DOE/EH-0533

DOE Occupational Radiation Exposure

Report

1992-1994

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Foreword

Foreword

The goal of the U.S. Department of Energy (DOE) is to conduct its radiological operations to ensure the health and safety of all DOE employees including contractors and subcontractors, and the general public. The DOE strives to maintain radiation exposures to its workers and the public and releases of radioactivity to the environment below administrative control levels and DOE limits and to further reduce these exposures and releases to levels that are As Low As Reasonably Achievable (ALARA).

The DOE Occupational Radiation Exposure Report, 1992-1994 provides summary and analysis of the occupational radiation exposure received by individuals associated with DOE activities. The DOE mission includes stewardship of the nuclear weapons stockpile and the associated facilities, environmental restoration of DOE and precursor agency sites, and energy research. Collective exposure at DOE has continued to decline for many reasons including: a pause in opportunities for exposure during the transition in DOE mission from weapons production to cleanup, deactivation, and decommissioning, and changes in reporting requirements and dose calculation methodology.

This report is the culmination of a significant effort in cooperation with the field to re-engineer the DOE Occupational Radiation Exposure Report. The intent is to make this report a valuable tool for managers in their management of radiological safety programs and commitment of resources. The process of data collection, analysis, and report generation is being streamlined to give managers a current assessment of the performance of the Department with respect to radiological operations. The cooperation of the sites in promptly reporting field radiation exposure information is key to the timeliness of this report.

Your feedback and comments are important to us to make this report meet your needs. A user survey form is included in Appendix E to collect your suggestions to improve this report.

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Acknowledgments

The Office of Worker Health and Safety wishes to gratefully acknowledge the assistance of several organizations that contributed to the revision of this report.

- The participants of the Annual Report Workshop conducted at DOE Headquarters in October 1995 that resulted in the core set of recommendations for this report.
- Pacific Northwest Laboratory for their work on previous reports and experience with the REMS data.
- Program Management Inc. for support in the analysis of the exposure information.
- NIOSH for reviewing and participating in the annual report working group.
- The U.S. Nuclear Regulatory Commission for project and computer systems support.
- This report was developed and prepared by Science Applications International Corporation.

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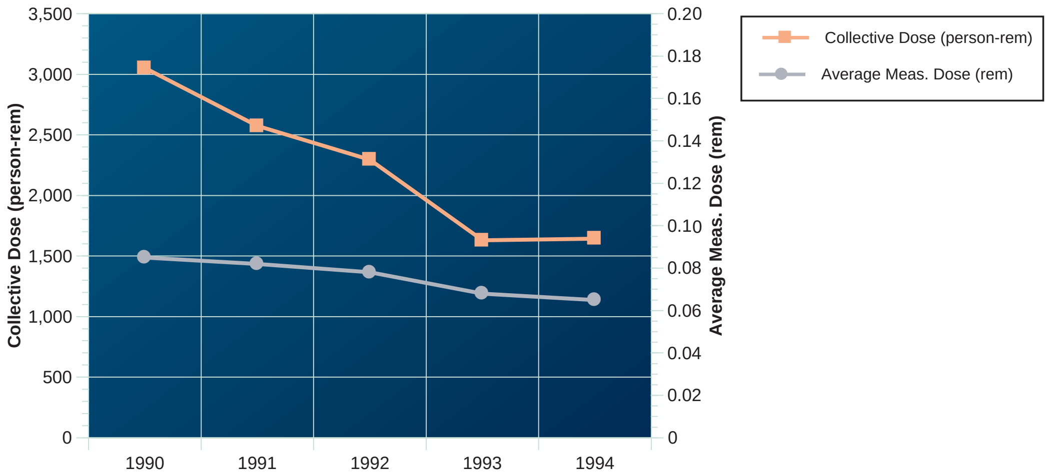
Executive Summary

This report is the result of a re-engineering process initiated by the U.S. Department of Energy (DOE) Office of Environment, Safety and Health (EH) to improve the DOE Occupational Radiation Exposure Report and associated database. The intent is to make this report a valuable tool for DOE/DOE contractor managers in their management of radiological safety programs and to assist them in the prioritization of resources. We appreciate the efforts and contributions from the various stakeholders within and outside the DOE and hope we have succeeded in making the report more useful.

The DOE Occupational Radiation Exposure Report, 1992-1994 presents an overview of the radiation exposure received by DOE employees, contractors, subcontractors, and the general public. The exposure information is analyzed in terms of collective data, dose to individuals, and dose by site. For the purposes of examining trends, data for the past 5 years are included in the analysis.

As shown in the figure below, the DOE collective total effective dose equivalent (TEDE) declined by 28% between 1992 and 1994. The number of individuals receiving measurable dose dropped by 14% between 1992 and 1994. Average dose to workers with measurable dose also declined 17% between 1992 and 1994.



Nearly 80% of the collective TEDE for the DOE complex was accrued at just six DOE sites. These six sites are Savannah River, Rocky Flats, Hanford, Los Alamos, Idaho, and Oak Ridge. Weapons fabrication and testing facilities account for the highest collective dose. Technicians receive the highest collective dose of any labor category.

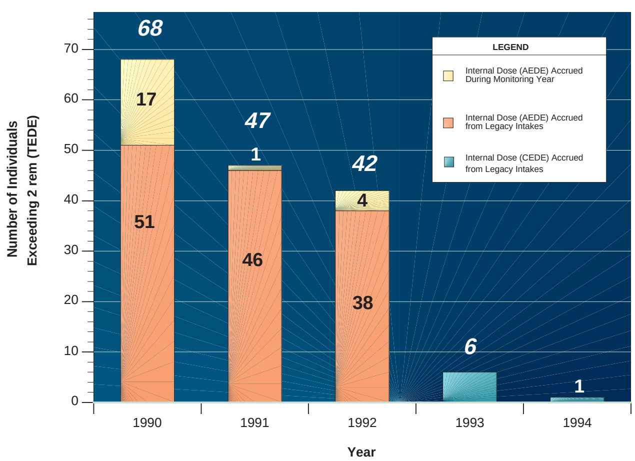
Occupational radiation exposure at DOE has been impacted over the past 5 years by changes in:

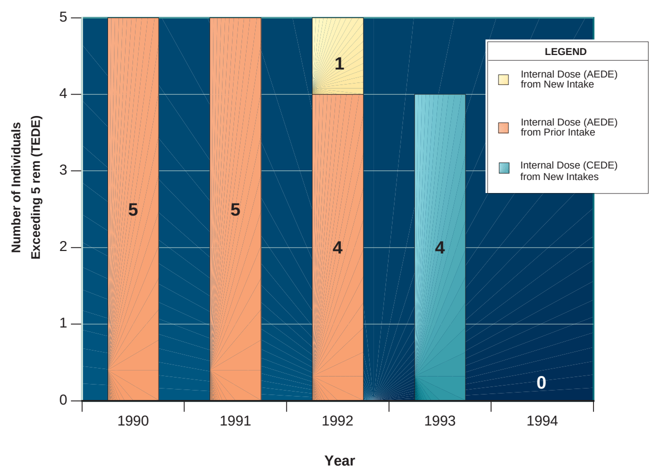
- operational status of DOE facilities,
- reporting requirements, and
- radiation protection standards and practices.

Changes in operational status of facilities is the predominant driver behind changes in the collective dose. As facilities are shut down and undergo transition from operation to stabilization or decommissioning and decontamination, there are significant reductions in the opportunities for individuals to be exposed. Changes in operational status resulted in a large reduction in dose in the late 1980s as many facilities were shut down (see Section 3.6).

There have also been changes in the reporting requirements that have had a significant impact on the collective dose at DOE. The change in internal dose methodology from annual effective dose equivalent (AEDE) to committed effective dose equivalent (CEDE) between 1992 and 1993 resulted in an apparent reduction of the collective TEDE by up to 28% because the dose from prior intakes is no longer reported.

Radiation protection practices have changed during the past 5 years because of the implementation of the DOE Radiological Control (RadCon) Manual. The RadCon Manual changed the methods of determining internal dose, established Administrative Control Levels (ACLs), standardized radiation protection programs, and formalized "As Low As Reasonably Achievable" (ALARA) practices. Doses in excess of ACLs and doses in excess of the DOE TEDE limit have decreased over the past 5 years, as shown in the figures below. There were no individuals with doses in excess of the DOE dose limits in 1994. Most of this decrease is because of the change in the method of determining internal dose.





The average dose at DOE is one-fifth of the average dose received in the commercial nuclear industry in the United States. In addition, doses to individuals in the higher dose ranges continue to decrease.

As a result of the analysis presented in this report, several recommendations are made.

- Because of the significance of changes in operational status, a "phase of operation" code should be added to the data reported to allow for further analysis of this information.
- Standardization in the use of facility type codes is also needed.
- DOE should establish a repository of intake information to allow for analysis of the legacy dose that is no longer reported.
- DOE should proceed to implement standardization of internal dosimetry through an accreditation process.

Section One

1

Introduction

Introduction

The *DOE Occupational Radiation Exposure Report, 1992-1994* reports occupational radiation exposures incurred by individuals at U.S. Department of Energy (DOE) facilities from 1992 through 1994. This report includes occupational radiation exposure information for all DOE employees, contractors, subcontractors, and visitors. This information is analyzed and trended over time to provide a measure of the DOE's performance in protecting its workers from radiation.

Occupational radiation exposure at DOE has been decreasing over the past 5 years. In particular, doses in the higher dose ranges are decreasing, including the number of doses in excess of the DOE limits and doses in excess of the 2 rem Administrative Control Level (ACL). This is an indication of greater attention being given to protecting these individuals from radiation in the workplace.

However, the analysis of trends is complicated by recent changes in internal dose reporting methodology and the shifting of the DOE mission from production of weapons to stabilization and clean-up activities across the DOE complex.

The change in internal dose reporting and its impact on the occupational exposure data are examined in Sections 2 and 3. An analysis of the change in mission and operational status of certain DOE facilities in relation to radiation exposure is included in Section 3.6.

In general, the occupational radiation exposure received by DOE workers is low compared to DOE exposures in prior years, particularly during the Cold War era, and in comparison with occupational exposure received in the commercial nuclear industry. Implementation of "As Low As Reasonably Achievable" (ALARA) activities at DOE sites is a key component of the DOE's radiation protection strategy.

1.1 Report Organization

This report is organized into the six sections listed below.

Supporting technical information, tables of data, and additional items that were identified by users as useful are provided in the appendices.

Section One	Provides the introduction of re-engineering efforts and organization of the report.
Section Two	Provides a discussion of the radiation protection and dose reporting requirements and their impacts on data interpretation. Additional information on dose calculation methodologies, personnel monitoring methods and reporting thresholds, regulatory dose limits, and ALARA are included.
Section Three	Presents the occupational radiation dose data from monitored individuals at DOE facilities from 1992 through 1994. The data are analyzed to show trends over the past 5 years.
Section Four	Compares the occupational radiation dose received within the DOE complex to other radiation protection programs around the world.
Section Five	Includes examples of successful ALARA projects within the DOE complex.
Section Six	Conclusions are presented based on the analysis contained in this report. Where applicable, recommendations are included to address issues that require attention.

1.2 Annual Report Improvement Process

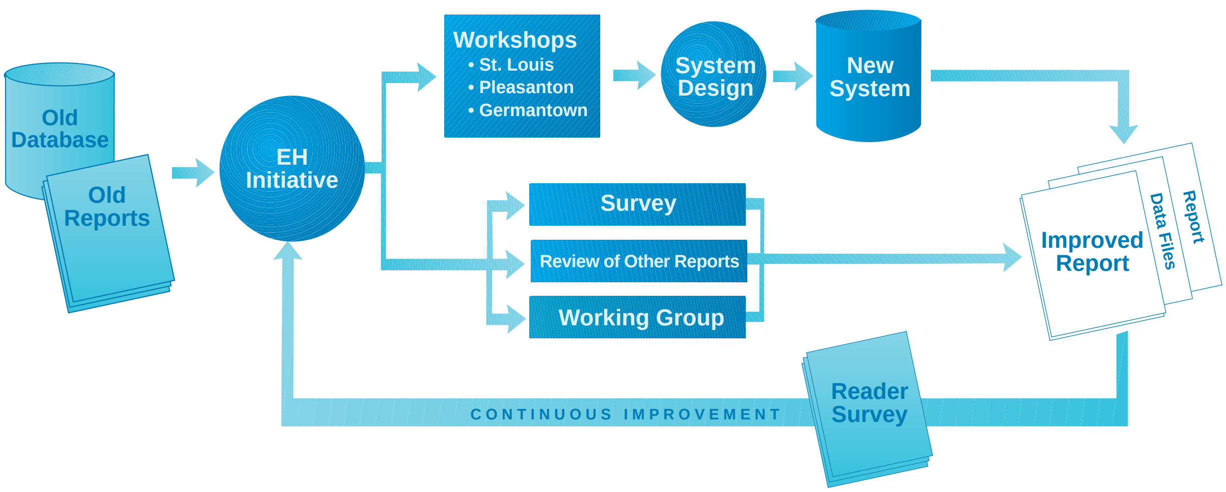
The organization of this report, as well as many other changes from previous reports, is the result of recommendations from a working group tasked with improving the usefulness of DOE occupational radiation exposure data. Additional input was obtained from a survey of report users and external stakeholders. Similar reports published by other agencies were reviewed to identify data treatment techniques that would better serve the report users. As seen in *Exhibit 1-1*, the report re-engineering process identified several analyses that may be useful to users but were not previously included in DOE exposure reports. This report is made possible by the valuable contributions and efforts of stakeholders.

DOE also instituted a process of continuous improvement to ensure the report continues to evolve in meeting user and stakeholder needs. As a part of this process, a questionnaire is included in this report (Appendix E) to collect suggestions for improving the report. The report provides DOE occupational radiation dose status and analysis of the dose data. The report is intended to be a valuable tool for DOE/DOE contractor managers to improve the radiation protection programs and ALARA programs, and to assist them in prioritizing allocation of resources. The report also is useful in demonstrating DOE radiation safety performance to external stakeholders.

1.3 Report Availability

Requests for additional copies of this report or access to the data files used to compile this report should be directed to Ms. Nirmala Rao, REMS Project Manager, U.S. Department of Energy, Office of Worker Protection Programs and Hazards Management (EH-52), Germantown, MD 20874. A discussion of the various methods of accessing the DOE occupational radiation exposure information is presented in Appendix E

Exhibit 1-1:
Report Re-engineering Process



Standards and Requirements

One of DOE's primary objectives is to ensure that all of its operations and those of its contractors are conducted safely. To help achieve this objective, DOE has established radiation protection standards and program requirements to protect workers and the public from ionizing radiation. The basic DOE standards are radiation dose limits, which establish maximum permissible doses to workers and visitors. In addition to the requirement that radiation doses not exceed the limits, it is DOE's policy that doses also be maintained ALARA.

This section discusses the radiation protection standards and requirements that were effective for the period 1992 through 1994. The requirements leading up to this time period are also included to facilitate a better understanding of changes that have occurred in the recording and reporting of occupational dose. Those requirements currently in effect, such as 10 CFR 835, "Occupational Radiation Protection," are discussed at the end of this section.

2.1 Radiation Protection Requirements

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]. These standards are provided to ensure that workers at DOE are adequately protected from exposure to ionizing radiation. This guidance, initially implemented in 1989, is based on the 1976 recommendations of the International Commission on Radiological Protection [2] and the National Council on Radiation Protection and Measurements [3]. The new guidance required that internal organ dose (resulting from the uptake of radionuclides) 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. The new DOE dose limits based on the TEDE were established from this guidance.

DOE became the first federal agency to implement the revised guidance when it promulgated DOE Order 5480.11, "Radiation Protection for Occupational Workers," in December 1988 [4]. DOE Order 5480.11 was effective from 1989 through 1995.

In June 1992, the DOE Radiological Control (RadCon) Manual [5] was issued and became effective in 1993. The RadCon Manual was the result of a Secretarial initiative to improve and standardize radiological protection practices throughout DOE and achieve the goal of making DOE the pacesetter for radiological health and safety. The RadCon Manual is a comprehensive guidance document written for line managers and senior management. The RadCon Manual states DOE's views on the best practices currently available in the area of radiological control. The RadCon Manual was revised in 1994 in response to comments from the field and to enhance consistency with the upcoming requirements in 10 CFR 835 [6].

2.1.1 Monitoring Requirements

Personnel monitoring was required by DOE Order 5480.11 and the RadCon Manual. Both required that personnel dosimetry be provided to personnel expected to receive an external whole body dose greater than 0.100 rem or an annual dose to the extremities, lens of the eye, or skin greater than 10% of the corresponding annual limits. In addition, the RadCon Manual required that neutron dosimetry be provided to persons likely to exceed 0.100 rem annually from neutrons. In 1992, the Order required that internal dose monitoring be provided to individuals expected to receive an Annual Effective Dose Equivalent (AEDE) greater than 0.100

rem, or if any organ or tissue dose equivalent might exceed 10% of the annual dose limit. For 1993 and 1994, the RadCon Manual required personnel to participate in a bioassay program when they were likely to receive intakes resulting in a Committed Effective Dose Equivalent (CEDE) greater than 0.100 rem. The revision of the RadCon Manual in 1994 added monitoring thresholds for minors and members of the public at 50% of the annual limits.

2.1.1.1 External Monitoring

External dosimeters are used to measure penetrating ionizing radiation. The choice of dosimeter is based on the type and energy of radiation that the individual is likely to encounter in the workplace. An algorithm is then used to convert the exposure readings into dose. External monitoring devices include photographic film (film badges), thermoluminescent dosimeters, pocket ionization chambers, electronic dosimeters, personnel nuclear accident dosimeters, bubble dosimeters, plastic dosimeters, and combinations of the above.

Beginning in 1990, the Department of Energy Laboratory Accreditation Program (DOELAP) formalized accuracy and precision performance standards for external dosimeters and quality assurance/quality control requirements on the overall external dosimetry programs for facilities within the DOE complex. All DOE facilities have been DOELAP accredited as of the fall of 1995.

External dosimeters have minimum sensitivity of approximately 0.010 - 0.030 rem per monitoring period. The differences are attributable to the particular type of dosimeter used and the types of radiation monitored. Monitoring periods are usually quarterly for individuals receiving less than 0.300 rem/year and monthly for individuals who routinely receive higher doses or who enter higher radiation areas.

2.1.1.2 Internal Monitoring

Personnel internal radiation monitoring programs include work area monitoring and bioassay monitoring. Work area monitoring includes both air sampling and surface contamination monitoring. The purpose of work area monitoring is to identify sources of loose radioactive material. Bioassay monitoring includes in-vitro (outside the body) and in-vivo (inside the body) sampling. In-vitro assays include urine and fecal samples, nose swipes, saliva samples, and hair samples. In-vivo assays include whole body counting, thyroid counting, lung counting, and wound counting.

Monitoring intervals for internal dosimetry are dependent on the radionuclides being monitored and their concentrations in the work environment. Proactive monitoring intervals may be monthly, quarterly, or annually, whereas reactive monitoring intervals may be daily or weekly, depending on the incident. Reporting thresholds for internal dosimetry are highly dependent on the monitoring methods, the radionuclides in question, and their chemical form. Follow-up measurements and analysis may take many months to confirm preliminary findings.

2.2 Radiation Dose Limits

Both DOE Order 5480.11 and the RadCon Manual include radiation dose limits to protect workers and visitors from both external radiation and internally deposited radionuclides. DOE dose limits from the RadCon Manual [5] are shown in *Exhibit 2-1*. The revision of the RadCon Manual in 1994 did not change the dose limits.

2.2.1 Administrative Control Levels

ACLs were included in the RadCon Manual. ACLs are established below the regulatory dose limits to administratively control and help reduce individual and collective radiation dose. ACLs are multi-tiered, with increasing levels of authority required to approve a higher level of exposure.

The RadCon Manual established a DOE ACL of 2 rem per year per person for all DOE activities. Prior to allowing an individual to exceed this level, approval from the appropriate Secretarial Officer or designee must be received. In addition, contractors were required to establish an annual facility ACL. This control level is established by the contractor senior site executive and is based upon an evaluation of historical and projected radiation exposures, work load, and mission. The RadCon Manual suggests an annual facility ACL of 0.5 rem or less; however, the Manual also states that a control level greater than 1.5 rem is, in most cases, not sufficiently challenging. Approval by the contractor senior site executive must be received prior to an individual exceeding the facility ACL.

2.2.2 ALARA Principle

Up until the 1970s, the fundamental radiation protection principle was to limit occupational radiation dose to quantities less than the regulatory limits and to be concerned mainly with high dose, high dose rate exposures. During the 1970s, there was a fundamental shift within the radiation protection community to be concerned with low dose, low dose rate exposures because it can be inferred from the linear-dose-response no-threshold hypothesis that there is no "safe" level of radiation exposure. The ALAP (As Low As Practicable) concept was initiated and became part of numerous guidance documents and radiation protection good practices. ALAP was eventually replaced by ALARA. DOE Order 5480.11, the RadCon Manual, and 10 CFR 835 formalized the guidance and required that each DOE facility have an ALARA Program as part of its overall Radiation Protection Program.

The ALARA methodology considers both individual and group doses and generally involves a cost-benefit analysis. The cost-benefit analysis considers social, technical, economic, practical, and public policy aspects to the overall goal of dose reduction. Because it is not feasible to reduce all doses at DOE facilities to zero, ALARA cost-benefit analysis must be used to optimize levels of radiation dose

Exhibit 2-1:
DOE Dose Limits from the RadCon Manual

Type of Exposure	Annual Limit
Radiological Worker:	
Whole Body	5 rem
Lens of Eye	15 rem
Extremity	50 rem
Any organ or tissue and skin	50 rem
Declared Pregnant Worker:	
Embryo/Fetus	0.5 rem per gestation period
Minors and Students:	
Whole Body	0.1 rem
Visitors and Public:	
Whole Body	0.1 rem

reduction. According to the ALARA principle, if doses are too high, resources should be spent to reduce them. At some point, the resources being spent to maintain low doses are balanced by the risks avoided. Reducing doses below this point results in a misallocation of resources; the resources could be spent elsewhere and have a greater impact on health and safety.

To ensure that doses are maintained ALARA at DOE facilities, the DOE mandated in DOE Order 5480.11 and, subsequently, in the RadCon Manual that ALARA plans and procedures be implemented and documented. To help facilities meet this requirement, the DOE developed a manual of good practices for reducing exposures to ALARA levels [7]. This document includes guidelines for administration of ALARA programs, techniques for performing ALARA calculations based on cost-benefit principles, guidelines for setting and evaluating ALARA goals, and methods for incorporating ALARA criteria into both radiological design and operations. The establishment of ALARA as a required practice at DOE facilities demonstrates DOE's commitment to ensure minimum risk to workers from the operation of its facilities.

2.3 Reporting Requirements

In 1987, the DOE promulgated revised reporting requirements in DOE Order 5484.1, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements [8]." Previously, contractors were required to report only the number of individuals who received an occupational whole body exposure in one of 16 dose equivalent ranges. The revised Order requires the reporting of exposure records for each individual employee and visitor. Required dose data reporting includes the TEDE, internal dose equivalent, shallow dose equivalent to the skin and extremities, and Deep Dose Equivalent (DDE). Other reported data included the individual's age, sex, employment status, and occupation, as well as the relevant organization and facility type.

2.4 Change in Internal Dose Methodology

Prior to 1989, uptakes of radionuclides into the body were not reported as dose, but as body burden in units of activity (μCi) of intake. The implementation of DOE Order 5480.11 in 1989 specified that the uptakes of radionuclides be converted to internal dose and reported using the AEDE methodology.

With the implementation of the RadCon Manual in 1993, the methodology used to calculate and report internal dose was changed from the AEDE to the 50-year CEDE. The change was made to conform with the consensus of the radiation protection community and the revised 10 CFR 20 [9], which was implemented in 1994 regulating commercial nuclear power plants and other commercial uses of radiation and radioactive materials.

The following is a description of these methodologies and a discussion of how this change has impacted the DOE dose data.

2.4.1 Annual Effective Dose Equivalent

The AEDE method of determining internal dose involves calculating the annual dose to the worker for each year since the original uptake event. Because many of the radionuclides used at DOE are long-lived, workers can receive an annual dose from past uptakes for many years, even a lifetime. DOE used the AEDE method for calculating internal dose equivalent because the annual dose resulting from an uptake was more representative of the actual dose received by the worker during each calendar year.

The AEDE method is problematic from a radiological control viewpoint. It does not account for the dose that would be received by an individual during his lifetime. Facilities must keep track of prior uptakes to determine the dose for the current year. The AEDE method does not consider the future dose to the worker resulting from a current year uptake. The AEDE method may also impact the individual's future job potential. The accumulation of prior year AEDE doses (legacy doses) may result in a current year dose in excess of the facility's ACL and restrict the individual's current year radiation work opportunities.

The AEDE method spreads the accounting of an uptake across many future years. This decreases the likelihood that the annual reported dose will exceed a regulatory limit or ACL and therefore reduces the likelihood of regulatory enforcement and/or corrective actions related to uptakes of radioactive material.

2.4.2 Committed Effective Dose Equivalent

The CEDE method assigns all of the dose the individual will receive from an uptake for the next 50 years to the year the uptake occurred. The sum of all AEDE doses over 50 years from a given uptake of radionuclides is equal to the CEDE from the same uptake. By assigning all of the future dose to the year of uptake, even small intakes of long-lived radioactive material can result in a relatively large dose being assigned to a single year in the year of uptake. The CEDE increases the pressure on facilities to limit such exposures and allows DOE to limit internal dose during the year of occurrence while not unduly impacting the worker's future employability.

2.4.3 Impact on the Dose Data

This change in internal dose accounting and reporting has two main impacts on the DOE dose data. First and foremost is that "legacy doses" (internal AEDE dose resulting from uptakes in years prior to the dose report year) are included in the reported dose from 1990 through 1992. Legacy doses represent a significant amount of dose to the DOE worker population during these years, as shown in *Exhibit 2-2*.

Readers should note that while the TEDE served as the key dose parameter during the period 1990 - 1994, the internal dose component changed from 1992 to 1993.

In 1992, nearly 5,500 individuals were receiving 65% of their annual dose from uptakes that occurred in prior years, many having occurred 20 to 30 years before. In the analysis of exposures in excess of the DOE limits and the 2 rem ACL presented in Sections 3.3.1 and 3.3.2, readers should note that most of the exposures from 1990 to 1992 were because of the inclusion of the AEDE from prior year uptakes.

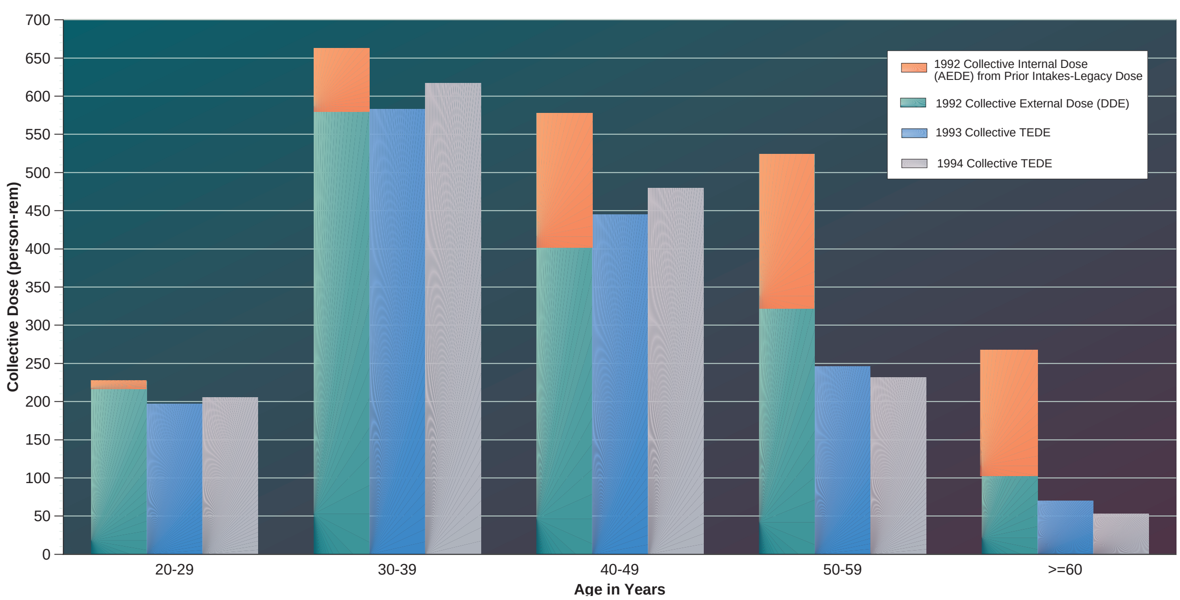
Beginning in 1993, internal dose was reported using the CEDE methodology. Legacy doses were no longer reported because the CEDE reports only those doses resulting from the uptakes occurring during the year of the report.

Because these legacy doses are no longer reported, there is an apparent large drop in 1993 in the total collective dose for all workers, and in the number of workers who received high doses. This is largely because of the change from AEDE to CEDE. Where applicable, the contribution from legacy dose has been highlighted. Readers should be alerted to the significance of this change in order to correctly interpret the data.

The second major impact of the change from AEDE to CEDE is in the internal dose for 1993 and 1994. As noted previously, the CEDE includes the dose to the individual for the next 50 years. This greatly magnifies the dose from small uptakes of long-lived radionuclides. Uptakes that would have resulted in an AEDE below ACLs prior to 1993 now may result in a CEDE above the regulatory limits. For long-lived radionuclides, the difference in values between AEDE and CEDE may be up to 50 times.

