DOE Occupational Radiation Exposure

2006 Report

SHIELD • ALARA • NEUTRON • AEDE • ELECTRON • TEDE • INTERNAL • CEDE • GAMMA • BETA • SHIELD • ALARA • NEUTRON • AEDE • ELECTRON • TEDE • INTERNAL • CEDE • GAMMA •

DEPARTMENT OF ENERGY
UNITED STATES OF AMERICA

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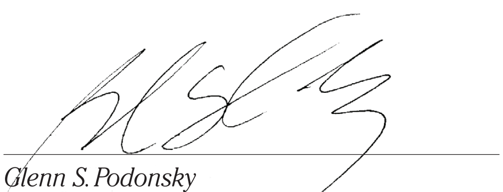
Foreword

One of the priorities of the U.S. Department of Energy (DOE) is to ensure the health, safety, and security of DOE employees, contractors, and subcontractors. To provide the corporate-level leadership and strategic vision necessary to better coordinate and integrate health, safety, environment, security, enforcement, and independent oversight programs, the Secretary of Energy officially established the Office of Health, Safety and Security (HSS) on August 30, 2006. The Office of Health, Safety and Security is committed to excellence in protecting the health and safety of our workers, the public, the environment, and our national security assets.

A key safety focus for DOE is to maintain radiation exposures of its workers below administrative control levels and DOE limits and to further reduce these exposures to levels that are "as low as reasonably achievable." The *DOE Occupational Radiation Exposure 2006 Report* provides a summary and analysis of the occupational radiation exposure received by individuals associated with DOE activities. This report is intended to be a valuable tool for managing radiological safety programs, epidemiologists, researchers, and national and international agencies involved in developing policies to protect individuals from harmful effects of radiation. The overall radiation dose decreased from 2005 to 2006 in terms of the collective dose. In addition to the reduction in the overall collective dose, fewer individuals received doses at higher dose levels. In 2006, no individual received a dose in excess of the DOE regulatory limits, or the DOE administrative control level.

One of the objectives of this report is to provide timely, useful, accurate, and complete information to the target audience. As part of a continuing improvement process, we would like to evaluate the process in order to streamline data collection, analysis, and report generation. We would appreciate your response to the user survey included in Appendix A to assist us in making this report better meet your needs.



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

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LIST OF EXHIBITS

TABLE OF ACRONYMS

ACL	Administrative Control Level
AEDE	Annual Effective Dose Equivalent
AEC	Atomic Energy Commission
ALARA	As Low As Reasonably Achievable
AMWTP	Advanced Mixed Waste Treatment Project
CDE	Committed Dose Equivalent
CEDE	Committed Effective Dose Equivalent
D&D	Decontamination and Decommissioning
DDE	Deep Dose Equivalent
DOE	U.S. Department of Energy
ETTP	East Tennessee Technology Park
HFIR	High Flux Isotope Reactor
HSS	Office of Health, Safety and Security
LANL	Los Alamos National Laboratory
LDE	Lens (of the Eye) Dose Equivalent
LLNL	Lawrence Livermore National Laboratory
mSv	Millisievert
NNSA	National Nuclear Security Adnimistration
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
PFP	Plutionium Finishing Plant
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
SRS	Savannah River Site
Sv	Sieverts
TEDE	Total Effective Dose Equivalent
TODE	Total Organ Dose Equivalent
TVA	Tennessee Valley Authority
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
WIPP	Waste Isolation Pilot Plant
Y-12 NSC	Y-12 National Security Complex

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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.* This report provides a summary and an analysis of occupational radiation exposure information for all monitored individuals associated with DOE activities. The occupational radiation exposure information is analyzed in terms of aggregate data, dose to individuals, and dose by site over the past five years.

One of the report's features includes the collective total effective dose equivalent (TEDE)—an indicator of the overall amount of radiation dose received during the conduct of operations at DOE. The DOE collective TEDE decreased by 18% from 2005 to 2006, as shown in *Exhibit ES-1*. This is the third consecutive year that the collective TEDE has decreased. The decrease in 2006 is due primarily to decreases in the amount of work performed that directly involves radioactive materials. In addition, several facilities completed cleanup operations and, therefore, no longer contribute to worker exposure. One of the largest reasons for the reduction of dose has been the closure of Rocky Flats, which ceased all operations in 2005 and therefore did not contribute to the DOE collective dose in 2006.

The TEDE is comprised of the external deep dose equivalent, 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. All of the components of the collective TEDE (photon, neutron, and CEDE) decreased from 2005 to 2006.

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 3% from 2005 to 2006, as shown in *Exhibit ES-2*, but remains near the value for 2005. The collective dose and the number of individuals who received a measurable dose both decreased, resulting in a relatively small change in the average measurable dose.

Exhibit ES-1:
Collective TEDE (person-rem), 2002–2006.

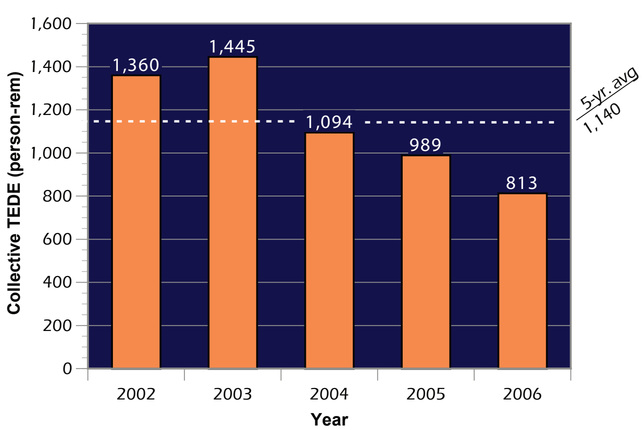
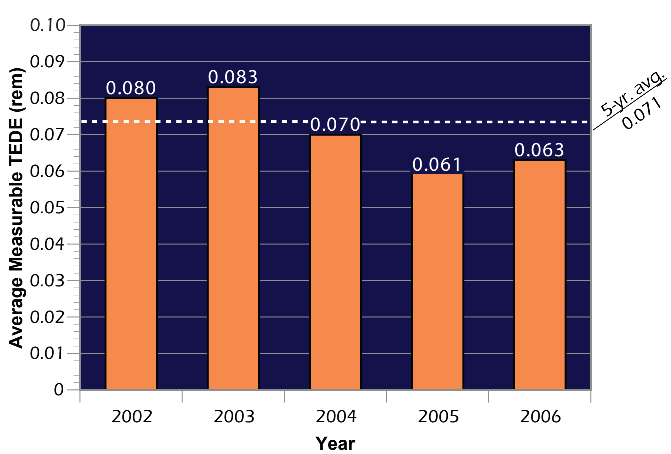


Exhibit ES-2:
Average Measurable TEDE (rem), 2002–2006.



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

Additional analysis shows that there were fewer individuals receiving doses at the higher dose levels in 2006, thereby confirming that workers received lower doses on an individual basis. No individuals received a dose in excess of the DOE regulatory limits during 2006. In addition, no individuals received an exposure in excess of the DOE administrative control level of 2 rem. This is the first year that has occurred since the implementation of the TEDE (as a summation of external and committed internal dose) in 1993.

In conclusion, the assessment of occupational radiation exposure for 2006 continues to show a declining trend in collective and individual doses. While the reduction in activities involving radiation at DOE sites is a primary factor in the decline in dose, the remaining work was performed at lower individual doses and well within the DOE occupational dose limits.

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

http://www.hss.energy.gov

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

Section One
Introduction

1

Introduction

The *DOE Occupational Radiation Exposure 2006 Report* analyzes occupational radiation exposures incurred by individuals at DOE facilities during 2006. This report includes occupational radiation exposure information for all DOE employees, contractors, and subcontractors, as well as members of the public who are monitored for exposure to radiation. The 95 DOE organizations submitting radiation exposure reports for 2006 have been grouped into 34 sites across the complex. This information is analyzed and trended over time to provide a measure of DOE's performance in protecting its workers from radiation.

1.1 Report Organization

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

1.2 Report Availability

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

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

- Annual Occupational Radiation Exposure Reports in pdf files since 1974
- Guidance on reporting radiation exposure information to the DOE Headquarters Radiation Exposure Monitoring System (REMS)
- Guidance on how to request a dose history for an individual
- Statistical data since 1987 for analysis
- Applicable DOE orders and manuals for the recordkeeping and reporting of occupational radiation exposure at DOE
- ALARA activities at DOE

Section One	Provides a description of the content and organization of this report.
Section Two	Provides a discussion of the radiation protection and dose reporting requirements.
Section Three	Presents the occupational radiation dose data from monitored individuals at DOE facilities for 2006. The data are analyzed to show trends over the past 5 years.
Section Four	Includes instructions to submit successful ALARA projects within the DOE complex.
Section Five	Presents conclusions based on the analysis contained in this report.
Appendices	In an effort to streamline this publication, the appendices are now offered in color on the DOE Radiation Exposure Web site. Please visit **http://www.hss.energy.gov** and select "HSS Reports" and "Occupational Radiation Exposure Reports" to review.

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Section Two

Standards and Requirements

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, DOE's Office of Health, Safety and Security establishes comprehensive and integrated programs for the protection of workers from hazards in the workplace, including ionizing radiation. The basic DOE standards are radiation dose limits, which establish maximum permissible doses to workers and members of the public. In addition to the requirement that radiation doses not exceed the limits, contractors and subcontractors are required to maintain exposures as low as reasonably achievable (ALARA).

