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United States Nuclear Regulatory Commission
Protecting People and the Environment

NUREG-0713
Vol. 31

Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities 2009

Forty-Second Annual Report

Office of Nuclear Regulatory Research

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PREVIOUS REPORTS IN THIS SERIES

WASH-1311	A Compilation of Occupational Radiation Exposure from Light Water Cooled Nuclear Power Plants, 1969–1973, U.S. Atomic Energy Commission, May 1974.
NUREG-75/032	Occupational Radiation Exposure at Light Water Cooled Power Reactors, 1969–1974, U.S. Nuclear Regulatory Commission, June 1975.
NUREG-0109	Occupational Radiation Exposure at Light Water Cooled Power Reactors, 1969–1975, U.S. Nuclear Regulatory Commission, August 1976.
NUREG-0323	Occupational Radiation Exposure at Light Water Cooled Power Reactors, 1969–1976, U.S. Nuclear Regulatory Commission, March 1978.
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NUREG-0594	Occupational Radiation Exposure at Commercial Nuclear Power Reactors, 1978, U.S. Nuclear Regulatory Commission, November 1979.
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NUREG-0713	Occupational Radiation Exposure at Commercial Nuclear Power Reactors, 1981, Vol. 3, U.S. Nuclear Regulatory Commission, November 1982.
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NUREG-0713	Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 1987, Vol. 9, U.S. Nuclear Regulatory Commission, November 1990.
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NUREG-0713	Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 1989, Vol. 11, U.S. Nuclear Regulatory Commission, April 1992.
NUREG-0713	Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 1990, Vol. 12, U.S. Nuclear Regulatory Commission, January 1993.
NUREG-0713	Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 1991, Vol. 13, U.S. Nuclear Regulatory Commission, July 1993.
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NUREG-0713	Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 1997, Vol. 19, U.S. Nuclear Regulatory Commission, November 1998.
NUREG-0713	Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 1998, Vol. 20, U.S. Nuclear Regulatory Commission, November 1999.
NUREG-0713	Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 1999, Vol. 21, U.S. Nuclear Regulatory Commission, October 2000.
NUREG-0713	Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 2000, Vol. 22, U.S. Nuclear Regulatory Commission, September 2001.
NUREG-0713	Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 2001, Vol. 23, U.S. Nuclear Regulatory Commission, September 2002.
NUREG-0713	Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 2002, Vol. 24, U.S. Nuclear Regulatory Commission, October 2003.
NUREG-0713	Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 2003, Vol. 25, U.S. Nuclear Regulatory Commission, October 2004.
NUREG-0713	Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 2004, Vol. 26, U.S. Nuclear Regulatory Commission, December 2005.
NUREG-0713	Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 2005, Vol. 27, U.S. Nuclear Regulatory Commission, December 2006.
NUREG-0713	Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 2006, Vol. 28, U.S. Nuclear Regulatory Commission, November 2007.
NUREG-0713	Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 2007, Vol. 29, U.S. Nuclear Regulatory Commission, December 2008.
NUREG-0713	Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 2008, Vol. 30, U.S. Nuclear Regulatory Commission, December 2009.

Previous reports in the NUREG-0714 series, which are now combined with NUREG-0713, are as follows:

WASH-1350-R1 through WASH-1350 R6	First through Sixth Annual Reports of the Operation of the U.S. AEC's Centralized Ionizing Radiation Exposure Records and Reporting System, U.S. Atomic Energy Commission.
NUREG-75/108	Seventh Annual Occupational Radiation Exposure Report for Certain NRC Licensees, 1974, U.S. Nuclear Regulatory Commission, October 1975.
NUREG-0119	Eighth Annual Occupational Radiation Exposure Report for 1975, U.S. Nuclear Regulatory Commission, October 1976.
NUREG-0322	Ninth Annual Occupational Radiation Exposure Report for 1976, U.S. Nuclear Regulatory Commission, October 1977.
NUREG-0463	Tenth Annual Occupational Radiation Exposure Report for 1977, U.S. Nuclear Regulatory Commission, October 1978.
NUREG-0593	Eleventh Annual Occupational Radiation Exposure Report for 1978, U.S. Nuclear Regulatory Commission, January 1981.
NUREG-0714	Twelfth Annual Occupational Radiation Exposure Report for 1979, Vol. 1, U.S. Nuclear Regulatory Commission, August 1982.
NUREG-0714	Occupational Radiation Exposure, Thirteenth and Fourteenth Annual Reports, 1980 and 1981, Vols. 2 and 3, U.S. Nuclear Regulatory Commission, October 1983.
NUREG-0714	Occupational Radiation Exposure, Fifteenth and Sixteenth Annual Reports, 1982 and 1983, Vols. 4 and 5, U.S. Nuclear Regulatory Commission, October 1985.