It is important to note that the change from AEDE to CEDE impacted the calculation of dose from only long-lived isotopes, such as uranium and plutonium. Internal dose from the uptake of isotopes with retention

Exhibit 2-2:
Internal Legacy Dose Contribution by Age Range, 1992-1994



periods of less than a year, such as tritium, were not impacted. For short-lived isotopes, AEDE is equal to the CEDE because the entire dose is accrued during the year of intake.

2.4.4 External Dose

The change from the AEDE to CEDE for internal dose does not affect the reporting of external dose. The only changes in the DDE data from1987 through 1994 have been the continuing improvements in dosimeter detection levels and standardization through accreditation by the DOELAP program. Interpreting the trends of DDE during this period is, therefore, consistent.

2.5 Future Requirements

On December 13, 1993, DOE published 10 CFR 835, "Occupational Radiation Protection [7]." This final rule became effective on January 13, 1994, and required full compliance by January 1, 1996. In general, 10 CFR 835 codifies existing radiation protection requirements in DOE Order 5480.11. The rule provides nuclear safety requirements that, if violated, will provide a basis for the assessment of civil and criminal penalties under the Price-Anderson Amendments Act of 1988, Public Law 100-408, August 20, 1988 [10].

During 1994 and 1995, DOE undertook an initiative to reduce the burden of unnecessary, repetitive, or conflicting requirements on DOE contractors. As a result, DOE Order 5484.1 requirements for reporting radiation dose summaries are now located in the associated manual, DOE M231.1-1, "Environment, Safety and Health Reporting [11]." The requirements are basically the same, however, the dose terminology was revised to reflect the changes made in radiation protection standards and requirements.

With the promulgation of 10 CFR 835 and the approaching compliance date, DOE Order 5480.11 was cancelled and the RadCon Manual was made non-mandatory guidance. However, DOE Notice 441.1, "Radiological Protection for DOE Activities [12]," (applicable to defense nuclear facilities) was issued to establish radiological protection program requirements that, combined with 10 CFR 835 and its associated non-mandatory implementation guidance, form the basis for such a comprehensive radiological protection program.

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Occupational Radiation Dose at DOE

Section Three

3

3.1 Analysis of the Data

The purpose of analyzing occupational radiation dose data is to reveal opportunities to improve safety and to demonstrate performance. This is accomplished through analysis and explanation of observed trends. Several indicators have been identified from the data submitted to the central data repository that can be used to evaluate the occupational radiation exposures received at DOE facilities. The analysis of these indicators falls into three categories: collective, individual, and site. In addition, the key indicators are analyzed to identify and correlate parameters having an impact on radiation dose at DOE.

The key indicators for collective analysis are: collective dose, number of workers and workers with measurable dose, average measurable dose, and the distribution of dose. Analysis of individual dose data includes an examination of doses exceeding DOE limits, and doses exceeding the 2 rem DOE ACL. Analysis of site data includes comparisons by site, labor category, and facility type.

3.2 Collective Analysis

3.2.1 Number of Monitored Individuals

The number of monitored individuals represents the size of the worker population at DOE provided with dosimetry. This number represents the sum of all monitored individuals, including all DOE employees, contractors, and visitors. The number of 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 dosimetry to individuals for reasons other than the potential for exposure to radiation and/or radioactive materials. 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, workers receiving measurable dose better represent the exposed workforce.

3.2.2 Number of Individuals with Measurable Dose

The 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.

Only 25% of monitored workers received a measurable dose over the past 5 years.

Exhibit 3-1 shows the total number of workers at DOE, the total number monitored, and the number with measurable dose for the past 5 years. From 1990 to 1994, 64% of DOE employees and contractors were monitored for radiation exposure. However, most of these individuals did not receive any measurable radiation dose. Only 25% of monitored workers (16% of the DOE workforce) received a measurable dose during this time period. The number of workers with measurable dose has decreased by 30% over the past 5 years.

Seventeen of the 28 sites experienced decreases in the number of workers with measurable dose during this period, with the largest decreases occurring at Rocky Flats and the Savannah River Site (SRS). However, a 6% increase in the number with measurable dose occurred between 1993 and 1994. This increase was primarily due to increases at Los Alamos National Laboratory (LANL), Idaho National Engineering Laboratory (INEL), and the SRS. A discussion of activities at these facilities is included in Section 3.6.2.

3.2.3 Collective Dose

The collective TEDE has decreased 45% at DOE over the past 5 years.

The collective dose is the sum of the dose received by all individuals with measurable dose (*Exhibit 3-1*) and is measured in units of person-rem. The collective dose is an indicator of the overall radiation exposure at DOE facilities and includes the dose to all DOE employees, contractors, and visitors. DOE's objective is to keep individual exposures and collective exposure ALARA. The collective dose is also used in analysis of the statistical risk of radiation injury to workers in an exposed population. For these reasons, DOE monitors the collective dose as a measure of success 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 has decreased at DOE by 45% from 1990-1994. 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 in order to examine the impact of the internal dose reporting change. The photon, neutron, and internal dose components are shown.

The internal dose component decreased by 4% from 1990 to 1992, and then shows a large decrease due to the change in calculating and reporting of internal dose from 1992 to 1993. *Exhibit 3-2* also shows the contribution to the internal dose from new intakes and from intakes that occurred in prior years. From 1990 to 1992, 700 - 750 person-rem of internal dose, the result of prior intakes (legacy dose), was still being reported under the AEDE method. This dose is no longer being reported under the CEDE method of calculating and reporting dose.

Exhibit 3-1: Number of Individuals

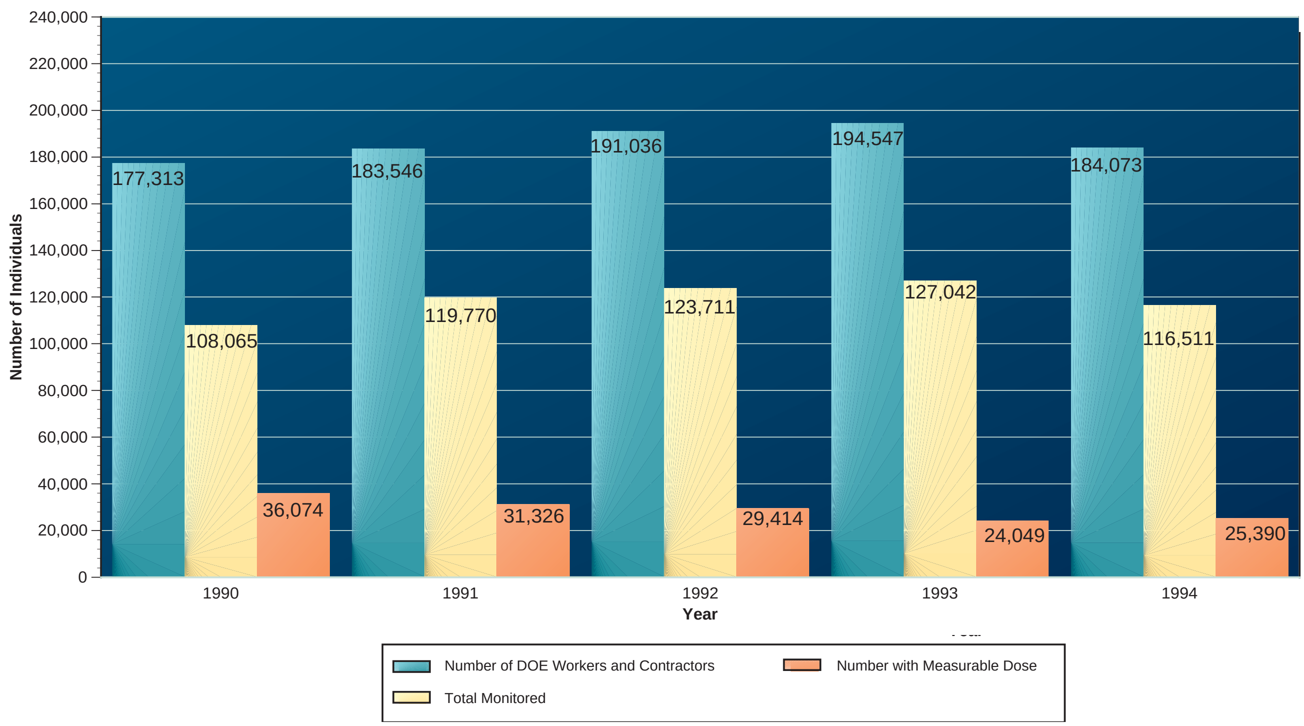


Exhibit 3-2:
Components of TEDE, 1990-1994

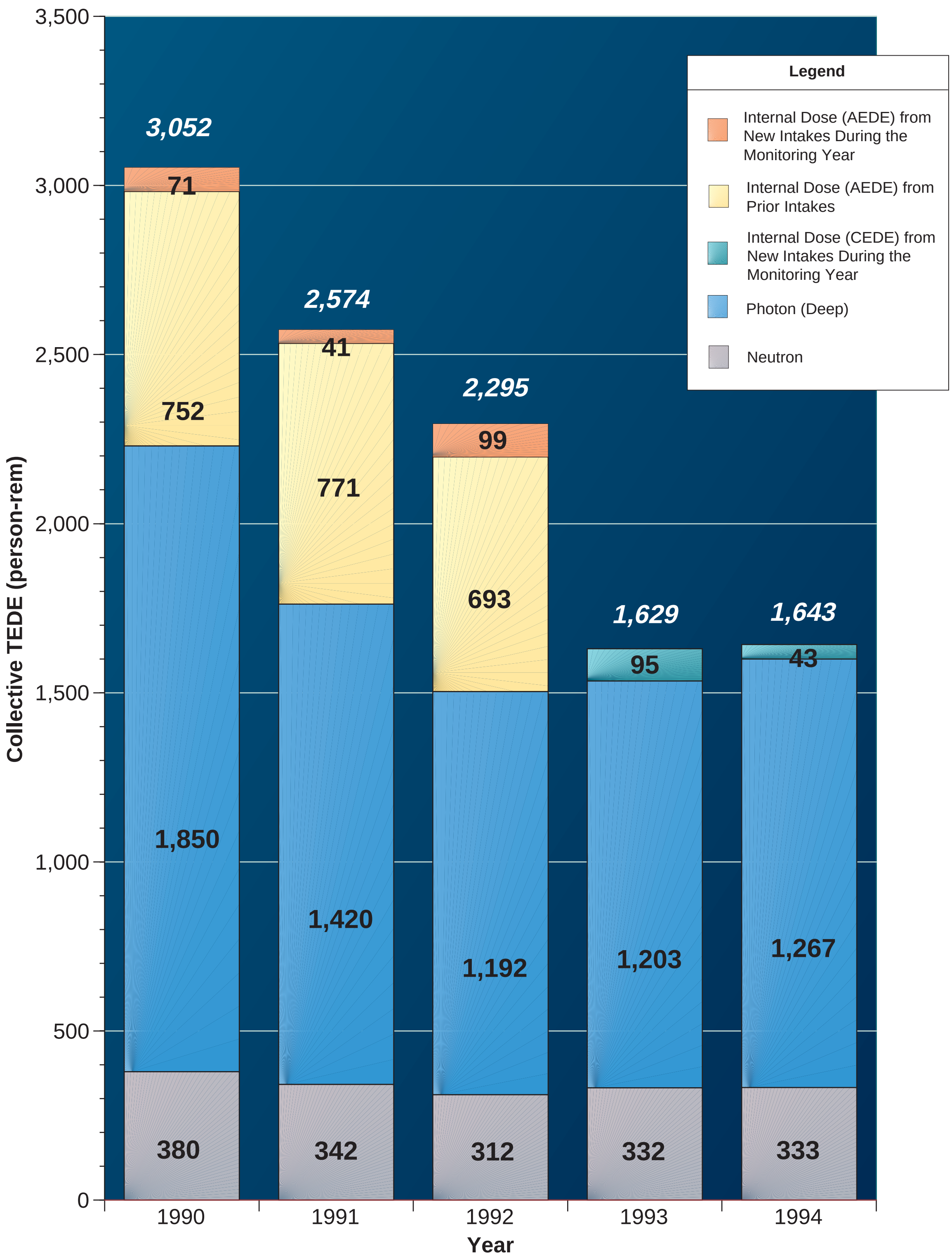
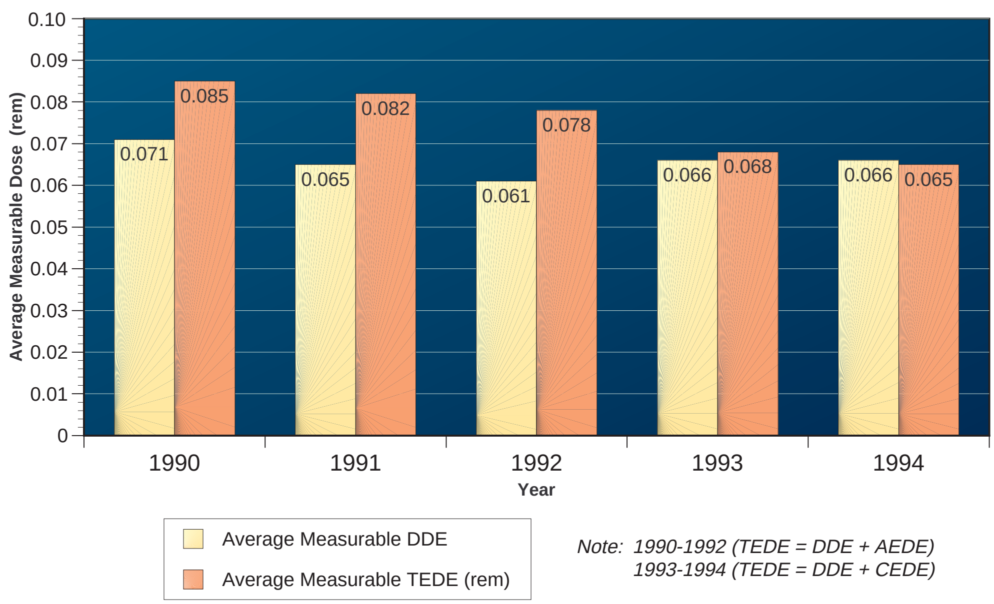


Exhibit 3-3:
Average Measurable DDE Dose and Average Measurable TEDE



It must be noted that the internal dose shown in *Exhibit 3-2* for 1993 and 1994 is based on the CEDE and therefore should not be compared with the AEDE internal dose from 1990 to 1992.

Because the reporting of internal dose changed in 1993 (see Section 2.4), it is instructive to analyze the collective external dose during this time period in order to examine the collective dose trend across the past 5 years. The photon dose decreased by 33% from 1990 to 1992 primarily because of decreases at the SRS, INEL, and LANL resulting from decreased activities at these facilities (see Section 3.6.2). The photon dose has remained fairly stable during the past 3 years. The neutron component has decreased by 12% over the 5-year period with virtually no change in the past 2 years. Collective dose information for prior years can be found in Appendix B.

3.2.4 Average Measurable Dose

The average measurable dose to DOE workers is determined by dividing the collective dose by the number of individuals with measurable dose. This is considered a key indicator 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 has decreased by 24% over the past 5 years, but the TEDE includes the internal dose component, which changed calculation and reporting methodology from 1992 to 1993. The average measurable DDE trend over the 5-year period is relatively constant.

While the collective dose and average measurable dose serve as measures of the magnitude of the dose accrued by workers at DOE, they do not provide any indication of how each dose was distributed across the worker population. An effective measure of ALARA is the reduction in dose to individuals, as well as to the overall workforce.

3.2.5 Dose Distribution

Exposure data are commonly analyzed in terms of dose intervals to depict the manner in which the dose is distributed among the worker population. *Exhibit 3-4* shows the number of individuals in each of 18 different dose ranges. The dose ranges are presented for the TEDE and DDE to allow analysis of the dose independent of the change in internal dose reporting from 1992 to 1993 (see Section 2.3).

Reductions in the numbers of individuals in the higher dose ranges as seen in *Exhibit 3-4* are one indication that ALARA principles are being effectively applied to reduce dose to individual workers in the DOE workplace. A few examples of this are included in Section 5. However, an analysis of the number of individuals in each dose range is limited, because the relative magnitude of the collective dose received by these individuals is not taken into consideration. Another way to examine the dose distribution is to analyze the percentage of the dose received above a certain dose value compared to the total collective dose.

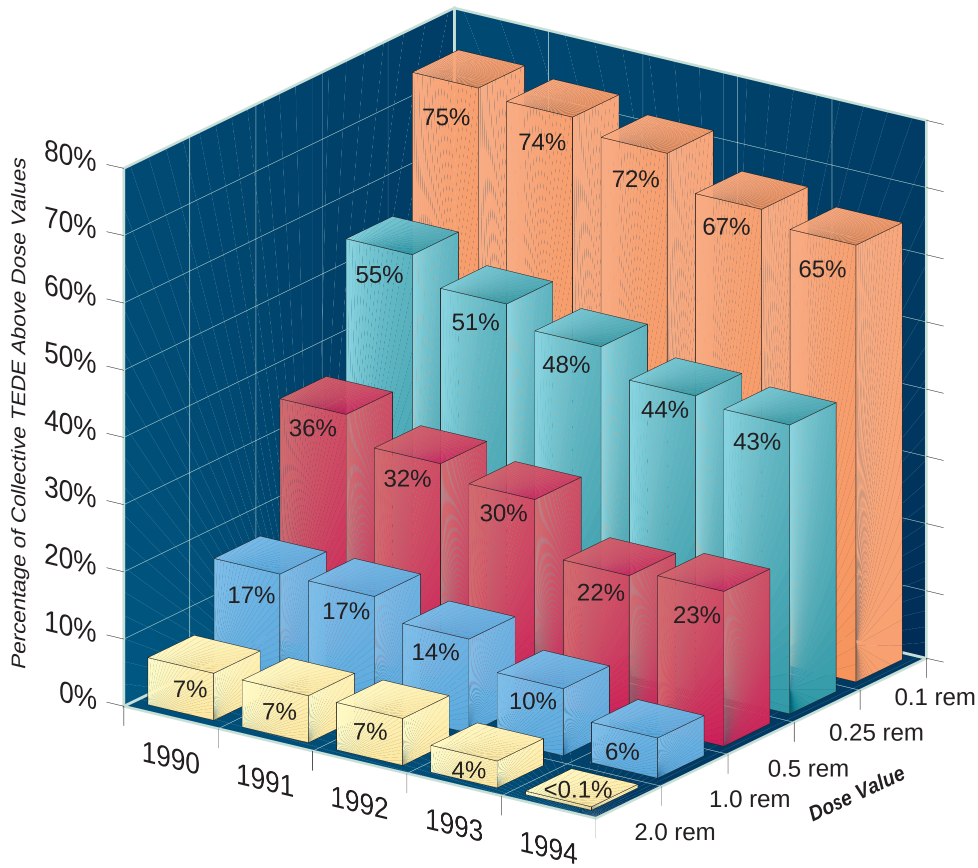
The majority (78%) of monitored individuals received no measurable exposure in 1994.

Exhibit 3-4:
Dose Distributions, 1990-1994

Dose Ranges (rem)	1990		1991		1992		1993		1994	
	TEDE	DDE	TEDE	DDE	TEDE	DDE	TEDE	DDE	TEDE	DDE
Number of Individuals in Each Dose Range*										
Less than Measurable	71,991	76,798	88,444	92,526	94,297	98,900	102,993	103,905	91,121	92,245
Measurable < 0.1	29,318	26,146	25,319	23,031	23,896	21,019	20,181	19,356	21,511	20,469
0.10 - 0.25	3,921	3,026	3,752	2,753	3,581	2,585	2,474	2,437	2,437	2,389
0.25 - 0.5	1,683	1,286	1,447	988	1,252	852	1,013	985	934	920
0.5 - 0.75	566	432	381	266	346	235	195	183	329	317
0.75 - 1.0	292	220	187	111	165	78	93	89	99	94
1 - 2	226	140	193	95	132	42	87	86	79	77
2 - 3	47	17	25		22					
3 - 4	8		9		9				1	
4 - 5	8		8		6		2	1		
5 - 6	1									
6 - 7	2		2		2					
7 - 8					1					
8 - 9	1		1				1			
9 - 10					1		1			
10 - 11										
11 - 12										
> 12	1		2		1		2			
Total Monitored	108,065	108,065	119,770	119,770	123,711	123,711	127,042	127,042	116,511	116,511
Number with Meas. Dose	36,074	31,267	31,326	27,244	29,414	24,811	24,049	23,137	25,390	24,266
% of Individuals with Meas. Dose	33%	29%	26%	23%	24%	20%	19%	18%	22%	21%
Collective Dose (person-rem)	3,052	2,230	2,574	1,762	2,295	1,504	1,629	1,534	1,643	1,600
Average Measurable Dose (rem)	0.085	0.071	0.082	0.065	0.078	0.061	0.068	0.066	0.065	0.066

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

Exhibit 3-5:
Distribution of Collective TEDE vs Dose Values



In 1982, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) [13] defined CR as the fraction of the collective dose delivered above 1.5 rem. UNSCEAR identified this parameter as an indicator of the efforts to reduce high doses. The DOE has adapted this approach to allow a quantification and analysis of the dose distribution at DOE.

The analysis involves calculating the percentage of the collective dose received above a certain dose level compared to the total collective dose. Ideally, only a small percentage of the collective dose is delivered to individuals in the higher dose ranges. In addition, a trend in the percentage above a certain dose range decreasing over time indicates the effectiveness of ALARA programs to reduce doses to individuals in the higher dose ranges.

Exhibit 3-5 shows the distribution ratio given by percentage of collective TEDE above each of five dose values, from 0.1 rem to 2 rem. This graph shows the two properties described above as the goal of effective ALARA programs at DOE: (1) a relatively small percentage of the collective dose accrued in the high dose ranges, and (2) a decreasing trend over time of the percentage of the collective dose accrued in the higher dose ranges. Much of the observed trend occurred from 1992 to 1993, coinciding with the change from AEDE to CEDE.

3.3 Dose to Individuals

The above analyses are all based on collective dose data for DOE. From an individual worker perspective as well as a regulatory perspective, it is important to more closely examine the doses received by individuals in the high dose ranges in order to more thoroughly understand the circumstances leading to high doses in the workplace and how these doses may be mitigated in the future. The following analysis focuses on doses received by individuals that were in excess of the DOE limit (5 rem TEDE) and the DOE ACL (2 rem TEDE).

3.3.1 Doses in Excess of DOE Limits

There were 19 records of doses in excess of the regulatory limit (5 rem TEDE) from 1990 through 1993 as shown in *Exhibit 3-6*. There were no records of doses in excess of the limit in 1994.

Of the 19 records, 15 records were of doses in excess of the limits from 1990 through 1992. Out of the 15 records, 14 are attributable to intakes of radionuclides prior to 1990 that resulted in an AEDE in excess of the limits (legacy intakes, see Section 2.2). Four individuals with an AEDE dose from legacy intakes accounted for 12 of these records, (one record per individual for each of the 3 years) as shown in *Exhibit 3-7*. One of the doses was attributed to a retiree who returned to work in 1991, thereby requiring the reporting of the AEDE dose from his prior intakes. There was one new intake of radionuclides in 1992 that resulted in a dose in excess of the limits using the AEDE methodology.

There were no individuals with a dose in excess of the limit in 1994.

All of the events resulting in doses in excess of DOE limits from 1990 to 1994 were from internal dose.

Exhibit 3-6:
Number of Individuals Exceeding 5 rem (TEDE), 1990-1994

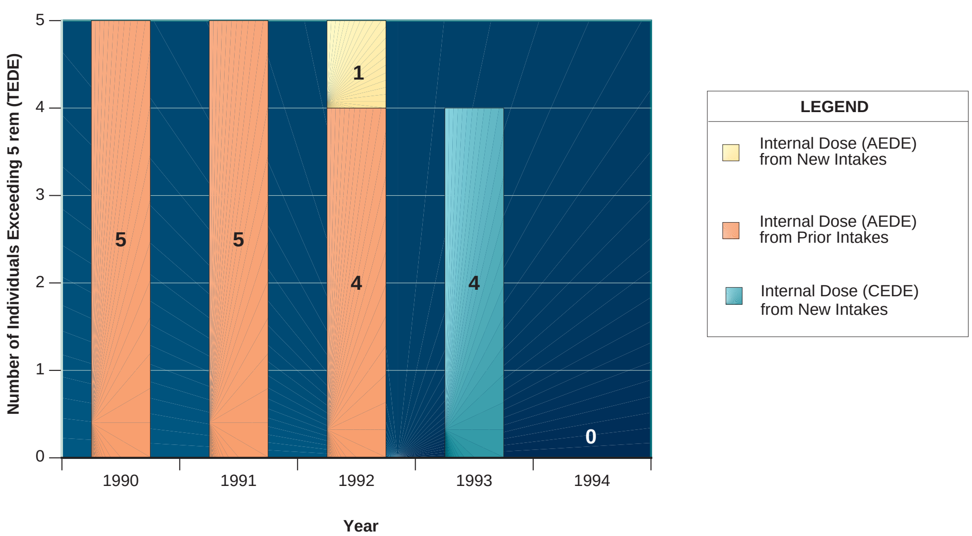


Exhibit 3-7:
Doses in Excess of DOE Limits, 1990-1994

Year	Year Uptake	Person	TEDE* (rem)	DDE (rem)	Internal Dose**	Intake Nuclides	Facility Types	Site
1990	1952	A	6.399	0	6.399	Pu238	Research, General	Los Alamos Nat'l. Lab.
1990	<1990	B	15.000	0.023	14.977	Pu239, Pu240, Am-241	Weapons Fabrication	Rocky Flats
1990	<1990	C	6.600	0.059	6.541	Pu239, Pu240, Am-241	Weapons Fabrication	Rocky Flats
1990	<1990	D	8.000	0	8.000	Pu239, Pu240, Am-241	Weapons Fabrication	Rocky Flats
1990	<1990		5.100	0	5.100	Pu239, Pu240, Am-241	Weapons Fabrication	Rocky Flats
1991	1952	A	6.339	0	6.339	Pu238	Research, General	Los Alamos Nat'l. Lab.
1991	1967		17.471	0	17.471	Pu238	Maint. & Support	Los Alamos Nat'l. Lab.
1991	<1991	B	15.000	0.050	14.950	Pu239, Pu240, Am-241	Weapons Fabrication	Rocky Flats
1991	<1991	C	6.500	0.034	6.466	Pu239, Pu240, Am-241	Weapons Fabrication	Rocky Flats
1991	<1991	D	8.000	0.057	7.943	Pu239, Pu240, Am-241	Weapons Fabrication	Rocky Flats
1992	1952	A	6.400	0	6.400	Pu238	Research, General	Los Alamos Nat'l. Lab.
1992	<1992	B	14.490	0.013	14.477	Pu239, Pu240, Am-241	Weapons Fabrication	Rocky Flats
1992	<1992	C	6.526	0.019	6.507	Pu239, Pu240, Am-241	Weapons Fabrication	Rocky Flats
1992	<1992	D	7.789	0.019	7.770	Pu239, Pu240, Am-241	Weapons Fabrication	Rocky Flats
1992	1992		9.855	0	9.855	Pu239, Pu240, Am-241	Weapons Fabrication	Rocky Flats
1993	1993		17.220	0	17.220	Pu239, Pu240	Maint. & Support	Los Alamos Nat'l. Lab.
1993	1993		22.068	0.189	21.879	Pu239, Pu240	Research, General	Los Alamos Nat'l. Lab.
1993	1993		8.709	0.209	8.500	Pu239, Pu240	Research, General	Los Alamos Nat'l. Lab.
1993	1993		9.218	0.058	9.160	Pu239, Pu240, Am-241	Weapons Fabrication	Rocky Flats
1994						None Reported		

* *TEDE is provided for 1990-1992 for comparison purposes only.*
** *AEDE for 1990-1992, CEDE for 1993, 1994.*
< *Year of uptake is unknown, but is known to be prior to the year indicated.*

Radionuclides of plutonium and americium accounted for all the intakes that resulted in doses in excess of the limits.

There were four reports of radionuclide intakes in 1993 that resulted in CEDEs in excess of the limits.

Seven of the reported doses in excess of the limits occurred at LANL from 1990 through 1993. One individual with legacy intakes was reported in all 3 years from 1990 to 1992. Another individual with legacy intakes returned to the site after retirement and was reported in 1991. There were three new intakes in 1993 at LANL that resulted in doses in excess of the limits. All doses in excess of the limits were a result of intakes of Pu238, Pu239, and/or Pu240. Five occurred in facilities identified as general research and the other two were in maintenance and support.

Twelve of the doses in excess of the DOE limits from 1990 through 1993 occurred at Rocky Flats. Three individuals were reported in each of the years 1990-1992. One individual with legacy intakes was reported in 1990 but was not reported in subsequent years because of retirement. There was one new intake at Rocky Flats in 1992 and another in 1993 that resulted in doses in excess of the limits. All were a result of intake of Pu239, Pu240, and/or Am241. All occurred in weapons fabrication facilities.

Radionuclides of plutonium and americium accounted for all the intakes that resulted in doses in excess of the limits. These long-lived radionuclides result in large committed doses per unit intake.

Description of Events

A discussion of the intake events occurring in prior years but resulting in AEDE doses in excess of 5 rem from 1990 to 1992 is outside the scope of this report because several of the intake events occurred in the 1960s and 1970s. Events that occurred within the past 5 years are described in the following paragraphs.