This section discusses the radiation protection standards and requirements in effect for 2006. For more information on past requirements, visit DOE's Web site for DOE Directives, Regulations, and Standards at **http://www.hss.energy.gov**.

2.1 Radiation Protection Requirements

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

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

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

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

2.2 Radiation Dose Limits

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

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

2.3 Reporting Requirements

On August 19, 2003, DOE approved and issued the revised DOE Order 231.1A. [5] The DOE Manual 231.1-1A, [6] which details the format and content of reporting radiation exposure records to DOE, was approved on March 19, 2004. The revisions affected the content and reporting of radiation exposure records, beginning with the 2005 monitoring year. This report is the second report in the series to include data from the new DOE Manual 231.1-1A. However, it should be noted that several DOE sites are not required to report under the revised requirements since they are exempted due to imminent closure or an undue impact on the dosimetry program at sites with relatively small numbers of monitored individuals. Ninety-two out of the 95 organizations reported under the revised Manual 231.1-1A, while the remaining three organizations reported under the previous DOE Manual 231.1-1. These three organizations accounted for only 0.3% of the total monitored individuals.

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

Personnel Category	Section of 10 CFR 835	Type of Exposure	Acronym	Annual Limit
General employees	835.202	Total effective dose equivalent.	TEDE	5 rem
		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 rem
		Lens (of the eye) dose equivalent.	LDE	15 rem
		Shallow dose equivalent to the skin of the whole body or to any extremity.	SDE-WB and SDE-ME	50 rem
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.

Section Three
Occupational Radiation Dose at DOE

3

Occupational Radiation Dose at DOE

3.1 Analysis of the Data

Several indicators were identified from the data submitted to the central data repository that can be used to evaluate the occupational radiation exposures received at DOE facilities. In addition, 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 and individuals with measurable dose, collective dose, average measurable dose, and dose distribution. Analysis of individual dose data includes an examination of doses exceeding DOE regulatory limits and doses exceeding the 2 rem (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

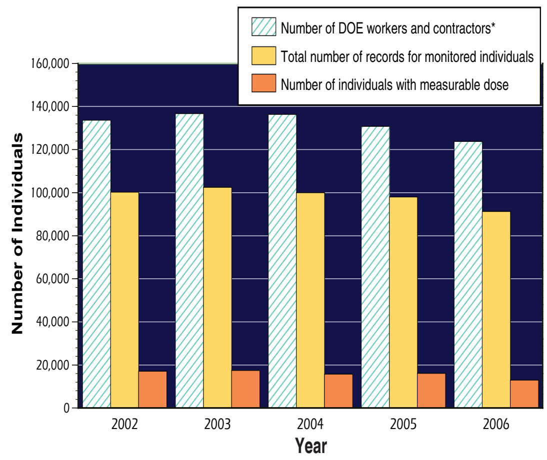
The number of records for monitored individuals represents the size of the DOE worker population provided with radiation dose monitoring. The number represents the sum of all records for monitored individuals, including all DOE employees, contractors, and subcontractors, as well as members of the public.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

3.2.2 Number of Records for Individuals with Measurable Dose

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

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

Exhibit 3-1a: Monitoring of the DOE Workforce, 2002–2006.



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

For 2006, 74% of the DOE workforce was monitored for radiation dose, and 14% of monitored individuals received a measurable dose.

For 2006, 74% of the DOE workforce was monitored for radiation exposure. Fourteen percent of monitored individuals received a measurable dose, and 86% of the monitored individuals did not receive any measurable radiation dose. Over the past five years, the percentage of individuals monitored for radiation exposure has remained within 2% of the five-year average; the percentage of monitored individuals receiving any measurable radiation dose each year was within 2% of the five-year average.

Twenty-six of the 34 reporting sites experienced decreases in the number of workers with measurable dose from 2005 to 2006. The largest decrease in total number of workers with measurable dose occurred at Rocky Flats, which ceased operations in 2005 and therefore had no workers with measurable dose in 2006. The largest increase in the number of workers receiving measurable dose occurred at Fermilab, where a number of repairs and improvements were made during an extended shutdown period. A discussion of activities at the highest-dose facilities is included in Section 3.4.3.

3.2.3 Collective Dose

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

As shown in *Exhibit 3-2*, the collective TEDE decreased at DOE by 18% from 989 person-rem (9.89 person-Sv) in 2005 to 813 person-rem (8.13 person-Sv) in 2006. Only 26% of the DOE sites (9 out of 34 sites) reported increases in the collective TEDE from the 2005 values. Four out of five of the sites that contributed to the majority of the DOE collective TEDE in 2006 reported decreases in the collective TEDE. The sites are (in descending order of collective dose for 2006) Los Alamos, Idaho, Hanford, Savannah River, and Oak Ridge.

These highest-dose sites attributed decreases in the collective dose to the following:

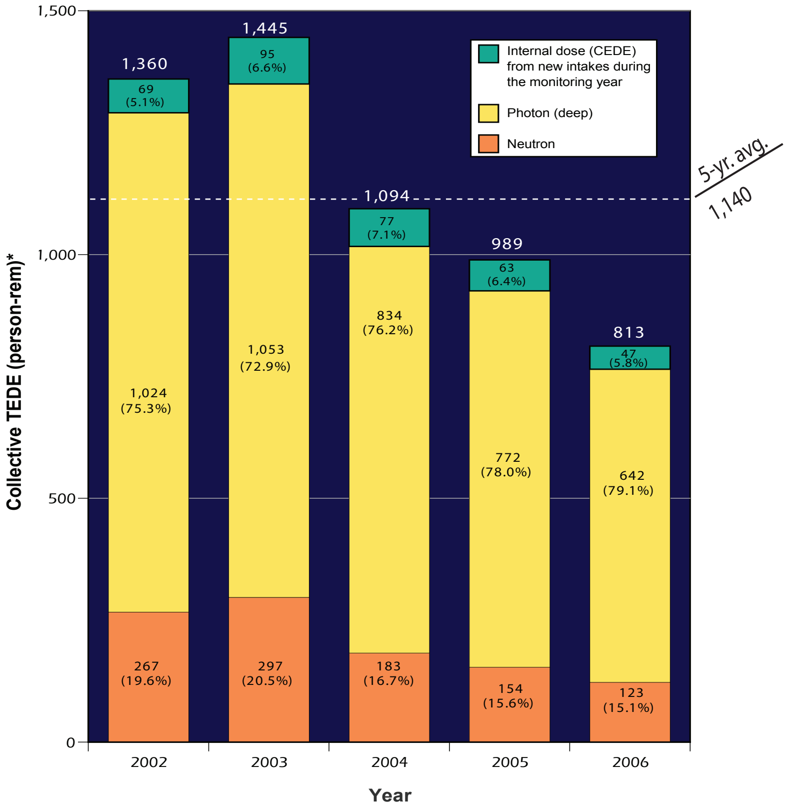
- Deactivation of facilities and a removal of radioactive and ALARA controls to reduce direct handling of transuranic drums at the Savannah River Site
- A reduction in the amount of work performed associated with the Tennessee Valley Authority off-specification fuel repackaging and other special projects at the Oak Ridge Y-12 National Security Complex (Y-12 NSC).
- A decrease in the isotope production work that took place at the Oak Ridge National Laboratory during 2006 due to an outage at the High Flux Isotope Reactor (HFIR) for the installation of the Cold Neutron Source
- A 41% reduction in the collective dose at the Advanced Mixed Waste Treatment Project (AMWTP) as a result of ALARA initiatives at Idaho

Exhibit 3-1b:
Monitoring of the DOE Workforce, 2002–2006.

Year	DOE & Contractor Workforce	Number of Workers Monitored	Percent of Workers Monitored*	Number Monitored w/Measurable Dose	Percent Monitored w/Measurable Dose*
2002	133,703	100,221	76% ▲	17,051	17%
2003	136,710	102,509	75% ▼	17,484	17%
2004	136,353	100,011	73% ▼	15,739	16% ▼
2005	130,795	98,040	75% ▲	16,136	16%
2006	123,768	91,280	74% ▼	12,953	14% ▼
5-Year Average	**132,266**	**98,412**	**74%**	**15,873**	**16%**

*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, 2002–2006.



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

The collective TEDE decreased by 18% at DOE from 2005 to 2006.

The collective internal dose decreased by 26% from 2005 to 2006.

Neutron dose decreased by 20% from 2005 to 2006.

Photon dose decreased by 17% from 2005 to 2006.

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

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

It should be noted that the internal dose shown in *Exhibit 3-2* for 2002 through 2006 is based on the 50-year CEDE methodology. The internal dose component decreased by 26% from 63 person-rem (630 person-mSv) in 2005 to 47 person-rem (470 person-mSv) in 2006. The collective internal dose can vary from year to year due to the relatively small number of intakes of radioactive material and the fact that the intakes often involve long-lived radionuclides, such as plutonium, which can result in relatively large committed doses. Due to the infrequent nature of these intakes, care should be taken when attempting to identify trends from the internal dose records.

The external deep dose (comprised of photon, energetic beta, and neutron dose) is shown in *Exhibit 3-2* in order to see the contribution of external dose to the collective TEDE. The collective photon dose decreased by 17% from 772 person-rem (7.72 person-Sv) in 2005 to 642 person-rem (6.42 person-Sv) in 2006.