ABSTRACT

This report summarizes the occupational exposure data that are maintained in the U.S. Nuclear Regulatory Commission's (NRC) Radiation Exposure Information and Reporting System (REIRS). The bulk of the information contained in the report was compiled from the 2009 annual reports submitted by five of the seven categories[1] of NRC licensees subject to the reporting requirements of 10 CFR 20.2206. Because there are no geologic repositories for high-level waste currently licensed and no NRC-licensed low-level waste disposal facilities currently in operation, only five categories will be considered in this report. The annual reports submitted by these licensees consist of radiation exposure records for each monitored individual. These records are analyzed for trends and presented in this report in terms of collective dose and the distribution of dose among the monitored individuals.

Annual reports for 2009 were received from a total of **195** NRC licensees. Compilations of the reports submitted by the **195** licensees indicated that **189,124** individuals were monitored, **88,429** of whom received a measurable dose (Table 3.1).[2] The collective dose incurred by these individuals was **11,892** person-rem, which represents a **5% increase** from the 2008 value. This increase was due to the increase in collective dose at commercial nuclear power reactors, while the collective dose for other categories of NRC licensees decreased. The number of individuals receiving a measurable dose also increased, resulting in an average measurable dose of **0.13** rem for 2009. The average measurable dose is defined as the total effective dose equivalent (TEDE) divided by the number of individuals receiving a measurable dose.

In calendar year 2009, the average annual collective dose per reactor for light water reactor (LWR) licensees was **96** person-rem. This represents a **9% increase** from the value reported for 2008 (88 person-rem). The increase in collective dose for power reactors was due to a 12% increase in total outage hours in 2009. During outages, activities involving increased radiation exposure such as refueling and maintenance are performed while the reactor is not in operation. The average annual collective dose per reactor for boiling water reactors (BWRs) was **151** person-rem for **35** BWRs, and for pressurized water reactors (PWRs), it was **69** person-rem for **69** PWRs. Analyses of transient individual data indicate that **29,293** individuals completed work assignments at two or more licensees during the monitoring year. The dose distributions are adjusted each year to account for the duplicate reporting of transient individuals by multiple licensees. The adjustment to account for transient individuals has been specifically noted in footnotes in the figures and tables for commercial reactors. In 2009, the average measurable dose per individual for all licensees calculated from reported data was **0.13** rem. The corrected dose distribution resulted in an average measurable dose per individual for all licensees of **0.18** rem.

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[1] Commercial nuclear power reactors and test reactor facilities, industrial radiographers; fuel processors (including uranium enrichment facilities), fabricators, and reprocessors; manufacturing and distribution of byproduct material; independent spent fuel storage installations; facilities for land disposal of low-level waste; and geologic repositories for high-level waste. There are currently no NRC licensees involved in low-level waste disposal or geologic repositories for high-level waste.

[2] The number of workers with measurable dose includes any individual with a dose greater than zero rem and does not include doses reported as "not detectable."

EDITOR'S NOTE

Technical staff in the U.S. Nuclear Regulatory Commission Offices of Nuclear Reactor Regulation, Nuclear Material Safety and Safeguards, New Reactors, Federal and State Materials and Environmental Management Programs, and Nuclear Regulatory Research assisted in the preparation of this NUREG, serving as technical reviewers. The U.S. Nuclear Regulatory Commission welcomes responses from readers.