In 1993, two individuals at LANL were exposed while checking argon flow in an experimental metal preparation operation within a glove box. Their CEDEs were determined to be 17.2 rem and 21.9 rem. Operations were suspended and an investigation conducted. The equipment was subsequently dismantled and removed. Another individual received a CEDE of 8.5 rem following an incident involving the unbolting of a valve during a decommissioning operation. The facility was placed in stand-down for 4 days and a new work control program was initiated to ensure the event would not happen again. The three incidents were fully addressed in an investigation conducted by the Albuquerque Operations Office [14]. In addition to the corrective actions taken to eliminate the source and to improve work controls, the individuals receiving exposures in excess of limits were notified.

In 1993, one individual working at Rocky Flats received a puncture wound while removing nails from a wooden box located inside a glove box. As a result of some plutonium entering the individual's bloodstream through the wound, a CEDE to the individual of 9.2 rem was calculated.

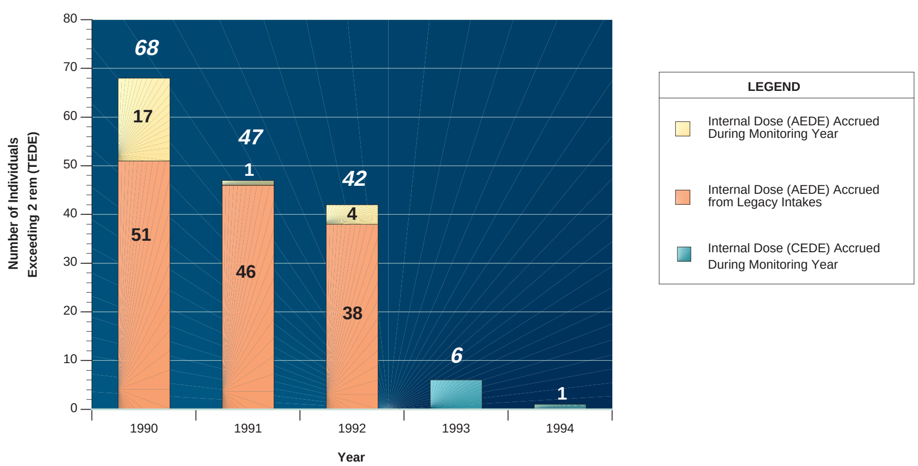
3.3.2 Doses in Excess of Administrative Control Level

The RadCon Manual sets a 2 rem ACL for TEDE, which cannot be exceeded without prior DOE approval. Each DOE site is required to establish its own, more restrictive ACLs that require contractor management approval to be exceeded. The number of individuals receiving doses in excess of the maximum ACL of 2 rem is a measure of how well the DOE has met the ACL specified in the RadCon Manual.

The number of individuals with exposures above 2 rem has dropped considerably during 1990-1994, as shown in *Exhibit 3-8*. However, most of the decrease in the number of these individuals occurred between 1992 and 1993 because of the change in internal dose reporting. Legacy internal doses contributed to the majority of the individuals above 2 rem from 1990 to 1992 as shown in *Exhibit 3-8*.

All of the doses in excess of 2 rem in 1993 and 1994 were attributed to internal dose calculated using the CEDE methodology. As discussed in Section 2.2, the CEDE method results in relatively large dose assigned to the worker during the year of intake because of the incorporation of the

Exhibit 3-8:
Number of Doses in Excess of the DOE 2 rem Administrative Control Level, 1990-1994



dose from the intake over the next 50 years. There were six such intakes in 1993, but only one in 1994.

There has only been one external dose exceeding the 2 rem ACL since 1990. In 1993, an engineering technician was reported to have received a dose of 4.5 rem at a reactor facility at Brookhaven National Laboratory. Subsequent investigation revealed that the individual's dosimeter was left in a radiation area and that the individual did not actually receive the recorded dose.

3.3.3 Internal Depositions of Radioactive Material

As discussed in Section 3.3.1, the most significant doses to individuals are 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) for 1990-1994 is shown in *Exhibit 3-9*. The internal depositions were categorized into one of eight radionuclide groups as shown in the table. Intakes involving multiple nuclides are listed as "mixed" nuclides. Nuclides where fewer than ten individuals had intakes over the 5-year period were grouped together as "other" nuclides.

To examine trends in intakes occurring during the past 5 years, *Exhibit 3-9* shows only new intakes that occurred during

Exhibit 3-9:
Number of Intakes, Collective Internal Dose, and Average Dose by Nuclides, 1990-1994

Nuclide	Number of Workers with New Intakes*			Collective AEDE from Intake (person-rem)			Average AEDE (rem)		
Year	1990	1991	1992	1990	1991	1992	1990	1991	1992
Hydrogen-3 (Tritium)	465	1,094	594	11.311	14.213	6.831	0.024	0.013	0.012
Technetium	174	39	956	6.571	0.166	11.651	0.038	0.004	0.012
Thorium	2			0.081			0.041		
Uranium	1,233	2,179	2,275	19.532	21.634	20.488	0.016	0.010	0.009
Plutonium	148	48	320	1.526	1.468	56.082	0.010	0.031	0.175
Americium	2	24	35	0.009	3.375	3.822	0.005	0.141	0.109
Other	18	10	28	0.163	0.178	0.458	0.009	0.018	0.016
Mixed	2,044	6	2	31.981	0.067	0.054	0.016	0.011	0.027
Totals	4,086	3,400	4,210	71.174	41.101	99.386	0.017	0.012	0.024

Nuclide	Number of Workers with New Intakes*		Collective CEDE (person-rem)		Average CEDE (rem)	
Year	1993	1994	1993	1994	1993	1994
Hydrogen-3 (Tritium)	304	908	4.641	10.680	0.015	0.012
Technetium	19	27	0.218	0.281	0.011	0.010
Thorium	268	279	3.387	2.870	0.013	0.010
Uranium	1,365	914	16.146	10.660	0.012	0.012
Plutonium	115	66	69.029	18.290	0.600	0.277
Americium-241	13	3	0.642	1.560	0.049	0.520
Other	23	14	0.167	0.072	0.007	0.005
Mixed	2	16	0.026	1.139	0.013	0.071
Totals	2,108	2,227	94.256	45.552	0.049	0.020

**Individuals may have received intakes of more than one nuclide and therefore may be counted more than once.*

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

each of the 5 years and does not include doses from intakes that occurred in prior years (legacy doses). The years 1990-1992 show the internal dose from new intakes in terms of AEDE, while the data for 1993 and 1994 show the dose in terms of CEDE (see Section 2.2). The difference between the AEDE and CEDE methodology is significant in terms of the number of intakes reported and the dose from the intakes. Long-lived nuclides, such as plutonium, therefore result in significantly higher CEDE doses.

Most intakes of radioactive material during the 5-year period were the result of exposure to tritium or uranium. The average doses (both AEDE and CEDE) from these intakes are quite low because of the radiological and biological characteristics of these radionuclides.

The largest collective and average doses for 1993 and 1994 are attributable to intakes of plutonium, which yields particularly high values for CEDE because of the long radiological half-life and the long-term deposition of the material in the bone. Americium intakes have a high average CEDE for similar reasons, but the number of intakes and collective dose is much smaller than for plutonium. The majority of plutonium intakes occurred at Rocky Flats and LANL. The large dose from plutonium intakes in 1993 was primarily due to an incident that occurred at LANL resulting in two exposures in excess of DOE limits (see Section 3.3.1). The large number of intakes listed as "mixed" for 1990 was reported by the SRS and included doses from tritium and plutonium. For 1991, the internal doses from these nuclides were reported separately.

The internal dose records indicate that the majority of the intakes reported are at very low doses. Eighty-five percent of the internal doses are below 0.020 rem representing only 25% of the collective internal dose. The 15% of the internal doses above 20 mrem accounts for 75% of the collective internal dose. Over the 5-year period, internal doses from new intakes accounted for only 4% of the collective TEDE.

The internal dose records indicate that the majority of the intakes reported are at very low doses.

Several of the large changes in the number of new intakes over the years resulted from changes in internal dosimetry practices. For example, increases in uranium and technetium-99 intakes from 1991 to 1992 were primarily because of a change in internal monitoring and reporting at Oak Ridge. More sensitive detection equipment and lower reporting thresholds were implemented during this time period.

Exhibit 3-10:
Internal Dose Distribution from Intakes, 1990-1994

Number of Individuals* with internal dose in each dose range (rem).

Year	<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	Total No. of Indiv. *	Total Collective Internal Dose ** (person-rem)
1990	2,989	1,002	47	9	3		3					4,053	71.174
1991	2,913	420	36	12	1		1					3,383	41.101
1992	2,970	537	70	12	13	8	4	1	2		1	3,618	99.386
1993	1,562	250	56	23	5	2	1			1	4	1,904	94.256
1994	1,712	224	29	17	7	2	2		1			1,994	45.552

Note: Individuals with doses equal to the dose value separating the dose ranges are included in the next higher dose range.
* Individuals may have multiple intakes in a year and, therefore, may be counted more than once.
** Collective internal dose = AEDE for 1990-1992, CEDE for 1993-1994.

Another example is the large increase in the number of technetium-99 intakes, which increased from 39 in 1991 to 956 reported in 1992. This was also because of the change in internal dosimetry practices at Oak Ridge whereby the detection limits and reporting levels were lowered and a larger number of low-dose intakes was reported.

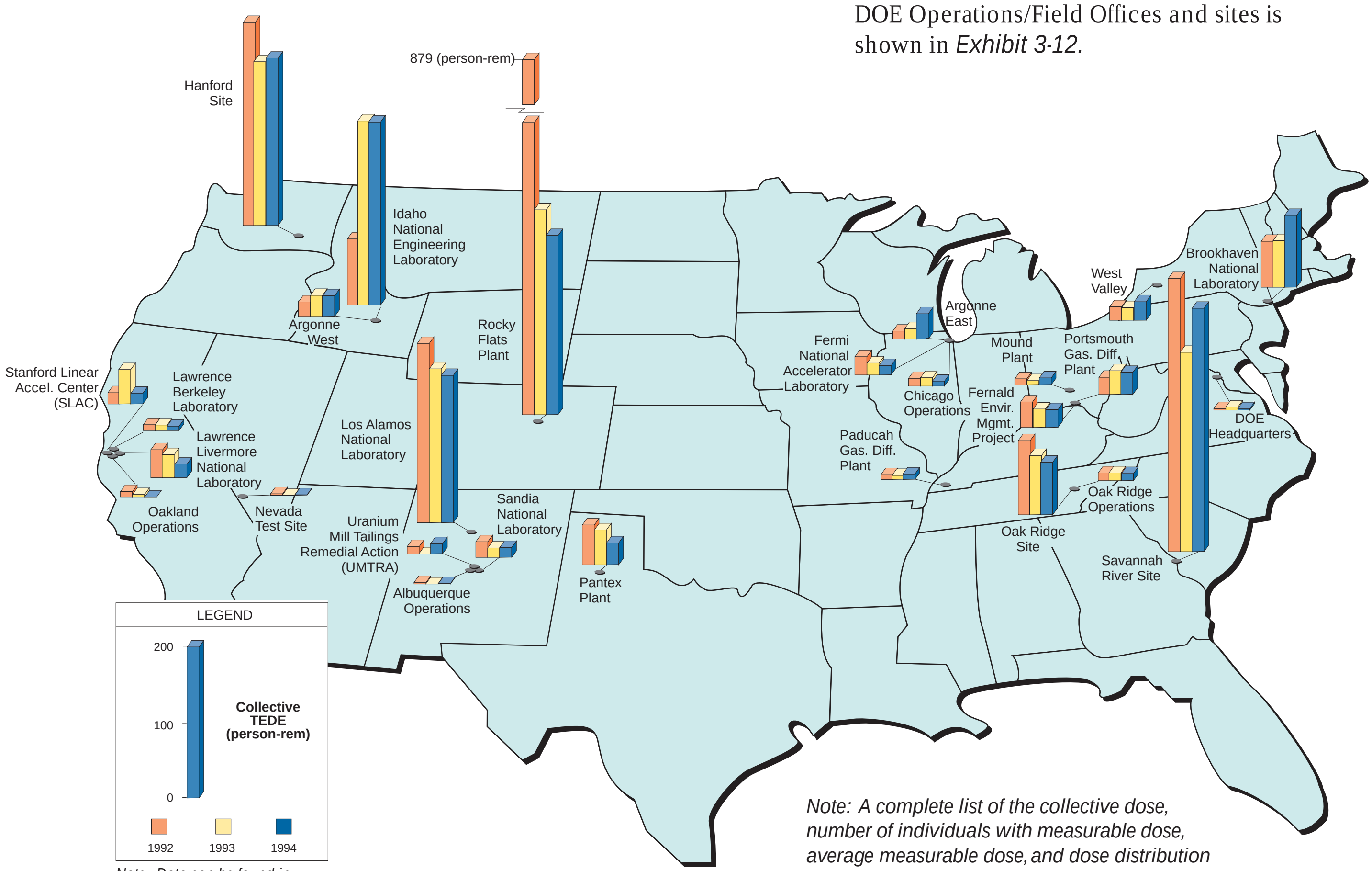
Exhibit 3-10 shows the distribution of the internal dose from 1990 to 1994. The total number of individuals with doses in each dose range is for each record of intake. The internal dose does not include doses from prior intakes (legacy dose). Individuals with multiple intakes during the year are counted more than once and for this reason the totals do not correspond to *Exhibit 3-9.* Doses below 0.020 rem are shown as a separate dose range to show the large number of doses in this low-dose range. Even with the change in methodology from AEDE to CEDE in 1993, all but six of the doses are below the 2 rem ACL and all but four are below the 5 rem DOE dose limit for the years 1993-1994.

3.4 Site Analysis

3.4.1 Collective Dose by Operations/Field Offices

The collective TEDE for 1992-1994 for the major DOE sites and Operations/Field Offices is shown in *Exhibit 3-11.* A list of the collective doses and number of individuals with measurable doses for the DOE Operations/Field Offices and sites is shown in *Exhibit 3-12.*

Exhibit 3-11: Collective Doses by Site/Facility



Note: Data can be found in Exhibit 3-12

Note: A complete list of the collective dose, number of individuals with measurable dose, average measurable dose, and dose distribution ratio for each Operations/Field Office can be found in Appendix B.

Exhibit 3-12:
Collective Dose and Number of Individuals with Measurable Dose by Site/Facility, 1992-1994

Operations/ Field Office	Site/Facility	1992 Collective TEDE (person-rem)	1992 Number with Meas. Dose	1993 Collective TEDE (person-rem)	1993 Number with Meas. Dose	1994 Collective TEDE (person-rem)	1994 Number with Meas. Dose
Albuquerque	Ops. and Other Facilities	2.8	108	0.5	28	0.4	26
	Los Alamos National Lab. (LANL)	230.4	1,724	199.2	1,391	190.0	2,448
	Pantex Plant (PP)	51.4	384	46.0	445	29.1	347
	Sandia National Lab. (SNL)	18.1	516	11.9	314	12.0	250
	Uranium Mill Tailings Remedial Action (UMTRA) Project	9.9	301	-	-	15.0	390
Chicago	Ops. and Other Facilities	9.2	355	10.8	321	8.3	233
	Argonne Nat'l. Lab. - East (ANL-E)	16.9	149	20.9	185	40.3	280
	Argonne Nat'l. Lab. - West (ANL-W)	18.9	248	28.4	263	26.3	343
	Brookhaven Nat'l. Lab.(BNL)	58.7	973	59.9	713	92.3	865
	Fermi Nat'l. Accelerator Lab.(FERMI)	22.5	478	16.0	238	14.3	526
DOE HQ	DOE Headquarters	0.6	69	3.4	61	2.7	43
Idaho	Idaho Site	87.6	1,007	235.5	1,175	236.8	1,659
Nevada	Nevada Test Site (NTS)	2.1	37	1.7	20	2.0	20
Oakland	Ops. and Other Facilities	9.6	32	3.0	32	0.8	20
	Lawrence Berkeley Lab. (LBL)	6.4	233	6.8	137	5.7	92
	Lawrence Livermore Nat'l. Lab. (LLNL)	48.6	243	30.2	194	18.8	146
	Stanford Linear Accelerator Center (SLAC)	16.6	193	44.0	615	16.3	219
Oak Ridge	Ops. and Other Facilities	9.2	193	8.6	171	6.8	255
	Oak Ridge Site	96.2	2,792	76.1	1,939	69.2	1,613
	Paducah Gaseous Diff. Plant (PGDP)	7.1	155	6.5	171	6.8	151
	Portsmouth Gaseous Diff. Plant (PORTS)	22.4	763	33.6	832	30.3	836
Ohio	Ops. and Other Facilities	-	-	-	-	0.0	2
	Fernald Environmental Management Project*	35.1	704	26.1	1,020	24.2	925
	Mound Plant**	7.2	219	6.6	258	9.1	299
	West Valley***	17.1	216	17.5	249	24.3	292
Rocky Flats	Rocky Flats Eng. Tech. Site (RFETS)	[878.9]	[7,790]	[265.9]	[5,605]	231.9	3,660
Richland	Hanford Site	260.0	3,022	211.5	3,147	214.8	3,166
Savannah River	Savannah River Site (SRS)	351.8	6,510	258.4	4,525	[314.5]	[6,284]
Totals		2,295.3	29,414	1,628.9	24,049	1,643.1	25,390

* Fernald Site reported under the Oak Ridge Ops. Office in 1992, the Fernald Field Office in 1993, and the Ohio Field Office in 1994.
** Mound Site reported under Albuquerque Ops. Office in 1992 and 1993 and now reports under the Ohio Field Office.
*** West Valley Site reported under Idaho Ops. Office in 1992 and 1993 and now reports under the Ohio Field Office.

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

Exhibit 3-13:
Doses by Labor Category, 1992-1994

Labor Category	Number with Meas. Dose			Collective TEDE* (person-rem)			Average Meas. TEDE (rem)		
	1992	1993	1994	1992	1993	1994	1992	1993	1994
Agriculture	17	6	7	0.5	0.8	0.7	0.029	0.133	0.100
Construction	2,977	2,426	2,335	188.8	136.8	149.0	0.063	0.056	0.064
Laborers	717	750	807	49.6	57.5	55.2	0.069	0.077	0.068
Management	2,524	2,111	2,003	178.3	75.9	80.6	0.071	0.036	0.040
Misc.	3,742	2,598	1,655	193.6	101.1	77.5	0.052	0.039	0.047
Production	4,215	3,137	3,090	501.4	265.9	284.5	0.119	0.085	0.092
Scientists	5,842	4,250	5,201	372.9	170.5	197.7	0.064	0.040	0.038
Service	1,264	1,225	1,201	54.4	44.4	51.8	0.043	0.036	0.043
Technicians	3,916	3,992	4,238	421.9	380.6	393.8	0.108	0.095	0.093
Transport	578	286	478	22.7	11.1	21.1	0.039	0.039	0.044
Unknown	3,622	3,268	4,375	311.2	384.4	331.2	0.086	0.118	0.076
Totals	29,414	24,049	25,390	2,295.3	1,628.9	1,643.1	0.078	0.068	0.065

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

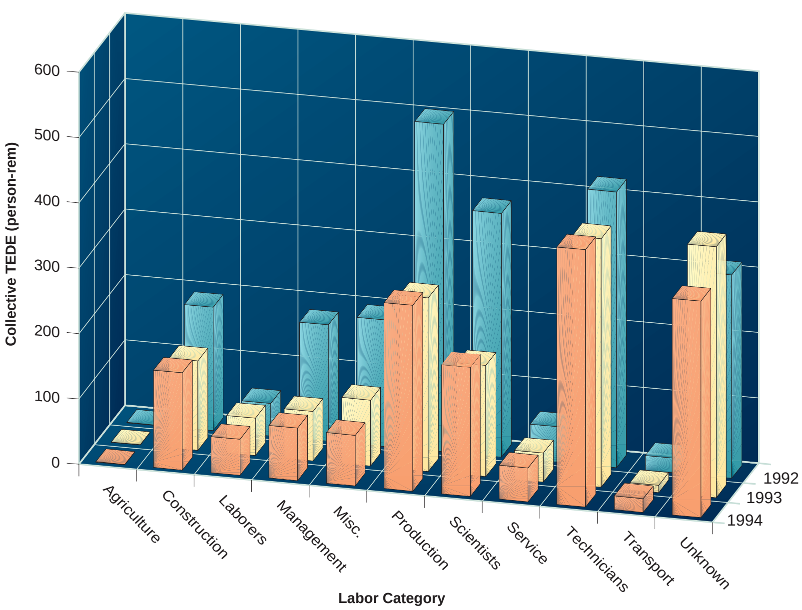
* *1992 TEDE = AEDE + DDE*
1993-1994 TEDE = CEDE + DDE

3.4.2 Dose by Labor Category

DOE occupational exposures are tracked by labor category at each site to facilitate identification of exposure trends, which assist management in prioritizing ALARA activities. Worker occupation codes are reported in accordance with DOE Order 5484.1 and are grouped into major labor categories in this report. The collective doses to each labor category for 1992-1994 are shown in *Exhibits 3-13 and 3-14*. Technicians and production staff have the highest collective doses for all 1992 and 1994 because they generally handle more radioactive sources than individuals in the other labor categories. The collective TEDE is also high for the "unknown" category. Sites must be more specific when reporting labor categories, if radiological control measures are to be directed at the worker level.

To examine internal dose by labor category independent of the legacy internal doses, the dose from new intakes occurring during the monitoring year is presented in Appendix B.

Exhibit 3-14:
Graph of Doses by Labor Category, 1992-1994



3.4.3 Dose by Facility Type

DOE occupational exposures are tracked by facility type at each site to better understand the nature of exposure trends and assist management in prioritizing ALARA activities. Contribution of certain facility types to the DOE collective TEDE is shown in *Exhibits 3-15* and *3-16*. The collective dose for each facility type at each Operations/Field Office is shown in Appendix B.

The highest collective doses for 1992-1994 were those at weapons fabrication and testing facilities, primarily Rocky Flats and the SRS. The large decrease in collective doses for weapons fabrication between 1992 and 1993 is attributable to the change in the methodology of accounting for internal dose. Weapons fabrication activities typically expose workers to long-lived isotopes, such as plutonium, used for the fabrication of the fissile components of weapons. As discussed in Section 2.2, the change in internal dose methodology particularly impacted exposures involving these long-lived isotopes.

To examine internal dose by facility type independent of the legacy internal doses, the dose from new intakes occurring during the monitoring year is presented in Appendix B.

Exhibit 3-15:
Graph of Doses by Facility Type, 1992-1994

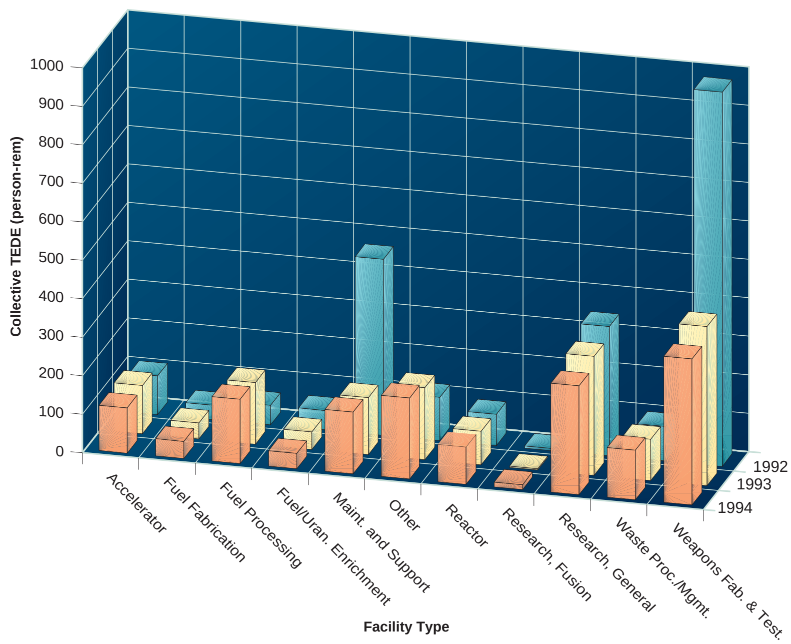


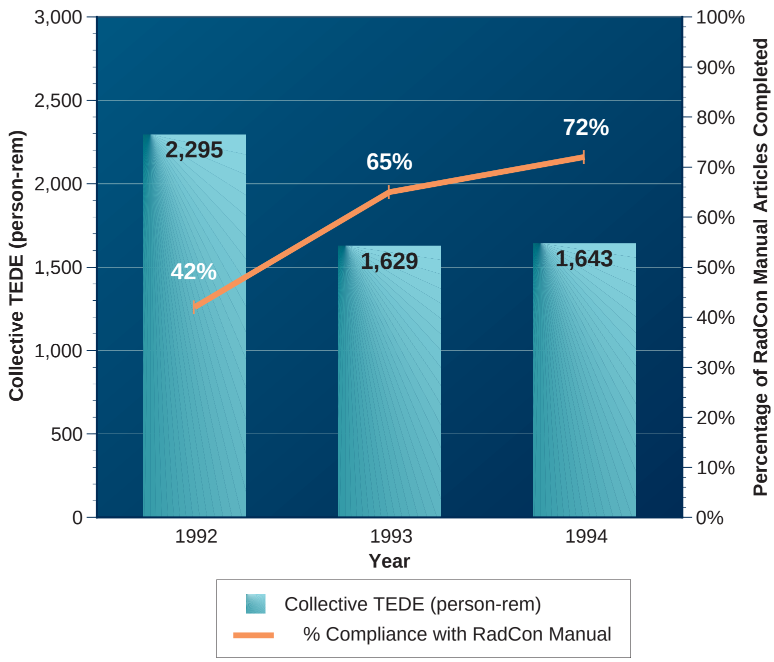
Exhibit 3-16:
Doses by Facility Type, 1992-1994

Facility Type	Number with Meas. Dose			Collective TEDE* (person-rem)			Average Meas. TEDE (rem)		
	1992	1993	1994	1992	1993	1994	1992	1993	1994
Accelerator	1,558	1,650	1,750	100.5	125.8	118.1	0.065	0.076	0.068
Fuel Fabrication	735	1,229	1,140	37.2	41.7	44.3	0.051	0.034	0.039
Fuel Processing	468	1,819	2,049	51.1	160.2	167.0	0.109	0.088	0.082
Fuel/Uranium Enrichment	1,928	1,150	1,121	50.6	45.3	40.1	0.026	0.039	0.036
Maintenance and Support	7,117	2,666	3,189	457.7	147.8	160.8	0.064	0.055	0.050
Other	2,651	1,771	2,889	112.3	187.1	211.1	0.042	0.106	0.073
Reactor	1,205	1,052	1,280	81.3	87.3	97.0	0.067	0.083	0.076
Research, Fusion	170	120	160	5.5	3.6	12.6	0.032	0.030	0.079
Research, General	2,946	2,894	3,435	336.3	309.1	283.0	0.114	0.107	0.082
Waste Processing/Mgmt.	1,069	1,894	2,923	90.2	107.3	129.2	0.084	0.057	0.044
Weapons Fab. and Testing	9,567	7,804	5,454	972.8	413.7	379.8	0.102	0.053	0.070
Totals	29,414	24,049	25,390	2,295.3	1,628.9	1,643.1	0.078	0.068	0.065

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

* *1992 TEDE = AEDE + DDE*
1993-1994 TEDE = CEDE + DDE

Exhibit 3-17:
Compliance with RadCon Manual vs Collective Dose, 1992-1994



Note: 1990-1992 (TEDE = DDE + AEDE)
1993-1994 (TEDE = DDE + CEDE)

3.5 Impact of the Radiological Control Manual on Collective Dose

The RadCon Manual was introduced in 1992 and was implemented across the DOE complex from 1992 to 1994. The RadCon Manual implementation standardized radiation protection practices among the DOE sites. This implementation had the potential to impact the occupational dose at DOE during this time period. To assess this impact, information was collected concerning the percentage of implementation of the RadCon Manual at each site [15, 16]. In addition, six of the highest dose sites were consulted and asked to submit further information concerning the impact of the RadCon Manual implementation at their site. These six sites accounted for nearly 80% of the collective TEDE over the past 5 years.

Based on this additional information, there does not appear to be a significant correlation between the implementation of the RadCon Manual and changes in the collective dose from 1992 to 1994. During this time period the RadCon Manual was being phased-in at the DOE sites. *Exhibit 3-17* shows the percentage of RadCon Manual articles that were implemented for each year as well as the collective dose. An analysis was performed calculating the correlation coefficient between RadCon Manual implementation and the collective dose for each individual site. No significant correlation was found.

Six of the sites with the highest collective doses were asked specifically about the impact of the RadCon Manual implementation on dose reduction. These sites stated that they had already implemented policies and practices similar to the RadCon Manual concerning issues that have the most significant impact on dose reduction. The RadCon Manual served to standardize administrative procedures rather than to contribute to significant dose reduction. One site indicated that the RadCon Manual had a positive impact on dose reduction, primarily through the implementation of training procedures, access control through use of radiation work permits, and certain recordkeeping procedures.

By the end of 1994, RadCon Manual compliance activities were beginning to shift to 10 CFR 835 compliance activities. The efforts to implement the RadCon Manual and 10 CFR 835 have focused more attention on control of exposure by radiological engineering and administrative controls in work areas with the highest potential for exposures. This increased attention coincides with the observed decrease in doses to individuals in the higher dose ranges as discussed in Section 3.2.5.

