Office of Health, Safety and Security

DOE 2009 Occupational Radiation Exposure

September 2010

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

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Department of Energy
REMS Program Web Site at:
http://www.hss.energy.gov/csa/analysis/rems/

Foreword

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

A key safety focus for DOE is to maintain radiation exposures of its workers below administrative control levels (ACL) and DOE limits and to further reduce these exposures to levels that are "as low as reasonably achievable (ALARA)." The annual DOE 2009 Occupational Radiation Exposure Report provides an evaluation of DOE-wide performance regarding compliance with 10 C.F.R. Part 835 dose limits and ALARA process requirements and an overview of the status of radiation exposures of the DOE workforce. In addition, this report is primarily 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.

Overall, the performance indicators examined in this report show that the 2009 values are below the five-year averages for individual, average, and collective doses, as well as the number of individuals monitored and the number of individuals with measurable dose. While the 2009 values increased slightly over the 2008 values, both years were below the 2007 values. In 2009, no individual received a dose in excess of any of the DOE annual dose limits or the DOE administrative control level of 2 rems (20 mSv). This reflects the continued emphasis on ALARA practices even as the DOE mission at many sites has shifted from production operations to stabilization and cleanup efforts. The REMS project 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
Chief Health, Safety and Security Officer
Office of Health, Safety and Security

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LIST OF EXHIBITS

LIST OF ACRONYMS

ACL	Administrative Control Level
AEC	Atomic Energy Commission
ALARA	As Low As Reasonably Achievable
ARRA	American Recovery and Reinvestment Act
BJC	Bechtel Jacobs Company LLC
CDE	Committed Dose Equivalent
CEDE	Committed Effective Dose Equivalent
D&D	Decontamination and Decommissioning
DDE	Deep Dose Equivalent
DOE	U.S. Department of Energy
EM	Office of Environmental Management
EPA	U.S. Environmental Protection Agency
ETTP	East Tennessee Technology Park
HSS	Office of Health, Safety and Security
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
LDE	Lens (of the Eye) Dose Equivalent
LLNL	Lawrence Livermore National Laboratory
mSv	Millisievert
NE	Office of Nuclear Energy, Science and Technology
NNSA	National Nuclear Security Administration
NRC	U. S. Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
PFP	Plutonium Finishing Plant
RCS	Radiological Control Standard
REMS	Radiation Exposure Monitoring System
SDE-ME	Shallow Dose Equivalent to the Maximally Exposed Extremity
SDE-WB	Shallow Dose Equivalent to the skin of the Whole Body
SNL	Sandia National Laboratories
SRS	Savannah River Site
Sv	Sieverts
TEDE	Total Effective Dose Equivalent
TODE	Total Organ Dose Equivalent
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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Executive Summary

Executive Summary

The U.S. Department of Energy (DOE) Office of Corporate Safety Analysis (HS-30) within the Office of Health, Safety and Security (HSS) publishes the annual DOE Occupational Radiation Exposure Report to provide an overview of the status of radiation protection practices at DOE.* The DOE 2009 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.

One of the report's features includes the collective total effective dose equivalent (TEDE)–an indicator of the overall amount of radiation dose received during the conduct of operations at DOE. Over the past 10 year period, 99.99% of the individuals receiving measurable dose have received doses below the 2 rems (20 millisievert [mSv]) TEDE administrative control level (ACL), which is well below the DOE regulatory limit of 5 rems (50 mSv) TEDE. The DOE collective TEDE increased by 5% from 2008 to 2009, as shown in *Exhibit ES-1*. This is the first year that the collective TEDE has increased since 2003. At two of the largest DOE facilities, the increase in collective TEDE in 2009 was due to accelerated clean-up at Hanford made possible by the American Recovery and Reinvestment Act (ARRA), increased work at Los Alamos Neutron Science Center (LANSCE) TA-55 Plutonium Processing Facility at Los Alamos National Laboratory (LANL), maintenance and Decontamination and Decommissioning (D&D) work at TA-53 LANSCE Station, and workers performing retrieval, repackaging, and shipping of radioactive solid waste at LANL waste facilities. West Valley Demonstration Project and Pantex Plant also experienced increases in the collective dose due to increased D&D activities at West Valley Demonstration Project and increases in production work assigned by National Nuclear Security Administration (NNSA) at Pantex Plant.

It should be noted that while 10 C.F.R. 835 was revised as of June 2007, full implementation was not required until July of 2010. Some sites were still in the process of transition and therefore this report continues to use the dose terminology used prior to the June 2007 amendment to 10 C.F.R. 835, such as TEDE. The 2010 report will reflect the changes in dose terminology required by the revision to 10 C.F.R. 835.

Exhibit ES-1:
Collective TEDE (person-rem), 2005–2009.

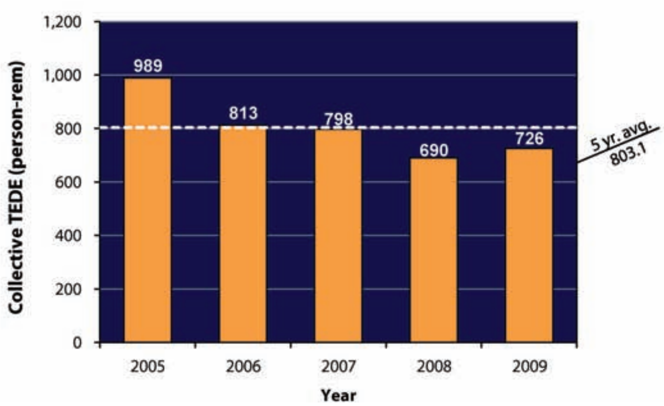
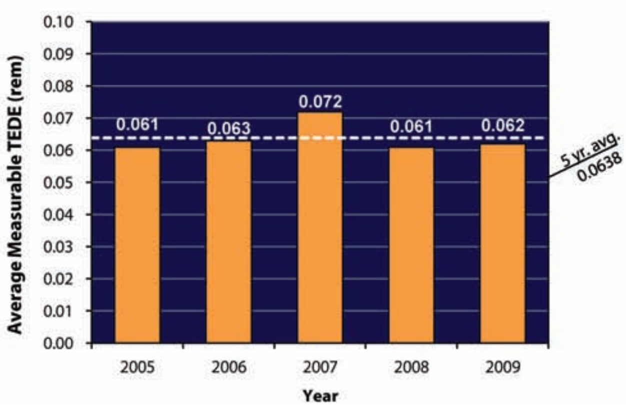


Exhibit ES-2:
Average Measurable TEDE (rem), 2005–2009.



* 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 LANL and Oak Ridge National Laboratory (ORNL). Overall from 2008 to 2009, there was nearly a 4% increase in the number of workers with measurable dose.

The TEDE is comprised of the external deep dose equivalent (DDE), which includes neutron and photon radiation, and the internal committed effective dose equivalent (CEDE), which results from the intake of radioactive material into the body. The photon and neutron dose both increased by 7% from 2008 to 2009, and internal dose components of the collective TEDE decreased by 13%.

Another primary indicator of the level of radiation exposure covered in this report is the average measurable dose, which normalizes the collective dose over the population of workers who actually received a measurable dose. The average measurable TEDE increased by 2% from 2008 to 2009, as shown in *Exhibit ES-2*. The collective dose and the average measurable dose both increased, as well as the number of individuals who received a measurable dose.

Additional analyses show that the dose distribution in 2009 was similar to the distribution in 2008 with the exception that no individual exceeded the 2 rems (20 mSv) DOE administrative control level limit. Almost all of the increase in monitored individuals occurred in the number of individuals with no measurable dose and the number of individuals receiving less than 0.1 rem (1 mSv).

In conclusion, the assessment of occupational radiation exposure for 2009 shows an increase in collective dose (5%), the number of individuals with a measurable dose (4%), and the average measurable dose (2%). While the collective dose and the number of individuals with measurable dose increased, these values remain consistent with the observed values for the past 5 years. In 2009, all DOE operations complied with 10 C.F.R. Part 835 dose limits and the DOE-wide dose constraints. Only 9% of the DOE workforce received measurable dose and the average measurable dose (0.062 rem) was slightly over 1% of the DOE annual limit of 5 rems TEDE to an individual.

As DOE continues consolidation and remediation efforts, it is anticipated that the long-term decreasing trend over the last 5 years in collective dose and the number of individuals with measurable dose will continue. At some sites where remediation activities are increased or accelerated, a temporary increase in dose may be observed, but should decrease once the effects of the remediation result in lower dose rates and fewer opportunities for exposure. The average measurable dose may fluctuate within 10% of the 5-year average as fewer individuals receive dose but should remain low as radiation protection practices and ALARA principles continue to reduce dose to individuals.

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

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

Section One

Introduction

1

Introduction

The *DOE 2009 Occupational Radiation Exposure Report* analyzes occupational radiation exposures at the U.S. Department of Energy (DOE) facilities during 2009. 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 100 DOE organizations submitting radiation exposure reports for 2009 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

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 at **http://www.hss.energy.gov/csa/analysis/rems/** 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
- As low as reasonably achievable (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 2009 occupational radiation dose data trended over the past 5 years.
Section Four	Includes instructions to submit successful ALARA projects within the DOE complex.
Section Five	Conclusions.
Appendices	The appendices are now offered in color on the DOE Radiation Exposure web site. Please visit **http://www.hss.energy.gov/csa/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 are 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 2009. 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 in 2009 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) [2] and the 1987 recommendations of the National Council on Radiation Protection and Measurements (NCRP) [3]. This guidance recommends that internal organ dose be added to the external whole-body dose to determine the TEDE. Prior to this guidance, the whole-body dose and internal organ dose were each limited separately.

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

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

Title	Date	Description
10 C.F.R. 835, "Occupational Radiation Protection." [4]	Issued 12/14/93. Amended 11/4/98. Amended 6/8/07.	Establishes radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation that results from the conduct of DOE activities.
DOE Order 231.1A, "Environment, Safety and Health Reporting." [5]	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." [6]	Approved 3/19/04.	Specifies the current format and content of the reports required by DOE Order 231.1A.

2.2 Radiation Dose Limits

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

2.3 Reporting Requirements

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

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)
- Adopted other changes intended to enhance radiation protection

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

*Limit applies to the embryo/fetus.

The rule became effective on July 9, 2007, and is required to be fully implemented by DOE sites by July 9, 2010. Therefore, the revisions were not applicable to all sites during this reporting period, although some began complying with the new requirements during 2009.