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

Page

LIST OF FIGURES

LIST OF TABLES

PREFACE

A number of U.S. Nuclear Regulatory Commission (NRC) licensees have inquired as to how the occupational radiation exposure data that are compiled from the individual exposure reports required by 10 CFR 20.2206 are used by the NRC staff. In combination with other sources of information, the principal uses of the data are to provide facts regarding routine occupational exposures to radiation and radioactive material that occur in connection with certain NRC-licensed activities. The data can be used by the NRC staff as indicated below:

1. The data permit evaluation of trends, both favorable and unfavorable, from the viewpoint of the effectiveness of overall NRC/licensee radiation protection and as low as is reasonably achievable (ALARA) efforts by licensees.
2. The data assist in the evaluation of the radiological risk associated with certain categories of NRC-licensed activities and are used for comparative analyses of radiation protection performance: U.S./foreign, boiling water reactors/pressurized water reactors (BWRs/PWRs), civilian/military, facility/facility, nuclear industry/other industries, etc.
3. The data are used as one of the metrics of the NRC Reactor Oversight Program to evaluate the effectiveness of the licensees' ALARA programs and also for inspection planning purposes.
4. The data permit evaluation of transient individuals who may affect dose distribution statistics through multiple counting.
5. The data are used in the establishment of priorities for the utilization of NRC health physics resources: research, standards development, and regulatory program development.
6. The data provide facts for answering Congressional and administration inquiries and for responding to questions raised by the public.
7. The data are used to provide radiation exposure histories to individuals who were exposed to radiation at NRC-licensed facilities.
8. The data provide information that may be used to conduct epidemiological studies.

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FOREWORD

Through this annual report, the U.S. Nuclear Regulatory Commission (NRC) supports openness in its regulatory process by providing the public with accurate and timely information about the radiation protection program of NRC's licensees. Toward that end, NUREG-0713, Volume 31, summarizes the 2009 occupational radiation exposure data maintained in the NRC's Radiation Exposure Information and Reporting System (REIRS) database.

Seven categories of NRC licensees are required to report annually on individual exposure in accordance with Title 10 of the Code of Federal Regulations, Section 20.2206 (10 CFR 20.2206, "Reports of Individual Monitoring"). Specifically, these categories include commercial nuclear power reactors; industrial radiographers; fuel processors (including uranium enrichment facilities), fabricators, and reprocessors; manufacturing and distribution of byproduct material; independent spent fuel storage installations; facilities for land disposal of low-level waste; and geologic repositories for high-level waste. Because NRC has not licensed any geologic repositories for high-level waste and no NRC-licensed low-level waste disposal facilities are currently in operation, this report considers only the first five categories of NRC licensees. As such, this report reflects the occupational radiation exposure data that NRC received from 195 licensees. In addition, 38 Agreement State licensees voluntarily reported 2009 annual data to the NRC. These licensees are listed in Appendix A, Tables A2 and A3, but are not included or analyzed within Section 3.

The data submitted by licensees consist of radiation exposure records for each monitored individual. In 2009, 138,658 individuals were monitored and 66,871 received a measurable dose (when adjusted for transient individuals). This report analyzes and presents these records in terms of collective dose and the distribution of dose among the monitored individuals. During 2009, these individuals incurred a collective dose of 11,892 person-rem, which represents a 5% increase from the 2008 value of 11,301 person-rem. This increase was due to the increase in collective dose at commercial nuclear power reactors, while the collective dose for other categories of NRC licensees decreased. The average measurable dose is the total collective dose divided by the number of individuals receiving a measurable dose. While the collective dose increased from 2008 to 2009, there was a proportional increase in the number of individuals receiving a measurable dose, resulting in the average measurable dose remaining the same at 0.18 rem in 2009. This value can be compared with the 0.31 rem [Ref. 1] that the average person in the United States receives annually from natural background radiation. Worldwide annual exposures to natural background radiation are generally expected to be in the range of 0.1 rem to 1.3 rem, with 0.24 rem [Ref. 2] being the current average worldwide value.

This annual report is useful in evaluating trends in occupational radiation exposure to assess the effectiveness of licensees' radiation protection programs to maintain exposures as low as is reasonably achievable (ALARA). For example, the NRC staff uses the data presented in this report as one of the metrics of the NRC's Reactor Oversight Program to evaluate the effectiveness of licensees' ALARA programs.