3.6 Changes in Mission and Operational Status of DOE Facilities

One of the most significant factors impacting the occupational dose at DOE is the operational status of DOE facilities. The shutdown of a facility that processes radioactive materials may limit the potential for radiation exposure of a large number of workers. Conversely, the resumption or acceleration of activities at a facility can increase exposures. This section of the report examines changes in mission and operational status of DOE facilities and the effects on the collective dose.

3.6.1 Events

Recent history of occupational radiation exposure at the DOE nuclear weapons complex can be better understood when placed in the context of two important international events — the nuclear reactor accident at Chernobyl and the end of the Cold War. The nuclear accident at Chernobyl in April 1986 focused attention on DOE's nuclear facilities and intensified safety reviews of DOE's large production and research reactors. A special safety panel was established to review the N-Reactor at the Hanford Site, which was the only American graphite production reactor.

The N-Reactor was shut down in January 1987, and the PUREX and UO_3 Plants at Hanford were shut down in 1988, leading to the end of plutonium production at the Hanford Site in 1990. In 1989, the Plutonium Fabrication Plant (PFP) at the Rocky Flats Site was shut down for safety code violations and many production functions were suspended. Plutonium operations were halted at the Rocky Flats Site in 1991. The K-Reactor at the SRS was prevented from restarting by a lawsuit filed by environmental groups. This action also affected the restart of the C- and L-Reactors at SRS and later contributed to the end of the production of materials for nuclear weapons at SRS. By late 1988, no DOE reactor was producing tritium for nuclear weapons.

In 1989, the Secretary of Energy established the Office of Environmental Restoration and Waste Management to strengthen the DOE environmental protection and waste management activities. Important events related to the end of the Cold War led to plans to reduce nuclear weapons stockpiles. Budget constraints facilitated the closing of experimental reactor facilities at Oak Ridge and Los Alamos. DOE accelerated the downsizing of the nuclear weapons complex and by 1992 the United States was no longer building nuclear weapons.

3.6.2 Impacts on the Collective Dose

A timeline of events leading to decreases in nuclear weapons production and occupational collective dose at DOE sites from 1985 to 1994 is shown in *Exhibit 3-18*. The collective dose shown includes only the external penetrating dose or DDE to obviate the consideration of the change in internal dose methodology.

Six major DOE nuclear weapons sites that contributed approximately 80% of the collective DDE over this period were selected for detailed review. The collective dose for these six sites as a function of their facility type is presented in *Exhibit 3-19* and indicates significant changes in the dose referenced in the text below.

The following is a summary of events and the corresponding impact on the collective DDE during the past 10 years. Reference numbers in circles (#) correspond to the reference numbers shown on *Exhibit 3-19*.

Exhibit 3-18:
Correlation of Occupational Radiation Exposure with Nuclear Weapons Production

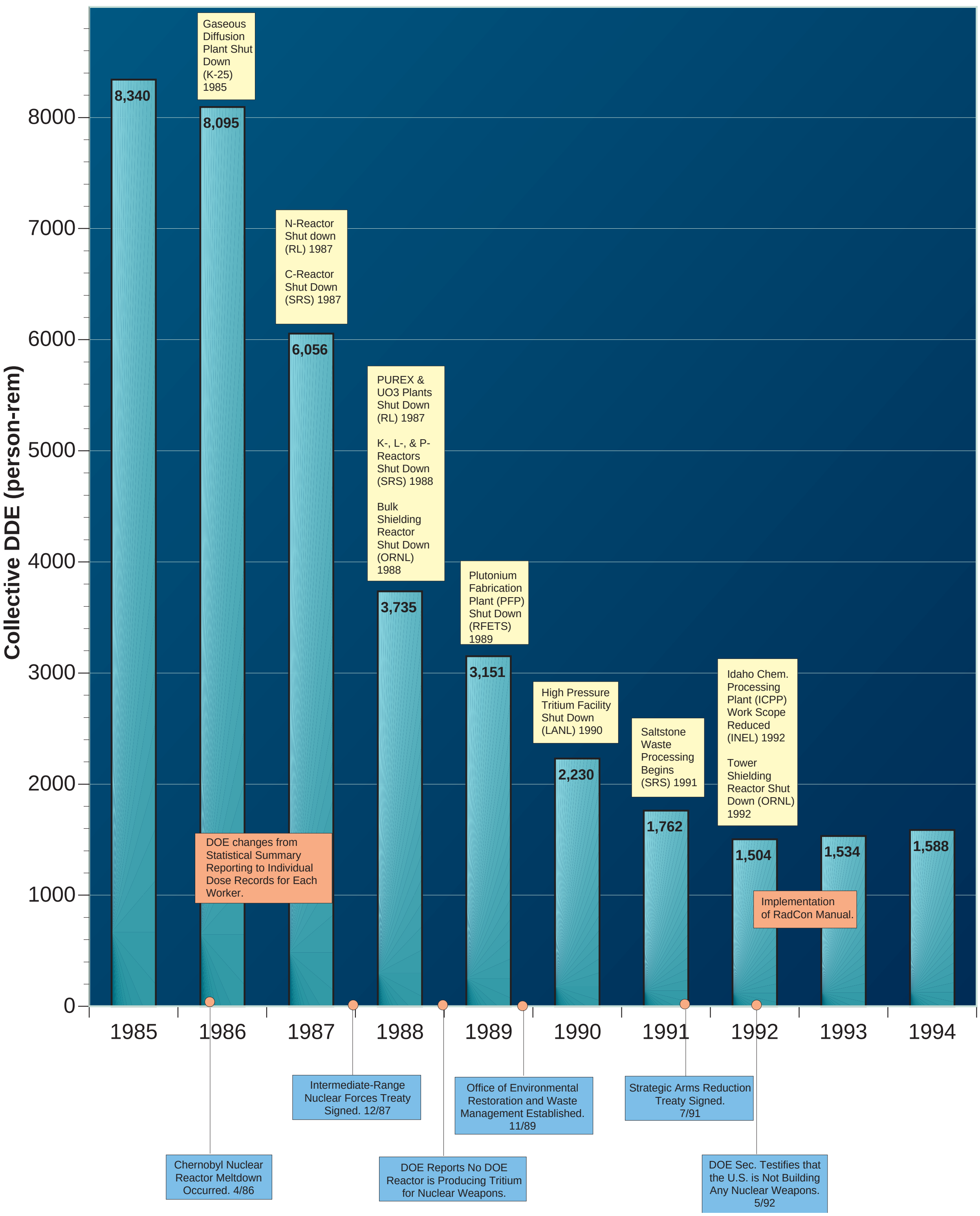


Exhibit 3-19:
Collective Dose for Six DOE Sites

Site	Facility	Total Collective DDE (person-rem)									
		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Idaho Nat'l. Engineering Lab.	Fuel Processing	169	156	141	145	218	146	61	38	65	73
	Maintenance & Support	0	16	10	8	6	5	2	2	2	8
	Other	12	214	11	9	28	150	61	14	117	91
	Reactor	166	144	79	44	40	31	33	28	43	51
	Research, General	0	4	2	27	19	12	4	4	8	8
	Waste Processing/Mgmt.	0	4	5	4	5	3	1	1	2	5
	INEL TOTAL	347	537	248	238	315	347	162	87	236	237
Los Alamos National Lab.	Accelerator	0	0	0	48	72	45	23	18	21	22
	Maintenance & Support	0	0	2	92	32	16	15	22	24	40
	Other	31	22	1	46	19	12	9	2	2	5
	Reactor	0	0	0	2	1	0	0	0	0	0
	Reseach, Fusion	0	0	0	1	0	0	0	1	0	0
	Research, General	745	548	376	199	201	146	113	89	93	108
	Waste Processing/Mgmt.	0	0	0	0	0	5	1	0	1	1
	Weapons Fab. & Testing	0	0	0	3	0	0	0	0	0	0
	LANL TOTAL	776	570	379	391	325	224	162	132	142	176
Oak Ridge Site	Fuel Processing	0	0	9	3	3	0	1	0	0	0
	Fuel/Uranium Enrichment	3	2	5	5	1	1	0	1	2	1
	Other	2	0	0	1	0	0	0	0	9	8
	Research, General	116	137	149	77	43	30	42	42	45	45
	Weapons Fab. & Testing	50	181	103	75	71	31	17	29	15	12
	Oak Ridge Site TOTAL	171	320	265	162	118	62	59	71	71	66
Rocky Flats	Weapons Fab. & Testing	1,370	1,245	880	654	412	145	313	297	250	229
	Rocky Flats TOTAL	1,370	1,245	880	654	412	145	313	297	250	229
Hanford Site	Fuel Fabrication	62	94	14	3	10	1	1	1	0	0
	Fuel Processing	0	0	14	22	62	11	8	10	5	5
	Maintenance & Support	0	0	1,098	172	152	118	103	86	72	77
	Other	1,105	887	29	7	16	9	10	13	17	19
	Reactor	1,183	964	776	152	163	51	19	20	14	13
	Research, General	183	307	103	56	85	55	42	46	47	44
	Waste Processing/Mgmt.	0	0	367	239	131	86	69	64	52	56
	Hanford Site TOTAL	2,533	2,251	2,402	652	619	330	252	239	207	213
Savannah River Site	Fuel Fabrication	70	89	57	49	31	33	0	0	15	19
	Fuel Processing	405	423	267	215	209	126	117	1	90	87
	Maintenance & Support	0	0	368	376	379	372	159	265	12	16
	Other	716	787	50	52	45	48	73	27	3	3
	Reactor	144	129	50	55	37	29	17	15	12	14
	Research, General	41	57	30	25	24	17	8	9	12	13
	Waste Processing/Mgmt.	0	0	112	105	76	51	35	0	46	61
	Weapons Fab & Testing	18	13	11	10	3	6	3	0	69	97
	SRS TOTAL	1,394	1,498	945	887	804	683	412	317	258	310
Totals	TOTAL FOR SIX SITES	6,592	6,422	5,119	2,983	2,593	1,791	1,360	1,144	1,163	1,231
	DOE OVERALL TOTAL*	8,340	8,095	6,056	3,735	3,151	2,230	1,762	1,504	1,534	1,600
	Percentages of Sites to DOE Overall	79%	79%	85%	80%	82%	80%	77%	76%	76%	78%

* Does not include Schenectady Naval Reactor Office or Pittsburgh Naval Reactor Office.

Events	Impacts
The N-Reactor closed at the Hanford Site in January 1987, followed by the shutdown of both the PUREX and UO3 plants in 1988, and the shutdown of the PFP in 1989.	A large decrease in the collective dose at the Hanford Site for the "Reactor" (1) and "Other" (2) facility types occurs between 1987 and 1988. The overall decrease in collective dose at the Hanford Site from 1987 to 1988 is dramatic (3).
DOE reported in mid-1988 that no DOE reactor was producing tritium for nuclear weapons. The C-Reactor at the SRS was shut down in 1987. The L-Reactor at SRS was restarted in 1985 and shutdown again in 1988. The P-Reactor and the K-Reactor at SRS were shut down in 1988 and never restarted except for a brief K-Reactor test run in 1992. The production of nuclear weapons materials at SRS ended in 1992.	Collective dose for the "Reactor" (4) and "Other" (5) facility types at the SRS decreased between 1986 and 1987. The overall decrease for the SRS indicates that there is a slowdown in activity at the SRS (6).
Rocky Flats PFP operations were curtailed in 1989 and many other functions suspended in the subsequent years with a total halt in plutonium operations in 1991. The plant began preparations to resume activities in 1991, but a change in mission to shut down, decontaminate, and decommission occurred in 1993.	The collective dose at the Rocky Flats Site decreased by 88% from 1986 to 1990 (7). It increased in 1991 (8) as a result of the aborted resumption effort, and has slowly decreased between 1991 and 1994.
The Office of Environmental Restoration and Waste Management (EM) was established in November 1989. The K-25 Plant at Oak Ridge was shut down in 1985 and became an EM site in 1992. The bulk shielding and tower shielding reactors at ORNL were shut down in 1988 and 1992, respectively. The mission of the Y-12 Plant has been changed to the dissassembly of nuclear weapons.	The collective dose at the Oak Ridge Site decreased from 1986 to 1991 (9) and increased slightly in 1992 (10). In general, the K-25 Plant is reported as a "Fuel/Uranium Enrichment" facility type, ORNL is reported as a "Research, General" facility type, and the Y-12 Plant is reported as a "Weapons, Fab & Testing" facility type. The shutdown of the K-25 Plant occurred before 1985. The shutdown of the experimental reactors at ORNL correlates with a collective dose decrease in the "Research, General" facility type from 1987 to 1990 (11). The Y-12 Plant, "Weapon, Fab & Testing" facility type collective dose decreased between 1986 and 1991 (12). This correlates with the end of weapons assembly.
The Secretary of Energy testified before Congress in May 1992 that the United States was not building any nuclear weapons for the first time since 1945. The high pressure tritium facility at LANL was shut down in 1990 and the work scope at the Idaho Chemical Processing Plant (ICPP) (INEL) was reduced in 1992.	The basic mission at the LANL has not changed and INEL has many missions with the US Navy. The collective dose shown for these sites shows gradual decrease. LANL collective dose decreases 82% from 1985 to 1992 (13). INEL shows a decrease of more than 79% during this period but this decrease is not consistent from year to year (14).

During the reporting period 1992-1994, the DOE overall collective DDE increased by 6% ( ). The collective DDE at the Hanford, Rocky Flats, and Oak Ridge Sites decreased (16) and the collective DDE at the SRS has remained about constant ( ). The collective dose increased at INEL and LANL (18) as a result of increased activities at the ICPP, and increased throughput for satellite heat sources at the LANL plutonium facilities.

As can be seen from this analysis, changes in mission and operational status can have a large impact on the occupational dose at DOE.

Comparison of DOE Dose to Other Activities

4.1 Comparison with the Nuclear Regulatory Commission

Comparison of DOE occupational radiation exposure to other large industrial and governmental endeavors is important in gaining an understanding of the relative scale of DOE operations to other licensed operations. A comparison of the DOE occupational radiation exposure to that of the U.S. Nuclear Regulatory Commission (NRC) licensees is provided in *Exhibits 4-1* and *4-2* [17]. The size of the exposed workforce within the DOE complex and the DOE collective dose is low compared to NRC-licensed facilities. The average measurable TEDE to DOE workers, 0.065 rem in 1994, is almost one-fifth of the NRC average measurable TEDE of 0.310 rem. NRC-licensed facilities began reporting the TEDE using the CEDE methodology for internal dose assessment in 1994. Internal dose is much less common at NRC facilities and is only a significant contributor to dose at fuel fabrication licensees where workers are exposed to uranium via inhalation.

Maximum individual doses may also be compared for these two agencies. During the 5-year period 1990-1994, NRC licensees reported a total of five exposures in excess of 5 rem to the whole body. During this same time period, the DOE reported a total of 19 exposures in excess of 5 rem to the whole body.

When looking at data for the DOE and NRC licensees, it is important to consider the type of exposures that typify the majority of their respective collective doses. NRC licensees' exposures in excess of the 5 rem limit all occurred from industrial

The DOE average measurable dose is one-fifth of the average dose at NRC licensees.

Exhibit 4-1:
Number of Individuals with Measurable Dose, 1974-1994

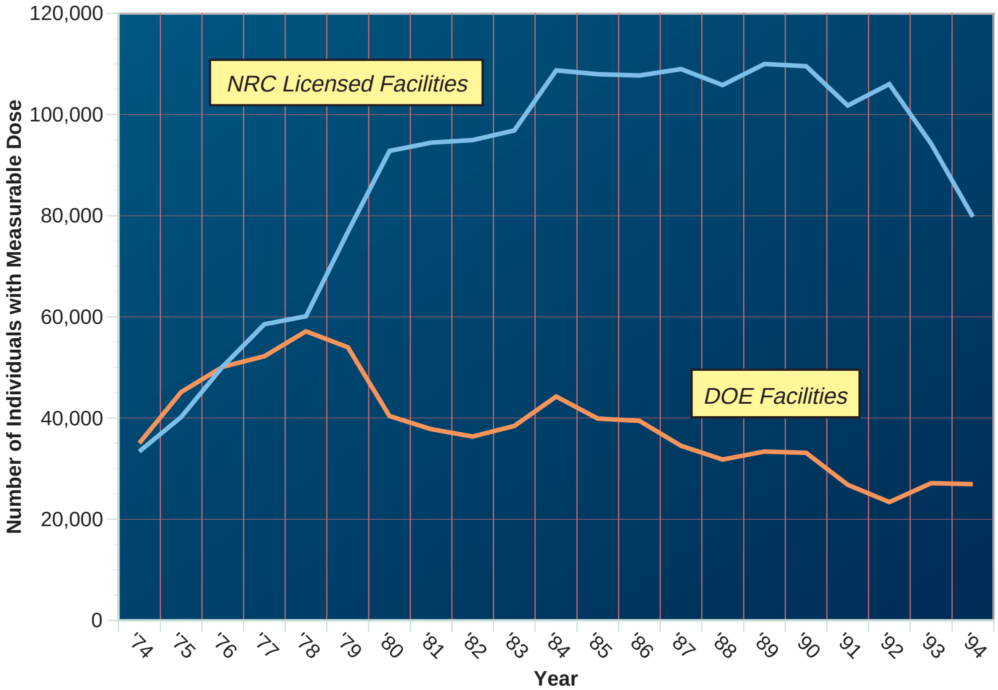
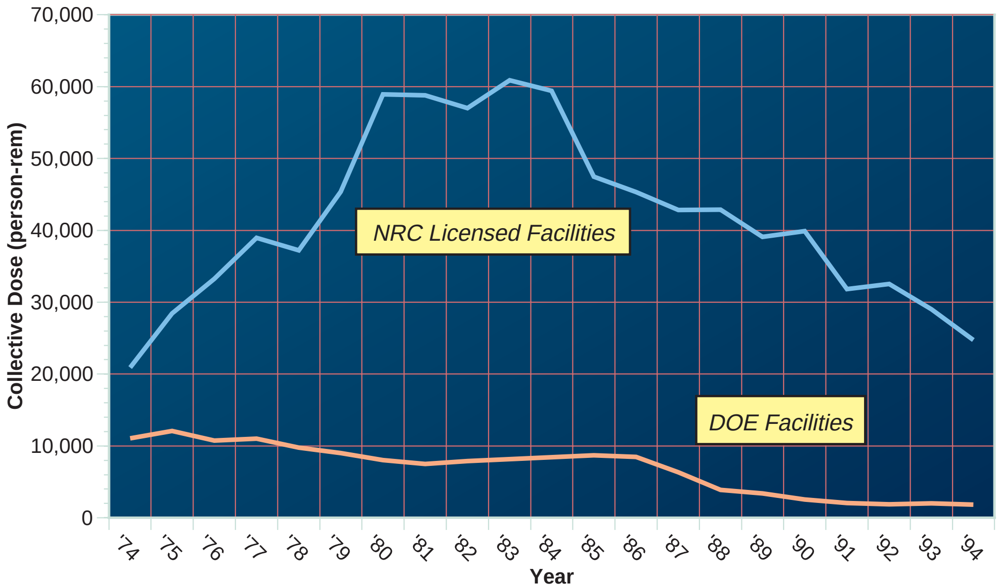


Exhibit 4-2
Collective Dose, 1974-1994



radiography activities and were caused by external exposure to radiography sources. Additionally, there were one skin exposure and six extremity exposures in excess of NRC limits during the same period. In contrast, all DOE doses in excess of the limits have been due to internal dose from the intake of radioactive material, and most of these exposures were from an intake from previous years. No DOE exposures in excess of the 5 rem whole body limit were reported in 1994, and no skin or extremity exposures in excess of the DOE limits were reported during the past 5 years.

4.2 Comparison with International Organizations

DOE and NRC occupational radiation doses may also be compared with other country's radiation protection programs. *Exhibit 4-3* provides a general comparison between DOE and NRC collective dose and that experienced by other countries with nuclear-related missions for 1992 through 1994, where available [18]. These programs vary considerably in size and mission and the reporting of collective dose is not uniform across all organizations. Some organizations do not include internal dose in their collective dose. Therefore, it is not possible to compare all the programs directly. Collective doses have either stabilized or decreased for most organizations indicating a general adherence to ALARA in the worldwide radiation protection community. Comparison of the different organizations is difficult because the data in *Exhibit 4-3* are incomplete.

To aid in the comparison of the available collective dose data between the different organizations, the following descriptions of their programs are provided.

DOE - The DOE collective dose is attributed to more than 1,200 radiological facilities involved in weapons dismantlement; operation of accelerators and nuclear reactors; handling of tritium, plutonium, uranium, and thorium in various forms; handling and storage of mixed fission products and spent nuclear fuel; processing of radioactive waste; use of X-ray machines and other radiation generating devices; and a myriad of activities associated with remediation of formerly utilized facilities. In 1994, 116,511 people were monitored for exposure to ionizing radiation.

U. S. NRC - The NRC collective dose is attributed to NRC licensees including 139 industrial radiography, 44 manufacturing and distribution, two low-level waste disposal, 1 independent spent fuel storage, 8 fuel fabrication and processing, and 109 commercial Light Water Reactors (LWRs). In 1994, 152,834 people were monitored for exposure to ionizing radiation.

Europe - The collective dose from the European reactors is attributed to 113 commercial LWRs. High Temperature Gas Cooled Reactor (HTGR) data were not available. The European group includes reactors in Belgium, Finland, France, Germany, the Netherlands, Spain, Sweden, and Switzerland. Data for the number of people monitored were not available.

Japan - The collective dose from the Japanese reactors is attributed to 46 commercial LWRs and one HTGR. Data for the number of people monitored were not available.

Exhibit 4-3:
Comparison of Collective Dose for Various International Organizations

Organization	Approximate Number of Facilities	Number of People Monitored			Collective Dose (person - rem)					
		1992	1993	1994	1992 DDE	1992 TEDE	1993 DDE	1993 TEDE	1994 DDE	1994 TEDE
DOE	>1,200 Facilities	123,711	127,042	116,511	1,504	2,295	1,534	1,629	1,600	1,643
U.S. NRC	109 Reactors (Only)	183,900	169,862	142,707	29,298		26,365			21,695
	194 Other Licensees	21,109	19,850	10,127	3,240		2,649			3,206
	303 Total	205,009	189,712	152,834	32,538		29,014			24,901
Europe	113 Reactors		NA*		23,103		21,069			NA
Japan	46 Reactors		NA		6,309		8,635			NA
United Kingdom	28 Reactors		NA		1,021		854			NA
Canada	22 Reactors		NA			1,962		1,642		NA
UK MOD (DRPS)	Navy Defense Facilities and Ships	7,778	7,534	7,474		620		560		500
UK MOD (AWE)	Aldermaston Atomic Weapons Establishment	4,153	4,259	4,320		110		100		80

* NA: Not Available

United Kingdom - The collective dose from UK reactors is attributed to 28 HTGRs. Data for the number of people monitored were not available.

Canada - The collective dose from Canadian reactors is attributed to 22 heavy water moderated reactors. Data for the number of people monitored were not available.

UK MOD (DRPS) - The collective dose for the UK Ministry of Defense (MOD) Defense Radiological Protection Services (DRPS) is attributed to service personnel and contractors, including submarine maintenance workers at naval dockyards. In 1994, 7,474 people were monitored for exposure to ionizing radiation.

UK MOD (AWE) - The collective dose for the UK MOD Atomic Weapons Establishment (AWE) includes facilities and staff at Aldermaston. In 1994, 4,320 people were monitored for exposure to ionizing radiation.

Radiation Protection Activities at DOE

5

This section recognizes highly successful ALARA projects and encourages the use of similar innovative ideas at other locations in the DOE complex. In future years, ALARA success stories, such as those described below, will be included in the *DOE Occupational Radiation Exposure Report.*

The following is a description of three successful ALARA projects that were conducted at DOE facilities within the past few years. These three project descriptions were submitted by INEL and SRS radiation protection staff and are representative of ALARA activities conducted at DOE sites.

5.1 INEL Vault Project

The mission of the INEL vault project was to install secondary containment to a hazardous waste tank system in accordance with Resource Conservation and Recovery Act Regulation (40 CFR 265.193) and a State of Idaho Consent Order.

The vault is 43 feet below ground level and entry is through a 3-foot square hatch in the vault ceiling. Two 18,000-gallon hazardous waste tanks are housed in the vault. The waste consists of spalled concrete from the vault floor and walls and dirt (silt).

Radiological concerns included:

- general area radiation fields in the vault ranging from 0.5 - 0.6 R/h,
- hot spots up to 20 R/h on the waste tanks,
- a 10 R/h general area radiation field around the floor sump located between the two tanks,
- contamination levels in the vault as high as 500,000 dpm/100 cm^2 beta-gamma and 28,000 dpm/100 cm^2 alpha, and
- radiation levels that could not be reduced by flushing the tanks because of blockage in the discharge lines.

ALARA activities used to reduce individual and project doses included:

- pre-job work planning,
- full-scale mockup,
- procedure development,
- specially designed shielding,
- remote video cameras and monitors, and
- teledosimetry units.

The pre-job work planning identified tasks that would require special training and accumulate significant dose. It was decided that the use of a full-scale mockup (*Exhibit 5-1*) of the work area would provide a nonradiological environment to develop efficient techniques and work procedures. Workers were able to resolve problems and modify work tasks before entering the radiological area. The

Mock-up training saved an estimated 35 person-rem.

Exhibit 5-1:
Technicians in Full Radiological Protective Gear Practicing Tasks to Help Reduce Stay Times

Photo Courtesy of INEL

Radiation Protection Activities at DOE

Exhibit 5-2: Portable Video Camera

Photo Courtesy of INEL

shielding was designed for ease of mobility and optimal protection of personnel. The portable video cameras *(Exhibit 5-2)* and monitors allowed the Radiological Control Technicians (RCTs) to observe work activities without being in the radiological area. The teledosimetry units provided real-time exposure monitoring, which allowed RCTs to efficiently plan stay times. The combination of these efforts reduced the number of man-hours in the radiological environment, increased distances between workers and the radiation source, and used effective shielding materials (time, distance, and shielding). It is estimated that these efforts resulted in an overall savings of 35 person-rem.

5.2 INEL Vessel Installation Project

The mission of this project was to place a vessel into a cell through a ceiling hatch. The installation required field verifications of vessel placement, as well as optimal vessel sizing and shaping.

Radiological concerns included:

- areas of high radiation levels and
- confined spaces in the cell.

ALARA activities used to reduce individual and project doses included:

- 3-dimensional laser computer drawing photography (photogrammetry) and
- pre-job work planning.

The model provided accurate and complete as-built configurations of the vessel and its placement and realistic tours of the area in the cell. Text was added to the computer screen to identify dose rates, hot spots, and additional information. The program was used to zoom in on specific components, such as valves, to assist with the installation planning. The simulated tours and job planning reduced the amount of time spent in the actual cell. It is estimated that these efforts resulted in an overall savings of 5 person-rem.

5.3 Savannah River Material Repackaging Project

The mission of this project was to repackage and move highly radioactive materials stored in 44 cans that had been brought on site in 1980. The material was sealed in double cans (3 in. diameter x 4 in. high) and stored in a vault. Because of over-pressurization and rupture of the original containers, the material had been moved to a locked cabinet (48 in. wide x 24 in. deep x 34 in. high).

Radiological concerns included:

- beta-gamma exposure rates of 0.25 rem/h at the face of the cabinet and
- potential contamination from the leaking containers inside the cabinet.

ALARA activities used to reduce individual and project doses included:

- pre-job planning,
- setting of an ALARA goal of 0.1 rem/person,
- developing a Technical Authorization,
- developing a 4-hour training video, and
- conducting an in-depth ALARA review.

The pre-job ALARA review included:

- performing procedure reviews,
- establishing health physics hold-points,
- performing walkdowns using dry-run mockups,
- using special tooling,
- preparing job site for contamination controls,
- ensuring adequate ventilation systems,
- reviewing the engineering design and temporary shielding,
- identifing and using low-dose areas,
- staging and preparation of equipment and personnel,

- using protective clothing and lead aprons, and
- determining appropriate dosimetry and estimating cumulative dose.

The task to repackage and move the material evolved over a 12-month period. The actual hands-on work took 6 months on three shifts and approximately 100 operators.

The initial exposure estimate of the repackaging alone was 63 person-rem. After the pre-job ALARA review, exhaustive ALARA efforts were planned and implemented. The actual dose attributed to repackaging and movement of the material was 10.2 person-rem. This represented an estimated dose savings of more than 50 person-rem.

5.4 Submitting ALARA Success Stories for Future Annual Reports

Individual success stories should be submitted in writing to the DOE Office of Worker Protection Programs and Hazards Management (use mailing address in Appendix E). The submittal 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 submittal should address the following:

- mission statement,
- project description,
- radiological concerns,
- 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), and
- point-of-contact for follow-up by interested professionals.

5.5 Lessons Learned Process Improvement Team

In March 1994, the Deputy Associate Secretary for Field Management established a DOE Lessons Learned Process Improvement Team (LLPIT). The purpose of the LLPIT is to develop a complex-wide program to standardize and facilitate identification, documentation, sharing, and use of lessons learned from actual operating experiences throughout the DOE complex. This information sharing and utilization is commonly termed "Lessons Learned" within the DOE community.