Several aspects of the amendment impact the recordkeeping and reporting of DOE occupational radiation exposure. A revision of the reporting requirements will be issued in order to conform to the amended rule. Changes that will affect the manual and the reporting of radiation exposure records include:

- A change in dosimetric terms
- A change in weighting factors to tissue weighting factors and a redefinition of the tissue weighting factor remainder
- A change in quality factors to radiation weighting factors; most significantly this affects neutron dose assessment
- A change eliminating the requirement for recording of internal dose for any monitoring result estimated to correspond to an individual receiving less than 0.01 rem (0.1 millisievert [mSv]) committed effective dose
- Addition of specific organ dose reporting for the colon, liver, stomach, esophagus, bladder, and skin

In anticipation of the revision to the reporting requirements, an optional format for reporting under the amendment to 835 has been developed and is available on the REMS web site. The optional format is an acceptable method of reporting radiation exposure records until the manual is officially revised.

DOE Manual 231-1A will be replaced and the reporting requirements will be issued in a new DOE Order. The specifications for reporting occupational exposure (currently in Appendix G of DOE Manual 231.1-1A) will be relocated to a user guide on the REMS web site. The expected completion date is April 2011.

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Section Three

Occupational Radiation Dose at DOE

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
- dose distribution

Analysis of individual dose data includes an examination of

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

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

3.2 Analysis of Aggregate Data

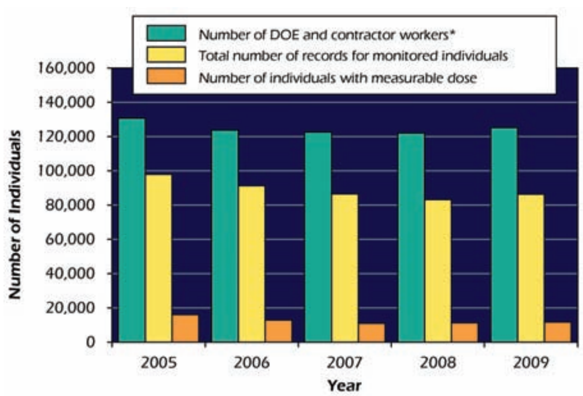
3.2.1 Number of Records for Monitored Individuals

The number of records for monitored individuals represents the size of the DOE worker population monitored for radiation dose. The number represents the sum of all records for monitored individuals, including all DOE employees, contractors, and subcontractors, as well as members of the public. The number of monitored individuals is the number of monitoring records submitted by each site. Because individuals may have more than one monitoring record, they may be counted more than once. Although an individual may be counted more than once, the overall effect on the numbers and analysis is minimal. The number of records for monitored individuals is an indication of the size of a dosimetry program, but it is not necessarily an 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. 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 TEDE.

Exhibit 3-1a:
Monitoring of the DOE Workforce, 2005–2009.



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

For 2009, 69% of the DOE workforce was monitored for radiation dose, and 14% of monitored individuals received a measurable dose.

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

Exhibits 3-1a and *3-1b* show the number of DOE and contractor workers, the total number of workers monitored for radiation dose, the number of individuals with 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 2% of the 5-year average.

Eleven of the 32 reporting sites experienced decreases in the number of workers with a measurable dose from 2008 to 2009. The largest decrease in total number of workers with a measurable dose occurred at the Idaho National Laboratory (INL) (and associated cleanup projects). The largest increase in the number of workers receiving a measurable dose occurred at LANL. 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 TEDE increased at DOE by 5% from 690 person-rems (6.90 person-Sv) in 2008 to 726 person-rems (7.26 person-Sv) in 2009.

The internal dose is based on the 50-year committed effective dose equivalent (CEDE) methodology, which assigns the projected dose delivered to the individual over the next 50 years following the intake. The internal dose component of the collective TEDE decreased by 13% from 58.0 person-rems (580 person-mSv) in 2008 to 50.6 person-rems (506 person-mSv) in 2009. The collective photon dose increased by 7% from 511 person-rems (5.11 person-Sv) in 2008 to 547 person-rems (5.47 person-Sv) in 2009.

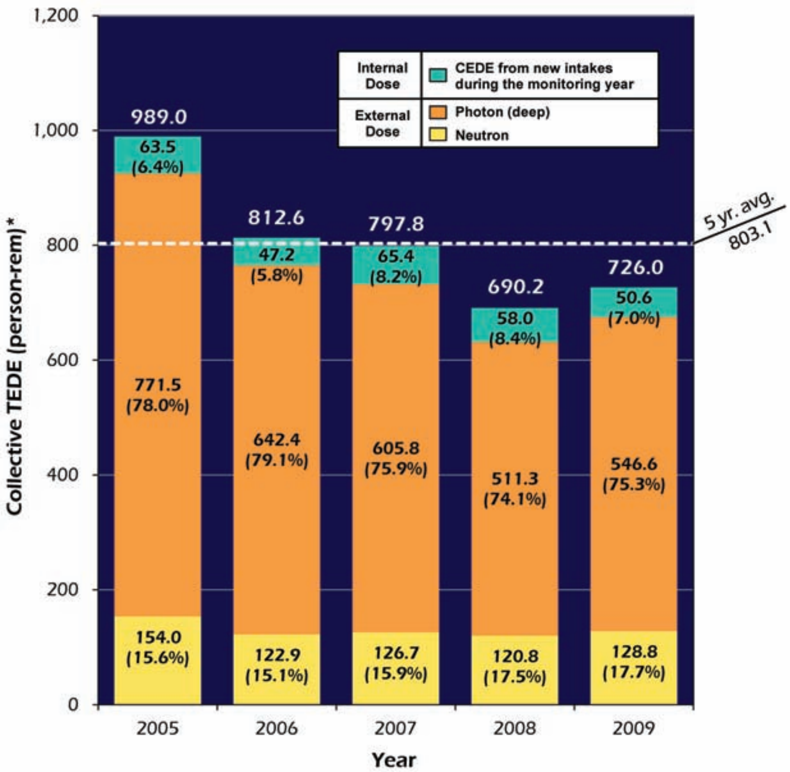
The neutron component of the TEDE increased by 7% from 121 person-rems (1.21 person-Sv) in 2008 to 129 person-rems (1.29 person-Sv) in 2009. This is due primarily to the 28% increase in neutron dose at LANL. LANL attributes the increase to a change in the calculation of neutron dose as a result of the implementation of the Amendment to 10 C.F.R. 835, specifically the change in radiation weighting factors for neutrons.

Exhibit 3-1b:
Monitoring of the DOE Workforce, 2005–2009.

Year	DOE & Contractor Workforce	Number of Workers Monitored	Percent of Workers Monitored*	Number Monitored w/Measurable Dose	Percent Monitored w/Measurable Dose*
2005	130,795	98,040	75%▲	16,136	16%▼
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%▲	11,720	14%
5-Year Average	**124,927**	**89,110**	**71%**	**12,640**	**14%**

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

Exhibit 3-2:
Components of TEDE, 2005–2009.



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

The collective TEDE increased by 5% at DOE from 2008 to 2009.

The collective internal dose decreased by 13% from 2008 to 2009.

Neutron dose increased by 7% from 2008 to 2009.

Photon dose increased by 7% from 2008 to 2009.

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

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

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

Forty percent of the DOE sites (13 of 32 sites) reported decreases in the collective TEDE from the 2008 values. The five sites that contributed to the majority of the DOE collective TEDE in 2009 were (in descending order of collective dose for 2009) Hanford (18%), Los Alamos National Laboratory (16%), Idaho National Laboratory (15%), Oak Ridge (15%) and Savannah River Site (SRS) (15%). Two of these five sites reported increases in the collective TEDE, while the other three sites reported decreases.

Hanford

The largest contributors to the collective TEDE at Hanford were Decontamination and Demolition of 100-K Area facilities including the KE reactor basins (24%), Waste and Fuels Project (retrieval, processing, and shipment of Transuranic [TRU] waste) (18%), Tank Farm activities (17%), Pacific Northwest National Laboratories activities (12%), Plutonium Finishing Plant (PFP) D&D (11%), 300 Area D&D (including 327 Radio metallurgy Building) (8%), and 100-N Area reactor facilities D&D (5%).

The increase in collective dose at the Hanford Site was due to an increase in radiological work activity associated with accelerated clean-up made possible by the American Recovery and Reinvestment Act.

Los Alamos National Laboratory

TA-55 Plutonium Processing Facility operations account for the majority of occupational dose at LANL, which includes occupational exposure from both weapons manufacturing and Pu-238 work, work on repackaging materials, access to storage areas, and providing RCT support for radiological work and system maintenance.

In addition, significant portions of LANL whole body dose were accrued by workers performing maintenance at TA-53 LANSCE Station (the linear accelerator), subcontractors performing D&D of a major experimental facility at TA-53 LANSCE Station, and workers performing retrieval, repackaging, and shipping of radioactive solid waste at LANL waste facilities at TA-50 Radioactive Liquid Waste Treatment Facility and TA-54 Radioassay and Nondestructive Testing Station.

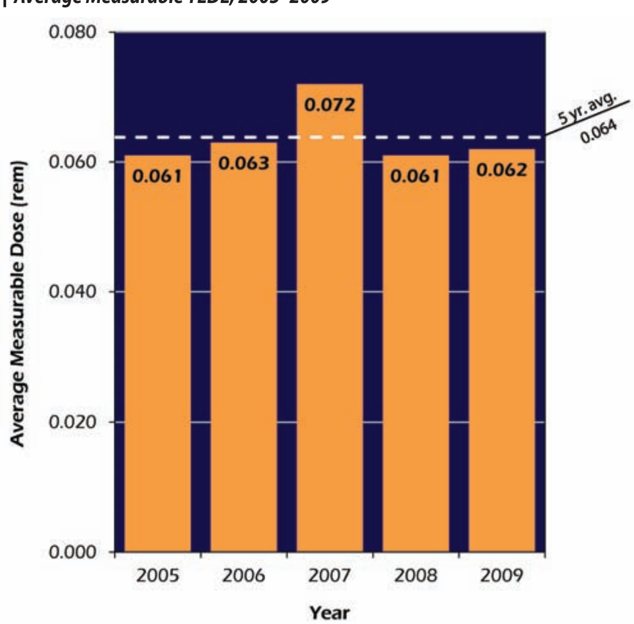
It should be noted that LANL experienced a safety-driven pause in operations for the first half of 2008 which lead to a significant decrease in the collective TEDE at LANL for 2008. Operations resumed for 2009 which resulted in the apparent increase in dose between 2008 and 2009. This operational pause at LANL is the primary reason for the apparent decrease in 2008 and increase in 2009 of the overall DOE collective dose.

Idaho National Laboratory
The decrease in collective dose at INL can be attributed to changes in retrieval and waste movement activities, receipt of offsite waste, and projects involving elevated dose rate waste drums and cargo container retrieval. The controls for these activities led to a decrease in the source term for the population. Much of this decrease was due to use of engineering controls in areas where exposure levels were anticipated to be high. There was also a reduced work scope because much of the D&D activities were complete or ahead of schedule.