The neutron component of the TEDE decreased by 20% from 154 person-rem (1.54 person-Sv) in 2005 to 123 person-rem (1.23 person-Sv) in 2006. This is due primarily to decreases in the neutron dose at the Savannah River Site (SRS) and Hanford. Hanford and SRS process plutonium, which can result in a neutron dose from the alpha/neutron reaction and from spontaneous fission of the plutonium. The neutron dose at the Hanford site decreased 46%. The majority of the site's neutron dose is from work activities at the Plutonium Finishing Plant (PFP). Overall dose at the PFP decreased as a result of the slowdown of decontamination and decommissioning of PFP facilities as priorities were shifted to the K Basins Closure Project.

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 for each dose type by the number of individuals with measurable dose for each dose type. This is one of the key indicators of the overall level of radiation dose received by DOE workers.

The average measurable TEDE is shown in *Exhibit 3-3*. The average measurable TEDE increased by 3% from 0.061 rem (0.61 mSv) in 2005 to 0.063 rem (0.63 mSv) in 2006. While the collective dose and average measurable dose serve as measures of the magnitude of the dose accrued by DOE workers, they do not indicate the distribution of doses among the worker population.

3.2.5 Dose Distribution

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

Exhibit 3-3:
Average Measurable TEDE, 2002–2006.

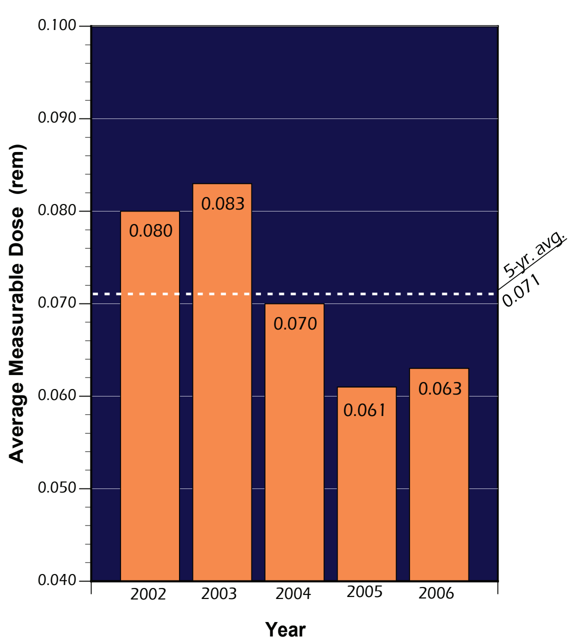


Exhibit 3-4 shows a reduction in the number of individuals in all dose ranges except for the 1–2 rem (10–20 mSv) range. Ninety-five percent of the individuals with measurable dose had doses less than 0.25 rem (2.5 mSv). It also shows that the collective TEDE increased from 2002 to 2003 but decreased by 44% from 2003 to 2006. For the first time, there were no individuals that were reported to receive a TEDE above 2 rem (20 mSv). Another way to examine the dose distribution is to analyze the percentage of the dose received above a certain dose value as compared to the total collective dose.

The United Nations' *Sources and Effects of Ionizing Radiation, United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2000 Report to the General Assembly, with Scientific Annexes, Volume I* [8] recommends the calculation of a parameter "SR" (previously referred to as CR) to aid in the examination of the distribution of radiation exposure among workers. The parameter SR is defined to be the ratio of the annual collective dose incurred by workers whose annual doses exceed 1.5 rem (15 mSv) to the total annual collective dose. The UNSCEAR report notes that a dose level of 1.5 rem (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 rem (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 rem (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.

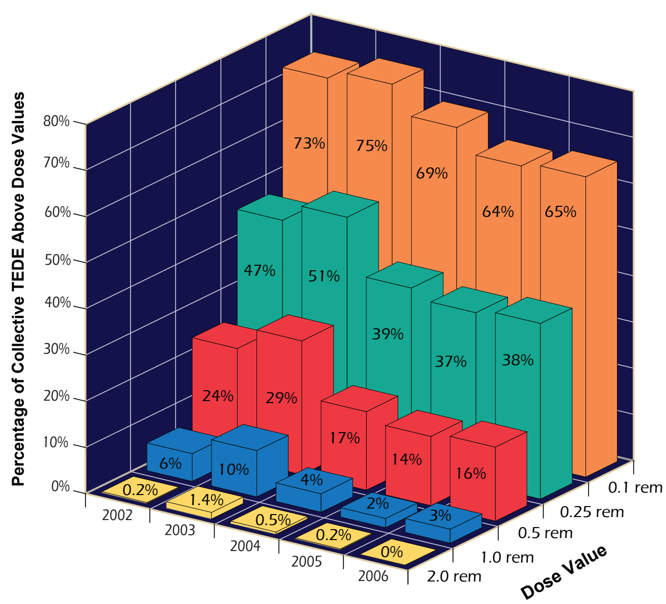
Exhibit 3-4:
Distribution of TEDE by Dose Range, 2002–2006.

	TEDE Range (rem)	2002	2003	2004	2005	2006
Number of Individuals in Each Dose Range*	Less than measurable	83,170	85,025	84,272	81,904	78,327
	measurable < 0.1	13,500	13,865	12,700	13,537	10,815
	0.10–0.25	2,202	2,205	2,086	1,753	1,441
	0.25–0.5	919	910	703	644	520
	0.5–0.75	269	287	157	141	120
	0.75–1.0	95	117	63	42	36
	1–2	65	97	28	18	21
	2–3	1	1	1	1	
	3–4			1		
	4–5					
	5–6					
	6–7					
	7–8					
	8– 9		1			
	9–10					
	10–11		1			
	11–12					
	> 12					
Total number of records for monitored Individuals		100,221	102,509	100,011	98,040	91,280
Number with measurable dose		17,051	17,484	15,739	16,136	12,953
Number with dose >0.1 rem		3,551	3,619	3,039	2,599	2,138
% of individuals with measurable dose		17%	17%	16%	16%	14%
Collective TEDE (person-rem)		1,360	1,445	1,094	989	813
Average measurable TEDE (rem)		0.080	0.083	0.070	0.061	0.063

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

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 rem (20 mSv). This graph facilitates the examination of two properties described above that may be used as indications of effective ALARA programs at DOE: (1) a relatively small percentage of the collective dose accrued in the higher dose ranges and (2) a decreasing trend over time of the 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. It should be noted that 2006 is the first year where there were no individuals reported to have received a TEDE above 2 rem (20 mSv). The decrease in the values shown in the dose distribution indicate that, in addition to a decrease in the collective dose, individuals received doses at lower dose values.

Exhibit 3-5:
Percentage of Collective TEDE Above Dose Values During 2002–2006.



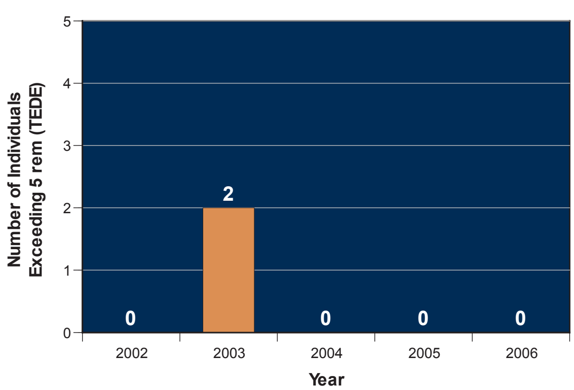
3.3 Analysis of Individual Dose Data

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 rem TEDE [50 mSv]) and the DOE recommended ACL (2 rem TEDE [20 mSv]).

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 rem [50 mSv]) from 2002 through 2006. There were no individuals that exceeded 5 rem (50 mSv) TEDE in the past three years.

Exhibit 3-6:
Number of Individuals Exceeding 5 rem (TEDE), 2002–2006.



In 2006, no individual received a dose in excess of the 5 rem (50 mSv) TEDE limit.

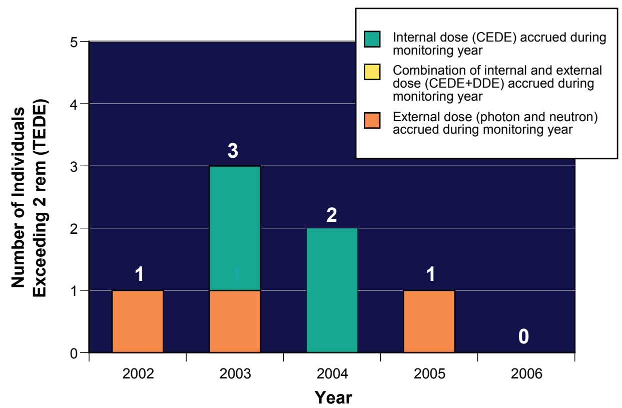
3.3.2 Doses in Excess of Administrative Control Level

The Radiological Control Standard (RCS) recommends a 2 rem (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 rem (20 mSv) ACL is a measure of the effectiveness of DOE's radiation protection program.

As shown in *Exhibit 3-7*, there were no individuals who received a TEDE above 2 rem (20 mSv) during 2006. This is the first year this has occurred since the implementation of the TEDE (defined as the summation of the CEDE and the DDE) in 1993.

In 2006, no individual received a dose in excess of the 2 rem (20 mSv) TEDE administrative control level.

Exhibit 3-7:
Number of Doses in Excess of the DOE 2 rem ACL, 2002–2006.