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ABBREVIATIONS

AEC	U.S. Atomic Energy Commission
ALARA	as low as is reasonably achievable
BWR	boiling water reactor
CDE	committed dose equivalent
CEDE	committed effective dose equivalent
CFR	Code of Federal Regulations
D&D	decontamination and decommissioning
DDE	deep dose equivalent
DOE	U. S. Department of Energy
ERDA	Energy Research and Development Administration
FSME	Office of Federal and State Materials and Environmental Management Programs
FSSR	final status survey report
ISFSI	independent spent fuel storage installation
LDE	lens dose equivalent
LTP	license termination plan
LWR	light water reactor
M&D	manufacturing and distribution
mSv	millisievert
MWe	megawatts electric
MW-yr	megawatt-year
ND	not detectable
NMSS	Office of Nuclear Material Safety and Safeguards
NR	not required to be reported
NRC	U.S. Nuclear Regulatory Commission
NRR	Office of Nuclear Reactor Regulation
PSDAR	Post shut-down decommissioning activities report
PSE	planned special exposure
PWR	pressurized water reactor
REIRS	Radiation Exposure Information and Reporting System
RES	Office of Nuclear Regulatory Research
SDE-ME	shallow dose equivalent maximum extremity
SDE-WB	shallow dose equivalent whole body
SI	international system of units
SR_E	collective dose distribution ratio
SSC	safety related structures, systems and components

ABBREVIATIONS (Continued)

Sv	sieverts
TEDE	total effective dose equivalent
TMI	Three Mile Island
TODE	total organ dose equivalent
UF_6	uranium hexafluoride
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
USEC	United States Enrichment Corporation

Section 1
INTRODUCTION

1.1 BACKGROUND

One of the basic purposes of the Atomic Energy Act and the implementing regulations in Title 10, Part 20, of the *Code of Federal Regulations* (10 CFR Part 20), is to protect the health and safety of the public, including the employees of the licensees conducting operations under those regulations. Among these regulations there is a requirement that licensees provide individuals likely to be exposed to radiation with devices to monitor their exposures. Each licensee is also required to maintain records of the results of such monitoring until the Commission terminates the license. However, there was no initial provision that these records or any summary of them be transmitted to a central location where the data could be retrieved and analyzed.

On November 4, 1968, the U.S. Atomic Energy Commission (AEC) published an amendment to 10 CFR Part 20 requiring the reporting of certain occupational radiation exposure information to a central repository at AEC Headquarters. At that time, there were only four categories[3] of AEC licensees required to report. These facilities were considered to have the greatest potential for significant occupational doses. A procedure was established whereby the appropriate occupational exposure data were extracted from these reports and entered into the AEC Radiation Exposure Information and Reporting System (REIRS), a computer system that was maintained at the Oak Ridge National Laboratory Computer Technology Center in Oak Ridge, Tennessee, until May 1990.

At that time, the data were transferred to a database management system and are now maintained at the Oak Ridge Institute for Science and Education, which is managed by Oak Ridge Associated Universities. The computerization of these data facilitates their retrieval and analysis. The data maintained in REIRS have been summarized and published in a report every year since 1969. Annual reports for each of the years 1969 through 1973 presented the data reported by both AEC licensees and contractors and were published in six documents designated as WASH-1350-R1 through WASH-1350-R6.

In January 1975, with the separation of AEC into the Energy Research and Development Administration (ERDA) and the U.S. Nuclear Regulatory Commission (NRC), each agency assumed responsibility for collecting and maintaining occupational radiation exposure information reported by the facilities under its jurisdiction. The annual reports published by NRC on occupational exposure for calendar year 1974 and subsequent years do not contain information pertaining to ERDA facilities or contractors. Comparable information for facilities and contractors under ERDA, now the U.S. Department of Energy (DOE), is collected and published by the DOE Office of Corporate Safety Analysis, a division of Health, Safety and Security, in Germantown, Maryland.

[3] Commercial nuclear power reactors; industrial radiographers; fuel processors (including uranium enrichment facilities as of 1997), fabricators, and reprocessors; and manufacturing and distribution of specified quantities of byproduct material.