Oak Ridge
The decrease in 2009 TEDE at ORNL is attributed to a decrease in waste operations tasks involving contact with and remote handling of waste containers, and transition into transportation and shipping operations.

Savannah River Site
The decrease at SRS was a combination of factors, but overall, a portion of the higher-dose-rate work was either reduced or postponed.

Exhibit 3-3:
Average Measurable TEDE, 2005–2009



3.2.4 Average Measurable Dose

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

The average measurable TEDE is shown in *Exhibit 3-3*. The average measurable TEDE increased by 2% from 0.061 rem (0.61 mSv) in 2008 to 0.062 rem (0.62 mSv) in 2009, but is below the five year average. The increase in the average measurable TEDE was due primarily to the increase in the collective TEDE, while the number of individuals with measurable dose increased only slightly. 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) [4].

Exhibit 3-4 shows that the dose distribution for 2009 was very similar to 2008 with the exception that no one exceeded 2 rems (20 mSv) in 2009. Ninety-nine percent of the individuals monitored had doses less than 0.25 rem (2.5 mSv). It also shows that the collective TEDE has decreased each year from 2005 to 2008 with a slight increase (5%) for 2009. In 2009, it can be seen that the distribution of doses above 0.5 rem (5 mSv) remained comparable with the 2008 distribution. 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* [8], recommends the calculation of a parameter "SR" (previously referred to as CR) to aid in the examination

Exhibit 3-4:
Distribution of TEDE by Dose Range, 2005–2009.

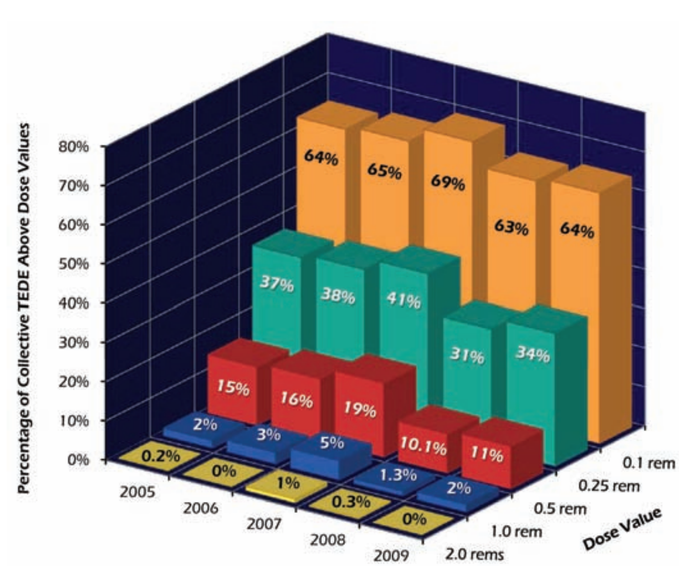
	TEDE Range (rem)	2005	2006	2007	2008	2009
Number of Individuals in Each Dose Range*	Less than measurable	81,904	78,327	75,549	71,921	74,651
	Measurable to 0.1	13,537	10,815	8,951	9,341	9,724
	0.10–0.25	1,753	1,441	1,428	1,425	1,396
	0.25–0.5	644	520	519	421	491
	0.5–0.75	141	120	147	73	71
	0.75–1.0	42	36	34	20	28
	1–2	18	21	22	6	10
	2–3	1			1	
	3–4					
	4–5					
	5–6					
	6–7					
	7–8			1		
	8–9					
	9–10					
	10–11					
	11–12					
	>12					
"Total number of records for monitored individuals"		98,040	91,280	86,651	83,208	86,371
Number with measurable dose		16,136	12,953	11,102	11,287	11,720
Number with dose >0.1 rem		2,599	2,138	2,151	1,946	1,996
"% of individuals with measurable dose"		16%	14%	13%	14%	14%
Collective TEDE (person-rems)		989.0	812.6	797.8	690.2	726.0
Average measurable TEDE (rem)		0.061	0.063	0.072	0.061	0.062

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

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

Exhibit 3-5 shows the dose distribution given by percentage of collective TEDE above each of five dose values from 0.1 rem (1 mSv) to 2 rems (20 mSv). This

Exhibit 3-5:
Percentage of Collective TEDE Above Dose Values During 2005–2009.

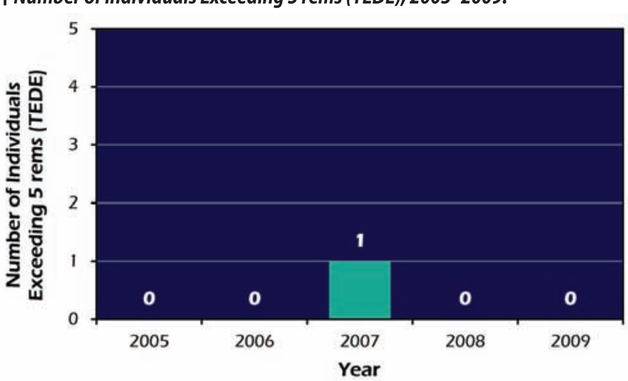


graph facilitates the examination of a property described above that may be used as an indication of effective ALARA programs at DOE: a relatively small percentage of the collective dose accrued in the higher dose ranges. *Exhibit 3-5* also shows that each successively higher dose range is responsible for a lower percentage of the collective dose. With the exception of the 2.0 rems dose value range, the percentage of the collective dose received in each dose range increased from 2008 to 2009. The 2009 values are equal to or lower than the values five years ago. The values for 2007 were elevated primarily from the one individual who received a TEDE above 5 rems (50 mSv) from an intake of plutonium at LANL. The percentage above 2 rems (20 mSv) is zero because no individual exceeded this value 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 analysis focuses on doses received by individuals that were in excess of the DOE limit (5 rems [50 mSv] TEDE) and the DOE recommended ACL (2 rems [20 mSv] TEDE).

Exhibit 3-6:
Number of Individuals Exceeding 5 rems (TEDE), 2005–2009.

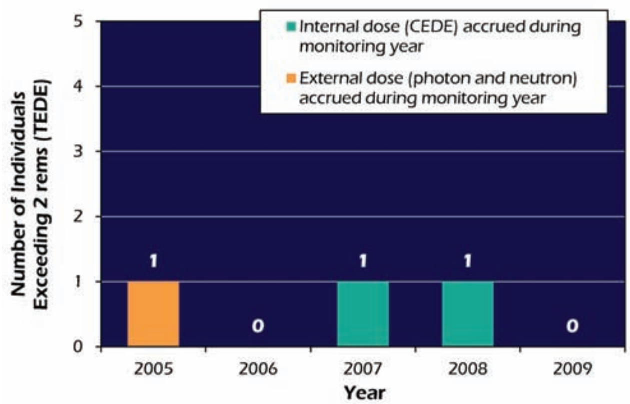


In 2009, no individual received a dose in excess of the 5 rems (50 mSv) TEDE limit out of the 86,403 individuals monitored.

3.3.1 Doses in Excess of DOE Limit

Exhibit 3-6 shows the number of doses in excess of the TEDE regulatory limit (5 rems [50 mSv]) from 2005 through 2009. There was no individual that exceeded 5 rems (50 mSv) TEDE from 2005 to 2006, but one individual received a TEDE in excess of 5 rems (50 mSv) in 2007. In 2008 and 2009, no individual received a TEDE in excess of 5 rems (50 mSv).

Exhibit 3-7:
Number of Doses in Excess of the DOE 2 rems ACL, 2005–2009.



3.3.2 Doses in Excess of Administrative Control Level

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

As shown in *Exhibit 3-7*, there was no individual who received a TEDE above 2 rems (20 mSv) during 2009.

3.3.3 Internal Depositions of Radioactive Material

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

The number of internal depositions of radioactive material (an indicator of worker intakes), collective

Exhibit 3-8:
Doses in Excess of DOE Limit, 2005–2009.

Year	TEDE (rem)	DDE (rem)	CEDE (rem)	CDE (rem)	Intake Nuclides	Facility Types	Site
2005	None reported						
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						

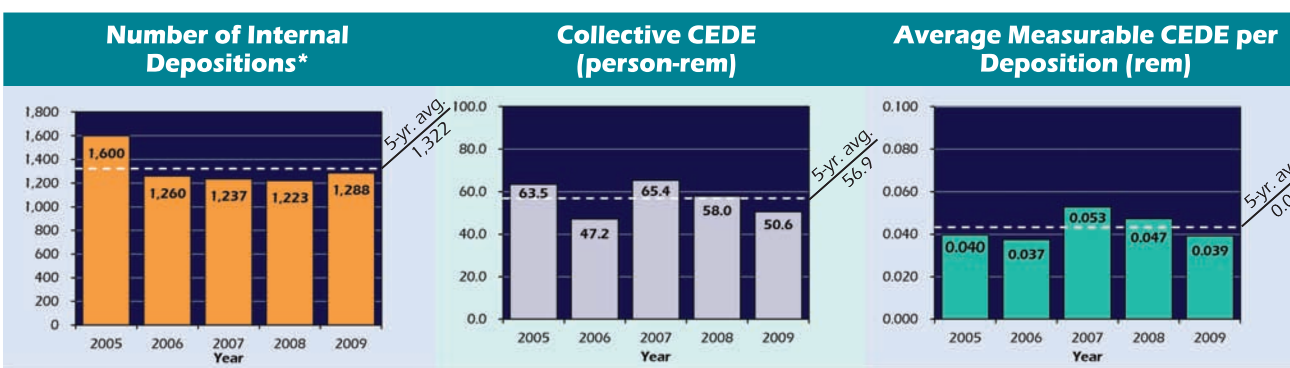
CEDE, and average measurable CEDE for 2005 to 2009 are shown in *Exhibit 3-9*. The number of internal depositions increased by 5% from 1,223 in 2008 to 1,288 in 2009, while the collective CEDE decreased by 13%. As a result, the average measurable CEDE decreased from 0.047 rem (0.47 mSv) in 2008 to 0.039 rem (0.39 mSv) in 2009.

A majority (97%) of the collective CEDE in 2009 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 fluctuations in the number of workers and collective CEDE can occur from year to year. While trend analysis is statistically limited, these values have exhibited an overall decreasing trend over the past 5 years.

Exhibit 3-10 shows the distribution of the internal dose from 2005 to 2009. 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. There was no internal dose above 5 rems (50 mSv) CEDE in 2009.

The internal dose records indicate that the majority of the intakes result in very low doses. In 2009, 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 7% of the collective TEDE, and 12% of the individuals who received internal doses were above the monitoring threshold (100 mrem [1 mSv]) specified in 10 C.F.R. 835.402(c) [4].