3.3.3 Internal Depositions of Radioactive Material

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

The number of internal depositions of radioactive material (otherwise known as worker intakes), collective CEDE, and average measurable CEDE for 2002–2006 are shown in *Exhibit 3-9*. The number of internal depositions decreased by 21% from 1,600 in 2005 to 1,260 in 2006, while the collective CEDE decreased by 26%. The average measurable CEDE decreased from 0.040 rem (0.40 mSv) in 2005 to 0.037 rem (0.37 mSv) in 2006, back down to the same values in 2003 and 2004.

Exhibit 3-8:
Doses in Excess of DOE Limits, 2002–2006.

Year	TEDE (rem)	DDE (rem)	CEDE (rem)	SDE Extremity (rem)	Intake Nuclides	Facility Types	Site*
2002	0.080	0.080	–	111		Research, General	LLNL
2003	8.170	0.949	7.221	1.302	Pu-238	Other	LANL
	10.197	0.609	9.588	0.834	Pu-238	Waste Processing	LANL
2004	None reported						
2005	None reported						
2006	None reported						

* LLNL = Lawrence Livermore National Laboratory: LANL = Los Alamos National Laboratory

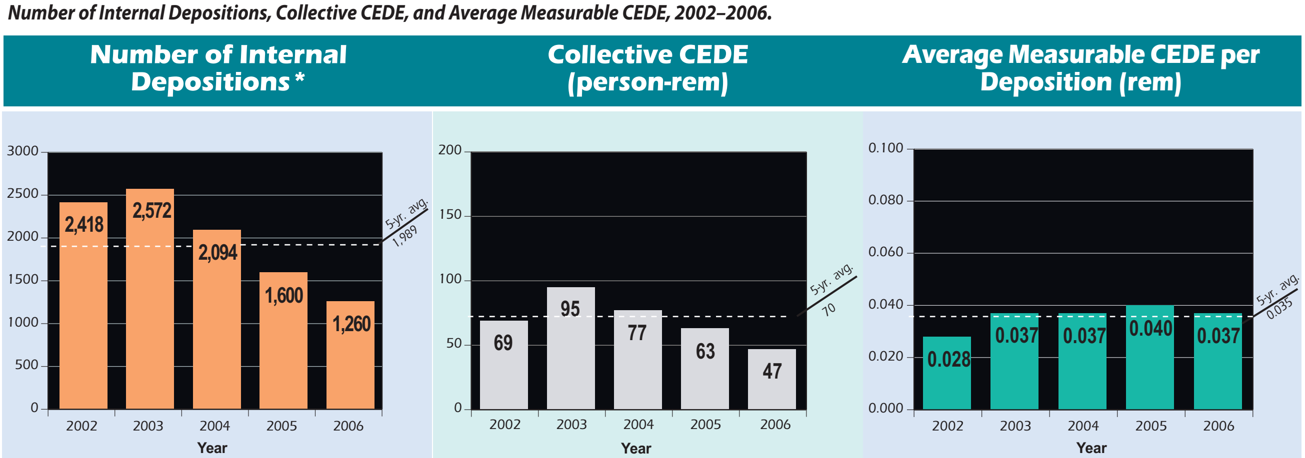
During the past 5 years, there have been several intakes from plutonium or uranium in excess of 2 rem (20 mSv) each year, with some of the doses in excess of 5 rem (50 mSv). While the numbers of internal depositions above 5 rem (20 mSv) have been few, they contributed significantly to the collective internal dose in 2003. In 2005 and 2006, there were no individuals with internal dose above 2 rem (20 mSv).

The highest collective CEDE and number of depositions in 2006 are due to uranium intakes. A majority (89%) of the collective CEDE was from uranium intakes at the Oak Ridge Y-12 NSC during the operation and management of Enriched Uranium Operations (EUO) facilities at the site. Because relatively few workers receive measurable internal dose, fluctuations in the number of workers and collective CEDE can occur from year to year.

Exhibit 3-10 shows the distribution of the internal dose from 2002 to 2006. 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 to show the large number of doses in this low-dose range. There were no internal doses above 2 rem (20 mSv) in 2005 and 2006.

The internal dose records indicate that the majority of the intakes result in very low doses. In 2006, 53% of the internal dose records were for doses below 0.020 rem (0.20 mSv). Over the five-year period, internal doses from intakes accounted for 6% of the collective TEDE, and 9% of the individuals who received internal doses were above the monitoring threshold specified (100 mrem [1 mSv]) in 10 CFR 835.402(c). [4]

Exhibit 3-9:
Number of Internal Depositions, Collective CEDE, and Average Measurable CEDE, 2002–2006.



* The number of internal depositions represents the number of internal dose records 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, 2002–2006.

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		
2002	1,534	734	131	16	3							2,418	68.690
2003	1,622	763	163	18	3		1				2	2,572	94.502
2004	1,364	521	184	12	7	3	1	1	1			2,094	77.311
2005	858	562	156	22	1	1						1,600	63.461
2006	664	474	106	15	1							1,260	47.229

*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 2005. Since this is the second year of reporting CEDE by radionuclide, type of bioassay, and number of bioassay measurements performed for the reporting year, there are not sufficient data to do a multiyear comparison or trend analysis. Urinalysis is 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. Fifty-eight percent of the urinalysis measurements were performed at four sites: Oak Ridge Y-12 NSC, Paducah, Los Alamos National Laboratory, and Hanford. All of the bioassay measurements reported as "other" were from air sampling, primarily at Fernald (66% of the measurements), Hanford, Mound, SRS, and Pantex. 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. The large number of air samples taken at Fernald is due to the fact that they provide air sampling for every worker who enters an area where thorium may be present. Work in these areas increased in 2006 during cleanup efforts.

Exhibit 3-12 shows the breakdown of the collective CEDE by radionuclide for 2006. Under the previous requirements, sites reported the radionuclides included in the determination of the CEDE, but they often reported groups or mixtures of radionuclides. Uranium-234 accounts for the largest percentage of the collective dose, with over 99% of this dose accrued at the Oak Ridge Y-12 NSC.

Exhibit 3-11:
Bioassay Measurements, 2006.

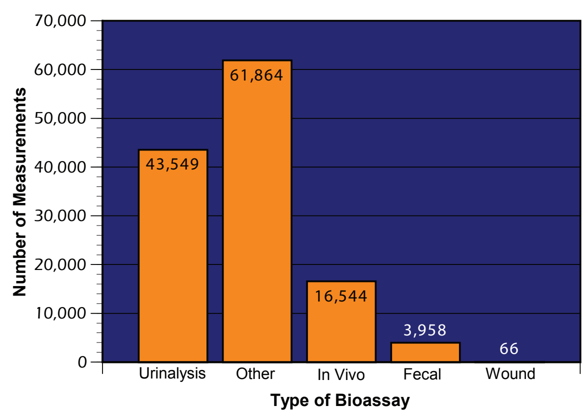
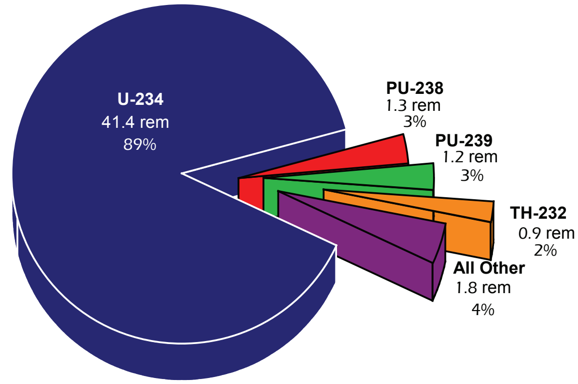


Exhibit 3-12:
Collective CEDE by Radionuclide, 2006.



3.4 Analysis of Site Data

3.4.1 Collective TEDE by Site and Other Facilities

The collective TEDE for 2004 through 2006 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*. Other small sites and facilities that do not contribute significantly to the collective dose are included within the numbers shown for site offices and other facilities. The collective TEDE decreased by 18% from 989 person-rem (9.89 person-Sv) in 2005 to 813 person-rem (8.13 person-Sv) in 2006, with LANL, Idaho, Hanford, SRS, and Oak Ridge (including East Tennessee Technology Park [ETTP], Y-12 NSC, Oak Ridge National Laboratory [ORNL], and Oak Ridge Institute for Science and Education [ORISE]) contributing 78% of the total DOE collective TEDE.

3.4.2 Changes by Site from 2005 to 2006

Exhibit 3-15 shows the collective TEDE, the number with measurable dose, the average measurable TEDE, and the percentage of the collective TEDE delivered above 0.500 rem by site for 2006, 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 Oak Ridge and Hanford in 2006.

The percentage of the collective TEDE above 0.500 rem is an indicator of the distribution of dose to individuals. As this value increases, more individuals are receiving doses above 0.500 rem. See Section 3.2.5 for more information on the characteristics of the distribution of doses to individuals above a certain dose value.

Exhibit 3-13:
Collective TEDE by DOE Site for 2004–2006.