The collected information is currently located on an Internet World Wide Web (Web) site as part of the Environmental Safety & Health (ES&H) Technical Information System (TIS). 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. DOE 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 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 work place 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 Web site address for DOE Lessons Learned is:

http://www.tis.eh.doe.gov:80/others/ll/ll.html

The specific Web site address may be subject to change. This Web site can always be accessed through the main ES&H TIS Web site at:

http://www.tis.eh.doe.gov

Conclusions and Recommendations

6.1 Conclusions

The current philosophy of radiation protection is based on the assumption that any radiation dose, no matter how small, may result in human health effects. Radiogenic health events have been observed in humans at doses in excess of 10 rem delivered at high dose rates. In the past, DOE workers were at risk for high occupational exposure to radiation. As the data clearly indicate, most exposures are less than 1 rem per year. It is important to monitor the DOE workforce, however, because there is less certainty about the effects of low doses delivered at low dose-rates over long time periods.

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. This also revealed the limitations of available data, and identified additional data needed to correlate more definitively trends in occupational exposure to past and present activities at DOE sites.

During the past 5 years, the occupational radiation dose at DOE has been impacted by three factors: changes in operational status, changes in reporting requirements, and changes in radiation protection standards and practices. These factors and their impact are discussed below in order of their significance.

The collective dose at DOE facilities has remained fairly stable over the past 5 years after experiencing a dramatic decrease from the mid-1980s. The main reasons for this large decrease were the shutdown of facilities because of safety problems within the weapons complex and the end of the Cold War era, which shifted the DOE mission from weapons production to shutdown, stabilization, and decommissioning and decontamination activities. The DOE weapons production sites have contributed the majority of the collective dose over the past 5 years. In addition, key facilities at these sites contribute the majority of the site dose. Change in operational status of these key facilities is the predominant driver behind changes in the collective dose. As facilities are shut down and undergo transition from operation to stabilization or decommissioning and decontamination, there are significant changes in the opportunities for individuals to be exposed (see Section 3.6). More modest reductions in collective dose have occurred during the past 5 years while facilities have continued to transition to shutdown and stabilization.

The change in methods to determine internal dose from AEDE to CEDE between 1992 and 1993 resulted in an overall reduction of the annual collective dose of approximately 700 person-rem because of the exclusion of the legacy internal dose. This represents a significant dose that is no longer accounted for in the collective dose reported to DOE Headquarters. Only 2 years of data are available under the new CEDE methodology and therefore trends in CEDE cannot yet be analyzed. As discussed in Section 3.3.3, changes in internal dosimetry detection levels and reporting practices at a site can significantly impact the number of reported intakes.

The implementation of the RadCon Manual has resulted in changes in radiation protection practices. As described previously, the RadCon Manual changed the methodology concerning internal dose. While it is not possible to quantify the impact of the RadCon Manual on the collective dose, it did establish ACLs, standardized radiation protection programs, engineering controls, and formalized ALARA practices to coincide with the observed reduction in doses to individuals in the higher dose ranges.

The average dose at DOE is one-fifth of the average dose received in the commercial nuclear industry in the United States. In addition, doses to individuals in the higher dose ranges continue to decrease.

The average dose at DOE is one-fifth of the average dose received in the commercial nuclear industry in the United States.

6.2 Recommendations

1. Because the change in operational status has been shown to be a large factor impacting the occupational dose, this information should be collected from DOE facilities. A "phase of operation" status code should be added to the occupational radiation reporting requirements for individual dose records (see Appendix A.4). In combination with the facility type codes already reported, this will provide an indication of the operational mode and type of activities being conducted at a given facility. This will become increasingly important as more facilities transition from stabilization activities into decommissioning and decontamination.

2. Attention should focus on the facility type code information currently reported by DOE sites. Analysis revealed that the sites are inconsistent in the assignment of the facility type codes and have difficulty correlating the dose from specific facilities at the site with the facility type codes. A standardized approach to facility categorization should be established to successfully augment the facility type information with the phase of operation information (see Appendix A.3). Standardization will allow analysis of how changes in operational status impact the occupational dose.

3. As stated above, the internal dose from prior intakes (legacy dose) is a significant contributor of dose to the individual worker. It is recommended that DOE establish a repository of intake information to allow analysis of the lifetime dose from prior (legacy) intakes. This information will allow analysis of the dose accrued each year for worker health and epidemiologic research in addition to the current requirements of monitoring and reporting the committed dose for regulatory enforcement purposes.

4. DOE should implement a standardized approach to internal dosimetry including DOELAP for radiobioassay (sample analysis) and a Technical Standard on Internal Dosimetry that will help to standardize monitoring and reporting of internal dose in future years.

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Glossary

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 work force 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. Annual effective dose equivalent 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.

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 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., $H_E,50 = \Sigma w_T H_T,50$. Committed effective dose equivalent is expressed in units of rem.

CR
CR is defined by the United Nations Scientific Committee on the Effects of Atomic Radiation as the ratio of the annual collective dose delivered at individual doses exceeding 1.5 rem to the collective dose.

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

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

Number of individuals with measurable exposure

The subset of all monitored individuals who receive a measurable exposure (greater than limit of detection for the monitoring system). Many personnel are monitored as a matter of prudence and may not receive a measurable exposure. For this reason, the number of individuals with measurable exposure is presented in this report as a more accurate indicator of the exposed workforce.

Occupational exposure

An individual's exposure to ionizing radiation (external and internal) as a result of that individual's work assignment. Occupational exposure does not include planned special exposures, exposure received as a medical patient, background radiation, or voluntary participation in medical research programs.

Total Effective Dose Equivalent (TEDE)

The sum of the effective dose equivalent for external exposures and the 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 monitored individuals

All individuals who are monitored and reported to the DOE Headquarters database system. This includes DOE employees, contractors, and visitors.

Appendix A

A

DOE Reporting Sites and Reporting Codes

DOE Reporting Sites and Reporting Codes

A.1 Labor Categories and Occupation Codes

The following is a list of the Occupation Codes that are reported with each individual's dose record to the DOE Radiation Exposure Monitoring System (REMS) system in accordance with DOE Order 5484.1 [8]. Occupation Codes are grouped into Labor Categories for the purposes of analysis and summary in this report.

Labor Category	Occupation Code (5484.1)	Occupation Name
Agriculture	0562	Groundskeepers
	0570	Forest Workers
	0580	Misc. Agriculture
Construction	0610	Mechanics/Repairers
	0641	Masons
	0642	Carpenters
	0643	Electricians
	0644	Painters
	0645	Pipe Fitters
	0650	Miners/Drillers
	0660	Misc. Repair/Construction
Laborers	0850	Handlers/Laborers/Helpers
Management	0110	Manager - Administrator
	0400	Sales
	0450	Admin. Support and Clerical
Misc.	0910	Military
	0990	Miscellaneous
Production	0681	Machinists
	0682	Sheet Metal Workers
	0690	Operators, Plant/ System/Utility
	0710	Machine Setup/Operators
	0771	Welders and Solderers
	0780	Misc. Precision/Production
Scientists	0160	Engineer
	0170	Scientist
	0184	Health Physicist
	0200	Misc. Professional
	0260	Doctors and Nurses
Service	0512	Firefighters
	0513	Security Guards
	0521	Food Service Employees
	0524	Janitors
	0525	Misc. Service
Technicians	0350	Technicians
	0360	Health Technicians
	0370	Engineering Technicians
	0380	Science Technicians
	0383	Radiation Monitors/Techs.
	0390	Misc. Technicians
Transport	0820	Truck Drivers
	0821	Bus Drivers
	0825	Pilots
	0830	Equipment Operators
	0840	Misc. Transport
Unknown	0001	Unknown

A.2 Organizations Reporting to DOE REMS, 1990-1994

The following is a listing of all organizations reporting to the DOE REMS from 1990 to 1994. The Operations Office and Site groupings used in this report are shown in addition to the organization reporting code and name.

Operations/ Field Office	Site	Organization Code	Organization Name
Albuquerque	Ops. and Other Facilities	0501001	Albuquerque Field Office
		0501006	Albuquerque Office Subs.
		0502009	Albuquerque Transportation Division
		0530001	Kansas City Area Office
		0531002	Allied-Signal, Inc.
		0550001	Pinellas Area Office
		0553002	Martin Marietta Specialty Components
		0590001	WIPP Project Integration Office
		0593004	WPSO Miscellaneous Contractors
		2806003	National Renewable Energy Lab (NREL)
	Los Alamos National Lab. (LANL)	0540001	Los Alamos Area Office
		0544003	Los Alamos National Laboratory
		0544809	Protection Technologies Los Alamos
		0544904	Johnson Controls, Inc.
	Pantex Plant (PP)	0510001	Amarillo Area Office
		0514004	Battelle - Pantex
		0515002	Mason & Hanger - Amarillo
		0515006	M&H - Amarillo - Subcontractors
		0515009	M&H - Amarillo - Security Forces
	Sandia National Lab. (SNL)	0570001	Kirtland Area Office
		0575003	Inhalation Toxicology Research
		0577004	Ross Aviation, Inc.
		0578003	Sandia National Laboratory
	Uranium Mill Tailings Remedial Action (UMTRA) Project	0580001	UMTRA Project Office
		0582004	MK-Ferguson Subs - UMTRA
		0582005	MK-Ferguson Co. - UMTRA
		0583004	Jacobs-Weston Team
Chicago	Ops. and Other Facilities	1000503	Ames Laboratory (Iowa State)
		1000903	Battelle Memorial Institute - Columbus
		1001501	Chicago Field Office
		1001606	Chicago Office Subs
		1002001	Environmental Meas. Lab.
		1004031	New Brunswick Laboratory
		1004503	Mass. Inst. of Tech.
		1005003	Princeton Plasma Physics Laboratory
		1006003	National Renewable Energy Lab (NREL)
	Argonne Nat'l. Lab. - East (ANL-E)	1000703	Argonne National Laboratory - East
	Argonne Nat'l. Lab. - West (ANL-W)	1000713	Argonne National Laboratory - West
	Brookhaven Nat'l. Lab.(BNL)	1001003	Brookhaven National Laboratory
	Fermi Nat'l. Accelerator Lab.(FERMI)	1002503	Fermi Lab.
DOE HQ	DOE Headquarters	1504001	DOE Headquarters
		1504506	DOE Office Subs
Idaho	Idaho Site	3000209	Protection Technology - INEL
		3000504	Chem-Nuclear Geotech
		3003003	EG&G Idaho, Inc.
		3003402	Babcock & Wilcox Idaho, Inc.
		3003502	Westinghouse Idaho Nuclear Co.
		3004001	Idaho Field Office
		3004004	Idaho Office Subs
		3005505	MK-Ferguson Company - ID
		3005506	MK-Ferguson Subcontractors - ID

A.2 Organizations Reporting to DOE REMS, 1990-1994 (continued)

Operations/ Field Office	Site	Organization Code	Organization Name
Nevada	Nevada Test Site (NTS)	3502504	EG&G Kirtland
		3502804	EG&G Special Technologies Laboratory
		3502904	EG&G Washington D.C.
		3503004	EG&G Las Vegas
		3503504	EG&G Los Alamos
		3504004	EG&G Amador Valley Operations
		3504504	EG&G Santa Barbara
		3505004	Fenix & Scisson, Inc. (old org. code)
		3505007	Fenix & Scisson, Inc.
		3506004	Raytheon Services - Nevada
		3506007	Holmes & Narver, Inc., ESD
		3506024	Raytheon Services Subcontractors
		3507501	Nevada Field Office
		3507514	Nevada Miscellaneous Contractors
		3507531	Defense Nuclear Agency - Kirtland
		3507551	Environmental Protection Agency (EPA)
		3508504	Reynolds Elec. & Engr. Co. Services
		3508505	Reynolds Elec. & Engr. Co. - NTS
		3508703	Science Applications Interntl Corp.
		3509009	Wackenhut Services, Inc. - NV
		3509504	Westinghouse Electric Corp. - NV
Oakland	Ops. and Other Facilities	8001003	Rockwell International, Rocketdyne
		8001013	Rockwell International, Atomics
		8006103	U. of Cal./Davis, Radiobiology Lab.
		8006303	U. of Cal./SF - Lab of Radiobiology
		8007001	Oakland Field Office
	Lawrence Berkeley Lab. (LBL)	8003003	Lawrence Berkeley Laboratory
	Lawrence Livermore Nat'l. Lab. (LLNL)	8004003	Lawrence Livermore National Laboratory
		8004004	LLNL Subcontractors
		8004009	LLNL Security
		8004024	LLNL Plant Services
		8005003	Lawrence Livermore Nat'l Lab.
	Stanford Linear Acc. Center (SLAC)	8008003	Stanford Linear Accelerator Center
Ohio	Ops. and Other Facilities	4500001	Ohio Field Office
		4510001	Miamisburg Area Office
Fernald Field, 1993	Fernald Environmental*	4521001	Fernald Area Office
Oak Ridge, 1992		4521004	Fernald Office Service Subcontractors
		4523702	Fernald Envir. Rest. Mgmt. Corp (FERMCO)
		2503702	Fernald Envir. Rest. Mgmt. Corp (FERMCO)
		4003702	Westinghouse Envir Mgmt. Co. of Ohio
Alburquerque, 1992	Mound Plant**	4516002	EG&G Mound Applied Technologies
Alburquerque, 1993		4516004	EG&G Mound Subcontractors
		4516009	EG&G Mound Security Forces
		0520001	Dayton Area Office
		0526002	EG&G Mound Applied Technologies
Idaho, 1992-1993	West Valley Project***	4539004	West Valley Nuclear Services, Inc
		3009004	West Valley Nuclear Services, Inc
Oak Ridge	Ops. and Other Facilities	4004203	Oak Ridge Inst. for Sci. & Educ.
		4004704	Bechtel National, Inc. - (FUSRAP)
		4005002	RMI Company
		4009006	Morrison-Knudsen (WSSRAP)
		4009503	Southeastern Univ Research Assoc.

* Fernald site reported under the Oak Ridge Ops. Office in 1992, the Fernald Field Office in 1993, and the Ohio Field Office in 1994.
** Mound Site reported under Albuquerque Ops. Office in 1992 and 1993 and now reports under the Ohio Field Office.
*** West Valley Site reported under Idaho Ops. Office in 1992 and 1993 and now reports under the Ohio Field Office.

A.2 Organizations Reporting to DOE REMS, 1990-1994 (continued)

Operations/ Field Office	Site	Organization Code	Organization Name
Oak Ridge	Oak Ridge Site	4005105	MK-Ferguson Co. - OR
		4006002	Martin Marietta (K-25)
		4006503	Martin Marietta (ORNL)
		4008002	Martin Marietta (Y-12)
	Paducah Gas. Diff. Plant (PGDP)	4007002	Martin Marietta (Paducah)
	Portsmouth Gaseous Diff. Plant (PORTS)	4002502	Martin Marietta (Portsmouth)
		4002504	M.M. Portsmouth Subcontractors
		4002506	M.M. Portsmouth Subcontractors
Rocky Flats	Rocky Flats Eng. Tech. Site (RFETS)	7700001	Rocky Flats Office
		7700006	Rocky Flats Office Subs
		7700007	Rocky Flats Office Subs
		7707002	EG&G Rocky Flats
		7707004	Rocky Mountain Management Group
		7707005	J. A. Jones - Rocky Flats
		7707006	EG&G Rocky Flats Subcontractors
		7707009	EG&G Rocky Flats Security Forces
		7707012	Precision Forge
		7709009	Wackenhut Services - Rocky Flats
Richland	Handford Site	7500503	Battelle Memorial Institute (PNL)
		7500705	Bechtel Power Co.
		7502504	Hanford Environmental Health Foundation
		7503005	Kaiser Engineers Hanford
		7506001	Richland Field Office
		7508805	US Corps of Engineers - RL
		7509004	Westinghouse Hanford Services
		7509104	Westinghouse Hanford Service Subs
Savannah River	Savannah River Site (SRS)	8500204	American Telephone & Telegraph
		8500505	Bechtel Construction - SR
		8501002	Westinghouse Savannah River Co.
		8501004	Service America
		8501014	Westinghouse S.R. Subcontractors
		8501024	Diversco
		8501034	Industrial Phases - SR
		8503001	S.R. Army Corps of Engineers
		8505001	S.R. Forest Station
		8505501	Savannah River Field Office
		8507004	Miscellaneous DOE Contractors
		8507504	Southern Bell Tel. & Tel.
		8509003	Univ. of Georgia Ecology Laboratories
		8509509	Wackenhut Services, Inc. - SR
Not included in this report			
Pittsburgh Naval Reactor Office	Pittsburgh Naval Reactor Office	6007001	Pittsburgh N.R. Office
		6007504	Westinghouse Plant Apparatus Division
		6008003	Westinghouse Electric (BAPL)
		6009003	Westinghouse Electric (NRF)
		6009014	Newport News Reactor Services
Schenectady Naval Reactor Office	Schenectady Naval Reactor Office	9004003	MM-KAPL - Kesselring
		9004005	Gen. Dynam. - Kesselring - Electric Boat
		9005003	MM-KAPL - Knolls
		9005004	MM-KAPL - Knolls Subs
		9007003	MM-KAPL - Windsor
		9007005	MM-KAPL - Windsor - Electric Boat
		9009001	

A.3 Facility Type Codes

The following is the list of facility type codes reported to REMS in accordance with DOE Order 5484.1 [8]. A facility type code is reported with each individual's dose record indicating the facility type where the majority of the individual's dose was accrued during the monitoring year.

Exhibit A-1.
Facility Type Codes.

Facility Type Code	Description
10	Accelerator
21	Fuel/Uranium Enrichment
22	Fuel Fabrication
23	Fuel Processing
40	Maintenance and Support (Site Wide)
50	Reactor
61	Research, General
62	Research, Fusion
70	Waste Processing/Mgmt.
80	Weapons Fab. and Testing
99	Other

See complete Facility Type descriptions shown in Appendix C.

A.4 Phase of Operation

In addition to the Facility Type listing that has been reported in the past, the DOE Office of Environment Safety and Health is interested in obtaining information on the operational status of these facilities. This information will be codified in terms of a Phase of Operation to describe the operating status of a facility. The listing that follows covers each of the phases of operation from construction to the final stage of surveillance and maintenance once a site has undergone environmental restoration.

The phase of operation will be recorded for the calendar year for which the phase of operation is most appropriate. For facilities that transition between phases during a year, the phase that is appropriate for the majority of the calendar year should be recorded. The Phase of Operation will be recorded and submitted along with the Facility Type as part of the monitored individual's dose record. Reporting format and specifications will be included in subsequent revisions to DOE M231.1-1 [11].

Each DOE facility falls into one of the Phase of Operations shown in *Exhibit A-2*. In general, each phase follows in sequential order, although a facility may forgo one or more phases or may not follow the order listed here.

This is the proposed table for the phases of operation of DOE facilities. Please submit comments, additions, or revisions to this table, to EH-52 (see Appendix E for address).

Exhibit A-2.
Phase of Operation - Lifecycle for a DOE Facility.

Code	Phase of Operation	Definition
A	Construction (includes Major Renovation)	New facilities that are brought on line to replace or augment existing facilities. This phase includes major renovations for existing facilities but does not include environmental restoration construction.
B	Operation/ Maintenance	Includes the operations and maintenance of the reported Facility Type.
C	Stabilization	Facilities that have been declared to be surplus (assigned to the environment restoration program). This includes facilities where all operations have been suspended but environmental restoration activities have not begun. This may include periods of surveillance and maintenance prior to environmental restoration activities.
D	Remediation	Period during which corrective actions that are necessary to bring the facility into regulatory compliance are being performed.
E	Decontamination and Decommissioning	Decontamination is the act of removing a chemical, biological, or radiological contaminant from, or neutralizing its potential effect on, a person, object or environment by washing, chemical action, mechanical cleaning, or other techniques. Decommissioning is the process of closing and securing a facility.
F	Waste Management	This phase includes the management of wastes generated during the environment restoration process. (D,E)
G	Surveillance and Maintenance	This phase includes those activities that provide for the safety and protection of a facility after the environmental restoration phase.
Z	Other	All DOE facilities should fit into one of the above categories. "Other" should be used only in highly unusual circumstances.

These phases comprise Environmental Restoration (D, E, F)

Appendix B
Additional Data

B-1a: Operations Office/Site Dose Data (1992)

Operations/ Field Office	Site	Collective TEDE (person-rem)	Percent Change from 1991	Number with Meas. Dose	Percent Change from 1991	Avg. Meas. TEDE (rem)	Percent Change from 1991	Percentage of Coll. TEDE above 0.500 rem	Percent Change from 1991
		1992							
Albuquerque	Ops. and Other Facilities	2.8	-10% ▼	108	17% ▲	0.026	-23% ▼	0%	-
	Los Alamos Nat'l. Lab. (LANL)	230.4	-15% ▼	1,724	14% ▲	0.134	-25% ▼	40%	-35% ▼
	Pantex Plant (PP)	51.4	130% ▲	384	74% ▲	0.134	32% ▲	39%	723% ▲
	Sandia Nat'l. Lab. (SNL)	18.1	-36% ▼	516	-10% ▼	0.035	-29% ▼	15%	-51% ▼
	Uranium Mill Tailings Remedial Action (UMTRA) Project	9.9	119% ▲	301	95% ▲	0.033	12% ▲	0%	-
Chicago	Ops. and Other Facilities	9.2	-47% ▼	355	1% ▲	0.026	-48% ▼	0%	100% ▲
	Argonne Nat'l. Lab. - East (ANL-E)	16.9	-46% ▼	149	-61% ▼	0.113	37% ▲	30%	85% ▲
	Argonne Nat'l. Lab. - West (ANL-W)	18.9	-	248	-	0.076	-	9%	-
	Brookhaven Nat'l. Lab. (BNL)	58.7	-34% ▼	973	-5% ▼	0.060	-31% ▼	12%	-57% ▼
	Fermi Nat'l. Accelerator Lab. (FERMI)	22.5	-34% ▼	478	-47% ▼	0.047	23% ▲	10%	159% ▲
DOE HQ	DOE Headquarters (includes DNFSB)	0.6	78% ▲	69	6% ▲	0.008	68% ▲	0%	-
Idaho	Idaho Site	87.6	-46% ▼	1,007	-2% ▼	0.087	-45% ▼	9%	-80% ▼
Nevada	Nevada Test Site (NTS)	2.1	-39% ▼	37	-8% ▼	0.056	-34% ▼	0%	-
Oakland	Ops. and Other Facilities	9.6	-16% ▼	32	33% ▲	0.299	-37% ▼	64%	-22% ▼
	Lawrence Berkeley Lab. (LBL)	6.4	11% ▲	233	29% ▲	0.028	-14% ▼	0%	-100% ▼
	Lawrence Livermore Nat'l. Lab. (LLNL)	48.6	4% ▲	243	-7% ▼	0.200	11% ▲	67%	21% ▲
	Stanford Linear Accelerator Center (SLAC)	16.6	24% ▲	193	30% ▲	0.086	-5% ▼	11%	19% ▲
Oak Ridge	Ops. and Other Facilities	9.2	-14% ▼	193	7% ▲	0.048	-20% ▼	15%	-
	Oak Ridge Site	96.2	30% ▲	2,792	10% ▲	0.034	18% ▲	20%	79% ▲
	Paducah Gaseous Diff. Plant (PGDP)	7.1	34% ▲	155	-38% ▼	0.046	114% ▲	0%	-
	Portsmouth Gaseous Diff. Plant (PORTS)	22.4	-20% ▼	763	-36% ▼	0.029	25% ▲	0%	-
Ohio	Ops. and Other Facilities	-		-		-		0%	
(Oak Ridge)	Fernald Environmental Mgmt. Project	35.1	-35% ▼	704	27% ▲	0.050	-49% ▼	10%	-69% ▼
(Albuquerque)	Mound Plant	7.2	-8% ▼	219	-33% ▼	0.033	36% ▲	39%	14% ▲
(Idaho)	West Valley Project	17.1	17% ▲	216	-12% ▼	0.079	32% ▲	12%	
Rocky Flats	Rocky Flats Eng. Tech. Site (RFETS)	878.9	-3% ▼	7,790	2% ▲	0.113	-4% ▼	39%	5% ▲
Richland	Hanford Site	260.0	-5% ▼	3,022	-1% ▼	0.086	-4% ▼	30%	-8% ▼
Savannah River	Savannah River Site (SRS)	351.8	-23% ▼	6,510	-22% ▼	0.054	-1% ▼	14%	29% ▲
Totals		2,295.3	-11% ▼	29,414	-6% ▼	0.078	-5% ▼	30%	-8% ▼

* Fernald site reported under the Oak Ridge Ops. Office in 1992, the Fernald Field Office in 1993, and the Ohio Field Office in 1994.
** Mound Site reported under Albuquerque Ops. Office in 1992 and 1993 and now reports under the Ohio Field Office.
*** West Valley Site reported under Idaho Ops. Office in 1992 and 1993 and now reports under the Ohio Field Office.
Note: Boxed values indicate the greatest value in each column.

B-1b: Operations Office/Site Dose Data (1993)

Operations/ Field Office	Site	1993 Collective TEDE (person-rem)	Percent Change from 1992	Number with Meas. Dose	Percent Change from 1992	Avg. Meas. TEDE (rem)	Percent Change from 1992	Percentage of Coll. TEDE above 0.500 rem	Percent Change from 1992
Albuquerque	Ops. and Other Facilities	0.5	-83% ▼	28	-74% ▼	0.017	-35% ▼	0%	
	Los Alamos Nat'l. Lab. (LANL)	199.2	-14% ▼	1,391	-19% ▼	0.143	7% ▲	50%	27% ▲
	Pantex Plant (PP)	46.0	-11% ▼	445	16% ▲	0.103	-23% ▼	32%	-18% ▼
	Sandia Nat'l. Lab. (SNL)	11.9	-34% ▼	314	-39% ▼	0.038	8% ▲	9%	-41% ▼
	Uranium Mill Tailings Remedial Action (UMTRA) Project****	-		-		-		0%	
Chicago	Ops. and Other Facilities	10.8	17% ▲	321	-10% ▼	0.034	30% ▲	0%	
	Argonne Nat'l. Lab. - East (ANL-E)	20.9	24% ▲	185	24% ▲	0.113	0% ▲	31%	2% ▲
	Argonne Nat'l. Lab. - West (ANL-W)	28.4	50% ▲	263	6% ▲	0.108	41% ▲	14%	46% ▲
	Brookhaven Nat'l. Lab. (BNL)	59.9	2% ▲	713	-27% ▼	0.084	39% ▲	21%	73% ▲
	Fermi Nat'l. Accelerator Lab. (FERMI)	16.0	-29% ▼	238	-50% ▼	0.067	43% ▲	22%	127% ▲
DOE HQ	DOE Headquarters (includes DNFSB)	3.4	497% ▲	61	-12% ▼	0.056	575% ▲	17%	
Idaho	Idaho Site	235.5	169% ▲	1,175	17% ▲	0.200	130% ▲	46%	410% ▲
Nevada	Nevada Test Site (NTS)	1.7	-20% ▼	20	-46% ▼	0.083	47% ▲	0%	
Oakland	Ops. and Other Facilities	3.0	-68% ▼	32	0% ▼	0.095	-68% ▼	41%	-35% ▼
	Lawrence Berkeley Lab. (LBL)	6.8	6% ▲	137	-41% ▼	0.049	80% ▲	10%	
	Lawrence Livermore Nat'l. Lab. (LLNL)	30.2	-38% ▼	194	-20% ▼	0.156	-22% ▼	58%	-13% ▼
	Stanford Linear Accelerator Center (SLAC)	44.0	165% ▲	615	219% ▲	0.072	-17% ▼	14%	26% ▲
Oak Ridge	Ops. and Other Facilities	8.6	-7% ▼	171	-11% ▼	0.050	5% ▲	0%	-100% ▼
	Oak Ridge Site	76.1	-21% ▼	1,939	-31% ▼	0.039	14% ▲	10%	-52% ▼
	Paducah Gaseous Diff. Plant(PGDP)	6.5	-9% ▼	171	10% ▲	0.038	-17% ▼	0%	
	Portsmouth Gaseous Diff. Plant (PORTS)	33.6	50% ▲	832	9% ▲	0.040	38% ▲	6%	
Ohio	Ops. and Other Facilities	-		-		-		0%	
(Fernald)	Fernald Environmental Mgmt. Project	26.1	-26% ▼	1,020	45% ▲	0.026	-49% ▼	0%	-100% ▼
(Albuquerque)	Mound Plant	6.6	-8% ▼	258	18% ▲	0.026	-22% ▼	0%	-100% ▼
(Idaho)	West Valley Project	17.5	2% ▲	249	15% ▲	0.070	-11% ▼	16%	28% ▲
Rocky Flats	Rocky Flats Eng. Tech. Site (RFETS)	265.9	-70% ▼	5,605	-28% ▼	0.047	-58% ▼	10%	-76% ▼
Richland	Hanford Site	211.5	-19% ▼	3,147	4% ▲	0.067	-22% ▼	17%	-43% ▼
Savannah River	Savannah River Site (SRS)	258.4	-27% ▼	4,525	-30% ▼	0.057	6% ▲	6%	-55% ▼
Totals		1,628.9	-29% ▼	24,049	-18% ▼	0.068	-13% ▼	22%	-24% ▼

* Fernald site reported under the Oak Ridge Ops. Office in 1992, the Fernald Field Office in 1993, and the Ohio Field Office in 1994.
** Mound Site reported under Albuquerque Ops. Office in 1992 and 1993 and now reports under the Ohio Field Office.
*** West Valley Site reported under Idaho Ops. Office in 1992 and 1993 and now reports under the Ohio Field Office.
**** Error in reporting TEDE for UMTRA in 1993.
Note: Boxed values indicate the greatest value in each column.