Exhibit 3-9:
Number of Internal Depositions, Collective CEDE, and Average Measurable CEDE, 2005–2009.



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

Exhibit 3-10:
Internal Dose Distribution from Intakes, 2005–2009.

Year	Number of Individuals with CEDE in the Ranges (rem)*											Total No. of Indiv.**	Total Collective CEDE (person-rem)
	Meas. <0.020	0.020-0.100	0.100-0.250	0.250-0.500	0.500-0.750	0.750-1.000	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	>5.0		
2005	858	562	156	22	1	1						1,600	63.5
2006	664	474	106	15	1							1,260	47.2
2007	623	436	151	22	3	1					1	1,237	65.4
2008	602	460	131	25	2	2	1					1,223	58.0
2009	701	449	117	16	4	1						1,288	50.6

* 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.

3.3.4 Bioassay and Intake Summary Information

The revised DOE Manual 231.1-1A [6] was issued on March 19, 2004. Reporting of bioassay and intake summary data under the revised DOE Manual 231.1-1A occurred for the first time in 2006. 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 3-11* 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" 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-two percent of the urinalysis measurements in 2009 were performed at three sites: LANL, Y-12, and Hanford. The majority of the bioassay measurements reported as other were from air sampling reported by Hanford.

Exhibit 3-12 shows the breakdown of the collective CEDE by radionuclide for 2009. Uranium-234 accounts for the largest percentage of the collective dose, with over 99% of this dose accrued at Y-12.

Exhibit 3-11:
Bioassay Measurements, 2007-2009.

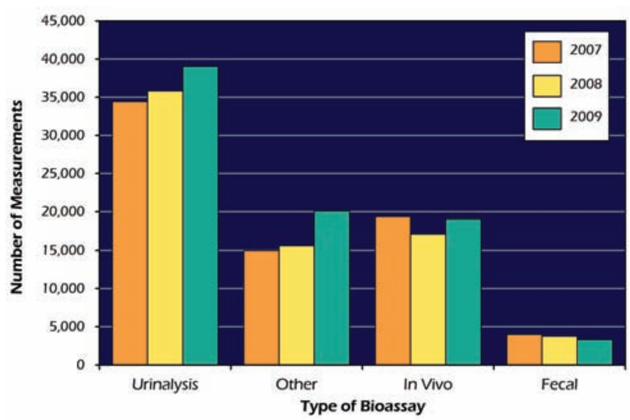
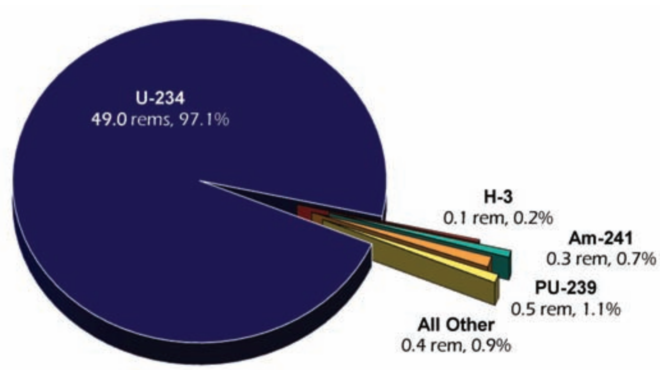


Exhibit 3-12:
Collective CEDE by Radionuclide, 2009.



3.4 Analysis of Site Data

3.4.1 Collective TEDE by Site and Other Facilities

The collective TEDE for 2007 through 2009 for the major DOE sites and operations/field offices is shown graphically in *Exhibit 3-13*. A list of the collective TEDE and number of individuals with measurable TEDE by DOE sites is shown in *Exhibit 3-14*. The collective TEDE increased by 5% from 690 person-rems (6.90 person-Sv) in 2008 to 726 person-rems (7.26 person-Sv) in 2009, with Hanford (including the Hanford Site, Pacific Northwest National Laboratory, and the Office of River Protection), LANL, INL, Oak Ridge sites (including East Tennessee Technology Park [ETTP], Y-12 National Security Complex, ORNL, and Oak Ridge Institute for Science and Education), and SRS contributing 79% of the total DOE collective TEDE.

3.4.2 Changes by Site from 2007 to 2008

Exhibit 3-15 shows the collective TEDE, the number with a measurable dose, the average measurable TEDE, and the percentage of the collective TEDE delivered above 0.500 rem by site for 2009, 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 2009.

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

3.4.3 Activities Significantly Contributing to Collective Dose in 2008

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 2009. These sites (Hanford, Los Alamos National Laboratory, Idaho National Laboratory, Oak Ridge, and Savannah River) had a collective dose over 100 person-rems and were the top contributors to the collective TEDE in 2009.

Exhibit 3-13:
Collective TEDE by DOE Site for 2007–2009.

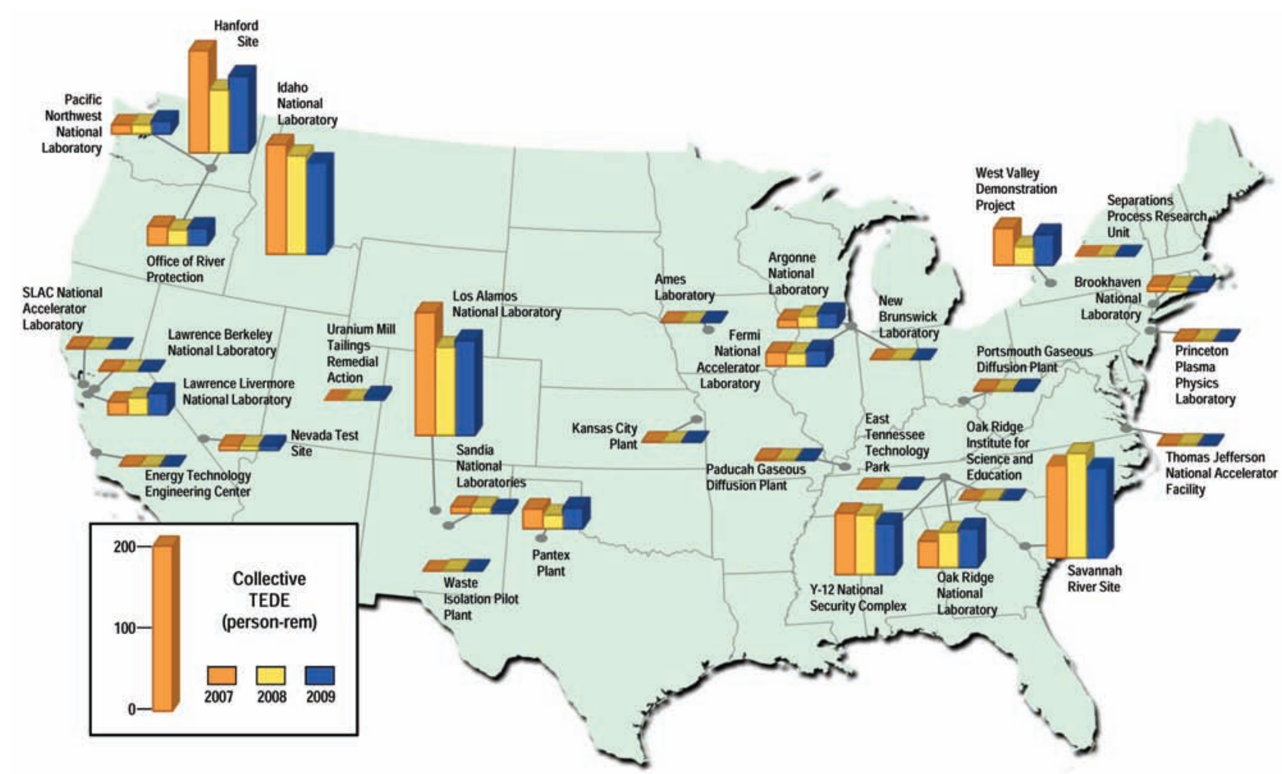


Exhibit 3-14:
Collective TEDE and Number of Individuals with Measurable TEDE by DOE Site, 2007–2009.

Site	2007		2008		2009	
	Collective TEDE (person-rem)	Number with Meas. TEDE	Collective TEDE (person-rem)	Number with Meas. TEDE	Collective TEDE (person-rem)	Number with Meas. TEDE
Ames Laboratory	0.2	6	0.5	30	0.7	31
Argonne National Laboratory	9.2	146	13.2	128	17.5	135
Brookhaven National Laboratory	6.3	191	5.4	149	5.2	180
Energy Technology Engineering Center	0.2	14	0.1	15	0.1	43
Fermi National Accelerator Laboratory	16.6	213	15.4	166	18.8	243
Hanford:						
Hanford Site	124.2	1,650	76.5	1,778	93.4	1,634
Office of River Protection	22.8	397	18.3	372	20.6	346
Pacific Northwest National Laboratory	11.0	181	11.1	226	15.3	242
Idaho National Laboratory	133.7	1,871	120.1	1,957	111.2	1,808
Kansas City Plant	0.1	22	0.1	39	0.5	10
Lawrence Berkeley National Laboratory	0.8	17	0.4	8	0.6	14
Lawrence Livermore National Laboratory	15.5	137	20.4	129	26.1	183
Los Alamos National Laboratory	**149.6**	1,392	107.3	1,219	**115.7**	1,392
Nevada Test Site	5.7	70	5.2	75	5.5	86
New Brunswick Laboratory	0.0	2	0.1	8	0.1	3
Oak Ridge:						
East Tennessee Technology Park	0.2	15	0.4	23	1.1	37
Oak Ridge Institute for Science and Education	0.1	35	0.2	53	0.2	62
Oak Ridge National Laboratory	31.8	424	42.7	492	46.9	659
Y-12 National Security Complex	74.3	1,258	72.1	1,301	61.7	1,379
Paducah Gaseous Diffusion Plant	1.7	29	1.3	44	1.2	79
Pantex Plant	23.9	293	16.5	287	25.2	302
Portsmouth Gaseous Diffusion Plant	1.5	18	1.4	36	1.5	32
Princeton Plasma Physics Laboratory	1.4	153	1.3	123	0.8	101
Sandia National Laboratories	7.8	175	7.2	160	4.1	88
Savannah River Site	112.4	**2,135**	**127.1**	**2,151**	108.8	**2,183**
Separations Process Research Unit	-	-	-	-	0.3	10
SLAC National Accelerator Laboratory	1.5	41	0.6	25	0.2	6
Thomas Jefferson National Accelerator Facility	0.8	19	1.5	51	0.7	27
Uranium Mill Tailings Remediation Action Project	-	-	-	-	3.6	92
Waste Isolation Pilot Plant	0.0	0	1.1	63	0.9	68
West Valley Demonstration Project	44.5	188	22.2	157	37.0	230
Site Office Personnel*	0.3	10	0.6	22	0.5	15
Totals**	**797.8**	**11,102**	**690.2**	**11,287**	**726.0**	**11,720**

Note: Bold values indicate the greatest value in each column.
* Includes site office personnel from Albuquerque and Oak Ridge in addition to several smaller facilities not associated with a DOE site.
** The collective TEDE totals are calculated from the dose records that are reported in millirem while the values shown are rounded to the nearest tenth of a rem.