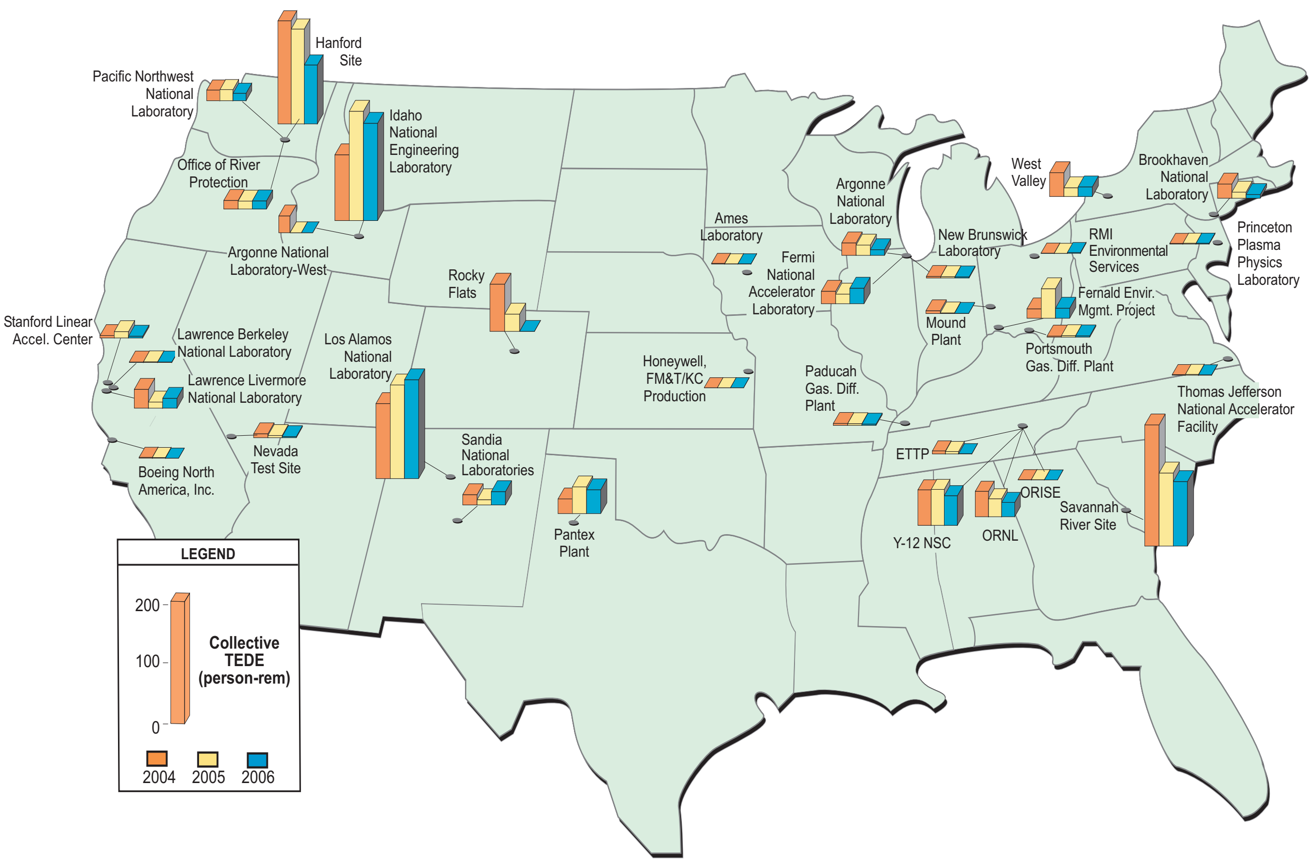


Exhibit 3-14:
Collective TEDE and Number of Individuals with Measurable TEDE by DOE Site, 2004–2006.

Site	2004 Collective TEDE (person-rem)	2004 Number with Meas. TEDE	2005 Collective TEDE (person-rem)	2005 Number with Meas. TEDE	2006 Collective TEDE (person-rem)	2006 Number with Meas. TEDE
Ames Laboratory	1.2	40	0.3	14	0.2	8
Argonne National Laboratory	20.5	172	17.0	267	9.5	158
Argonne National Laboratory–West*	28.0	326				
Boeing North America, Inc.–Research	1.3	55	1.1	29	0.0	5
Brookhaven National Laboratory	23.7	301	10.2	216	6.1	147
Fermi National Accelerator Laboratory	20.6	498	16.1	425	25.7	776
Fernald Environmental Management Project	15.5	615	48.8	846	16.8	462
Hanford:						
Hanford Site	185.8	2,049	170.8	1,828	106.1	1,451
Office of River Protection	14.0	288	13.2	272	13.5	278
Pacific Northwest National Laboratory	19.3	229	20.1	194	13.3	182
Honeywell, FM&T/KC Production	0.1	33	0.1	24	0.2	26
Idaho National Laboratory	109.5	1,471	**181.6**	2,054	161.7	2,023
Lawrence Berkeley National Laboratory	0.7	18	1.2	22	0.9	16
Lawrence Livermore National Laboratory	31.2	232	10.0	185	16.4	134
Los Alamos National Laboratory	124.5	1,709	155.4	2,168	**164.0**	1,985
Mound Plant	4.6	152	1.0	119	0.2	15
Nevada Test Site	6.6	116	3.6	71	1.8	39
New Brunswick Laboratory	0.0	1	0.2	4	0.1	2
Oak Ridge:						
East Tennessee Technology Park	5.4	240	4.4	161	0.5	22
Oak Ridge Institute for Science and Education	0.2	48	0.3	36	0.0	8
Oak Ridge National Laboratory	45.8	554	32.2	547	25.6	416
Y-12 NSC	64.1	1,335	64.8	1,277	53.3	1,171
Paducah Gaseous Diffusion Plant	3.4	41	2.8	45	2.2	25
Pantex Plant	24.3	270	44.2	334	39.7	327
Portsmouth Gaseous Diffusion Plant	1.9	32	2.6	45	2.2	40
Princeton Plasma Physics Laboratory	1.0	123	1.2	136	1.5	155
RMI Environmental Services	0.2	14	0.0	1	1.5	66
Rocky Flats Environmental Technology	77.4	1,021	28.3	1,507	–	–
Sandia National Laboratories	17.1	317	8.5	222	22.0	268
Savannah River Site	**201.2**	**2,966**	121.3	**2,360**	107.2	**2,387**
Stanford Linear Accelerator Center	3.9	149	10.4	359	3.0	102
Thomas Jefferson National Accelerator Facility	1.1	43	1.5	72	0.5	29
West Valley	39.7	241	14.5	210	16.1	189
Site Office Personnel**	1.5	97	1.3	85	0.7	41
Totals	**1,095.5**	**15,796**	**989.0**	**16,135**	**812.6**	**12,953**

* In 2005, Argonne National Laboratory–West was integrated into the Idaho National Laboratory and no longer reports as a separate facility.

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

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

Exhibit 3-15:
Site Dose Data, 2006.

	2006							
Site	Collective TEDE (person-rem)	Percent Change from 2005	Number with Meas. Dose	Percent Change from 2005	Avg. Meas. TEDE (rem)	Percent Change from 2005	Percentage of Coll. TEDE above 0.500 rem	Percent Change from 2005
Ames Laboratory	0.2	-46% ▼	8	-43% ▼	0.023	-6% ▼		
Argonne National Laboratory	9.5	-44% ▼	158	-41% ▼	0.060	-5% ▼	8%	-43% ▼
Argonne National Laboratory–West*		-						
Boeing North America, Inc.–Research	0.0	-97% ▼	5	-83% ▼	0.007	-82% ▼		
Brookhaven National Laboratory	6.1	-40% ▼	147	-32% ▼	0.042	-12% ▼		
Fermi National Accelerator Laboratory	25.7	60% ▲	776	**83%** ▲	0.033	-13% ▼	2%	
Fernald Environmental Management Project	16.8	-66% ▼	462	-45% ▼	0.036	-37% ▼		
Hanford:								
Hanford Site	106.1	-38% ▼	1,451	-21% ▼	0.073	-22% ▼	15%	-38% ▼
Office of River Protection	13.5	2% ▲	278	2% ▲	0.049	0%		
Pacific Northwest National Laboratory	13.3	-34% ▼	182	-6% ▼	0.073	-30% ▼		
Honeywell, FM&T/KC Production	0.2	74% ▲	26	8% ▲	0.006	60% ▲		
Idaho National Laboratory	161.7	-11% ▼	2,023	-2% ▼	0.080	-10% ▼	17%	30% ▲
Lawrence Berkeley National Laboratory	0.9	-21% ▼	16	-27% ▼	0.059	9% ▲		
Lawrence Livermore National Laboratory	16.4	63% ▲	134	-28% ▼	**0.122**	**125%** ▲	41%	**77%** ▲
Los Alamos National Laboratory	**164.0**	5% ▲	1,985	-8% ▼	0.083	15% ▲	34%	25% ▲
Mound Plant	0.2	-84% ▼	15	-87% ▼	0.010	24% ▲		
Nevada Test Site	1.8	-50% ▼	39	-45% ▼	0.046	-9% ▼		
New Brunswick Laboratory	0.1	-47% ▼	2	-50% ▼	0.043	6% ▲		
Oak Ridge:								
East Tennessee Technology Park	0.5	-90% ▼	22	-86% ▼	0.021	-24% ▼		
Oak Ridge Institute for Science and Education	0.0	-82% ▼	8	-78% ▼	0.006	-20% ▼		
Oak Ridge National Laboratory	25.6	-20% ▼	416	-24% ▼	0.062	5% ▲	9%	31% ▲
Y-12 NSC	53.3	-18% ▼	1,171	-8% ▼	0.045	-10% ▼	13%	
Paducah Gaseous Diffusion Plant	2.2	-21% ▼	25	-44% ▼	0.088	43% ▲		
Pantex Plant	39.7	-10% ▼	327	-2% ▼	0.121	-8% ▼		
Portsmouth Gaseous Diffusion Plant	2.2	-15% ▼	40	-11% ▼	0.056	-4% ▼		
Princeton Plasma Physics Laboratory	1.5	33% ▲	155	14% ▲	0.010	16% ▲		
RMI Environmental Services	1.5		66		0.023	11% ▲		
Rocky Flats Environmental Technology	–	-100% ▼	–	-100% ▼		-100% ▼		
Sandia National Laboratories	22.0	**158%** ▲	268	21% ▲	0.082	114% ▲	**44%**	
Savannah River Site	107.2	-12% ▼	**2,387**	1% ▲	0.045	-13% ▼	1%	-77% ▼
Stanford Linear Accelerator Center	3.0	-71% ▼	102	-72% ▼	0.030	3% ▲		
Thomas Jefferson National Accelerator Facility	0.5	-65% ▼	29	-60% ▼	0.018	-12% ▼		
West Valley	16.1	11% ▲	189	-10% ▼	0.085	23% ▲		
Site Office Personnel**	0.7	-45% ▼	41	-52% ▼	0.018	14% ▲		
Totals	**812.6**	**-18%** ▼	**12,953**	**-20%** ▼	**0.063**	**2%** ▲	**16%**	**8%** ▲