In 1982 and 1983, 10 CFR 20.408(a) was amended to require three additional categories of NRC licensees to submit annual statistical exposure reports and individual termination exposure reports. The three additional NRC licensee categories were: (1) geologic repositories for high-level radioactive waste, (2) independent spent fuel storage installations, and (3) facilities for the land disposal of low-level radioactive waste. This document presents the exposure information that was reported by NRC licensees representing one of these categories; there are no geologic repositories for high-level waste currently licensed, and there are no low-level land disposal facilities currently in operation that report to the NRC.

In May 1991, 10 CFR Part 20 was revised. The revision redefined the radiation monitoring and reporting requirements of NRC licensees. Instead of submitting summary annual reports (§20.407) and termination reports (§20.408), licensees are now required to submit an annual report of the dose received by each monitored individual (§20.2206). Licensees were required to implement the new requirements no later than January 1994.

This report summarizes information reported for the current year and previous ten years. More licensee-specific data for the previous ten years, such as the annual reports submitted by each commercial nuclear power reactor pursuant to 10 CFR 20.407 and 20.2206 (after 1993) and their technical specifications (prior to Volume 20 of this report), may be found in the documents listed on the inside of the front cover of this report for the specific year desired. Additional operating data and statistics for each commercial nuclear power reactor for the years 1973 through 1982 may be found in a series of reports, Nuclear Power Plant Operating Experience [Refs. 3–11]. These documents are available for viewing at all NRC public document rooms, as well as on the NRC public Web site (www.nrc.gov), or they may be purchased from the National Technical Information Service, as shown in the References section.

1.2 RADIATION EXPOSURE INFORMATION ON THE INTERNET

In May 1995, NRC began pursuing the dissemination of radiation exposure information via a Web site on the Internet. This site allows interested parties with the appropriate equipment to access the data electronically rather than through the published NUREG-0713 document. A Web site was created for radiation exposure and linked into the main NRC Web page. The Web site contains up-to-date information on radiation exposure, as well as information and guidance on reporting radiation exposure information to NRC. Interested parties may read the documents online or download information to their systems for further analysis. The Radiation Exposure Monitoring and Information Transmittal System, a software application designed to maintain licensee dose records, and REIRView, a software package designed to validate a licensee's annual data submittal, are also available for downloading via the Web site. There are also links to other Web sites dealing with the topics of radiation and health physics. Individuals may submit requests for their dose records contained in REIRS on this Web site. In addition, organizations that have provided documentation to the NRC may also submit requests for dose records contained in REIRS on this website.

NRC intends to continue pursuing the dissemination of radiation exposure information via the Web and will focus more resources on the electronic distribution of information rather than the publication of hard-copy reports.

The main Web address for NRC is

http://www.nrc.gov

The NRC radiation exposure information Web URL is

http://www.reirs.com

Comments on this report or the NRC's radiation exposure Web page should be directed to

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Section 2
LIMITATIONS OF THE DATA

All of the figures compiled in this report relating to exposures and occupational doses are based on the results and interpretations of the readings of various types of personnel-monitoring devices employed by each licensee. This information, obtained from routine personnel-monitoring programs, is sufficient to characterize the radiation exposure incident to individuals' work and is used in evaluating the radiation protection program.

Monitoring requirements are specified in 10 CFR 20.1502, which requires licensees to monitor individuals who receive or are likely to receive, in one year, a dose in excess of 10% of the applicable limits. For occupational individuals, the annual limit for the whole body is 5 rem, so 0.5 rem per year is the level above which monitoring is required. Separate dose limits have been established for minors, declared pregnant women, and members of the public. Monitoring is also required for any individual entering a high or very high radiation area. Depending on the administrative policy of each licensee, persons such as visitors and clerical individuals may also be provided with monitoring devices, even though the probability of their exposure to measurable levels of radiation is extremely small.