Exhibit 3-15:
Site Dose Data, 2009.

	2009							
Site	**Collective TEDE (person-rem)**	**Percent Change from 2008**	**Number with Meas. Dose**	**Percent Change from 2008**	**Avg. Meas. TEDE (rem)**	**Percent Change from 2008**	**Percentage of Coll. TEDE above 0.500 rem**	**Percent Change from 2008**
Ames Laboratory	0.717		31		0.023			
Argonne National Laboratory	17.488	33% ▲	135	5% ▲	0.130	26% ▲	33%	-2% ▼
Brookhaven National Laboratory	5.191	-4% ▼	180	21% ▲	0.029	-21% ▼		
Energy Technology Engineering Center	0.125		43		0.003			
Fermi National Accelerator Laboratory	18.75	22% ▲	243	46% ▲	0.077	-17% ▼	3%	-58% ▼
Hanford:								
Hanford Site	93.358	22% ▲	1,634	-8% ▼	0.057	33% ▲	7%	**943%** ▲
Office of River Protection	20.639	13% ▲	346	-7% ▼	0.060	22% ▲		
Pacific Northwest National Laboratory	15.326	38% ▲	242	7% ▲	0.063	29% ▲	11%	
Idaho National Laboratory	111.159	-7% ▼	1,808	-8% ▼	0.061	0%	1%	-77% ▼
Kansas City Plant	0.525		10		0.053			
Lawrence Berkeley National Laboratory	0.613		14		0.044			
Lawrence Livermore National Laboratory	26.099	28% ▲	183	42% ▲	0.143	-10% ▼	**67%**	5% ▲
Los Alamos National Laboratory	**115.733**	8% ▲	1,392	14% ▲	0.083	-6% ▼	22%	-26% ▼
Nevada Test Site	5.519	6% ▲	86	15% ▲	0.064	-8% ▼		
New Brunswick Laboratory	0.059		3		0.020			
Oak Ridge:								
East Tennessee Technology Park	1.123	**156%** ▲	37	61% ▲	0.030	**59%** ▲		
Oak Ridge Institute for Science and Education	0.231		62		0.004			
Oak Ridge National Laboratory	46.899	10% ▲	659	34% ▲	0.071	-18% ▼	6%	-55% ▼
Y-12 National Security Complex	61.697	-14% ▼	1,379	6% ▲	0.045	-19% ▼	7%	38% ▲
Paducah Gaseous Diffusion Plant	1.151	-10% ▼	79	**80%** ▲	0.015	-50% ▼		
Pantex Plant	25.158	53% ▲	302	5% ▲	0.083	45% ▲	9%	
Portsmouth Gaseous Diffusion Plant	1.54	10% ▲	32	-11% ▼	0.048	24% ▲		
Princeton Plasma Physics Laboratory	0.786		101		0.008			
Sandia National Laboratories	4.125	-43% ▼	88	-45% ▼	0.047	4% ▲		
Savannah River Site	108.788	-14% ▼	**2,183**	1% ▲	0.050	-16% ▼	2%	-44% ▼
Separations Process Research Unit	0.288		10		0.029			
SLAC National Accelerator Laboratory	0.169		6		0.028			
Thomas Jefferson National Accelerator Facility	0.69		27		0.026			
Uranium Mill Tailings Remediation Action Project	3.624		92		0.039			
West Valley Demonstration Project	36.985	67% ▲	230	46% ▲	**0.161**	14% ▲	23%	
Waste Isolation Pilot Plant	0.909		68		0.013			
Site Office Personnel*	0.511		15		0.034			
Totals**	**726.0**	**5%** ▲	**11,720**	**4%** ▲	**0.062**	**2%** ▲	**11%**	**7%** ▲

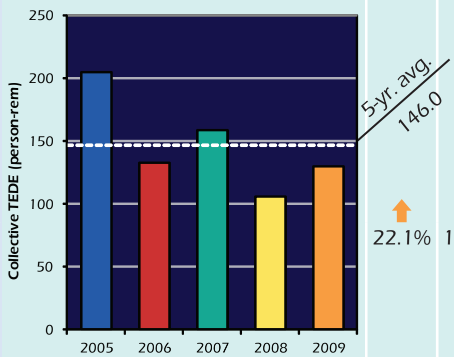
Note: Bold values indicate the greatest value in each column.

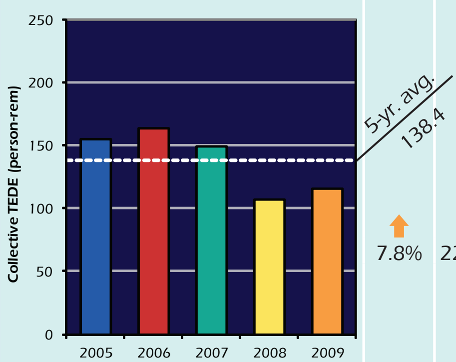
* Includes site office personnel from Albuquerque and Oak Ridge in addition to several smaller facilities not associated with a DOE site.

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

These sites comprised 79% of the total collective TEDE at DOE. Two of the sites reported increases in the collective TEDE, which contributed to a 5% increase in the DOE collective TEDE from 690 person-rems (6.90 person-Sv) in 2008 to 727 person-rems (7.27 person-Sv) in 2009. The sites significantly contributing to the collective TEDE in 2009 are shown in *Exhibit 3-16*, including a description of activities that affected the collective TEDE.

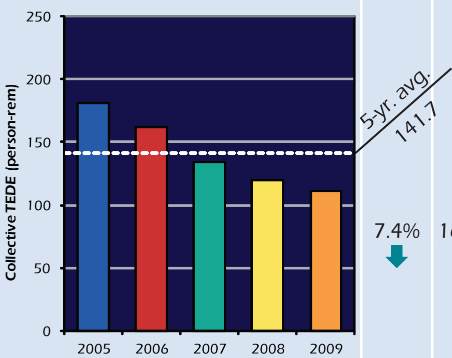
Exhibit 3-16 :
Activities Significantly Contributing to Collective TEDE in 2009.

Hanford	**Percent Change***			**Description of Activities at the Site**
	2008-2009 (last yr.)	**2007-2009 (3 yr.)**	**2005-2009 (5 yr.)**	
	↑ 22.1%	18.2% ↓	36.7% ↓	The collective TEDE at Hanford (which includes the Hanford Site, the Office of River Protection, and the Pacific Northwest National Laboratory) was 129.323 person-rem. The largest contributors to the collective TEDE at Hanford were Decontamination and Demolition (D&D) of 100K facilities including the KE reactor basins (24%), Waste and Fuels Project (retrieval, processing, and shipment of Transuranic [TRU] waste)(18%), Tank Farm activities (17%), Pacific Northwest National Laboratories activities (12%), Plutonium Finishing Plant (PFP) D&D (11%), 300 Area D&D (including 327 Radio metallurgy Building) (8%), and 100-N Area reactor facilities D&D (5%). The increase in collective dose at Hanford Site was due to an increase in radiological work activity associated with accelerated clean-up made possible by the American Recovery and Reinvestment Act. The neutron dose at Hanford Site decreased 44%. The majority of the neutron dose was from work activities at the PFP. Overall dose at PFP decreased as a result of removal of radioactive material from the facility in preparation for demolition. No individuals at Hanford were exposed to greater than 2.0 rems in 2009.

Los Alamos National Laboratory	**Percent Change***			**Description of Activities at the Site**
	2007-2008 (last yr.)	**2006-2008 (3 yr.)**	**2004-2008 (5 yr.)**	
	↑ 7.8%	22.7% ↓	25.6% ↓	At Los Alamos National Laboratory (LANL) for the 9,366 records submitted, the collective TEDE was 115.733 person-rems and no individual exceeded 2 rems. TA-55 Plutonium Processing Facility operations account for the majority of occupational dose at LANL. CY09 doses in this facility were only slightly higher than 2008, as radiological work was less than in typical years. Besides occupational exposure from both weapons manufacturing and Pu-238 work (relatively less than typical years), work on repackaging materials, access to storage areas, and providing RCT support for radiological work and system maintenance were major contributors to worker dose at TA-55 Plutonium Processing Facility. In addition to TA-55 Plutonium Processing Facility operations, significant portions of LANL whole body doses were accrued by workers performing maintenance at TA-53 LANSCE Station (the linear accelerator), subcontractors performing D&D of a major experimental facility at TA-53 LANSCE Station, and workers performing retrieval, repackaging, and shipping of radioactive solid waste at LANL waste facilities at TA-50 Radioactive Liquid Waste Treatment Facility and TA-54 Radioassay and Nondestructive Testing Station. Internal doses reflect a combination of routine tritium doses from LANL tritium operations, routine uranium doses from LANL uranium operations, and unanticipated low-level intakes of plutonium and americium. The highest reported internal dose (0.110 rem CEDE) was not attributable to an event at LANL, but rather was an artifact from a previously undetected intake from another DOE site.

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

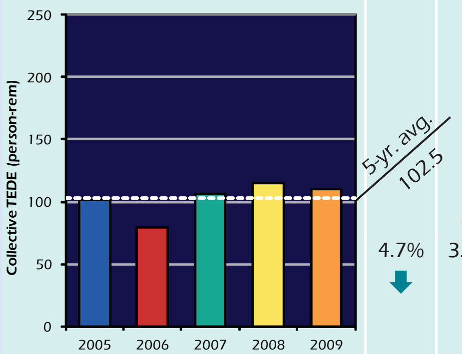
Exhibit 3-16 (Continued):
Activities Significantly Contributing to Collective TEDE in 2008.