* In 2005, Argonne National Laboratory–West was integrated into the Idaho National Laboratory and no longer reports as a separate facility.

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

Note: Boxed and bolded values indicate the greatest value in each column. Up arrows indicate an increase in change. Down arrows indicate a decrease in change.

3.4.3 Activities Significantly Contributing to Collective Dose in 2006

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 2006. These sites (Los Alamos, Idaho, Hanford, Savannah River, and Oak Ridge) had a collective dose near 100 person-rem and were the top contributors to the collective TEDE in 2006. These sites comprised 78% of the total collective TEDE at DOE. Four of the sites reported decreases in the collective TEDE, which contributed to an 18% decrease in the DOE collective TEDE from 989 person-rem (9.89 person-Sv) in 2005 to 813 person-rem (8.13 person-Sv) in 2006. The sites significantly contributing to the collective TEDE in 2006 are shown in *Exhibit 3-16*, including a description of activities that affected the collective TEDE.

The collective dose at LANL exhibited an upward trend for the third year in a row. From 2005 to 2006 it increased by 5% resulting in the highest collective dose at DOE for 2006. The activities contributing to this increase are presented in Exhibit 3-16.

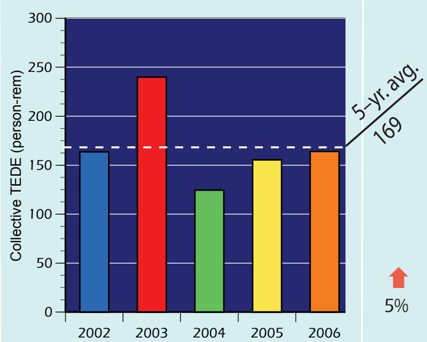
Idaho National Laboratory had the 2nd highest collective dose in 2006, and although the collective dose decreased from 2005 to 2006, it remained well above the value for 2004. One contributing factor to the increase from 2004 to 2005 was the integration of Argonne National Laboratory (West) with Idaho National Laboratory.

In previous annual reports, Rocky Flats has been included among the top contributors to the collective TEDE. In the fall of 2005, the site ceased all operations involving radioactive material and therefore did not contribute at all to occupational radiation exposure during 2006. The closure of Rocky Flats contributed to an estimated 16% of the reduction in the collective dose at DOE from 2005 to 2006 as determined by the collective dose reported by Rocky Flats in 2005.

As noted in last year's annual report, Fernald experienced a 216% increase between 2004 and 2005 due to the treatment of radioactive material from two storage silos. These activities were completed in May 2006, and, as anticipated, the collective dose decreased by 66% from 2005 to 2006.

Exhibit 3-16:
Activities Significantly Contributing to Collective TEDE in 2006.

Los Alamos National Lab.



Percent Change*		
2005-2006 (last yr.)	2004-2006 (3 yr.)	Since 2002 (5 yr.)
↑ 5%	↑ 32%	↑ <1

Description of Activities at the Site

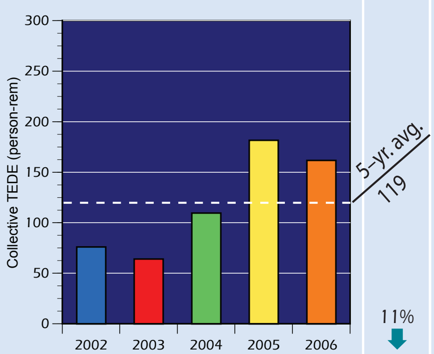
The collective TEDE at LANL increased 6% from 155.4 person-rem in 2005 to 164.0 person-rem in 2006, resulting in the highest collective dose at DOE for 2006.

In mid-December 2005, an event occurred regarding the failure of a container of radioactive materials at the Plutonium Facility. During 2006, the recovery from this event, the compensatory measures established to prevent future contaminations, and increased emphasis on working off older containers of radioactive material caused a commensurate increase in dose to affected organizations.

In late February 2006, discrepancies were found regarding the fire suppression system at the Plutonium Facility. Programmatic work was suspended, and all efforts were focused on resolving these discrepancies. There was a commensurate reduction in programmatic dose during this period, but infrastructure and support organizations experienced a commensurate increase in dose.

In addition to typical Plutonium Facility operations, significant portions of LANL dose were accrued by workers performing maintenance at LANSCE (the linear accelerator), and those supporting retrieval, repackaging, and shipping radioactive solid waste to the Waste Isolation Pilot Plant.

Idaho



Percent Change*		
2005-2006 (last yr.)	2004-2006 (3 yr.)	Since 2002 (5 yr.)
↓ 11%	↑ 48%	↑ 113%

Description of Activities at the Site

The collective TEDE at the Idaho National Laboratory decreased by 11% from 2005 to 2006. Idaho National Laboratory had the 2nd highest collective dose in 2006, and although the collective dose decreased from 2005 to 2006, it remained well above the value for 2004.

The primary Idaho Cleanup Project activities, performed by CH2M-WG Idaho, LLC, leading to radiation exposure included deactivation and grouting activities at the CPP-603 fuel storage basins; cleanup and decontamination and decommissioning activities at Test Area North including disposal of deactivated tanks at Idaho Cercla Disposal Facility; Voluntary Consent Order and D&D activities at Reactor Technology Complex including decontamination of the Engineering Test Reactor primary/secondary cubicles; and activities in support of closure of tank farm vessels at Idaho Nuclear Technology and Engineering Center.

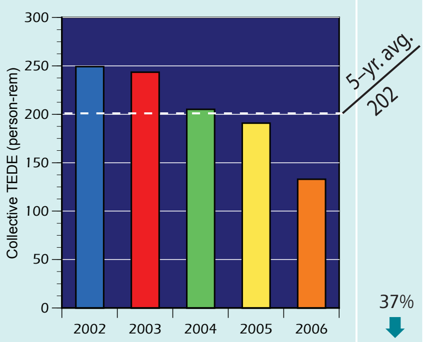
The radiation exposure activities performed by Battelle Energy Alliance during 2006 at the Idaho National Laboratory included Advanced Test Reactor power operations and maintenance (i.e., loop maintenance and decontamination and primary heat exchanger inspections and repair; research and development activities; hot cell and laboratory operations; and homeland security training and exercises).

Bechtel BWXT Idaho, LLC (Advanced Mixed Waste Treatment Project): Bechtel BWXT Idaho's 2006 work activities continued direct support of the 1995 Idaho/U.S. Navy/U.S. DOE Settlement Agreement requiring the removal of TRU waste from DOE's Idaho operation areas. 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 TRU and by-product waste materials from Idaho to DOE's Waste Isolation Pilot Plant facility and other commercial disposal sites. Through ALARA initiatives outlined in Lessons Learned #2007-ID-AMWTP-002, the AMWTP was able to achieve a TEDE reduction of over 41% from 2005 to 2006. These activities resulted in the shipment of over 6,600 cubic meters of TRU waste out of Idaho.

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

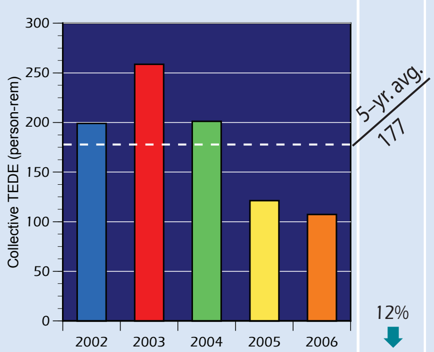
Exhibit 3-16 (Continued):
Activities Significantly Contributing to Collective TEDE in 2006.