Pursuant to 10 CFR 20.2206(b), certain categories of licensees must submit an annual report of the results of individual monitoring carried out by the licensee for each individual for whom monitoring was required by Section 20.1502. In addition to this requirement, many licensees elect to report the doses for every individual for whom they provided monitoring. This practice increases the number of individuals that are monitored for radiation exposure. In an effort to account for this increase, the number of individuals reported as having "no measurable dose"[4] is subtracted from the total number of monitored individuals. This resulting number can then be used to calculate the average measurable dose per individual as well as the average dose per monitored individual.

This report contains information reported by NRC licensees and some Agreement State[5] licensees. Since NRC licenses all commercial nuclear power reactors, fuel processors and fabricators, and independent spent fuel storage installations, information shown for these categories reflect all relevant activity in the United States. This is not the case, however, for the remaining categories of industrial radiography, manufacturing and distribution of specified quantities of byproduct material, and low-level waste disposal. Many companies that conduct these types of activities are located in Agreement States. More than three times as many facilities are licensed and regulated by Agreement States than are licensed by NRC. Agreement States are not required to adopt the reporting requirements in 10 CFR 20.2206. As a result, Agreement State licensees are not required to submit occupational dose reports to the NRC. Although some Agreement State licensees voluntarily submit occupational dose reports to NRC, these results are not included in the analyses presented in Sections 3, 5, and 6 of this report. The data are, however, included in Appendix A for completeness. In addition, this report does not include compilations of

[4] The number of workers with measurable dose includes any individual with a total effective dose equivalent greater than zero rem. Workers reported with zero dose, or no detectable dose, are included in the number of workers with no measurable exposure.

[5] Agreement States are States that have entered into formal agreement with NRC under which the State regulates the use of certain byproduct, source, and small quantities of special nuclear material in that State. In 2009, there were 37 Agreement States.

nonoccupational exposure, such as exposure received by medical patients from X-rays, fluoroscopy, or accelerators.

The average dose per individual, as well as the dose distributions shown for groups of licensees, also can be affected by the multiple reporting of individuals who were monitored by two or more licensees during the year. Licensees are only required to report the doses received by individuals at their licensed facilities. A dose distribution for a single licensee does not consider that some of the individuals may have received doses at other facilities. When the data are summed to determine the total number of individuals monitored by a group of licensees, individuals may be counted more than once if they have worked at more than one facility during the calendar year. These occurrences can also affect the distribution of doses because individuals may be counted multiple times in the lower dose ranges rather than one time in the higher range corresponding to the actual accumulated dose for the year (the sum of an individual's dose accrued at all facilities). This source of error has the greatest potential impact on the data reported by commercial nuclear power reactors since they employ many short-term individuals. Section 5 contains an analysis that corrects for transient individuals being counted more than once.

When examining the annual statistical data it is important to note that all of the personnel included in the report may not have been monitored throughout the entire year. Many licensees, such as radiography firms and commercial nuclear power reactors, may monitor numerous individuals for periods much less than a year. The average doses calculated from these data, therefore, are less than the average dose that an individual involved in that activity would receive for the full year.

Considerable attention should be given when referencing the collective totals presented in this report. The differences between the totals presented for all licensees that reported versus only those licensees that are required to report should be noted. See Section 1.1 for the categories of licensees that are required to report to REIRS. A number of licensees are not required to report to REIRS, but voluntarily report for convenient recordkeeping or because they have reported in the past and have decided to continue to do so. Some Agreement State licensees report to REIRS in accordance with their state requirements. These licensees are listed in Appendix A, Tables A2 and A3.

Likewise, one should distinguish between the doses attributed to the pressurized water reactors (PWRs) and the doses attributed to boiling water reactors (BWRs). The totals may be inclusive or exclusive of those licensees that were in commercial operation for less than one full year. These parameters vary throughout the tables and appendices of this report. The apparent discrepancies among the various tables are a necessary side effect of this endeavor.

The data contained in this report are subject to change because licensees may submit corrections or additions to data for previous years. For the 2009 report, additional 2006 data was received from a manufacturing and distribution licensee.

All dose equivalent values in this report are given in units of rem in accordance with the general provisions for records in 10 CFR 20.2101(a). In order to convert rem into the International System of Units (SI) unit of sieverts (Sv), readers should divide the value in rem by 100. Therefore, 1 rem = 0.01 Sv. In order to convert rem into millisieverts (mSv), readers should multiply the value in rem by 10.