B-1c: Operations Office/Site Dose Data (1994)

1994									
Operations/ Field Office	Site	Collective TEDE (person-rem)	Percent Change from 1993	Number with Meas. Dose	Percent Change from 1993	Avg. Meas. TEDE (rem)	Percent Change from 1993	Percentage of Coll. TEDE above 0.500 rem	Percent Change from 1993
Albuquerque	Ops. and Other Facilities	0.4	-10% ▼	26	-7% ▼	0.016	-3% ▼	0%	
	Los Alamos Nat'l. Lab. (LANL)	190.0	-5% ▼	2,448	76% ▲	0.078	-46% ▼	44%	-12% ▼
	Pantex Plant (PP)	29.1	-37% ▼	347	-22% ▼	0.084	-19% ▼	15%	-54% ▼
	Sandia Nat'l. Lab. (SNL)	12.0	1% ▲	250	-20% ▼	0.048	26% ▲	24%	182% ▲
	Uranium Mill Tailings Remedial Action (UMTRA) Project	15.0		390		0.039		0%	
Chicago	Ops. and Other Facilities	8.3	-23% ▼	233	-27% ▼	0.036	6% ▲	6%	
	Argonne Nat'l. Lab. - East (ANL-E)	40.3	**93%** ▲	280	51% ▲	**0.144**	27% ▲	**48%**	57% ▲
	Argonne Nat'l. Lab. - West (ANL-W)	26.3	-7% ▼	343	30% ▲	0.077	-29% ▼	11%	-24% ▼
	Brookhaven Nat'l. Lab. (BNL)	92.3	54% ▲	865	21% ▲	0.107	27% ▲	29%	41% ▲
	Fermi Nat'l. Accelerator Lab. (FERMI)	14.3	-11% ▼	526	**121%** ▲	0.027	**-60%** ▼	0%	-100% ▼
DOE HQ	DOE Headquarters (includes DNFSB)	2.7	-20% ▼	43	-30% ▼	0.064	14% ▲	0%	-100% ▼
Idaho	Idaho Site	236.8	1% ▲	1,659	41% ▲	0.143	-29% ▼	42%	-8% ▼
Nevada	Nevada Test Site (NTS)	2.0	20% ▲	20	0% ▼	0.099	20% ▲	0%	
Oakland	Ops. and Other Facilities	0.8	-72% ▼	20	-38% ▼	0.042	-56% ▼	0%	-100% ▼
	Lawrence Berkeley Lab. (LBL)	5.7	-17% ▼	92	-33% ▼	0.062	24% ▲	9%	-10% ▼
	Lawrence Livermore Nat'l. Lab. (LLNL)	18.8	-38% ▼	146	-25% ▼	0.129	-17% ▼	47%	-19% ▼
	Stanford Linear Accelerator Center (SLAC)	16.3	-63% ▼	219	-64% ▼	0.074	4% ▲	10%	-28% ▼
Oak Ridge	Ops. and Other Facilities	6.8	-20% ▼	255	49% ▲	0.027	-47% ▼	0%	
	Oak Ridge Site	69.2	-9% ▼	1,613	-17% ▼	0.043	9% ▲	7%	-28% ▼
	Paducah Gaseous Diff. Plant(PGDP)	6.8	5% ▲	151	-12% ▼	0.045	19% ▲	0%	
	Portsmouth Gaseous Diff. Plant (PORTS)	30.3	-10% ▼	836	0% ▲	0.036	-10% ▼	4%	-31% ▼
Ohio	Ops. and Other Facilities	0.0		2		0.023		0%	
	Fernald Environmental Mgmt. Project	24.2	-7% ▼	925	-9% ▼	0.026	2% ▲	0%	
	Mound Plant	9.1	37% ▲	299	16% ▲	0.030	18% ▲	6%	
	West Valley Project	24.3	39% ▲	292	17% ▲	0.083	19% ▲	20%	28% ▲
Rocky Flats	Rocky Flats Eng. Tech. Site (RFETS)	231.9	-13% ▼	3,660	-35% ▼	0.063	34% ▲	3%	-73% ▼
Richland	Hanford Site	214.8	2% ▲	3,166	1% ▲	0.068	1% ▲	21%	20% ▲
Savannah River	Savannah River Site (SRS)	**314.5**	22% ▲	**6,284**	39% ▲	0.050	-12% ▼	22%	**245%** ▲
Totals		1,643.1	1% ▲	25,390	6% ▲	0.065	-4% ▼	23%	4% ▲

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

B-2: Internal Dose by Operations/Site, 1990 - 1994

Operations/ Field Office	Site	No. of Individuals with New Intakes*			Collective AEDE Dose from Uptake (person-rem)			Average AEDE (rem)		
		1990	1991	1992	1990	1991	1992	1990	1991	1992
Albuquerque	Ops. and Facilities	17	22	17	0.175	0.380	0.138	0.010	0.017	0.008
	LANL	78	41	129	2.955	3.981	5.206	0.038	0.097	0.040
	Pantex	11	14	20	0.109	0.040	0.048	0.010	0.003	0.002
	Sandia	19	33	25	3.220	0.489	0.229	0.169	0.015	0.009
Chicago	Ops. and Other Facilities	3	1		0.110	0.004		0.037	0.004	
	ANL-E	4	7	18	0.122	0.197	0.729	0.031	0.028	0.041
	BNL	37	36	45	3.070	1.280	2.790	0.083	0.036	0.062
Idaho	Idaho Site	15	6	19	0.306	0.121	0.525	0.020	0.020	0.028
Oakland	LLNL	22	15	3	0.471	1.379	0.020	0.021	0.092	0.007
Oak Ridge	Ops. and Other Facilities	16	77	87	0.666	8.482	6.339	0.042	0.110	0.073
	Oak Ridge Site	900	1,926	2,110	15.817	11.828	22.284	0.018	0.006	0.011
	Paducah	432	128	67	7.934	0.304	0.223	0.018	0.002	0.003
	Portsmouth	97	49	219	1.716	0.850	3.284	0.018	0.017	0.015
Ohio	Fernald		7	1		0.213	0.078		0.030	0.078
	Mound Plant	144	82	97	1.177	0.750	0.401	0.008	0.009	0.004
Rocky Flats	Rocky Flats	11	8	285	0.121	0.265	54.380	0.011	0.033	0.191
Richland	Hanford Site	105	33	12	0.312	0.310	0.123	0.003	0.009	0.010
Savannah River	Savannah River Site	2,095	895	332	32.893	10.228	2.589	0.016	0.011	0.008
Totals		4,006	3,380	3,486	71.174	41.101	99.386	0.018	0.012	0.029

Facilities with no new intakes: UMTRA, ANL-W, Fermi, DOE-HQ, NTS, Oakland Ops., LBL, SLAC, Ohio Ops., West Valley Project.

Operations/ Field Office	Site	No. of Individuals with New Intakes*		Coll. CEDE Dose from Uptake (person-rem)		Average CEDE (rem)	
		1993	1994	1993	1994	1993	1994
Albuquerque	Ops. and Facilities	10	6	0.097	0.015	0.010	0.003
	LANL	159	112	57.039	15.810	0.359	0.141
	Pantex	69	50	0.259	0.115	0.004	0.002
	Sandia	15	12	0.265	0.192	0.018	0.016
Chicago	Ops. and Other Facilities	31	52	0.257	0.477	0.008	0.009
	ANL-E	20	61	0.547	1.708	0.027	0.028
	ANL-W	1		0.106		0.106	
	BNL	51	50	3.050	5.090	0.060	0.102
Idaho	Idaho Site	7	8	0.237	0.133	0.034	0.017
Oakland	LBL	4	4	0.190	0.327	0.048	0.082
	LLNL	1	4	0.024	0.004	0.024	0.001
Oak Ridge	Ops. and Other Facilities	60	21	5.973	1.741	0.100	0.083
	Oak Ridge Site	942	511	6.881	4.327	0.007	0.008
	Paducah	47	27	0.169	0.086	0.004	0.003
	Portsmouth	270	280	6.578	5.817	0.024	0.021
Ohio	Fernald		32		0.261		0.008
	Mound Plant	94	70	0.285	0.254	0.003	0.004
Rocky Flats	Rocky Flats	22	24	6.776	2.916	0.308	0.122
Richland	Hanford Site	12	12	4.825	1.553	0.402	0.129
Savannah River	Savannah River Site	6	613	0.698	4.726	0.116	0.008
Totals		1,821	1,949	94.256	45.552	0.052	0.023

* Only includes intakes that occurred during the monitoring year. Individuals may be counted more than once.
Note: Boxed values indicate the greatest value in each column.
Facilities with no new intakes: UMTRA, Fermi, DOE-HQ, NTS, Oakland Ops., SLAC, Ohio Ops., West Valley Project.

B-3: Distribution of Deep Dose Equivalent (DDE) and Total Effective Dose Equivalent (TEDE), 1974-1994

Deep Dose Equivalent (DDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Year	Less than Meas.	Meas.-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12	Total Monitored	No. with Meas. DDE	Coll. DDE (person-rem)	Avg. Meas. DDE (rem)
1974	37,060	29,735	1,531	652	149	40	4								69,171	32,111	10,202	0.318
1975	41,390	36,795	1,437	541	122	28				1					80,314	38,924	9,202	0.236
1976	38,408	41,321	1,296	387	70	6	1								81,489	43,081	8,938	0.207
1977	41,572	44,730	1,499	540	103	23			1	2				2	88,472	46,900	10,199	0.217
1978	43,317	51,444	1,311	439	53	11									96,575	53,258	9,390	0.176
1979	48,529	48,553	1,281	416	33	10	1							2	98,825	50,296	8,691	0.173
1980	43,663	35,385	1,113	387	16										80,564	36,901	7,760	0.210
1981	43,775	33,251	967	263	29	5									78,290	34,515	7,223	0.209
1982	47,420	30,988	990	313	56	28									79,795	32,375	7,538	0.233
1983	48,340	32,842	1,225	294	49	31									82,781	34,441	7,720	0.224
1984	46,056	38,821	1,223	312	31	11									86,454	40,398	8,113	0.201
1985	54,582	34,317	1,362	356	51	8				1					90,677	36,095	8,340	0.231
1986	53,586	33,671	1,279	349	35	1		1					1		88,923	35,337	8,095	0.229
1987	45,241	28,995	1,210	283	36										75,765	30,524	6,056	0.198
1988	48,704	27,492	502	34											76,732	28,028	3,735	0.133
1989	56,363	28,925	428	21											85,737	29,374	3,151	0.107
1990	76,798	31,110	140	17											108,065	31,267	2,230	0.071
1991	92,526	27,149	95												119,770	27,244	1,762	0.065
1992	98,900	24,769	42												123,711	24,811	1,504	0.061
1993	103,905	23,050	86			1									127,042	23,137	1,534	0.066
1994	92,245	24,189	77												116,511	24,266	1,600	0.066

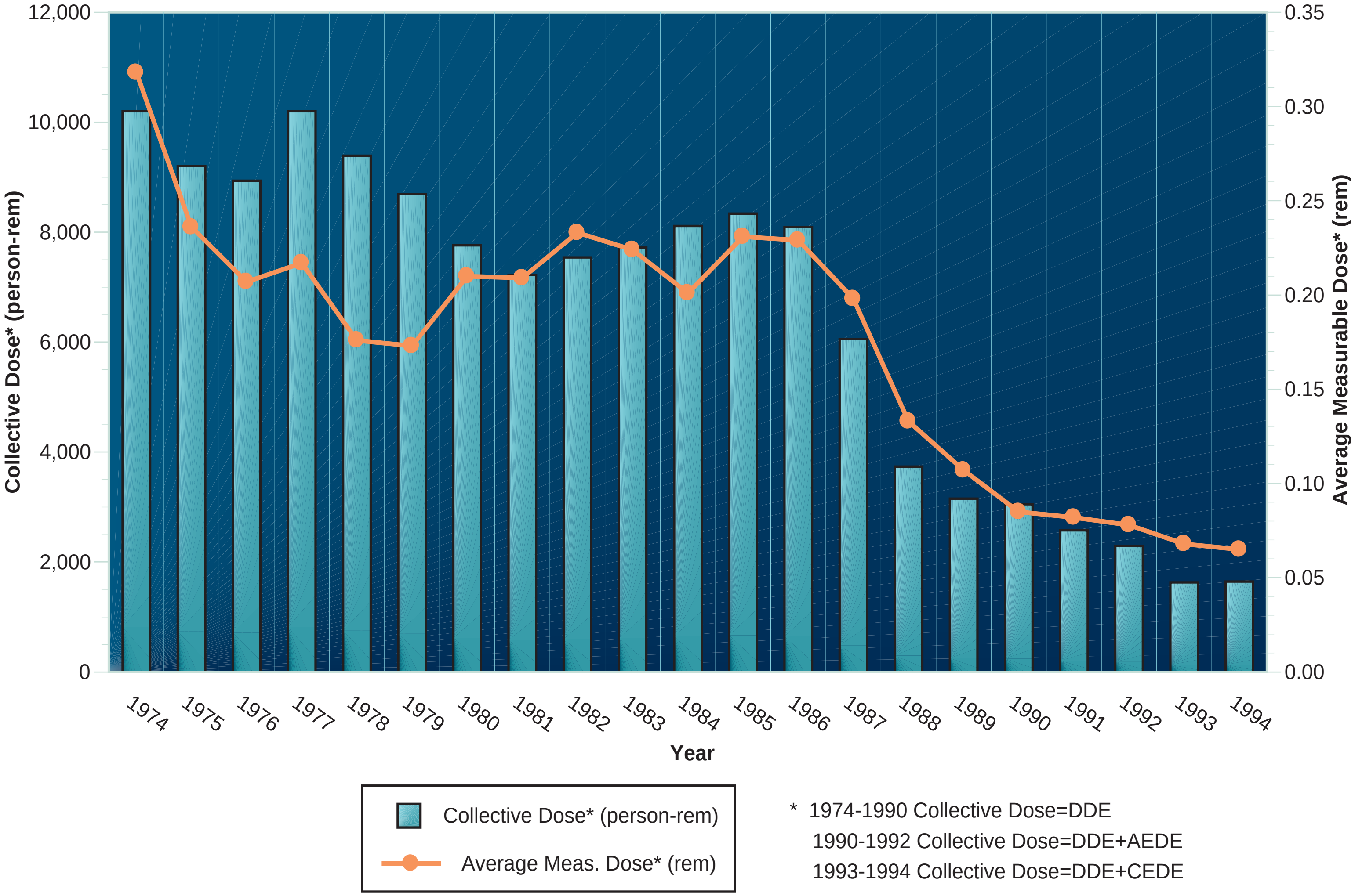
Total Effective Dose Equivant (TEDE)*

Year	Less than Meas.	Meas.-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12	Total Monitored	No. with Meas. TEDE	Coll. TEDE (person-rem)	Avg. Meas. TEDE (rem)
1990	71,991	35,780	226	47	8	8	1	2		1				1	108,065	36,074	3,052	0.085
1991	88,444	31,086	193	25	9	8		2		1				2	119,770	31,326	2,574	0.082
1992	94,297	29,240	132	22	9	6		2	1		1			1	123,711	29,414	2,295	0.078
1993	102,993	23,956	87			2				1	1			2	127,042	24,049	1,629	0.068
1994	91,121	25,310	79		1										116,511	25,390	1,643	0.065

* 1990-1992 TEDE=DDE+AEDE   1993-1994 TEDE=DDE+CEDE

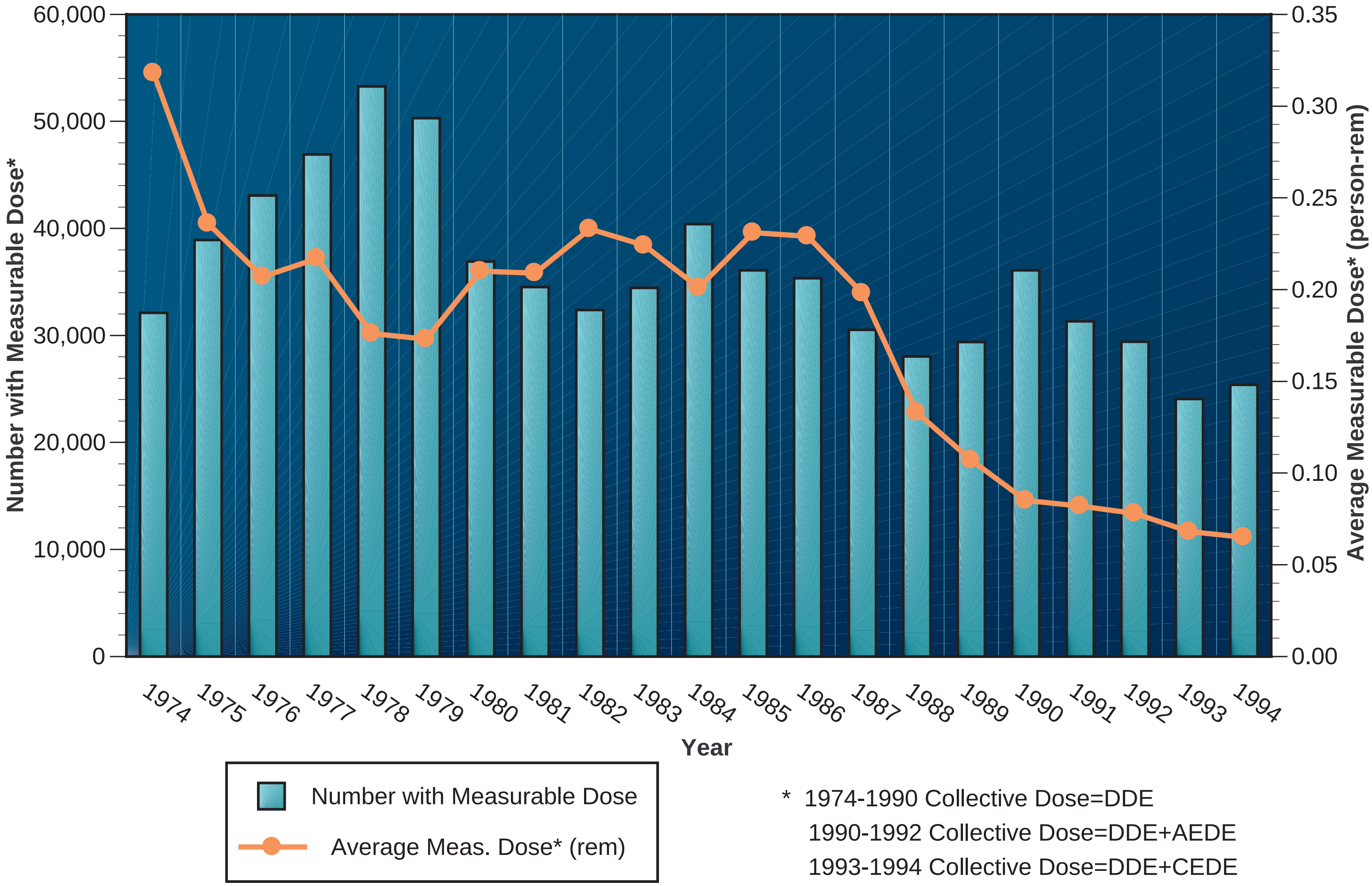
Note: Boxed values indicate the greatest value in each column.

B-4: Collective Dose and Average Measurable Dose* 1974-1994



* 1974-1990 Collective Dose=DDE
1990-1992 Collective Dose=DDE+AEDE
1993-1994 Collective Dose=DDE+CEDE

B-5: Number with Measurable Dose and Average Measurable Dose* 1974-1994



* 1974-1990 Collective Dose=DDE
1990-1992 Collective Dose=DDE+AEDE
1993-1994 Collective Dose=DDE+CEDE

B-6a: Distribution of TEDE by Facility Type - 1992

Total Effective Dose Equivalent (TEDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Facility Type	Less than Meas.	Meas.-0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Average Meas. TEDE (rem)
Accelerator	7,123	1,271	202	72	11	2													8,681	18%	1,558	100.521	0.065
Fuel/Uran. Enrich.	8,826	1,831	84	7	1	4	1												10,754	18%	1,928	50.638	0.026
Fuel Fabrication	2,511	631	77	23	2	1	1												3,246	23%	735	37.176	0.051
Fuel Processing	2,128	318	102	29	10	9													2,596	18%	468	51.112	0.109
Maint. and Support	24,862	5,920	817	274	65	26	11	3		1									31,979	22%	7,117	457.653	0.064
Reactor	2,338	994	140	56	10	4	1												3,543	34%	1,205	81.254	0.067
Research, General	16,432	2,173	431	195	68	34	39	3	1	1		1							19,378	15%	2,946	336.257	0.114
Research, Fusion	1,337	159	9	2															1,507	11%	170	5.477	0.032
Waste Proc./Mgmt.	4,350	807	170	74	7	5	4	2											5,419	20%	1,069	90.152	0.084
Weapons Fab. & Test.	11,029	7,408	1,352	467	161	77	72	14	8	4		1	1		1			1	20,596	46%	9,567	972.759	0.102
Other	13,361	2,384	197	53	11	3	3												16,012	17%	2,651	112.271	0.042
Totals	94,297	23,896	3,581	1,252	346	165	132	22	9	6	0	2	1	0	1	0	0	1	123,711	24%	29,414	2,295.270	0.078

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

This table displays the distribution of TEDE for the monitored DOE employees and contractors by facility type, including the total number of monitored individuals, the number of individuals with measurable TEDE, the collective TEDE, and the average TEDE.

B-6b: Distribution of TEDE by Facility Type - 1993

Total Effective Dose Equivalent (TEDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Facility Type	Less than Meas.	Meas.-0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Average Meas. TEDE (rem)
Accelerator	7,248	1,316	231	78	14	7	4												8,898	19%	1,650	125.837	0.076
Fuel/Uran. Enrich.	12,441	1,066	55	23	3	3													13,591	8%	1,150	45.347	0.039
Fuel Fabrication	3,082	1,142	66	16	5														4,311	29%	1,229	41.736	0.034
Fuel Processing	4,062	1,382	261	141	23	5	7												5,881	31%	1,819	160.151	0.088
Maint. and Support	17,084	2,306	252	90	12	5												1	19,750	13%	2,666	147.817	0.055
Reactor	2,899	794	162	91	2	1	1			1									3,951	27%	1,052	87.285	0.083
Research, General	19,293	2,208	371	195	63	31	24							1				1	22,187	13%	2,894	309.102	0.107
Research, Fusion	1,269	112	7	1															1,389	9%	120	3.584	0.030
Waste Proc./Mgmt.	7,209	1,560	253	77	2	2													9,103	21%	1,894	107.269	0.057
Weapons Fab. & Test.	14,702	6,862	663	225	40	11	1			1					1				22,506	35%	7,804	413.701	0.053
Other	13,704	1,433	153	76	31	28	50												15,475	11%	1,771	187.098	0.106
Totals	102,993	20,181	2,474	1,013	195	93	87	0	0	2	0	0	0	1	1	0	0	2	127,042	19%	24,049	1,628.927	0.068

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

This table displays the distribution of TEDE for the monitored DOE employees and contractors by facility type, including the total number of monitored individuals, the number of individuals with measurable TEDE, the collective TEDE, and the average TEDE.

B-6c: Distribution of TEDE by Facility Type - 1994

Total Effective Dose Equivalent (TEDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Facility Type	Less than Meas.	Meas.-0.10	0.10-0.25	0.25-0.50	0.50 0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Average Meas. TEDE (rem)
Accelerator	6,458	1,463	171	83	20	8	5												8,208	21%	1,750	118.135	0.068
Fuel/Uran. Enrich.	10,072	1,037	62	20	1	1													11,193	10%	1,121	40.055	0.036
Fuel Fabrication	2,793	1,074	41	9	8	8													3,933	29%	1,140	44.315	0.039
Fuel Processing	3,441	1,641	204	123	69	11	1												5,490	37%	2,049	167.049	**0.082**
Maint. and Support	16,734	2,796	242	115	25	9	2												19,923	16%	3,189	160.756	0.050
Reactor	1,911	1,019	140	94	25	1	1												3,191	**40%**	1,280	97.025	0.076
Research, General	16,776	2,776	373	157	65	37	26		1										**20,211**	17%	3,435	283.028	**0.082**
Research, Fusion	983	133	12	8	3	2	2												1,143	14%	160	12.602	0.079
Waste Proc./Mgmt.	5,974	2,582	257	71	11	1	1												8,897	33%	2,923	129.249	0.044
Weapons Fab. & Test.	14,023	4,528	691	172	57	5	1												19,477	28%	**5,454**	**379.796**	0.070
Other	11,956	2,462	244	82	45	16	40												14,845	19%	2,889	211.054	0.073
Totals	91,121	21,511	2,437	934	329	99	79	0	1	0	0	0	0	0	0	0	0	0	116,511	22%	25,390	1,643.064	0.065

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

This table displays the distribution of TEDE for the monitored DOE employees and contractors by facility type, including the total number of monitored individuals, the number of individuals with measurable TEDE, the collective TEDE, and the average TEDE.

B-7a: Collective TEDE by Facility Type, 1992

DOE Operations	Site	Accelerator	Fuel/Uranium Enrichment	Fuel Fabrication	Fuel Processing	Maintenance and Support	Reactor	Research, General	Research, Fusion	Waste Processing/ Management	Weapons Fab. and Testing	Other	Totals
Albuquerque	Ops. and Other Facilities									0.6	0.6	1.5	2.8
	Los Alamos National Lab. (LANL)	18.4				42.5	0.3	160.1	1.1	4.7	0.0	3.3	230.4
	Pantex Plant (PP)	0.6				1.4					46.9	2.4	51.4
	Sandia National Lab. (SNL)	0.2				2.0	6.2	7.4		0.3	1.1	0.9	18.1
	Uranium Mill Tailings Remedial Action (UMTRA) Project											9.9	9.9
Chicago	Ops. and Other Facilities	0.7				3.2		1.0	4.3			0.0	9.2
	Argonne Nat'l. Lab. - East (ANL-E)	5.2				0.5		8.4		0.4		2.4	16.9
	Argonne Nat'l. Lab. - West (ANL-W)			1.3		1.2	3.9	12.2				0.3	18.9
	Brookhaven Nat'l. Lab.(BNL)	30.0				1.6	7.1	8.4		1.4		10.1	58.7
	Fermi Nat'l. Accelerator Lab.(FERMI)	22.5											22.5
DOE HQ	DOE Headquarters											0.6	0.6
Idaho	Idaho Site				38.3	1.6	28.3	4.3		1.0		14.0	87.6
Nevada	Nevada Test Site (NTS)	2.0									0.1	0.0	2.1
Oakland	Ops. and Other Facilities							9.4				0.2	9.6
	Lawrence Berkeley Lab.(LBL)	4.3						2.1					6.4
	Lawrence Livermore Nat'l. Lab. (LLNL)		6.4			12.8		15.8	0.0	0.1	5.7	7.7	48.6
	Stanford Linear Acceletrator Center (SLAC)	16.6											16.6
Oak Ridge	Ops. and Other Facilities				2.0			1.2		6.1			9.2
	Oak Ridge Site		14.7					45.2			36.3		96.2
	Paducah Gaseous Diff. Plant (PGDP)		7.1										7.1
	Portsmouth Gaseous Diff. Plant (PORTS)		22.4										22.4
Ohio	Ops. and Other Facilities												
(Oak Ridge)	Fernald Environmental Mgmt. Project			35.1									35.1
(Albuquerque)	Mound Plant					4.0				0.0	3.1	0.1	7.2
(Idaho)	West Valley											17.1	17.1
Rocky Flats	Rocky Flats Eng. Tech. Site (RFETS)										878.9		878.9
Richland	Hanford Site	0.1		0.5	9.8	90.5	19.5	50.2		75.4		13.9	260.0
Savannah River	Savannah River Site (SRS)			0.3	1.0	296.3	15.8	10.6		0.1	0.0	27.7	351.8
	Totals	100.5	50.6	37.2	51.1	457.5	81.3	336.3	5.5	90.2	972.8	112.3	2,295.3

* Fernald site reported under the Oak Ridge Ops. Office in 1992, the Fernald Field Office in 1993, and the Ohio Field Office in 1994.
** Mound Site reported under Albuquerque Ops. Office in 1992 and 1993 and now reports under the Ohio Field Office.
*** West Valley Site reported under Idaho Ops. Office in 1992 and 1993 and now reports under the Ohio Field Office.
Note: Boxed values indicate the greatest value in each column.