Hanford



Percent Change*			Description of Activities at the Site
2005-2006 (last yr.)	**2004-2006 (3 yr.)**	**Since 2002 (5 yr.)**	
37% ↓	42% ↓	52% ↓	The collective dose at the Hanford Site (which does not include the dose from the Office of River Protection) decreased by 37% from 2005 to 2006. The largest contributors to the collective TEDE at Hanford were the K Basins Closure Project (removal of contaminated equipment from the basins and retrieval of sludge) (34%), Waste Stabilization and Disposal Project (retrieval, processing, and shipment of transuranic waste, and the solidification of K Basins sludge (26%), Tank Farm activities (10%), Pacific Northwest National Laboratories activities (10%), the Plutonium Finishing Plant (PFP) Closure Project (decontamination and decommissioning [D&D] of PFP facilities) (8%), and other D&D projects (5%). The neutron dose at the Hanford site decreased 46%. The majority of the site's neutron dose is from work activities at the PFP. Overall dose at the PFP decreased as a result of the slowdown of D&D of PFP facilities, as priorities were shifted to the K Basins Closure Project.

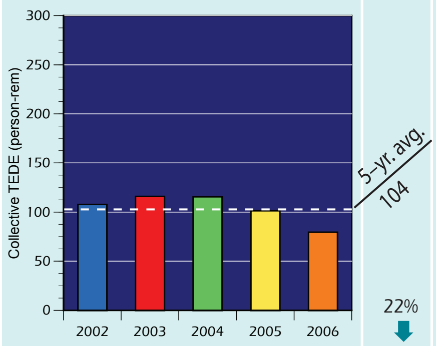
Savannah River Site



Percent Change*			Description of Activities at the Site
2005-2006 (last yr.)	**2004-2006 (3 yr.)**	**Since 2002 (5 yr.)**	
12% ↓	47% ↓	46% ↓	The collective TEDE at Savannah River decreased 12% from 2005 to 2006. The Savannah River Site continued with deactivation of facilities, de-inventory of material that was secured and stored by the end of the second quarter, start-up of the Saltstone process, which occurred later than planned, and ALARA controls to reduce direct handling of transuranic drums. These activities proved effective in reducing radiological source terms and time spent by employees in areas of elevated radiation exposure. In other site facilities, employee dose increased with the addition of emergent and/or expanded work activities. Examples of increased dose work activities included mechanical cleaning of a high-level waste evaporator, high-level waste transfer line repairs, process equipment line repair and replacement, high-level waste tank sampling, drum repackaging activities of transuranic wastes for disposition at the Waste Isolation Pilot Plant, and plutonium packaging support work. These increases were more than offset by decreases in other radiological activities.

* 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 2006.

Oak Ridge Reservation	Percent Change*: 2005-2006 (last yr.)	Percent Change*: 2004-2006 (3 yr.)	Percent Change*: Since 2002 (5 yr.)	Description of Activities at the Site
	22% ⬇	31% ⬇	26% ⬇	The collective TEDE at the Oak Ridge Reservation decreased 22% from 101.4 person-rem in 2005 to 79.5 person-rem in 2006. For the purposes of this exhibit, the Oak Ridge Reservation includes ORNL, Y-12 NSC, and East Tennessee Technology Park (ETTP, formerly known as K-25). <u>BWXT Y-12</u>: The 2006 collective DDE for the Y-12 complex decreased by 13.2% from 13.5 person-rem in 2005 to 11.7 person-rem in 2006. This decrease is a result of a reduction in the amount of work performed associated with the TVA Off-Specification Fuel repackaging and other special projects. Average DDE decreased from 0.0026 rem in 2005 to 0.0023 rem in 2006. Collective CEDE decreased 19.2% from 51.3 person-rem in 2005 to 41.4 person-rem in 2006, while the average CEDE decreased 15.0% from 0.020 rem in 2005 to 0.017 rem in 2006. Of the 2,451 workers monitored for internal exposure, there were 109 workers who received an internal dose in excess of 100 mrem (CEDE). Collective TEDE decreased 17.9% from 2005 (64.8 person-rem) to 2006 (53.2 person-rem), while the total persons monitored decreased by 4.6% from 5,228 to 4,988. The average TEDE decreased. <u>Oak Ridge National Laboratory:</u> The collective TEDE for ORNL decreased by 17.7% from 2005 to 2006. This decrease can be attributed to a decrease in the isotope production work that took place at ORNL during 2006 due to an outage at HFIR for the installation of the Cold Neutron Source. <u>Bechtel Jacobs Company, LLC (BJC):</u> The BJC collective TEDE decreased by 44% from 2005 to 2006. The BJC scope of work included activities at all three Oak Ridge sites—ETTP, ORNL, and Y-12 NSC for 2006. The major activities performed at the BJC sites consisted of environmental restoration work, removal or stabilization of buried hazardous wastes, decontamination of facilities, surveillance and maintenance tasks, stabilization of inactive facilities, and demolition of surplus facilities.

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

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 purposes 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 dose received by these individuals.

Exhibit 3-17 shows the dose distribution and total number of transient individuals from 2002 to 2006. Over the past five years, the records of transient individuals have averaged 2.7% of the total records for all monitored individuals at DOE, who received, on an average, 3% of the collective dose. The collective dose for transients decreased by 36% from 39.8 person-rem (398 person-mSv) in 2005 to 25.5 person-rem (255 person-mSv) in 2006. The decrease was due primarily to decreases in dose to transient workers at LANL, Idaho, and Hanford and the cessation of activities at Rocky Flats. The average measurable TEDE increased from 0.049 rem (0.49 mSv) in 2005 to 0.056 rem (0.56 mSv) in 2006. Since 1993, these parameters have remained relatively constant, even though DOE has become extensively involved in decontamination and decommissioning (D & D) activities and other types of operations.

3.6 Historical Data

3.6.1 Prior Years

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

Exhibits 3-18 and *3-19* show the collective dose, average measurable dose, and number of workers with measurable dose from 1974 to 2006. As can be seen from the graph, 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.

Exhibit 3-17:
Dose Distribution of Transient Workers, 2002–2006.

	Dose Ranges (TEDE in rem)	2002	2003	2004	2005	2006
Transients	Less than measurable dose	2,298	2,063	1,917	2,067	1,888
	Measurable < 0.1	470	492	439	715	412
	0.10–0.25	50	59	52	79	24
	0.25–0.5	12	23	9	13	9
	0.5–0.75	11	9	4	3	4
	0.75–1.0	5	7		2	3
	1.0–2.0	2	12	1	1	2
	Total number of individuals monitored*	2,848	2,665	2,422	2,880	2,342
	Number with measurable dose	550	602	505	813	454
	% with measurable dose	19%	23%	21%	28%	19%
	Collective TEDE (person rem)	36.477	56.141	25.609	39.757	25.532
	Average measurable TEDE (rem)	0.066	0.093	0.051	0.049	0.056
All DOE	Total number of records for monitored individuals	100,221	102,509	100,011	98,040	91,280
	Number with measurable dose	17,051	17,484	15,739	16,136	12,953
	% of total monitored who are transient	2.8%	2.6%	2.4%	2.9%	2.6%
	% of the number with measurable dose who are transient	3.2%	3.4%	3.2%	5.0%	3.5%

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

Exhibit 3-18:
Collective Dose and Average Measurable Dose, 1974–2006.