Idaho National Laboratory	**Percent Change***			**Description of Activities at the Site**
	2008-2009 (last yr.)	**2007-2009 (3 yr.)**	**2005-2009 (5 yr.)**	
	7.4% ↓	16.8% ↓	38.8% ↓	**<u>CH2M, WG Idaho LLC, and Battelle Energy Alliance (Idaho National Laboratory and Idaho Cleanup Project [ICP])</u>** For the 5,686 records submitted, the total TEDE for all individuals is 82.956 person-rems and no individual exceeded 2 rems. The ICP activities performed by CH2M-WG Idaho, LLC leading to radiation exposure included; an increase in radiological work activity associated with accelerated D&D work, Accelerated Retrieval Project (ARP) activities, liquid waste and nuclear materials disposition activities, Voluntary Consent Order (VCO) and D&D activities at Reactor Technology Complex (RTC), cleanout and characterization of a hot cell facility, cleanout and removal of piping, waste management activities. The radiation exposure activities, performed by Battelle Energy Alliance (BEA) during 2009 at the Idaho National Laboratory, included; installation, operations, and removal of Loop tests, experiments, sizing and shipment of TMIST Test trains and upgrade and testing of the Dry Transfer Cubicle, INIS-2 Cask shipments, routine outage operations, chemistry, RCT support, canal and reactor top activities, minor PM/CM, and work area inspections. Fewer Multi-Mission radioisotope thermoelectric generators assembled in the Space & Security Power Systems (SSPS) facility resulted in a reduction in total dose received at BEA Facilities. **<u>Department of Energy Idaho Operations Office</u>** For the187 records submitted, the total TEDE for all individuals is .222 person-rems. Activities conducted by Department of Energy, Idaho Operations Office personnel are limited to oversight activities, including Operational Awareness surveillances by Facility Representatives (to which the majority of dose can be contributed), participation on various Operational Readiness Reviews, Readiness Assessments, and various scheduled and non-scheduled surveillance activities. **<u>Bechtel BWXT Idaho, LLC (Advanced Mixed Waste Treatment Project)</u>** For the 1,478 records submitted, the total TEDE for all individuals is 27.981 person-rems and no individual exceeded 2 rems. The primary work activities at the AMWTP that contributed to workforce dose included TRU waste retrieval from burial, waste characterization, and waste handling operations in support of shipment of transuranic and by-product waste materials from Idaho to the DOE WIPP facility and other commercial disposal sites. This decrease in collective dose can be attributed to changes in retrieval and waste movement activities, receipt of offsite waste, and projects involving elevated dose rate waste drums and cargo container retrieval. The controls for these activities lead to a decrease in the source term for the population.

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

Exhibit 3-16 (Continued):
Activities Significantly Contributing to Collective TEDE in 2009.

Oak Ridge



	Percent Change*		
	2008-2009 (last yr.)	2007-2009 (3 yr.)	2005-2009 (5 yr.)
Oak Ridge	4.7% ↓	3.3% ↑	8.4% ↑

Description of Activities at the Site

ORNL, East Tennessee Technology Park – Bechtel Jacobs Company LLC (BJC)
There were a total of 2,422 individuals monitored by BJC in 2009, resulting in a collective TEDE of 2.803 person-rems and a total committed effective dose equivalent (CEDE) of 0 person-rem for all BJC sites.

The major activities performed at BJC sites consisted of environmental restoration work, removal of decontamination facilities, surveillance and maintenance tasks, and stabilization of inactive facilities and demolition of surplus facilities.

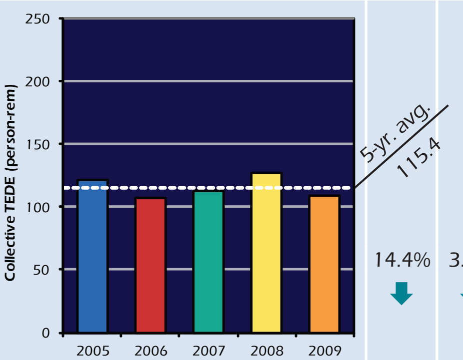
The decrease in TEDE for 2009 is attributed to a decrease in waste operations tasks at ORNL involving contact and remote handling of waste containers and transition into Transportation and Shipping operations. The decreases in total neutron dose and total extremity dose for 2009 were also due to the decrease in waste operations work at ORNL. There were no unusual events related to occupational radiation exposure at BJC facilities for 2009.

ORNL-UT Battelle
The reported TEDE for ORNL during 2009 is about 14% lower than the 2008 reported TEDE. During 2009, ORNL saw a decrease in isotope processing and a decrease in cleanup and waste disposal activities, which attributed to this decrease.

Y-12 National Security Complex – Babcock & Wilcox (B&W)
The 2009 collective deep dose equivalent for the Y-12 Complex decreased by 30%, from 18.1 person-rem in 2008 to 12.7 person-rem in 2009. This decrease is attributable to the completion of some projects with atypical material types and increased containerization that led to less direct handling of certain material. Most of these additional individuals monitored were part of the American Recovery and Reinvestment Act (ARRA) work, which has had low deep dose potential.

Collective TEDE decreased 14% from 72.1 person-rem in 2008 to 61.7 person-rem in 2009, while the total persons monitored increased by 12% from 5,168 to 5,791.

Savannah River Site



	Percent Change*		
	2008-2009 (last yr.)	2007-2009 (3 yr.)	2005-2009 (5 yr.)
Savannah River Site	14.4% ↓	3.2% ↓	10.3% ↓

Description of Activities at the Site

For calendar year 2009, the Savannah River Site (SRS) cumulative radiation exposure totals were 14% lower than in 2008.

The decrease was a combination of factors, but overall, some of the higher dose-rate work was either reduced or postponed. Savannah River Nuclear Solutions, LLC, handled high-dose-rate TRU drums in Solid Waste, handled spent fuel for the Low Enriched Uranium campaign in H-Area Materials Disposition, and repaired the A and B cell Block cranes in the Savannah River National Lab. The Super Kukla campaign in H-Canyon, the K-Area Material Storage fire suppression work, and International Atomic Energy Agency surveillance in K-Area were completed. New work scope began under the ARRA in Area Completion and Solid Waste. Savannah River Remediation, LLC, continued bulk waste removal, salt processing, and other tank closure activities.

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

In addition to the information provided in *Exhibit 3-16*, several of the DOE sites provided further information on operations conducted during the monitoring year. DOE Manual 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 that are not among the top contributors to the DOE collective dose in 2009.

Argonne National Laboratory

The collective TEDE at Argonne was approximately 18 person-rems, up from approximately 13 person-rems the previous year. The Alpha Gamma Hot Cell Facility (AGHCF) was the primary dose contributor in 2009. The doses at AGHCF were accrued mainly during maintenance periods and campaigns to remove radioactive waste from the hot cell. The number of waste removal campaigns increased significantly this year. The other major contributor was site waste management operations.

Brookhaven National Laboratory

The collective TEDE at Brookhaven National Laboratory (BNL) decreased by 4.6% from 5.430 person-rems in calendar year (CY) 2008 to 5.191 person-rems in 2009. This includes 0.136 person-rem Committed Effective Dose Equivalent (CEDE) and 5.055 person-rems deep-dose equivalent (DDE). The slight decrease in total dose, and extremely low bioassay dose, are primarily due to the slow pace of continued on-site remediation on the Brookhaven Graphite Research Reactor Project. The highest individual dose was 0.338 rem, so no individual exceeded 2 rems TEDE or exceeded any DOE occupational dose limit.

Fermi National Accelerator Laboratory

The total collective TEDE for 2009 increased by 22%, from 15.4 person-rems in 2008 to 18.8 person-rems in 2009. During calendar year (CY) 2009, there was one major shutdown of the accelerators that began on June 15 lasted approximately 3 months. The shutdown was necessary to perform accelerator maintenance and improvements. The majority of the work performed during these shutdown periods involved Accelerator Division personnel.

While Fermi National Accelerator Laboratory 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 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 TEDE. The TEDE for 2009 is, in fact, within the expected range for a year in which a major shutdown has occurred.

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.

Kansas City Plant

The Kansas City Plant's (KCP) collective TEDE is from routine activities, as there were no special projects contributing to these doses for 2009.

Lawrence Berkeley National Laboratory

There were no intakes of radioactive materials detected in 2009. The collective TEDE at Lawrence Berkeley National Laboratory (LBNL) increased slightly from 0.429 person-rem in 2008 to 0.613 person-rem in 2009. Seventy-five percent of the collective TEDE 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

Lawrence Livermore National Laboratory (LLNL) operations require the use of a wide range of radiation-producing devices (e.g., x-ray machines, accelerators, electron-beam welders) and radioactive material. The types of radioactive materials range from tritium to transuranics; the quantities range from nanocuries (i.e., normal environmental background values) to kilocuries.

The 2009 total collective TEDE of 25.834 person-rems reflects an increase from the 2008 total collective TEDE of 20.356 person-rems and represents increased operations in the Plutonium Facility and at LLNL. Doses for 2009 are as expected.

Lawrence Livermore National Laboratory – Nevada Test Site

The 2009 total collective TEDE of 0.265 person-rem reflects an increase from the 2008 total collective TEDE of 0 person-rem. There was no intake file submitted, as there were no uptakes during the 2009 reporting year.

Paducah Gaseous Diffusion Plant

The exposure information for activities at the Paducah site covers Paducah Remediation Services, LLC (PRS) activities performed under the DOE contract scope for environmental remediation, facility decontamination, and final assessment of buildings and areas at the site. There were a total of 980 individuals monitored by PRS, resulting in a maximum individual effective dose equivalent (TEDE) of 0.069 person-rem and a CEDE of 0.069 person-rem for all PRS activities. The major activities performed at PRS sites consisted of environmental restoration work, decontamination of facilities, stabilization of inactive facilities, and demolition of surplus facilities. There was a slight increase in TEDE and CEDE for 2009 versus 2008 due to additional decontamination and decommissioning work activities. There were no unusual events related to occupational radiation exposure at PRS facilities for 2009.

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 those 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 dose to Pantex Plant workers increased by 53% in 2009 compared with 2008. The increase was due to known variations in the specific types and quantities of production work performed by B&W Pantex. However, the final population dose for 2009 was 3.8% less than the ALARA goal. The ALARA goal took into account the increased production work that NNSA assigned to the Pantex Plant in 2009. No individual's dose exceeded 0.75 rem TEDE in 2009.

SLAC National Accelerator Laboratory

Compared with the previous 2008 collective TEDE (0.560 person-rem), the 2009 collective TEDE (0.169 person-rem) is about 30% of the 2008 total. This decrease in collective TEDE for 2009 is not associated with any operational activities for PEP-II and BaBar facilities compared with 2008. PEP-II and BaBar operations ended in April 2008; thus, the beams from LINAC Sectors 0-19, including associated klystrons, have been turned off since then. A review of the Radiological Work Permit (RWP) program in 2009 also shows no significant works involving elevated personal exposures. Thus, the collective dose reduction in 2009 was in line with less work activities conducted in radiological areas, especially in high radiation areas and contamination areas during 2009.

Sandia National Laboratories

The collective dose at Sandia National Laboratories (SNL – all locations) is relatively low compared with other NNSA facilities. This year's collective dose shows no anomalies compared with previous years. SNL radiological operations include operation of a research reactor, gamma irradiation facility, hot cell facility, several accelerators, light laboratory work involving x-ray machines and use of tracer radionuclides, and waste operations. Site collective dose was 7.219 person-rems in 2009, a significant drop from the 2008 amount. This can be attributed to the closure and decommissioning of the Sandia Pulsed Reactor III performed in 2008.