B-7b: Collective TEDE by Facility Type, 1993

DOE Operations	Site	Accelerator	Fuel/Uranium Enrichment	Fuel Fabrication	Fuel Processing	Maintenance and Support	Reactor	Research, General	Research, Fusion	Waste Processing/ Management	Weapons Fab. and Testing	Other	Totals
Albuquerque	Ops. and Other Facilities										0.5	0.0	0.5
	Los Alamos National Lab. (LANL)	21.3				44.1	0.2	129.3	0.6	1.8	0.0	1.8	199.2
	Pantex Plant (PP)										46.0		46.0
	Sandia National Lab. (SNL)	0.5				0.7	4.8	4.0	0.0	0.4	0.8	0.7	11.9
	Uranium Mill Tailings Remedial Action (UMTRA) Project												
Chicago	Ops. and Other Facilities					6.0		1.9	3.0			0.0	10.8
	Argonne Nat'l. Lab. - East (ANL-E)	8.6				0.8		10.4		1.1			20.9
	Argonne Nat'l. Lab. - West (ANL-W)			0.3		1.4	1.7	23.5				1.4	28.4
	Brookhaven Nat'l. Lab.(BNL)	31.2				2.5	12.1	10.1		0.9		3.1	59.9
	Fermi Nat'l. Accelerator Lab.(FERMI)	16.0											16.0
DOE HQ	DOE Headquarters											3.4	3.4
Idaho	Idaho Site				64.9	2.3	42.7	7.6		1.9		116.2	235.5
Nevada	Nevada Test Site (NTS)	0.0								0.0	1.6	0.1	1.7
Oakland	Ops. and Other Facilities							3.0					3.0
	Lawrence Berkeley Lab.(LBL)	4.1						2.7					6.8
	Lawrence Livermore Nat'l. Lab. (LLNL)	0.1	3.4			2.1		12.5	0.0	0.0	6.0	6.0	30.2
	Stanford Linear Acceletrator Center (SLAC)	44.0											44.0
Oak Ridge	Ops. and Other Facilities							1.6		1.1		5.9	8.6
	Oak Ridge Site		1.8					43.7			20.5	10.1	76.1
	Paducah Gaseous Diff. Plant (PGDP)		6.5										6.5
	Portsmouth Gaseous Diff. Plant (PORTS)		33.6										33.6
Ohio	Ops. and Other Facilities												
(Fernald Field Off.)	Fernald Environmental Mgmt. Project			26.1									26.1
(Albuquerque)	Mound Plant					2.5				0.0	4.0	0.1	6.6
(Idaho)	West Valley											17.5	17.5
Rocky Flats	Rocky Flats Eng. Tech. Site (RFETS)										265.9		265.9
Richland	Hanford Site	0.0		0.2	4.6	73.3	14.2	47.0		54.3		18.0	211.5
Savannah River	Savannah River Site (SRS)			15.1	90.7	11.9	11.7	11.9		45.8	68.6	2.8	258.4
	Totals	125.8	45.3	41.7	160.2	147.8	87.3	309.1	3.6	107.3	413.7	187.1	1,628.9

* Fernald site reported under the Oak Ridge Ops. Office in 1992, the Fernald Field Office in 1993, and the Ohio Field Office in 1994.
** Mound Site reported under Albuquerque Ops. Office in 1992 and 1993 and now reports under the Ohio Field Office.
*** West Valley Site reported under Idaho Ops. Office in 1992 and 1993 and now reports under the Ohio Field Office.
Note: Boxed values indicate the greatest value in each column.

B-7c: Collective TEDE by Facility Type, 1994

DOE Operations	Site	Accelerator	Fuel/Uranium Enrichment	Fuel Fabrication	Fuel Processing	Maintenance and Support	Reactor	Research, General	Research, Fusion	Waste Processing/ Management	Weapons Fab. and Testing	Other	Totals
Albuquerque	Ops. and Other Facilities							0.1			0.2	0.1	0.4
	Los Alamos National Lab. (LANL)	23.7				44.0	0.2	**114.3**	0.7	1.6	0.0	5.5	190.0
	Pantex Plant (PP)										29.1		29.1
	Sandia National Lab. (SNL)	0.4				0.8	5.4	2.8	0.0	0.2	0.4	2.0	12.0
	Uranium Mill Tailings Remedial Action (UMTRA) Project											15.0	15.0
Chicago	Ops. and Other Facilities					1.8		3.3	3.2			0.0	8.3
	Argonne Nat'l. Lab. - East (ANL-E)	5.7				1.0		9.5		2.2		21.9	40.3
	Argonne Nat'l. Lab. - West (ANL-W)			0.2		0.8	2.6	22.5				0.1	26.3
	Brookhaven Nat'l. Lab. (BNL)	**53.7**				2.7	7.5	13.3		1.5		13.7	92.3
	Fermi Nat'l. Accelerator Lab. (FERMI)	14.3											14.3
DOE HQ	DOE Headquarters											2.7	2.7
Idaho	Idaho Site				73.4	8.0	**51.2**	8.1		5.5		**90.6**	236.8
Nevada	Nevada Test Site (NTS)	0.1									1.9		2.0
Oakland	Ops. and Other Facilities							0.8					0.8
	Lawrence Berkeley Lab.(LBL)	1.9						3.8					5.7
	Lawrence Livermore Nat'l. Lab. (LLNL)	0.3	1.2			1.0		1.7			2.2	3.6	10.0
	Stanford Linear Acceletrator Center (SLAC)	16.3							**8.8**				25.1
Oak Ridge	Ops. and Other Facilities	1.9			0.5			0.7		1.7		2.0	6.8
	Oak Ridge Site		1.8					44.9			14.7	7.9	69.2
	Paducah Gaseous Diff. Plant (PGDP)		6.8										6.8
	Portsmouth Gaseous Diff. Plant (PORTS)		**30.3**										30.3
Ohio	Ops. and Other Facilities					0.0							0.0
	Fernald Environmental Mgmt. Project			**24.2**									24.2
	Mound Plant					6.4					2.4	0.2	9.1
	West Valley											24.3	24.3
Rocky Flats	Rocky Flats Eng. Tech. Site (RFETS)										**231.9**		231.9
Richland	Hanford Site			0.4	4.9	**77.7**	13.4	43.8		56.0		18.7	214.8
Savannah River	Savannah River Site (SRS)			19.5	**88.3**	16.4	16.8	13.3		**60.7**	96.9	2.6	314.5
	Totals	118.1	40.1	44.3	167.1	160.8	97.0	283.0	12.6	129.2	379.8	211.1	1,643.1

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

B-8: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Accelerator Facilities, 1994

ACCELERATOR FACILITIES

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas.- 0.10	0.10- 0.25	0.25- 0.50	0.50- 0.75	0.75- 1.00	1.00- 2.00	>2	Total Monitored	% of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	% of above TEDE 0.5 rem
CH	Brookhaven Nat. Lab.	831	298	63	40	18	7	3		1,260	34%	429	53.650	0.125	37%
CH	Argonne - East	994	47	14	7					1,062	6%	68	5.733	0.084	0%
OAK	Stanford Linear Acc.	1,984	175	32	10	1	1			2,203	10%	219	16.299	0.074	10%
AL	Los Alamos	276	301	42	23	1		2		645	57%	369	23.705	0.064	14%
OAK	Lawrence Berkeley	7	34	4						45	84%	38	1.870	0.049	0%
OAK	Lawrence Livermore	252	7	1						260	3%	8	0.313	0.039	0%
CH	Fermilab	1,104	509	15	2					1,630	32%	526	14.260	0.027	0%
NV	Nevada Test Site	73	2							75	3%	2	0.051	0.026	0%
OR	CEBAF	709	74		1					784	10%	75	1.880	0.025	0%
AL	Sandia Nat. Lab.	221	16							237	7%	16	0.374	0.023	0%
RL	Pacific Northwest Lab.	7								7	0%	0	0.000	0.000	0%
	Grand Totals	6,458	1,463	171	83	20	8	5	0	8,208	21%	1,750	118.135	0.068	21%

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

This table displays the distribution of TEDE for Accelerator facilities in order of decreasing average measurable TEDE, including the total number of monitored individuals, the number of individuals with measurable TEDE, the collective TEDE, and the percentage of TEDE accrued above 0.5 rem.

B-9: *Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Fuel Facilities, 1994*

FUEL FACILITIES	Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)														
Ops. Office	Site/Contractor	Less than Meas.	Meas.- 0.10	0.10- 0.25	0.25- 0.50	0.50- 0.75	0.75- 1.00	1.0- 2.0	>2	% of Monitored Total Monitored	No. with w/ Meas. TEDE	Collective Meas. TEDE	TEDE (person-rem)	Avg. Meas. TEDE (rem)	% of above TEDE 0.5 rem
	ENRICHMENT														
OAK	Lawrence Livermore Nat. Lab.	515	6	3	1					525	2%	10	1.181	0.118	0%
OR	Paducah GDP	1,968	134	12	5					2,119	7%	151	6.789	0.045	0%
OR	Portsmouth GDP	3,568	777	43	14	1	1			4,404	19%	836	30.330	0.036	4%
OR	Oak Ridge K-25	4,021	120	4						4,145	3%	124	1.755	0.014	0%
	Total	10,072	1,037	62	20	1	1			11,193	10%	1,121	40.055	0.036	3%
	FABRICATION														
RL	Westinghouse Hanford	15	3		1					19	21%	4	0.400	0.100	0%
SR	Savannah River	248	170	8	8	8	8			450	45%	202	19.478	0.096	61%
CH	Argonne - West	29	8							37	22%	8	0.241	0.030	0%
OH	Fernald	2,499	892	33						3,424	27%	925	24.186	0.026	0%
RL	Kaiser Engineering, Hanford	2	1							3	33%	1	0.010	0.010	0%
	Total	2,793	1,074	41	9	8	8			3,933	29%	1,140	44.315	0.039	27%
	PROCESSING														
RL	Hanford	13	14	3	10					40	68%	27	4.860	0.180	0%
ID	Idaho Nat. Eng. Lab.	1,986	328	91	51	38	5	1		2,500	21%	514	73.439	0.143	39%
OR	Oak Ridge	8	5	2						15	47%	7	0.486	0.069	0%
SR	Savannah River	1,434	1,294	108	62	31	6			2,935	51%	1,501	88.264	0.059	27%
	Total	3,441	1,641	204	123	69	11	1		5,490	37%	2,049	167.049	0.082	32%
	Grand Totals	16,306	3,752	307	152	78	20	1	0	20,616	21%	4,310	251.419	0.058	26%

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

This table displays the distribution of TEDE for Fuel facilities in descending order of average measurable TEDE for Enrichment, Fabrication, and Processing facilities. Also included are the total number of monitored individuals, the number of individuals with measurable TEDE, the Collective TEDE, and the percentage of TEDE accrued above 0.5 rem.

B-10: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Maintenance and Support, 1994

MAINTENANCE AND SUPPORT

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas.- 0.10	0.10- 0.25	0.25- 0.50	0.50- 0.75	0.75- 1.00	1.00- 2.00	>2	Total Monitored	% of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	% of TEDE above 0.5 rem
RL	Kaiser Engineering, Hanford	1,283	307	58	41	9	2			1,700	25%	417	36.958	0.089	0%
RL	Pacific Northwest Lab.-Battelle	19	4		1					24	21%	5	0.380	0.076	19%
CH	Argonne - East	759	11	2	1					773	2%	14	1.042	0.074	0%
AL	Los Alamos Nat. Lab.	2,969	673	47	30	13	6	1		3,739	21%	770	43.999	0.057	0%
RL	Westinghouse Hanford	2,878	667	77	31	1	1	1		3,656	21%	778	40.302	0.052	31%
ID	Idaho Nat. Eng. Lab.	703	145	13	7					868	19%	165	8.006	0.049	7%
OAK	Lawrence Livermore Nat. Lab.	3,010	20	3						3,033	1%	23	1.025	0.045	0%
CH	Argonne - West	32	18	1						51	37%	19	0.829	0.044	0%
CH	Brookhaven Nat. Lab.	700	53	8	1					762	8%	62	2.690	0.043	0%
CH	Battelle Memorial Inst.-Columbus	378	49	2						429	12%	51	1.835	0.036	0%
OH	Ohio Field Office - Mound	2,098	203	12	1	1				2,315	9%	217	6.441	0.030	0%
AL	Sandia Nat. Lab.	594	27	1						622	5%	28	0.760	0.027	0%
SR	Savannah River	1,094	615	18	2	1				1,730	37%	636	16.429	0.026	0%
RL	Bechtel Hanford, Inc.	206	4							210	2%	4	0.060	0.015	0%
NV	Nevada Test Site	11								11	0%	0	0.000	0.000	0%
	Totals	16,734	2,796	242	115	25	9	2	0	19,923	16%	3,189	160.756	0.050	15%

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

This table displays the distribution of TEDE for Maintenance and Support facilities, listed in descending order of average measurable TEDE, including the total number of monitored individuals, the number of individuals with measurable TEDE, the collective TEDE, and the percentage of TEDE accrued above 0.5 rem. Note that only 16% of individuals monitored received any measurable TEDE.

B-11: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Reactor Facilities, 1994

REACTOR FACILITIES

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas.-0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	% of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	% of TEDE above 0.5 rem
ID	Idaho Nat. Engineering Lab.	389	118	70	65	20				662	41%	273	51.167	0.187	23%
AL	Sandia Nat. Lab.	70	18	6	3	3	1			101	31%	31	5.402	0.174	23%
CH	Brookhaven Nat. Lab.	135	35	17	9	1				197	31%	62	7.450	0.120	54%
RL	Westinghouse Hanford	460	147	14	15	1		1		638	28%	178	12.950	0.073	41%
CH	Argonne - West	126	34	10						170	26%	44	2.615	0.059	0%
AL	Los Alamos Nat. Lab.	10	5							15	33%	5	0.152	0.030	0%
RL	Kaiser Engineering, Hanford	32	14	1						47	32%	15	0.430	0.029	0%
SR	Savannah River	658	647	22	2					1,329	50%	671	16.839	0.025	18%
RL	Bechtel Hanford	30	1							31	3%	1	0.020	0.020	0%
RL	Pacific Northwest Lab.-Battelle	1								1	0%	0	0.000	0.000	0%
	Grand Totals	1,911	1,019	140	94	25	1	1	0	3,191	40%	1,280	97.025	0.076	29%

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

This table displays the distribution of TEDE for Reactor facilities, listed in descending order of average measurable TEDE, including the total number of monitored individuals, the number of individuals with measurable TEDE, the collective TEDE, and the percentage of TEDE accrued above 0.5 rem.

B-12: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Research-General, 1994

RESEARCH, GENERAL

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas.-0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	% of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE(rem)	% of TEDE above 0.5 rem
CH	Brookhaven Nat. Lab.	460	41	17	14	3		2		537	14%	77	13.320	0.173	33%
CH	Argonne - East	1,263	47	10	4	3	2	1		1,330	5%	67	9.460	0.141	33%
AL	Los Alamos Nat'l Lab.	2,467	803	83	60	36	23	16	1	3,489	29%	1,022	114.332	0.112	53%
OAK	Lawrence Livermore Nat. Lab.	1,070	10	6	1					1,087	2%	17	1.719	0.101	57%
RL	Pacific Northwest Lab.-Battelle	864	351	33	22	13	8	7		1,298	33%	434	43.202	0.100	0%
ID	Idaho Nat. Eng. Lab.	652	61	8	12	1				734	11%	82	8.065	0.098	51%
CH	Argonne - West	524	184	69	6	2	2			787	33%	263	22.492	0.086	6%
OR	Oak Ridge Nat. Lab.	5,980	386	111	29	5	2			6,513	8%	533	44.910	0.084	12%
OAK	Lawrence Berkeley Lab.	20	44	6	3	1				74	73%	54	3.790	0.070	11%
AL	Inhalation Toxicology Research	241	16	1	1					259	7%	18	0.841	0.047	8%
OAK	Rocketdyne - ETEC	11	17	3						31	65%	20	0.835	0.042	0%
CH	Ames Lab. Iowa State	65	73	4						142	54%	77	3.194	0.041	0%
CH	New Brunswick Lab.	51	2							53	4%	2	0.077	0.039	0%
RL	Westinghouse Hanford	152	18		1					171	11%	19	0.630	0.033	0%
AL	Sandia Nat'l Lab.	1,786	76	3	1					1,866	4%	80	1.956	0.024	0%
SR	Savannah River	920	592	19	3	1				1,535	40%	615	13.333	0.022	5%
AL	Nat. Renewable Energy Lab.	17	8							25	32%	8	0.130	0.016	0%
OR	ORISE	103	47							150	31%	47	0.742	0.016	0%
RL	Bechtel Hanford	2								2	0%	0	0.000	0.000	0%
CH	Chicago Operations	33								33	0%	0	0.000	0.000	0%
CH	Environmental Meas. Lab.	28								28	0%	0	0.000	0.000	0%
RL	Kaiser Engineering, Hanford	1								1	0%	0	0.000	0.000	0%
NV	Nevada Operations	22								22	0%	0	0.000	0.000	0%
OH	Mound	5								5	0%	0	0.000	0.000	0%
OAK	U. of Cal./SF	39								39	0%	0	0.000	0.000	0%
	Grand Totals	16,776	2,776	373	157	65	37	26	1	20,211	17%	3,435	283.028	0.082	32%

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

This table displays the distribution of TEDE for General Research facilities, listed in descending order of average measurable TEDE, including the total number of monitored individuals, the number of individuals with measurable TEDE, the collective TEDE, and the percentage of TEDE accrued above 0.5 rem. Note that one exposure was greater than 2 rem and was due to an internal uptake, resulting in 3.8 rem CEDE.

B-13: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Research-Fusion, 1994

RESEARCH, FUSION

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas.-0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	% of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	% of TEDE above 0.5 rem
OAK	Lawrence Livermore	334	17	7	6	2	2	2		370	10%	36	8.765	0.243	58%
CH	Princeton Plasma Lab.	519	94	5	1	1				620	16%	101	3.155	0.031	16%
AL	Los Alamos Nat. Lab.	59	21		1					81	27%	22	0.667	0.030	0%
AL	Sandia Nat. Lab.	71	1							72	1%	1	0.015	0.015	0%
	Grand Totals	983	133	12	8	3	2	2	0	1,143	14%	160	12.602	0.079	45%

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

This table displays the distribution of TEDE for Research Fusion facilities, listed in descending order of average measurable TEDE, including the total number of monitored individuals, the number of individuals with measurable TEDE, the collective TEDE, and the percentage of TEDE accrued above 0.5 rem. Note that although Lawrence Livermore had allowed only 10% of the monitored individuals to receive a measurable exposure, six individuals exceeded the recommended facility administrative limits (0.5 rem).

B-14: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Waste Processing/Management, 1994

WASTE PROCESSING, MANAGEMENT

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas.-0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	>2	Total Monitored	% of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	% of TEDE above 0.5 rem
CH	Brookhaven Nat. Lab. (BNL)	2	13	4	1					20	90%	18	1.470	0.082	0%
CH	Argonne - East	60	27	9						96	38%	36	2.220	0.062	0%
RL	Westinghouse Hanford	2,027	739	111	39	3	1	1		2,921	31%	894	53.953	0.060	0%
ID	Idaho Nat. Eng. Lab.	281	80	11	2	1				375	25%	94	5.456	0.058	7%
RL	Kaiser Engineering, Hanford	225	37	5	1					268	16%	43	1.990	0.046	9%
SR	Savannah River	1,598	1,528	113	28	7				3,274	51%	1,676	60.697	0.036	0%
AL	Sandia Nat. Lab.	115	6							121	5%	6	0.189	0.032	6%
AL	Los Alamos Nat. Lab.	225	66	3						294	23%	69	1.566	0.023	0%
OR	WSSRAP	793	65	1						859	8%	66	1.314	0.020	0%
OR	Bechtel (FUSRAP)	284	19							303	6%	19	0.374	0.020	0%
RL	Bechtel Hanford	40	2							42	5%	2	0.020	0.010	0%
OAK	Lawrence Livermore Nat. Lab.	102								102	0%	0	0.000	0.000	0%
NV	Nevada Test Site	118								118	0%	0	0.000	0.000	0%
AL	WIPP	104								104	0%	0	0.000	0.000	0%
	Grand Totals	5,974	2,582	257	71	11	1	1	0	8,897	33%	2,923	129.249	0.044	6%

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

This table displays the distribution of TEDE for Waste Processing and Waste Management facilities, listed in descending order of average measurable TEDE, including the total number of monitored individuals, the number of individuals with measurable TEDE, the collective TEDE, and the percentage of TEDE accrued above 0.5 rem. Westinghouse Hanford and Savannah River account for 42% and 48% of the collective TEDE in the Waste Processing and Management facilities category. Note that the average measurable TEDE is 0.021 rem lower than the overall DOE average.

B-15: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Weapons Fabrication and Testing, 1994

WEAPONS FABRICATION AND TESTING

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas.- 0.10	0.10- 0.25	0.25- 0.50	0.50- 0.75	0.75- 1.0	1.0- 2.0	>2	Total Monitored	% of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	% of TEDE above 0.5 rem
OAK	Lawrence Livermore Nat. Lab.	530	12		1	1	1			545	3%	15	2.200	0.147	70%
SR	Savannah River	612	505	156	78	43	3			1,397	56%	785	96.910	0.123	70%
NV	Nevada Test Site	1,201	10	7	1					1,219	1%	18	1.936	0.108	29%
AL	Pantex	2,737	273	42	25	7				3,084	11%	347	29.109	0.084	0%
RFO	Rocky Flats	1,648	3,126	460	66	6	1	1		5,308	69%	3,660	231.852	0.063	15%
OH	Mound	438	67	5						510	14%	72	2.424	0.034	3%
OR	Martin Marietta (Y-12)	6,121	497	21	1					6,640	8%	519	14.670	0.028	0%
AL	Albuquerque Operations	213	7							220	3%	7	0.182	0.026	0%
AL	Sandia Nat. Lab.	245	20							265	8%	20	0.438	0.022	0%
AL	Los Alamos	11	2							13	15%	2	0.020	0.010	0%
AL	Pinellas	267	9							276	3%	9	0.055	0.006	0%
	Grand Totals	14,023	4,528	691	172	57	5	1	0	19,477	28%	5,454	379.796	0.070	11%

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

This table displays the distribution of TEDE for Weapons Fabrication and Testing facilities, listed in descending order of average measurable TEDE, including the total number of monitored individuals, the number of individuals with measurable TEDE, the collective TEDE, and the percentage of TEDE accrued above 0.5 rem.

B-16: Distribution of TEDE by Facility Type Listed in Descending Order of Average Measurable TEDE for Other, 1994

OTHER

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Ops. Office	Site/Contractor	Less than Meas.	Meas.- 0.10	0.10- 0.25	0.25- 0.50	0.50- 0.75	0.75- 1.00	1.00- 2.00	>2	Total Monitored	% of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Avg. Meas. TEDE (rem)	% of TEDE above 0.5 rem
CH	Argonne Nat. Lab.-East	1	50	23	4	9	5	4		96	99%	95	21.888	0.230	66%
ID	Idaho Nat. Eng. Lab.	336	377	60	33	25	6	30		867	61%	531	90.633	0.171	64%
OAK	Lawrence Livermore	2,795	34		1		1	1		2,832	1%	37	3.582	0.097	61%
RL	Pacific Northwest Lab.-Battelle	549	124	14	8	5	3			703	22%	154	13.182	0.086	44%
OH	West Valley	1,102	223	53	11	1	1	3		1,394	21%	292	24.306	0.083	20%
RL	Kaiser Engineering, Hanford	90	5	3	1					99	9%	9	0.720	0.080	0%
DOE	DOE Headquarters	532	36	4	3					575	7%	43	2.742	0.064	0%
CH	Brookhaven Nat. Lab.	3	183	22	9	2		1		220	99%	217	13.700	0.063	18%
OR	Oak Ridge-RMI	74	32	9						115	36%	41	2.025	0.049	0%
AL	Ross Aviation, Inc.	35	26	5						66	47%	31	1.501	0.048	0%
RL	Westinghouse Hanford	484	53	2	1			1		541	11%	57	2.690	0.047	41%
AL	UMTRA	960	355	30	5					1,350	29%	390	15.030	0.039	0%
AL	Los Alamos Nat. Lab.	1,025	179	4	3	3				1,214	16%	189	5.538	0.029	31%
AL	Sandia Nat. Lab.	373	19							392	5%	19	0.546	0.029	0%
AL	Kansas City Plant	57	2							59	3%	2	0.050	0.025	0%
OH	Mound	125	12							137	9%	12	0.245	0.020	0%
OR	MK-Ferguson Co. - OR	1,546	424	11	2					1,983	22%	437	7.872	0.018	0%
RL	Richland Operations	678	102	1						781	13%	103	1.830	0.018	0%
CH	Argonne - West		9							9	100%	9	0.126	0.014	0%
SR	Savannah River	621	194	3	1					819	24%	198	2.593	0.013	0%
RL	Bechtel Hanford	240	10							250	4%	10	0.115	0.012	0%
RL	Hanford Env. Health	52	11							63	17%	11	0.120	0.011	0%
CH	Chicago Operations	99	2							101	2%	2	0.020	0.010	0%
OAK	LERHR, U of Cal./Davis	60								60	0%	0	0.000	0.000	0%
NV	Nevada Test Site	55								55	0%	0	0.000	0.000	0%
NV	Nevada Operations	64								64	0%	0	0.000	0.000	0%
	Grand Totals	11,956	2,462	244	82	45	16	40	0	14,845	19%	2,889	211.054	0.073	43%

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

This table displays the distribution of TEDE for all Other facility types, listed in descending order of average measurable TEDE. This includes individuals that did not match one of the ten types listed, those who did not work for any appreciable times at any specific facility (e.g., transient workers), or those for whom the facility type was not indicated when reported. Also included are the number of individuals with measurable TEDE, the collective TEDE, and the percentage of TEDE accrued above 0.5 rem. The Other category accounts for 13% of the DOE collective dose, 13% of the total number of monitored individuals, and has one of the largest percentages of the collective dose above 0.5 rem of all the facility types.

B-17: Internal Dose by Facility Type, 1990-1994

AEDE

Facility Category	Number of Individuals with New Intakes*			Collective AEDE (person-rem)			Average AEDE (rem)		
	1990	1991	1992	1990	1991	1992	1990	1991	1992
Accelerator	6	3	6	0.258	0.057	0.084	0.043	0.019	0.014
Fuel Fabrication	23	7	1	0.180	0.213	0.078	0.008	0.030	0.078
Fuel Processing	21	122	25	0.217	7.869	1.880	0.010	0.065	0.075
Fuel/Uranium Enrich.	556	575	1,264	9.710	2.454	17.403	0.017	0.004	0.014
Maint. & Support	1,308	374	262	19.857	4.799	1.984	0.015	0.013	0.008
Other	249	138	63	2.621	1.461	0.828	0.011	0.011	0.013
Reactor	628	350	165	14.090	4.449	3.875	0.022	0.013	0.023
Research, Fusion	19	3	24	0.374	0.091	0.434	0.020	0.030	0.018
Research, General	168	119	166	7.268	5.941	5.995	0.043	0.050	0.036
Waste Processing/ Management	103	69	76	0.983	2.023	4.796	0.010	0.029	0.063
Weapons Fabrication	924	1,621	1,434	15.616	11.744	62.029	0.017	0.007	0.043
Totals	4,005	3,381	3,486	71.174	41.101	99.386	0.018	0.012	0.029

CEDE

Facility Category	No. of Individuals with New Intakes*		Collective CEDE (person-rem)		Average CEDE (rem)	
	1993	1994	1993	1994	1993	1994
Accelerator	11	11	0.267	1.843	0.024	0.168
Fuel Fabrication		34		0.579		0.017
Fuel Processing	11	157	0.767	1.527	0.070	0.010
Fuel/Uranium Enrich.	376	390	7.004	6.239	0.019	0.016
Maint. & Support	120	167	21.421	4.680	0.179	0.028
Other	191	139	8.298	4.018	0.043	0.029
Reactor	49	384	2.930	7.828	0.060	0.020
Research, Fusion	41	63	0.446	0.506	0.011	0.008
Research, General	126	96	36.717	11.208	0.291	0.117
Waste Processing/ Management	37	24	4.114	0.765	0.111	0.032
Weapons Fabrication	859	485	12.292	6.359	0.014	0.013
Totals	1,821	1,950	94.256	45.552	0.052	0.023

* Only included intakes that occurred during the monitoring year. Individuals may be counted more than once.

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

B-18a: Distribution of TEDE by Labor Category, 1992

Total Effective Dose Equivalent (TEDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Labor Category	Less than Meas.	Meas.-0.10	0.10-0.25	0.25-0.5	0.5 0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Average Meas. TEDE (rem)
Agriculture	107	15	2																124	14%	17	0.537	0.032
Construction	6,887	2,502	324	108	26	10	5		1	1									9,864	30%	2,977	188.773	0.063
Laborers	1,615	567	116	24	7	2	1												2,332	31%	717	49.629	0.069
Management	13,976	2,120	260	93	22	13	13	3											16,500	15%	2,524	178.344	0.071
Misc.	7,311	3,395	242	63	16	10	9	2	3	1					1				11,053	34%	3,742	193.602	0.052
Production	4,182	2,922	795	320	105	40	22	5	3	1			1					1	8,397	50%	4,215	501.381	0.119
Scientists	29,777	5,055	516	164	39	33	28	5	1	1									35,619	16%	5,842	372.914	0.064
Service	5,485	1,123	113	25		2	1												6,749	19%	1,264	54.391	0.043
Technicians	9,383	2,741	764	274	76	29	26	4		1		1							13,299	29%	3,916	421.856	0.108
Transport	1,487	520	49	8	1														2,065	28%	578	22.659	0.039
Unknown	14,087	2,936	400	173	54	26	27	3	1	1		1							17,709	20%	3,622	311.184	0.086
Totals	94,297	23,896	3,581	1,252	346	165	132	22	9	6	0	2	1	0	1	0	0	1	123,711	24%	29,414	2,295.270	0.078

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

This table displays the distribution of TEDE for the monitored DOE employees and contractors by labor category, including the total number of monitored individuals, the number of individuals with measurable TEDE, the collective TEDE, and the average TEDE.