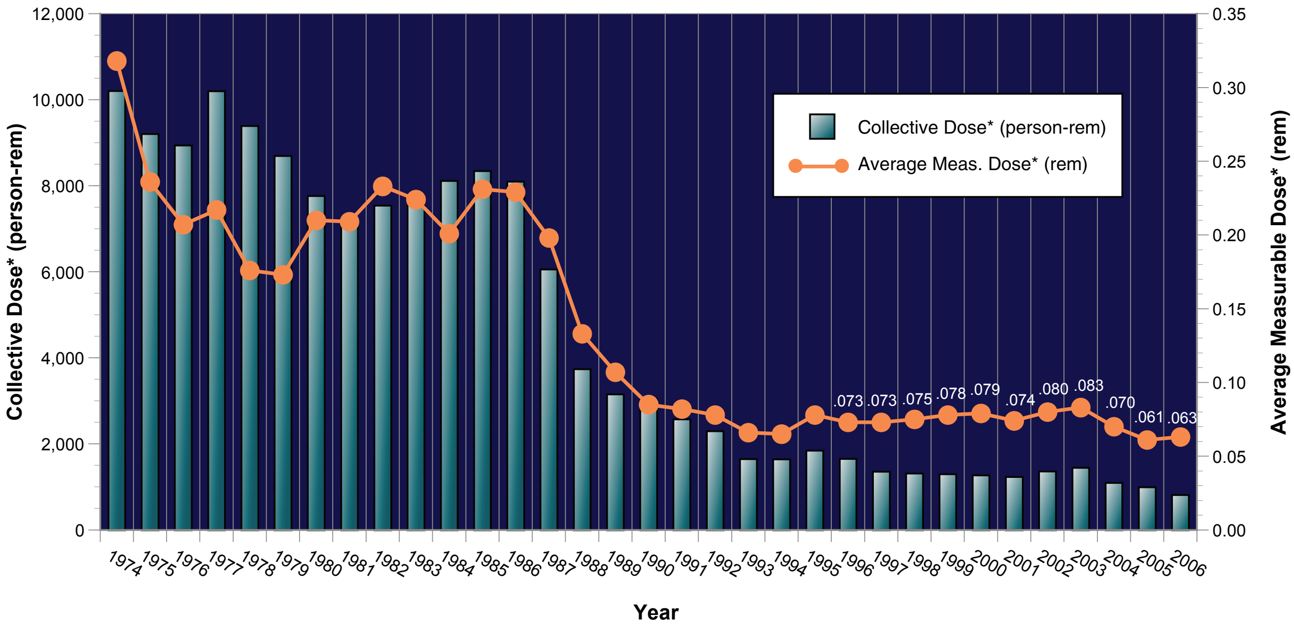
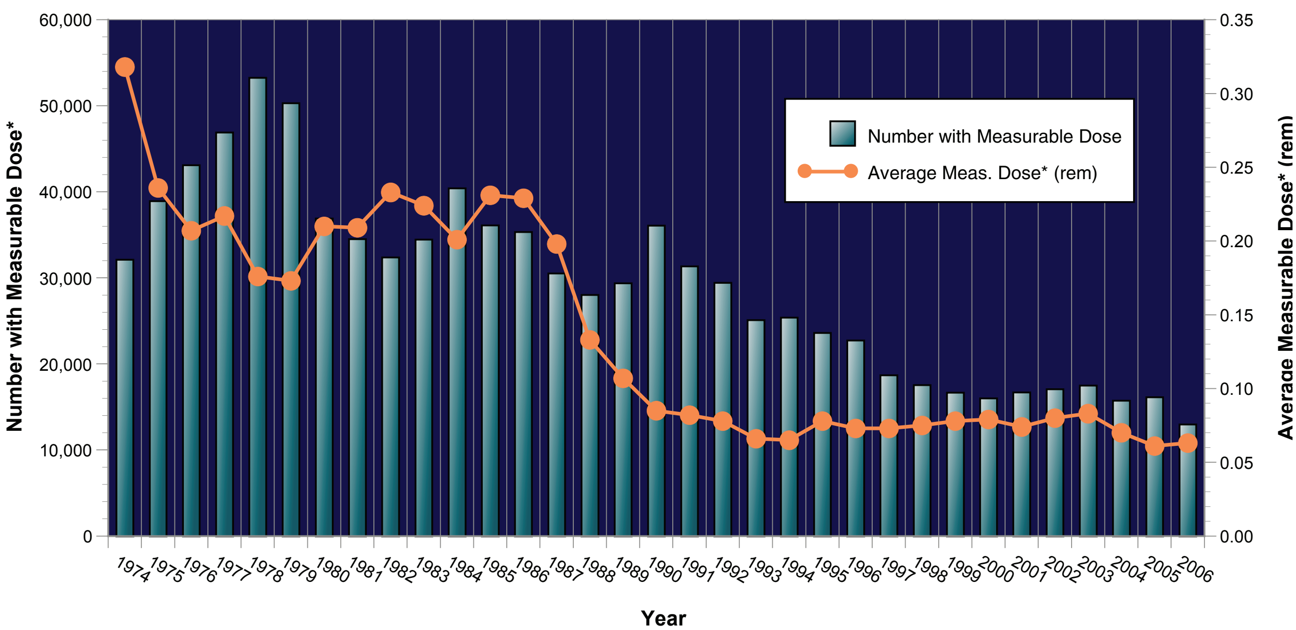


Exhibit 3–19
Number of Workers with Measurable Dose and Average Measurable Dose, 1974–2006.



* 1974–1989 collective dose = DDE
1990–1992 collective dose = DDE + AEDE
1993–2006 collective dose = DDE + CEDE

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

3.6.2 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. No additional sites have reported historical data during the year 2006.

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

Sites that have voluntarily reported historical data are as follows:

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

Section Four

ALARA Activities at DOE

4

In past years, the published annual report has included descriptions of ALARA activities at DOE for the purposes of sharing strategies and techniques that have shown promise in the reduction of radiation exposure. For 2006, these ALARA activity descriptions have been moved to the HSS REMS Web site to facilitate the dissemination among DOE radiation protection managers and others interested in these project descriptions. Readers should be aware that the project descriptions are voluntarily submitted from the sites and are not independently verified or endorsed by DOE. Program and site offices and contractors who are interested in benchmarks of success and continuous improvement in the context of integrated safety management and quality are encouraged to provide input.

4.1 Submitting ALARA Project Descriptions for Future Annual Reports

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

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

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

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

4.2 Lessons Learned Process

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

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

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

The specific Web site address may be subject to change. Information services can be accessed through the Office of Health, Safety and Security Web site as follows:

http://www.hss.energy.gov

Section Five

Conclusions

5

Conclusions

The collective dose at DOE facilities has experienced a dramatic (90%) decrease since 1986. The main reasons for this large decrease are 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.

Over the past 10 years, the collective dose and exposed workforce size have remained at fairly stable levels. For the past three years, there has been a decreasing trend in almost all of the indicators used in the analysis of occupational exposure. Most of this decrease has been attributed to the completion of cleanup activities at various facilities. In particular, the closure of Rocky Flats in 2005 contributed to reductions in the collective dose for 2005 and 2006.

The detailed nature of the data available has made it possible to investigate distribution and trends in data and to identify and correlate parameters having an effect on occupational radiation exposure at DOE sites. A summary of the findings for 2006 is shown in *Exhibit 5-1*.

Exhibit 5-1:
2006 Radiation Exposure Fact Sheet.

- The collective TEDE decreased 18% from 989 person-rem (9.89 person-Sv) in 2005 to 813 person-rem (8.13 person-Sv) in 2006.
- Sites contributing significantly to collective dose were (in descending order of collective dose) Los Alamos, Idaho, Hanford, Savannah River, and Oak Ridge. These sites accounted for 78% of the collective dose at DOE in 2006.
- Decreases in collective dose at four of the highest dose sites were attributed to deactivation of facilities and a removal of radioactive material, delayed start-up of the Saltstone process, and ALARA controls to reduce direct handling of TRU drums at the SRS; a reduction in the amount of work performed associated with the TVA off-specification fuel repackaging and other special projects at the Oak Ridge Y-12 NSC; a decrease in the isotope production work that took place at ORNL during 2006 due to an outage at the HFIR for the installation of the Cold Neutron Source; and a 41% reduction in the collective dose at the AMWTP as a result of ALARA initiatives at Idaho.
- There were no exposures in excess of the DOE 5 rem (50 mSv) annual TEDE limit.
- There were also no exposures in excess of the DOE ACL of 2 rem (20 mSv) TEDE. This is the first year this has occurred since the implementation of the TEDE (defined as the summation of the CEDE and the DDE) in 1993.
- The collective internal dose (CEDE) decreased by 26% between 2005 and 2006.
- The collective dose for transient workers decreased by 36% from 39.8 person-rem (398 mSv) in 2005 to 25.5 person-rem (255 mSv) in 2006. The decrease was due primarily to decreases in dose to transient workers at LANL, Idaho, and Hanford and the cessation of activities at Rocky Flats.
- The total number of bioassay measurements performed increased by 40% from 89,725 in 2005 to 125,981 in 2006. The largest portion of this increase was due to an increase in air sampling measurements at Fernald in work areas where workers are potentially exposed to thorium. Urinalysis accounted for 35% of the bioassay measurements. Eighty-nine percent of the collective CEDE was attributed to U-234, with over 99% of this dose accrued at the Oak Ridge Y-12 NSC.

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Glossary

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

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

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

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

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

Committed Dose Equivalent (CDE) (HT,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) (HE,50)
The sum of the committed dose equivalents to various tissues in the body (HT,50), each multiplied by the appropriate weighting factor (wT) (i.e., HE,50 = wTHT,50). CEDE is expressed in units of rem.

CR See SR.

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

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

Effective Dose Equivalent (HE)
The summation of the products of the dose equivalent received by specified tissues of the body (HT) and the appropriate weighting factor (wT)(i.e., HE = wTHT). It includes the dose from radiation sources internal and/or external to the body. The effective dose equivalent is expressed in units of rem.

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

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

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

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

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

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

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

Total Effective Dose Equivalent (TEDE)
The sum of the effective dose equivalent for external exposures and the committed effective dose equivalent for internal exposures. Deep dose equivalent to the whole body is typically used as effective dose equivalent for external exposures. The internal dose component of TEDE changed from the annual effective dose equivalent (AEDE) to the committed effective dose equivalent (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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6. DOE Manual 231.1-1A, 2004, "Environment, Safety and Health Reporting Manual," Approved March 19, 2004.

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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 Occupational Radiation Exposure Report. **Your feedback is important.** Constructive feedback will ensure the report can continue to meet user needs. Please fill out the attached survey form and return it to

Ms. Nirmala Rao
DOE HS-32 270 / CC
19901 Germantown Road
Germantown, MD 20874
nimi.rao@hq.doe.gov
Fax: (301) 903-1257

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

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   Title:...

   Mailing Address:..

   ....

   ....

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2. Distribution:

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

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

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

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

Executive Summary	1	2	3	4	5
Aggregate Data Analysis	1	2	3	4	5
Collective dose	1	2	3	4	5
Average measurable dose	1	2	3	4	5
Dose distribution	1	2	3	4	5
Dose to Individuals	1	2	3	4	5
Doses above 2 rem ACL	1	2	3	4	5
Doses in excess of 5 rem	1	2	3	4	5
Internal depositions of radioactive material	1	2	3	4	5
Analysis of Site Data	1	2	3	4	5
Collective dose by site	1	2	3	4	5
Description of activities related to dose	1	2	3	4	5
Historical data	1	2	3	4	5
ALARA activities at DOE	1	2	3	4	5
Conclusions	1	2	3	4	5

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

Not important				Critical
1	2	3	4	5

Please provide any additional input or comments on the report.

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