Separations Process Research Unit

The Separations Process Research Unit—land area project remediated about 12,200 loose cubic yards (15,900 tons) of low-level contaminated soil. Approximately 22,300 man-hours of work were performed in association with radiation work permits on this project. The 2009 project collective TEDE was 0.288 person-rem. This is expected to increase in 2010 as activities include preparation for being "Demolition Ready." The Separations Process Research Unit—building project activities in 2009 of dose concern were characterization of the facility radiological condition prior to planned demolition in 2010-2011. These activities included initial entry to radiological areas and decontamination activities in support of characterization.

Waste Isolation Pilot Plant

The collective TEDE for the Waste Isolation Pilot Plant (WIPP) for the calendar year 2009 is 0.909 person-rem.

This is a decrease of 0.160 person-rem from 2008. All doses received were from routine activities associated with the disposal of transuranic waste.

West Valley Demonstration Project

Two major projects involving radiation continue to be D4 Projects and Waste Management. D4 activities included Decontamination & Decommissioning work in extraction and support cells in preparation for being declared "Demolition Ready." Waste Management activities included waste processing and shipping for disposal. Waste Management was also involved in modifying facilities to accommodate the remaining waste to be processed.

The 2009 collective TEDE of 36.985 person-rems is approximately 70% higher than the 2008 collective TEDE of 22.181 person-rems. This increase was due primarily to an increased level of effort in D&D tasks and the hiring of employees under the American Recovery and Reinvestment Act (ARRA).

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 3-17* shows the number of individuals with measurable dose, the collective TEDE, and the average measurable TEDE by DOE program office. The Office of Environmental Management (EM) and the NNSA account for the largest percentages of the collective dose (49% and 33%, respectively). EM works to mitigate the risks and hazards posed by the legacy of nuclear weapons production and research. NNSA is responsible for the management and security of the nation's nuclear weapons, nuclear nonproliferation, and naval reactor programs, as well as responding to radiological emergencies and the transportation of nuclear weapons and special nuclear materials. In general, the missions of EM and NNSA require more interaction and activities involving radioactive materials. These offices account for nearly 82% of the collective dose at DOE.

The primary sites contributing to the collective TEDE at EM are Hanford, SRS, and INL. For NNSA, the primary contributors are LANL and Y-12. For the Office of Nuclear Energy, Science and Technology (NE), the primary contributor is INL.

A more detailed breakdown of the exposure information by site, program office, and contractor is available at http://www.hss.energy.gov/csa/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 3-18* shows the dose distribution and total number of transient individuals from 2005 to 2009. Over the past 5 years, the records of transient individuals have averaged 2.9% of the total records for all monitored individuals at DOE. These individuals received, on an average, 3% of the collective dose. The collective dose for transients increased by 46% from 21.4 person-rems (214 person-mSv) in 2008 to 31.2 person-rems (312 person-mSv) in 2009. The average measurable TEDE increased from 0.044 rem (0.44 mSv) in 2008 to 0.052 rem (0.52 mSv) in 2009. Since 1993, these parameters 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, HSS has the oversight responsibility of ensuring that DOE workers who work at multiple sites do not exceed annual limits. 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.

Exhibit 3-17:
Program Office Dose Data, 2009.

Program Office	Collective TEDE (person-rem)	Percent Change from 2008	Number with Meas. Dose	Percent Change from 2008	Avg. Meas. TEDE (rem)	Percent Change from 2008
Office of Energy Efficiency and Renewable Energy (EE)						
National Renewable Energy Laboratory	0.0		5		0.006	
EE Totals*	**0.0**		**5**		**0.006**	
Office of Environmental Management (EM)						
East Tennessee Technology Park	1.1		37		0.030	**59%** ▲
Energy Technology Engineering Center	0.1		43		0.003	-69% ▼
Hanford Site	93.4	22% ▲	1,634	-8% ▼	0.057	33% ▲
Idaho National Laboratory	65.7	57% ▲	1,134	53% ▲	0.058	2% ▲
Oak Ridge National Laboratory	19.5	45% ▲	257	**85%** ▲	0.076	-22% ▼
Office of River Protection	20.6	13% ▲	346	-7% ▼	0.060	22% ▲
Paducah Gaseous Diffusion Plant	1.2	-10% ▼	79	80% ▲	0.015	-50% ▼
Portsmouth Gaseous Diffusion Plant	1.5	10% ▲	32	-11% ▼	0.048	24% ▲
Savannah River Site	**108.8**	-14% ▼	**2,183**	1% ▲	0.050	-16% ▼
Separations Process Research Unit	0.3		10		0.029	
Site Office Personnel	0.1		5		0.016	-53% ▼
Uranium Mill Tailings Remedial Action Project	3.6		92		0.039	
Waste Isolation Pilot Plant	0.9	-15% ▼	68	8% ▲	0.013	-21% ▼
West Valley Demonstration Project	37.0	**67%** ▲	230	46% ▲	**0.161**	14% ▲
EM Totals*	**353.9**	**16%** ▲	**6,150**	**11%** ▲	**0.058**	**5%** ▲
National Nuclear Security Administration (NNSA)						
Kansas City Plant	0.5		10		0.053	
Lawrence Livermore National Laboratory	26.1	28% ▲	183	**42%** ▲	**0.143**	-10% ▼
Los Alamos National Laboratory	**115.7**	8% ▲	**1,392**	14% ▲	0.083	-6% ▼
Nevada Test Site	5.5	6% ▲	86	15% ▲	0.064	-8% ▼
Pantex Plant	25.2	**53%** ▲	302	5% ▲	0.083	**45%** ▲
Sandia National Laboratories	4.1	-43% ▼	88	-45% ▼	0.047	4% ▲
Y-12 National Security Complex	61.7	-14% ▼	1,379	6% ▲	0.045	-19% ▼
NNSA Totals*	**238.8**	**5%** ▲	**3,440**	**7%** ▲	**0.069**	**-3%** ▼
Office of Nuclear Energy, Science and Technology (NE)						
Idaho National Laboratory	45.4	-42% ▼	674	-44% ▼	0.067	4% ▼
NE Totals*	**45.4**	**-42%** ▼	**674**	**-44%** ▼	**0.067**	**4%** ▼
Office of Science (SC)						
Ames Laboratory	0.7		31		0.023	**36%** ▲
Argonne National Laboratory	17.5	33% ▲	135	5% ▲	**0.130**	26% ▲
Brookhaven National Laboratory	5.2	-4% ▼	180	21% ▲	0.029	-21% ▼
Fermi National Accelerator Laboratory	18.8	22% ▲	243	**46%** ▲	0.077	-17% ▼
Lawrence Berkeley National Laboratory	0.6		14		0.044	-18% ▼
New Brunswick Laboratory	0.1		3		0.020	
Oak Ridge Institute for Science and Education	0.2		62		0.004	15% ▲
Oak Ridge National Laboratory	**27.4**	-6% ▼	**402**	14% ▲	0.068	-18% ▼
Pacific Northwest National Laboratory	15.3	**38%** ▲	242	7% ▲	0.063	29% ▲
Princeton Plasma Physics Laboratory	0.8	-39% ▼	101	-18% ▼	0.008	-25% ▼
Site Office Personnel	0.4		5		0.081	
SLAC National Accelerator Laboratory	0.2		6		0.028	26% ▲
Thomas Jefferson National Accelerator Facility	0.7	-55% ▼	27	-47% ▼	0.026	-14% ▼
SC Totals*	**87.8**	**11%**	**1,451**	**10%**	**0.061**	**1%**

Note: Boxed values indicate the greatest value in each column section. 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).
*The collective TEDE totals are calculated from the dose records that are reported in millirem while the values shown are rounded to the nearest tenth of a rem.

Exhibit 3-18:
Dose Distribution of Transient Workers, 2005–2009.

	Dose Ranges (TEDE in rem)	2005	2006	2007	2008	2009
Transients	Less than measurable	2,067	1,888	2,182	2,085	2,056
	measurable <0.1	715	412	388	430	523
	0.10–0.25	79	24	51	43	51
	0.25–0.5	13	9	8	9	20
	0.5–0.75	3	4			
	0.75–1.0	2	3			3
	1.0–2.0	1	2		1	
	Total number of individuals monitored*	2,880	2,342	2,629	2,568	2,653
	Number with measurable dose	813	454	447	483	597
	% with measurable dose	28%	19%	17%	19%	23%
	Collective TEDE (person-rem)	39.757	25.532	22.111	21.410	31.163
	Average measurable TEDE (rem)	0.049	0.056	0.049	0.044	0.052
All DOE	Total number of records for monitored individuals	98,040	91,280	86,651	83,208	86,372
	Number with measurable dose	16,136	12,953	11,102	11,287	11,725
	% of total monitored who are transient	2.9%	2.6%	3.0%	3.1%	3.1%
	% of the number with measurable dose who are transient	5.0%	3.5%	4.0%	4.3%	5.1%

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

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 3-19* and *3-20* are presented to show a summary of occupational exposures back to 1974, when the Atomic Energy Commission (AEC) split into the Nuclear Regulatory Commission (NRC) and the Energy Research and Development Administration (ERDA), which subsequently became DOE. *Exhibits 3-19* and *3-20* show the collective dose, average measurable dose, and number of workers with a measurable dose from 1974 to 2009. 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 2009.

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 Test Site
- Oak Ridge K-25 Site
- Pantex Plant
- Portsmouth Gaseous Diffusion Plant
- Rocky Flats Environmental Technology Site
- Sandia National Laboratories
- Savannah River Site

Exhibit 3-19:
Collective Dose and Average Measurable Dose, 1974–2009.

