations of the International Commission on Radiological Protection," ICRP Publication 60, Annals of the ICRP, Vol. 21, Nos. 1-3 (Pergamon Press, New York).

5. ICRP (International Commission on Radiological Protection), 1994. "Dose Coefficients for Intakes of Radionuclides by Workers," ICRP Publication 68, Annals of the ICRP, Vol. 24, No. 4 (Pergamon Press, New York).

6. 10 C.F.R. 835, 1998, "Occupational Radiation Protection." Amended June 8, 2007. Rule; DOE *Federal Register*, November 4, 1998. Amended June 8, 2007.

7. DOE O 231.1A, 2003, "Environment, Safety and Health Reporting," August 19, 2003.

8. DOE M 231.1-1A, 2004, "Environment, Safety and Health Reporting Manual," March 19, 2004.

9. Computerized Accident and Incident Reporting System (CAIRS), "DOE and Contractor Injury and Illness Data by Year by Quarter" report. Online at http://www.hss.doe.gov/sesa/analysis/cairs/cairs/home.htm.

10. United Nations, *2000, 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*, General Assembly of Official Records, United Nations, New York, 2000.

11. DOE Standard, DOE-STD-1098-99, *"Radiological Control,"* July 1999

12. DOE O 210.2A, "DOE Corporate Operating Experience Program," April 8, 2011

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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 2010 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:

Ms. Nirmala Rao
DOE Office of Analysis (HS-24)
Office of Health, Safety and Security
19901 Germantown Road
Germantown, MD 20874
nimi.rao@hq.doe.gov
Fax: (301) 903-1257

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

1. Identification:

   Name: .....

   Title: .....

   Mailing Address: .....

   .....

   .....

   .....

2. Distribution:

   2.1 Do you wish to remain on the distribution for the report? _____ yes _____ no

   2.2 Do you wish to be added to the distribution? _____ yes _____ no

(continued on back)

Please circle one.

	Not Useful				Very Useful
Please rate the usefulness of this report overall:	1	2	3	4	5

Please rate the usefulness of the analysis presented in the following sections:

Executive Summary	1	2	3	4	5
Analysis of Aggregate Data	1	2	3	4	5
Collective Dose	1	2	3	4	5
Average Measurable Dose	1	2	3	4	5
Dose Distribution	1	2	3	4	5
Analysis of Individual Dose Data	1	2	3	4	5
Doses above 2 rems ACL	1	2	3	4	5
Doses in Excess of 5 rems	1	2	3	4	5
Internal Depositions of Radioactive Material	1	2	3	4	5
Analysis of Site Data	1	2	3	4	5
Collective Dose by Site	1	2	3	4	5
Description of Activities Related to Dose	1	2	3	4	5
Historical Data	1	2	3	4	5
ALARA Activities at DOE	1	2	3	4	5
Conclusions	1	2	3	4	5

Please rate the importance of the timeliness of the publication of this report as it relates to your professional need for the information on occupational radiation exposure at DOE:

	Not important				Critical
	1	2	3	4	5

Please provide any additional input or comments on the report.

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