Section 3

ANNUAL PERSONNEL MONITORING REPORTS – 10 CFR 20.2206

3.1 DEFINITION OF TERMS AND METHODOLOGIES

3.1.1 Number of Licensees Reporting

The number of licensees refers to the NRC licenses issued to use radioactive material for certain activities that would place the licensees in one of the seven[6] categories that are required to report pursuant to 10 CFR 20.2206. The third column in Table 3.1 shows the number of licensees that have filed such reports during the last eleven years. All commercial nuclear power reactors, fuel processors and fabricators, and independent spent fuel storage installations are required to report occupational exposure to NRC, whether or not they are in an Agreement State. Agreement State licensees, in the industrial radiography and manufacturing and distribution categories, are not required to submit exposure reports to NRC. However, some Agreement State licensees in these two categories voluntarily submit exposure reports to NRC (see Section 3.3.7). Data from licensees that voluntarily submitted exposure reports to NRC are presented in Appendix A, Tables A2 and A3.

3.1.2 Number of Monitored Individuals

The number of monitored individuals refers to the total number of individuals that NRC licensees reported as being monitored for exposure to external and internal radiation during the year. This number includes all individuals for whom monitoring is required, under 10 CFR 20.1502. This number also includes visitors, service representatives, contract individuals, clerical individuals, and any other individuals for whom the licensee determines that monitoring devices should be provided, although monitoring was not required.

The total number of individuals was determined from the number of unique personal identification numbers submitted per licensee. Uniqueness is defined by the combination of identification number and identification type [Ref. 12].

3.1.3 Number of Individuals with Measurable Dose

The number of individuals with measurable dose includes any individual with a TEDE greater than zero rem.

3.1.4 Collective Dose

The concept of collective dose is used in this report to denote the summation of the TEDE received by all monitored individuals and is reported in units of person-rem. Since 10 CFR 20.2206 requires that the TEDE be reported, the collective dose is calculated by summing the TEDE for all monitored individuals. The phrase "collective dose" is used throughout this report to mean the collective TEDE, unless otherwise specified.

Prior to the implementation of the revised dose reporting requirements of 10 CFR 20.2206 in 1994, the collective dose, in some cases,

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[6] These categories are commercial nuclear power reactors; industrial radiographers; fuel processors (including uranium enrichment facilities), fabricators, and reprocessors; manufacturing and distribution of byproduct material; independent spent fuel storage installations; facilities for land disposal of low-level waste; and geologic repositories for high-level waste. There are currently no NRC licensees involved in low-level waste disposal or geologic repositories for high-level waste.

TABLE 3.1
Average Annual Exposure Data for Certain Categories of NRC Licensees
1999–2009