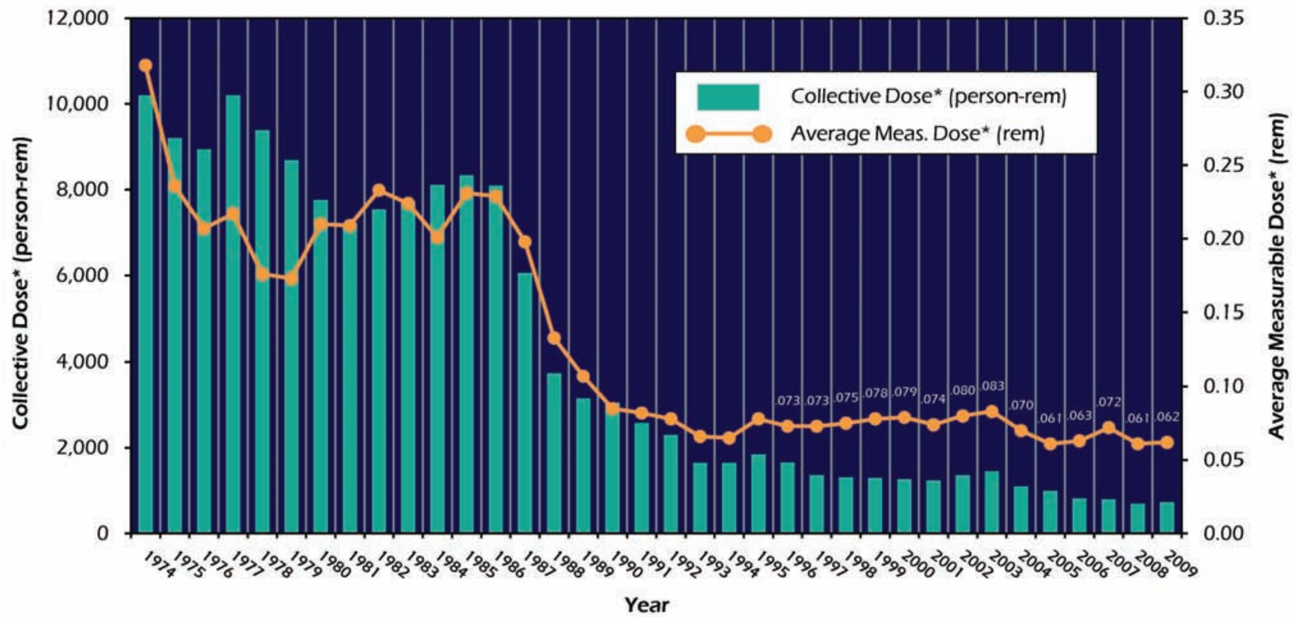
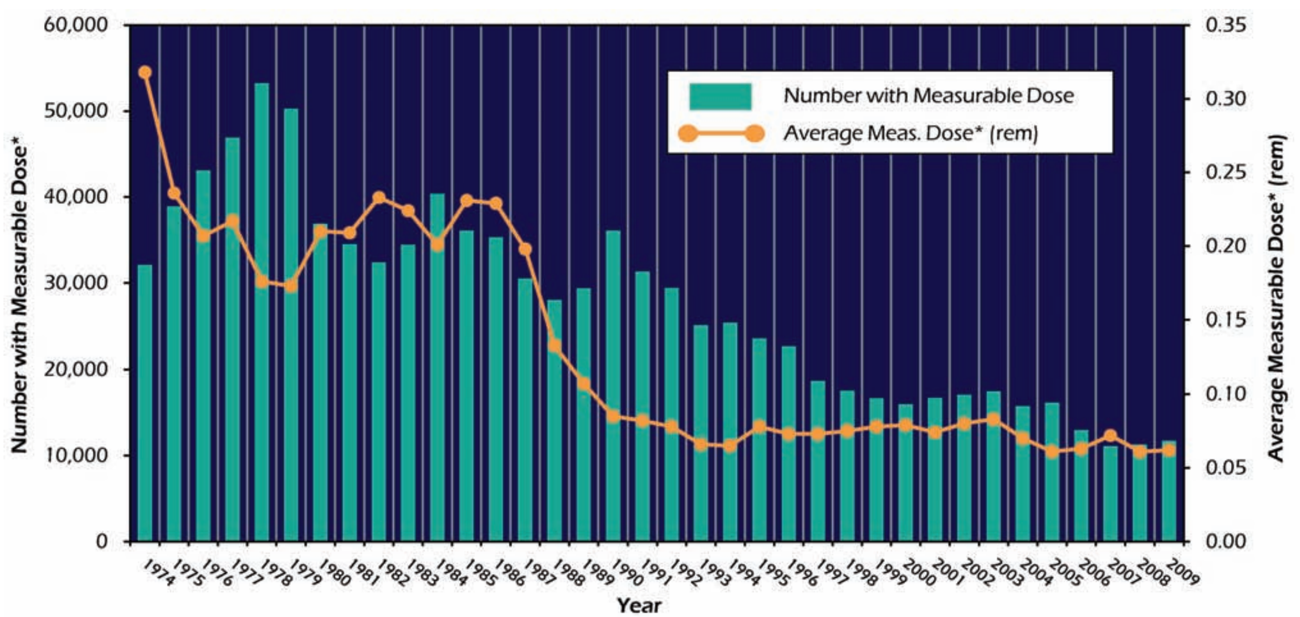


Exhibit 3–20:
Number of Workers with Measurable Dose and Average Measurable Dose, 1974–2009.



* 1974–1989 collective dose = DDE
1990–1992 collective dose = DDE + AEDE
1993–2009 collective dose = DDE + CEDE

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

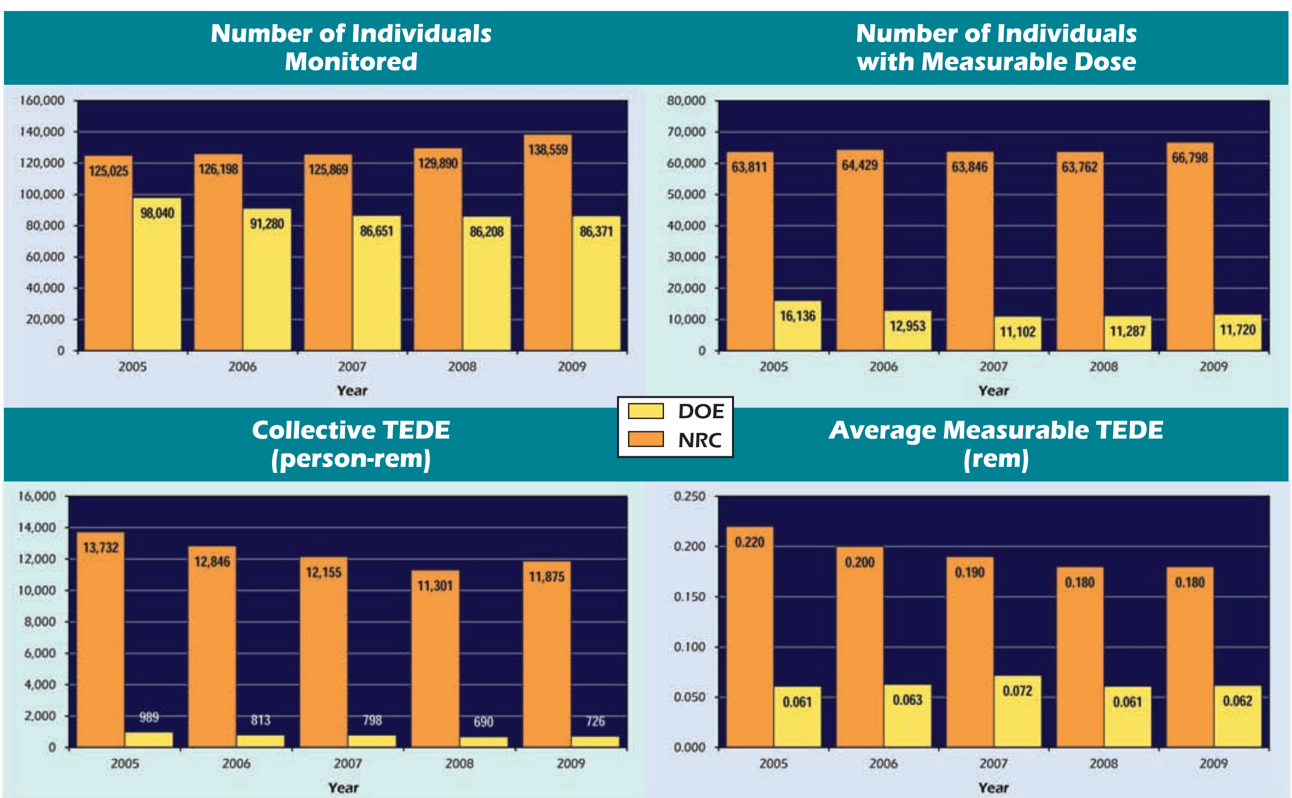
3.7 Comparison of DOE Dose to Other Activities

3.7.1 Comparison with Activities Regulated by the 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 2009 report includes the DOE occupational exposure in relation to activities regulated by the U.S. Nuclear Regulatory Commission (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 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 95% 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 3-21* cover the past 5 years (2005 to 2009). 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 18% of the NRC total for this time period. The percentages of DOE's collective dose and average measurable dose were 6% and 34% of the NRC totals, respectively.

Exhibit 3–21:
Comparison of Occupational Exposure for DOE and NRC, 2005 –2009 .



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Section Four
ALARA Activities at DOE

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

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

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

http://www.hss.energy.gov/CSA/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 Order 210.2, *DOE Corporate Operating Experience Program* [9]. 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.energy.gov/csa/analysis/ll/

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 2009, 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. While in 2009 the collective dose and the number of individuals with measurable dose increased, these values remain consistent with the observed values for the past 5 years. See *Exhibit 5-1* 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 5 years, there has been a decrease in collective dose and the number of individuals with measurable dose.

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

Exhibit 5-1:
2009 Radiation Exposure Summary.

- There was no exposure in excess of the DOE 5 rems (50 mSv) annual TEDE limit.
- There was no exposure in excess of the DOE ACL of 2 rems (20 mSv) TEDE.
- The collective TEDE increased 5% from 690 person-rems (6.90 person-Sv) in 2008 to 726 person-rems (7.26 person-Sv) in 2009.
- Sites contributing significantly to collective dose were (in descending order of collective dose) Hanford, Los Alamos, Idaho, Oak Ridge, and Savannah River. These sites accounted for 79% of the collective dose at DOE in 2009.
- The collective internal dose (CEDE) decreased by 13% between 2008 and 2009.
- Ninety-seven percent of the collective CEDE at DOE was due to U-234.
- The collective dose for transient workers increased by 46% from 21.4 person-rems (214 person-mSv) in 2008 to 31.2 person-rems (312 person-mSv) in 2009, but did not exceed the highest value within the past 5 years.
- The total number of bioassay measurements increased by 13% from 72,346 in 2008 to 81,532 in 2009.

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Glossary

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

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

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

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

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

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

CR
See SR.

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

DOE site
A geographic location operated under the authority of the 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.

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

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

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

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

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

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

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

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

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

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

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7. Computerized Accident and Incident Reporting System (CAIRS), "DOE and Contractor Injury and Illness Data by Year by Quarter" report. Online at http://www.hss.energy.gov.

8. 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.

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User Survey

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 2009 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, HS-32
DOE REMS Project Manager
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, D.C. 20585-1290
E-mail: nimi.rao@hq.doe.gov
Fax: (301) 903-1257

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

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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
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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:

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1	2	3	4	5

Please provide any additional input or comments on the report.

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