B-18b: Distribution of TEDE by Labor Category, 1993

Total Effective Dose Equivalent (TEDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Labor Category	Less than Meas.	Meas.-0.10	0.10-0.25	0.25-0.50	0.50 0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Average Meas. TEDE (rem)
Agriculture	123	3	2	1															129	5%	6	0.780	0.130
Construction	7,350	2,063	254	84	15	7	3												9,776	25%	2,426	136.837	0.056
Laborers	1,789	587	105	48	3	2	5												2,539	30%	750	57.533	0.077
Management	15,805	1,989	83	30	6	2	1												17,916	12%	2,111	75.881	0.036
Misc.	6,396	2,385	155	50	6	1	1												8,994	29%	2,598	101.145	0.039
Production	4,565	2,361	496	235	32	12	1												7,702	41%	3,137	265.871	0.085
Scientists	30,057	3,885	269	75	11	5	5												34,307	12%	4,250	170.471	0.040
Service	5,013	1,136	80	8	1														6,238	20%	1,225	44.381	0.036
Technicians	9,716	2,902	712	287	55	25	9			2									13,708	29%	3,992	380.582	0.095
Transport	1,563	265	16	5															1,849	15%	286	11.057	0.039
Unknown	20,616	2,605	302	190	66	39	62							1	1			2	23,884	14%	3,268	384.389	0.118
Totals	102,993	20,181	2,474	1,013	195	93	87	0	0	2	0	0	0	1	1	0	0	2	127,042	19%	24,049	1,628.927	0.068

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

This table displays the distribution of TEDE for the monitored DOE employees and contractors by labor category, including the total number of monitored individuals, the number of individuals with measurable TEDE, the collective TEDE, and the average TEDE.

B-18c: Distribution of TEDE by Labor Category, 1994

Total Effective Dose Equivalent (TEDE)

Number of Individuals Receiving Radiation Doses in Each Dose Range (rem)

Laobr Category	Less than Meas.	Meas.-0.10	0.10-0.25	0.25-0.50	0.50 0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12	Total Monitored	Percent of Monitored with Meas. TEDE	No. with Meas. TEDE	Collective TEDE (person-rem)	Average Meas. TEDE (rem)
Agriculture	63	4	2	1															70	10%	7	0.688	0.098
Construction	6,218	1,964	232	97	34	4	4												8,553	27%	2,335	148.978	0.064
Laborers	1,141	660	101	36	7	2	1												1,948	41%	807	55.208	0.068
Management	16,143	1,855	113	28	7														18,146	11%	2,003	80.552	0.040
Misc.	7,703	1,488	107	35	16	7	2												9,358	18%	1,655	77.546	0.047
Production	3,524	2,343	426	203	96	21	1												6,614	47%	3,090	284.523	0.092
Scientists	28,106	4,848	256	69	15	8	5												33,307	16%	5,201	197.716	0.038
Service	4,279	1,099	86	10	5	1													5,480	22%	1,201	51.849	0.043
Technicians	8,691	3,118	739	281	62	21	17												12,929	33%	4,238	393.785	0.093
Transport	1,176	426	44	7	1														1,654	29%	478	21.055	0.044
Unknown	14,077	3,706	331	167	86	35	49		1										18,452	24%	4,375	331.164	0.076
Totals	91,121	21,511	2,437	934	329	99	79	0	1	0	0	0	0	0	0	0	0	0	116,511	22%	25,390	1,643.064	0.065

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

This table displays the distribution of TEDE for the monitored DOE employees and contractors by labor category, including the total number of monitored individuals, the number of individuals with measurable TEDE, the collective TEDE, and the average TEDE.

B-19: Internal Dose by Labor Category, 1990 - 1994

AEDE

Labor Category	Number of Individuals with New Intakes*			Collective AEDE (person-rem)			Average AEDE (rem)		
	1990	1991	1992	1990	1991	1992	1990	1991	1992
Construction	1,257	582	658	20.550	4.804	8.237	0.016	0.008	0.013
Laborers	170	121	65	2.650	0.730	0.478	0.016	0.006	0.007
Management	214	277	311	2.660	3.274	7.621	0.012	0.012	0.025
Misc.	66	69	334	2.266	1.972	45.564	0.034	0.029	0.136
Production	1,018	943	771	18.713	9.420	8.820	0.018	0.010	0.011
Scientists	483	347	320	9.918	7.271	10.565	0.021	0.021	0.033
Service	128	97	89	1.482	0.872	1.342	0.012	0.009	0.015
Technicians	340	415	391	7.477	6.313	7.395	0.022	0.015	0.019
Transport	16	14	10	0.328	0.059	0.126	0.021	0.004	0.013
Unknown	314	515	537	5.130	6.386	9.238	0.016	0.012	0.017
Totals	4,006	3,380	3,486	71.174	41.101	99.386	0.018	0.012	0.029

CEDE

Labor Category	No. of Individuals with New Intakes*		Collective CEDE (person-rem)		Average CEDE (rem)	
	1993	1994	1993	1994	1993	1994
Construction	240	211	4.656	2.521	0.019	0.012
Laborers	57	67	1.280	1.334	0.022	0.020
Management	166	110	4.099	2.455	0.025	0.022
Misc.	27	184	1.472	2.527	0.055	0.014
Production	479	571	7.622	6.454	0.016	0.011
Scientist	141	159	4.618	4.862	0.033	0.031
Service	60	109	1.275	2.186	0.021	0.020
Technicians	201	241	10.068	6.182	0.050	0.026
Transport	3	8	0.003	0.047	0.001	0.006
Unknown	447	289	59.163	16.984	0.132	0.059
Totals	1,821	1,949	94.256	45.552	0.052	0.023

* Only included intakes that occurred during the monitoring year. Individuals may be counted more than once.
No intakes were reported for individuals in the Agriculture labor category.

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

Facility Type Code Descriptions

DOE Order 5484.1 [8] requires contractors to indicate for each reported individual the facility contributing the predominant portion of that individual's effective dose equivalent. In cases when this cannot be distinguished, the facility type indicated should represent the facility type wherein the greatest portion of work service was performed.

The facility type indicated must be one of 11 general facility categories shown in *Exhibit C-1*. Because it is not always a straightforward procedure to determine the appropriate facility type for each individual, the assignment of an individual to a particular facility type is a policy decision of each contractor.

The facility descriptions that follow indicate the types of facilities included in each category. Also included are the types of work performed at the facilities and the sources of the majority of the radiation exposures.

Accelerator

The DOE administers approximately a dozen laboratories that perform significant accelerator-based research. The accelerators range in size from small single-room electrostatic devices to a 4-mile circumference synchrotron, and their energies range from keV to TeV.

The differences in accelerator types, sizes, and energies result in differences in the radiation types and dose rates associated with the accelerator facilities. In general, radiation doses to employees at the facilities are attributable to neutrons and X-rays, as well as muons at some larger facilities. Dose rates inside the primary shielding can range up to 0.2 rem/h as a result of X-ray production near some machine components. Outside the shielding, however, X-ray exposure rates are very low, and neutron dose rates are generally less than 0.005 rem/h. Average annual doses at these facilities are slightly higher than the overall average for DOE; however, the collective dose is lower than the collective dose for most other DOE facility categories because of the relatively small number of employees at accelerator facilities. Regarding internal exposures, tritium and short-lived airborne activation products exist at some accelerator facilities, although annual internal doses are generally quite low.

Fuel/Uranium Enrichment

The DOE involvement in the nuclear fuel cycle generally begins with uranium enrichment operations and facilities [19]. The current method of enrichment is isotopic separation using the gaseous diffusion process, which involves diffusing uranium through a porous membrane and using the different molecular weights of the uranium isotopes to achieve separation.

Exhibit C-1: Facility Type Codes

Facility Type Code	Description
10	Accelerator
21	Fuel/Uranium Enrichment
22	Fuel Fabrication
23	Fuel Processing
40	Maintenance and Support (Site Wide)
50	Reactor
61	Research, General
62	Research, Fusion
70	Waste Processing/Mgmt.
80	Weapons Fab. and Testing
99	Other

Although current facility designs and physical controls result in low doses from internally deposited uranium, the primary radiological hazard is the potential for inhalation of airborne uranium [19]. Because of the low specific activity of uranium, external dose rates are usually a few millirem per hour or less. Most of the external doses that are received are attributable to gamma exposures, although neutron exposures can occur, especially when work is performed near highly enriched uranium. Both the average and collective external doses at these facilities are among the lowest of any DOE facility category.

Fuel Fabrication

Activities at fuel fabrication facilities involve the physical conversion of uranium compounds to usable forms, usually rod-shaped metal. Radiation exposures to personnel at these facilities are attributable almost entirely to gamma and beta radiation. However, beta radiation is considered the primary external radiation hazard because of high beta dose rates (up to several hundred mrad per hour) at the surface of uranium rods [19]. For example, physical modification of uranium metal by various metalworking operations, such as machining and lathing operations, requires protection against beta radiation exposures to the skin, eyes, and extremities. Average external doses at fuel fabrication facilities are generally higher than at other types of DOE facilities; however, collective doses are relatively low because the number of employees is low. Internal doses from inhalation of uranium are kept very low.

Fuel Processing

The DOE administers several facilities that reprocess spent reactor fuel. These facilities separate the plutonium produced in reactors for use in defense programs. They also separate the fission products and uranium; the fission products are normally designated as radioactive waste products, while the uranium can be refabricated for further use as fuel.

The very high radioactivity of fission products in spent nuclear fuel results in employees at fuel processing facilities consistently having among the highest average doses of any DOE facility type. However, the collective dose at these facilities is less significant because of the small total number of employees. Penetrating doses are attributable primarily to gamma photons, although some neutron exposures do occur. Skin and extremity doses from handling samples are also significant, although only a few employees typically receive skin doses greater than 5 rem/year. Strict controls are in place at fuel reprocessing facilities to prevent internal depositions; however, several measurable intakes typically occur per year. Plutonium isotopes represent the majority of the internal depositions, and annual effective dose equivalents from the depositions are typically less than 0.5 rem.

Maintenance and Support

Most DOE sites have facilities dedicated to maintaining and supporting the site. In addition, some employees may be classified under this facility type if their main function is to provide site maintenance and support, even though they may not be located at a single facility dedicated to that purpose.

Because many maintenance and support activities at DOE sites do not involve work near sources of ionizing radiation, the average dose equivalent per monitored employee is typically among the lowest of any facility type. However, those employees who do perform work near radiation sources receive relatively high average annual doses, as is indicated by the relatively high average annual dose per employee who receives a measurable exposure. Also, collective doses are relatively high because there is a large number of these employees relative to the number classified under other facility types. The sources of ionizing radiation exposure are primarily gamma photons. However, variations in the types of work performed and work locations result in exposures of all types, including exposures to beta particles, x-rays, neutrons, and airborne radioactivity.

Reactor

The DOE and its predecessors have built and operated dozens of nuclear reactors since the mid-1940s. These facilities have included plutonium and tritium production reactors, prototype reactors for energy production, research reactors, reactors designed for special purposes such as production of medical radioisotopes, and reactors designed for the propulsion of naval vessels.

In 1992, many of the DOE reactors were not operating. As a result, personnel exposures at DOE reactor facilities were attributable primarily to gamma photons and beta particles from contaminated equipment and plant areas, spent reactor fuel, activated reactor components, and other areas containing fission or activation products encountered during plant maintenance and decommissioning operations. Neutron exposures do occur at operating reactors, although the resulting doses are a very small fraction of the collective penetrating doses. Gamma dose rates in some plant areas can be very high (up to several rems per hour), requiring extensive protective measures. The average and collective external doses relative to other facility types are highly dependent on the status of reactor operations. Inhalation of airborne radioactive material is a concern in some plant areas. However, protective measures, such as area ventilation or use of respiratory-protection equipment, result in low internal doses.

Research, General

The DOE contractors perform research at many DOE facilities, including all of the national laboratories. Research is performed in general areas including biology, biochemistry, health physics, materials science, environmental science, epidemiology, and many others. Research is also performed in more specific areas such as global warming, hazardous waste disposal, energy conservation, and energy production.

The spectrum of research involving ionizing radiation or radioactive materials being performed at DOE facilities results in a wide variety of radiological conditions. Depending on the research performed, personnel may be exposed to virtually any type of external radiation, including beta particles, gamma photons, x-rays, and neutrons. In addition, there is the potential for inhalation of radioactive material. Area dose rates and individual annual doses are highly variable. Relative to other facility types, average annual individual doses are slightly above average at general research facilities. The collective dose equivalent is higher than at most other facility types because of the many individuals employed at general research facilities.

Research, Fusion

DOE currently operates both major and small facilities that participate in research on fusion energy. In general, both penetrating and shallow radiation doses are minimal at these facilities because the dose rates near the equipment are both low and intermittent. The external doses that do occur are attributable primarily to x-rays from energized equipment. Relative to other DOE facility types, average individual doses and collective doses are typically the lowest at fusion research facilities. Regarding internal exposures, airborne tritium is a concern at some fusion research facilities, although the current level of operation results in minimal doses.

Waste Processing/ Management

Most DOE sites have facilities dedicated to the processing and disposal of radioactive waste. In general, the dose rates to employees when handling waste are very low because of the low specific activities or the effectiveness of shielding materials. As a result, very few employees at these facilities receive annual doses greater than 0.1 rem. At two DOE sites, however, large-scale waste processing facilities exist to properly dispose of radioactive waste products generated during the nuclear fuel cycle. At these facilities, radiation doses to some employees can be relatively high, sometimes exceeding 1 rem/ year. Penetrating doses at waste processing facilities are attributable primarily to gamma photons; however, neutron exposures are significant at the large-scale facilities. Skin doses are generally not a significant problem. Overall, average annual doses at waste processing/ management facilities are among the highest of any DOE facility type, which is attributable primarily to the two large-scale facilities and the shift in DOE mission from national defense production to waste management and environmental restoration. The annual collective doses are closer to the average of all facility types, however, because of the relatively small number of employees at this type of facility.

Weapons Fabrication and Testing

The primary function of a facility in this category is to fabricate weapons-grade material for the production or testing of nuclear weapons. At the testing facilities, radiation doses received by personnel are generally minimal because of the strict controls over personnel access to testing areas, although extremity doses can be relatively high from handling neutron-activated materials. Radiation doses are a greater concern at facilities where weapons and weapons-grade nuclear material are handled. At these facilities, neutron radiation dose rates can be significant when processing relatively small quantities of ^{238}Pu or larger quantities of mixed plutonium isotopes [20]. Penetrating doses from gamma photons and plutonium x-rays can also be significant in some situations, as can skin and extremity doses from plutonium x-rays. Overall, average individual annual doses at these facilities are slightly higher than the DOE average. The collective doses received by employees at these facilities are generally higher than the collective doses at other facility types because of the large number of individuals employed.

Also of significant concern at these facilities is inhalation of plutonium, where inhalation of very small amounts can result in doses exceeding limits. To prevent plutonium intakes, strict controls are in place including process containment, contamination control procedures, and air monitoring and bioassay programs [20]. As a result, significant internal exposures are very rare at these facilities.

Other

Individuals included in this facility type can be generally classified under three categories: (1) those who worked in a facility that did not match one of the ten facility types described above; (2) those who did not work for any appreciable time at any specific facility, such as transient workers; or (3) those for whom facility type was not indicated on the report forms. Examples of a facility type not included in the ten described above include construction and irradiation facilities. In general, employees classified under this facility type receive annual doses significantly less than the annual doses averaged over all DOE facilities. However, the wide variation in the type of work performed by these individuals results in a wide variation in the types and levels of exposures. Although exposures to gamma photons are predominant, some individuals may be exposed to beta particles, x-rays, neutrons, or airborne radioactive material.

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Appendix D

Limitations of Data

The following is a description of the limitations of the data currently available in the DOE Radiation Exposure Monitoring System (REMS). While these limitations have been taken into consideration in the analysis presented in this report, readers should be alert to these limitations and consider their implications when drawing conclusions from these data.

Individual Dose Records vs Dose Distribution

Prior to 1987, exposure data were reported from each facility in terms of a statistical dose distribution wherein the number of individuals receiving a dose within specific dose ranges was reported. The collective dose was then calculated from the distribution by multiplying the number of individuals in each dose range by the midpoint value of the dose range. Starting in 1987, reports of individual exposures were collected that recorded the specific dose for each monitored individual. The collective dose can be accurately determined by summing the total dose for each individual. The dose distribution reporting method prior to 1987 resulted in up to a 20% overestimation of collective dose. The reason is that the distribution of doses within a range is usually skewed toward the lower end of the range. If the midpoint of the range is multiplied by the number of people in the range, the product overestimates the collective dose.

Monitoring Practices

Radiation monitoring practices differ widely from site to site and are based on the radiation hazards and work practices at each site. Sites use different dosimeters and have different policies on which workers to monitor. While all sites have achieved compliance with the DOE Laboratory Accreditation Program (DOELAP), which standardizes the quality of dosimetry measurements, there are still differences in the dosimeters used that can contribute to differences in the collective dose from site to site. The number of monitored individuals can significantly impact the site's collective dose. Some sites supply dosimeters to virtually all workers. While this tends to inflate the number of monitored workers with no dose, it also can add a large number of very low dose workers to the total number of workers with measurable dose, thereby lowering the site's average measurable dose. Even at low doses, these workers add significantly to the site collective dose. In contrast, other sites only monitor workers who exceed the monitoring requirement threshold (10% of the dose limit). This tends to reduce the number of monitored workers and reports only those workers receiving doses in the higher dose ranges. This can decrease the site's collective dose while increasing the average measurable dose.

AEDE vs CEDE

Prior to 1990, the dose resulting from penetrating ionizing radiation (external dose) and the dose resulting from the uptake of radionuclides (internal dose), was reported separately. In 1993, the DOE changed the internal dose calculation methodology from annual effective dose equivalent (AEDE) to the 50-year committed effective dose equivalent (CEDE). The total effective dose equivalent (TEDE) then became the sum of the CEDE and the deep dose equivalent (DDE). This report presents TEDE data from 1990 through 1994. Internal AEDE data are reported from 1990 through 1992 and internal CEDE data are reported for 1993 and 1994. Where possible, the legacy component of the AEDE data is highlighted when presenting TEDE data that are trended from 1990 through 1994. See Section 2.4 for a discussion of this change in requirements.

Occupation Codes

Each individual's dose record includes the occupation code for the individual while he or she worked at the DOE site during the monitoring year. Any change in occupation during the monitoring year is not reflected in the current database. The occupation codes are very broad categorizations and are grouped into nine general categories. Each year a large percentage (up to 20%) of the occupations are listed as unknown, or as miscellaneous. The definitions of each of the labor categories are subject to interpretation by the reporting organization and/or the individual's employer.

Facility Type

The facility type is also recorded with each dose record for the monitoring year. It is intended to reflect the type of facility where the individual received most of their occupational radiation exposure during the monitoring year. While the facility types are clearly defined (see Appendices A and C), the reporting organizations often have difficulty tracking which facility type contributed to the majority of the individual's exposure. Certain individuals tend to work in the proximity of several different facility types throughout the monitoring year and are often included in the "Maintenance and Support (Site-wide)" facility type. The facility type for temporary contract workers and visitors is often not reported and is defaulted to "unknown."

In addition to these uncertainties, the phase of operation of the facility types is not currently reported. A facility type of "accelerator" may be reported when in fact, the accelerator has not be in operation for a considerable time and may be in the process of stabilization, decommissioning, or decontamination. In addition, several sites have commented that they have difficulty assigning the facility type, because many of the facilities are no longer operational. For example, some sites commented that a reactor that is being decommissioned is no longer considered a "reactor" facility type. Other sites continue to categorize a facility based on the original intent or design of the facility, regardless of its current status.

DOE Headquarters will be reviewing the Facility Type codification scheme and modifying the reporting requirements to standardize the use of facility type classifications and improve the quality of the data and the data analysis.

Organization Code

Facilities report data to the central repository based on an "organization code". This code identifies the Operations or Field Office, the reporting facility, and the contractor or subcontractor that is reporting the exposure information. The organization code changes over time as DOE Offices are reorganized. In some cases, new Operations or Field Offices are created, in other cases a Field Office may change organizations and begin reporting with another Field Office. Two such changes are noteworthy within the past several years. The Fernald Field Office began reporting independently in 1993. Prior to 1993 it reported under the Oak Ridge Field Office. In 1994, Fernald was incorporated into the newly created Ohio Field Office. The Ohio Field Office began reporting in 1994. For this reason, the Fernald data are shown under the Ohio Field Office. The Mound Plant and West

Valley Project also changed Operations Office during the past 3 years and are now shown under the Ohio Field Office. Footnotes indicate the change in Operations Offices.

Naval Reactor Facilities

The exposure information for the Schenectady and Pittsburgh Naval Reactor facilities is not included in this report because of limited information concerning these exposures. Readers should note that the dose information for the overall DOE complex presented in this report may differ from other reports or sources of information because of the exclusion of these data.

Exposure information for Naval Reactor programs can be found in the following reports:

- NT-93-2, February 1993 — "Occupational Radiation Exposure from U.S. Naval Nuclear Plants and Their Support Facilities",
- NT-93-3, March 1993 — "Occupational Radiation Exposure from U.S. Naval Reactors' Department of Energy Facilities",
- NT-94-2, March 1994 — "Occupational Radiation Exposure from U.S. Naval Nuclear Plants and Their Support Facilities, and
- NT-94-3, March 1994 — "Occupational Radiation Exposure from U.S. Naval Reactors' Department of Energy Facilities".

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User Survey

DOE and DOE Contractor Employees Annual Radiation Exposure Report

User Survey

DOE, striving to meet the needs of its stakeholders, is looking for suggestions on ways to improve the DOE and DOE Contractor Employees Annual 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 EH-52 270/cc
19901 Germantown Road
Germantown, MD 20874

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

— —

1. Identification:

Name: ....

Title: ....

Mailing Address: ....

....

....

....

2. Distribution:

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

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

3. Was the presentation/discussion of dose distribution data for:

DOE-wide .... adequate ___ inadequate ___

Sites .... adequate ___ inadequate ___

Facilities .... adequate ___ inadequate ___

Occupation/Labor .... adequate ___ inadequate ___

Comments/areas for improvement:

....

....

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....

....

....

4. Was the presentation/discussion of dose trends for:

DOE-wide .... adequate ___ inadequate ___
Sites................................ adequate ___ inadequate ___
Facilities .... adequate ___ inadequate ___
Occupation/Labor .... adequate ___ inadequate ___

Comments/areas for improvement:

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5. Was the discussion of ALARA Projects at specific sites:

Useful ___ Keep in future reports ___
Not useful ___ Delete from future reports ___

6. Was the discussion of AEDE vs CEDE helpful?

Useful ___ Keep in future reports ___
Not useful ___ Delete from future reports ___

7. Would additional/different breakouts of the data be helpful?

Yes ___ No ___

Comments/areas for improvement:

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8. Suggestions for new facility type, occupation, and/or labor codes.

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9. If/when the data become available, would person/rem-hour or person-rem/RWP be useful in this report?

Yes ___ No ___

Comments/areas for improvement:

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....
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....
....
....
....

10. To publish this report in the second quarter and to be able to use it as a management tool, we need the data *as soon as possible* after you have processed it. Please indicate when you can provide the data.

Quarterly ___
Semi-Annually ___
Yearly*___

*By end of January, February, March
(please circle one)

11. DOE is considering the addition of a code for indicating the Phase of Operation of the facility type that is currently reported with each dose record (see A-4). The Phase of Operation will allow for expanded analysis of the dose information by considering the operational phase of the facility. Please indicate whether this information is available at your site, and the years the information would cover.

Available___ Years:________to_________
Not available___

Appendix F

Access to Radiation Exposure Information

F

Radiation Exposure Monitoring System

The data used to compile this report were obtained from the DOE Radiation Exposure Monitoring System (REMS), which serves as the central repository of radiation exposure information for DOE Headquarters. Recently the REMS has undergone an extensive redesign effort in combination with the efforts involved in revising the annual report. One of the main goals of the redesign effort is to allow researchers better access to the REMS data. However, there is considerable diversity in the goals and needs of these researchers. For this reason, a multi-tiered approach has been developed to allow researchers flexibility in accessing the REMS data.

Exhibit F-1 lists the various ways of accessing the DOE radiation exposure information contained in REMS. A description is given for each access method as well as requirements for access and skill sets needed for each method. Descriptions of the intended research audience and experience level (for computer systems) are also provided. To obtain further information, a contact name and phone number is provided.

A brief summary of the multi-tier access to the REMS information is shown in *Exhibit F-1.*

Comprehensive Epidemiologic Data Resource

Of interest to researchers in radiation exposure is the health risk associated with the exposure. While the health risk from occupational exposure is not treated in this report, it has been extensively researched by DOE. The Comprehensive Epidemiologic Data Resource (CEDR) serves as a central resource for radiation health risk studies at the DOE.

Epidemiologic studies on health effects of radiation exposures have been supported by the DOE for more than 30 years. The results of these studies, which initially focused on the evaluation of mortality among workers employed in the nuclear weapons complex, have been published in scientific literature. However, the data collected during the conduct of the studies were not widely shared. CEDR has now been established as a public-use database to broaden independent access and use of these data. At its introduction in 1993, CEDR included primarily occupational studies of the DOE workforce, including demographic, employment, exposure, and mortality follow-up information on more than 420,000 workers. In the past 2 years, the program's holdings have been expanded to include data from both occupational and community health studies, such as those examining the impact of fallout from nuclear weapons testing, community dose reconstructions, data from the decades of follow-up on atomic bomb survivors, and health surveillance reports on current DOE workers.

CEDR accomplishes this by a hierarchical structure that accommodates analysis and working files generated during a study, as well as files of documentation that are critical for understanding the data. CEDR provides easy access to its holdings through the Internet or dial-up connections, phone and mail interchanges, and provides an extensive catalog of its holdings. CEDR has become a unique resource comprising the majority of data that exist on the risks of radiation exposure.

For further information concerning the CEDR system, contact

Ms. Barbara G. Brooks
Program Manager
Office of Epidemiologic Studies, EH-62
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874-1290

E-mail: barbara.brooks@hq.doe.gov
Or access the CEDR internet web page at http://cedr.lbl.gov

F-1: Methods of Accessing REMS Information

REMS Information Access Method	Experience Requirements			Software Requirements[3]	Eligibility Requirements	To Access
	Knowledge of REMS Data	Computer Expertise				
		User	System Adminstrator-Setup			
Hardcopy Annual Report	None. Data explained in report.	N/A	N/A	None.	None.	Contact EH-52[1] to request that you be added to Annual Report mailing list.
Web Page	Low. General knowledge/interest in radiation data.	Minimal computer skills. Knowledge of how to use the Web browser, and an Internet connection.	Medium. LAN connection to Internet or Internet Provider. Support Web browser.	Internet access. Web browser client software.	None.	Connect to http://www.saic.com/home/doe_rad
InfoMaker - Pre-defined reports	Medium. Limitations of the data in REMS, and what the exposure data represent.	Minimal. Familiarity with Windows applications. Under-stand difference between Query and Reports.	Medium. Client-server computer configuration can be complex, but this is a one-time effort. InfoMaker support provided by DOE HQ.	Internet access (TCP/IP). Oracle SQLNet. PowerSoft InfoMaker. [Oracle SNS software if Category 1 user]	No requirements for Category 2 users[4]. Category 1 users must get "need to know" Privacy Act authorization from EH-52[1].	Contact OIM[2] to request access. EH-52 authorization required for Category 1 users.
InfoMaker - Ad Hoc Queries	High. Thorough understanding of the data dictionary, relationships and structure of the database. Limitations of the data.	Medium (to High). Some knowledge of SQL highly recommended. Familiarity with "Report generation"-type software.	Medium. Client-server computer configuration can be complex, but this is a one-time effort. InfoMaker support provided by DOE HQ.	Internet access (TCP/IP). Oracle SQLNet. PowerSoft InfoMaker. [Oracle SNS software if Category 1 user]	No requirements for Category 2 users[4]. Category 1 users must get "need to know" Privacy Act authorization from EH-52[1].	Contact OIM[2] to request access. EH-52 authorization required for Category 1 users.
Client query tool other than InfoMaker	High. Thorough understanding of the data dictionary, relationships and structure of the database. Limitations of the data.	High. Skill in SQL and connecting to the system. Need to be skilled in the use of whatever query tool is used.	Medium. Support for LAN connection to Internet or Internet Provider. Support user query software.	Internet access (TCP/IP). Oracle SQLNet. ODBC Drivers. Query Tool client. [Oracle SNS software if Category 1 user]	No requirements for Category 2 users[4]. Category 1 users must get "need to know" Privacy Act authorization from EH-52[1].	Contact OIM[2] to request access. EH-52 authorization required for Category 1 users.
Running SQL on the REMS Server	High. Thorough understanding of of the data dictionary, relationships and structure of the database. Limitations of the data.	High. Skill in SQL and connecting to the system.	Medium. Support for LAN connection to Internet or Internet Provider. Support TELNet software.	Internet access (TCP/IP). TELNet software.	Category 2 use only. TELNet authorization required for firewall.	Contact OIM[2] to request access.

① EH-52 contact Ms. Nirmala Rao at — Phone: (301) 903-2297, Fax: (301) 903-7773, E-mail: Nimi.Rao@hq.doe.gov
② OIM contact Mr. Pat Heinig at — Phone: (301) 903-9850, Fax: (301) 903-0118, E-mail: Pat.Heinig@hq.doe.gov
③ See REMS User Manual for detailed software requirements.
④ Category 1 - All data in the REMS system, including Privacy Act data such as name and social security number of the monitored individual.
Category 2 - Access to non-sensitive radiation monitoring information per monitored individual. See REMS Reference Manual for details.