NRC License Category * and Program code	Calendar Year	Number of Licensees Reporting	Number of Monitored Individuals	Number of Individuals with Measurable TEDE	Collective TEDE (person-rem)	Average TEDE (rem)	Average Measurable TEDE per Individual (rem)
Industrial Radiography 03310 03320	1999	131	3,557	2,689	1,548.110	0.44	0.58
	2000	128	3,157	2,454	1,525.143	0.48	0.62
	2001	123	3,560	3,040	2,106.213	0.59	0.69
	2002	100	3,420	2,842	1,729.222	0.51	0.61
	2003	118	3,115	2,651	1,584.249	0.51	0.60
	2004	113	3,568	3,014	1,603.591	0.45	0.53
	2005	90	3,009	2,623	1,504.575	0.50	0.57
	2006	78	2,388	1,981	1,109.347	0.46	0.56
	2007	74	2,607	2,224	1,315.171	0.50	0.59
	2008	61	2,967	2,587	1,460.757	0.49	0.56
	2009	63	2,637	2,290	1,314.001	0.50	0.57
Manufacturing and Distribution 02500 03211 03212 03214	1999	40	2,205	836	418.993	0.19	0.50
	2000	39	2,460	1,187	415.402	0.17	0.35
	2001	35	1,705	1,184	344.743	0.20	0.29
	2002	29	1,437	1,052	328.092	0.23	0.31
	2003	33	2,372	1,796	436.660	0.18	0.24
	2004	28	2,539	1,787	347.258	0.14	0.19
	2005	23	2,566	1,557	388.547	0.15	0.25
	2006	22	1,256	795	273.028	0.22	0.34
	2007	23	2,106	1,463	291.326	0.14	0.20
	2008	18	1,934	1,341	222.123	0.11	0.17
	2009	16	1,933	1,386	179.222	0.09	0.13
Independent Spent Fuel Storage 23100 23200	1999	2	86	33	5.172	0.06	0.16
	2000	2	146	83	5.571	0.04	0.07
	2001	2	154	107	13.088	0.08	0.12
	2002	2	75	67	6.013	0.08	0.09
	2003	2	55	46	2.791	0.05	0.06
	2004	1	37	27	1.257	0.03	0.05
	2005	2	59	30	0.769	0.01	0.03
	2006	2	59	26	2.108	0.04	0.08
	2007	2	57	26	1.697	0.03	0.07
	2008	2	53	21	1.248	0.02	0.06
	2009	2	72	34	1.465	0.02	0.04
Fuel Cycle Licenses - Fabrication Processing and Uranium Enrich. 21200 21210	1999	10	9,773	3,935	1,020.333	0.10	0.26
	2000	9	9,336	4,649	1,339.398	0.14	0.29
	2001	9	8,145	3,980	1,162.262	0.14	0.29
	2002	8	7,937	3,886	660.899	0.08	0.17
	2003	8	7,738	3,633	556.297	0.07	0.15
	2004	8	7,562	3,813	513.929	0.07	0.13
	2005	9	7,695	3,370	496.502	0.06	0.15
	2006	9	7,417	3,415	521.525	0.07	0.15
	2007	9	7,536	3,225	428.717	0.06	0.13
	2008	9	7,184	2,770	420.898	0.06	0.15
	2009	10	8,101	2,965	372.666	0.05	0.13
Commercial Light Water Reactors (LWRs) ** 4111	1999	104	150,287	75,420	13,665.711	0.09	0.18
	2000	104	147,901	74,108	12,651.682	0.09	0.17
	2001	104	140,776	67,570	11,108.552	0.08	0.16
	2002	104	149,512	73,242	12,126.190	0.08	0.17
	2003	104	152,702	74,813	11,955.570	0.08	0.16
	2004	104	150,322	69,849	10,367.897	0.07	0.15
	2005	104	160,701	78,127	11,455.807	0.07	0.15
	2006	104	164,823	80,265	11,021.186	0.07	0.14
	2007	104	164,081	79,530	10,120.013	0.06	0.13
	2008	104	169,324	79,450	9,195.940	0.05	0.12
	2009	104	176,381	81,754	10,024.804	0.06	0.12
Grand Totals and Averages	1999	287	165,908	82,913	16,658.319	0.10	0.20
	2000	282	163,000	82,481	15,937.196	0.10	0.19
	2001	273	154,340	75,881	14,734.858	0.10	0.19
	2002	243	162,381	81,089	14,850.416	0.09	0.18
	2003	265	165,982	82,939	14,535.567	0.09	0.18
	2004	254	164,028	78,490	12,833.932	0.08	0.16
	2005	228	174,030	85,707	13,846.200	0.08	0.16
	2006	215	175,943	86,482	12,927.194	0.07	0.15
	2007	212	176,387	86,468	12,156.924	0.07	0.14
	2008	194	181,462	86,169	11,300.966	0.06	0.13
	2009	195	189,124	88,429	11,892.158	0.06	0.13

* These categories consist only of NRC licensees. Agreement State licensed organizations are not required to report occupational exposure data to NRC.

** This category includes all LWRs in commercial operation for a full year for each of the years indicated. Reactor data have not been corrected to account for the multiple counting of transient reactor workers (see Section 5).

was calculated from the dose distributions by multiplying the number of individuals reported in each of the dose ranges by the midpoint of the corresponding dose range, and then summing the products. This assumed that the midpoint of the range was equal to the arithmetic mean of the individual doses in the range. Experience has shown that the actual mean dose of individuals reported in each dose range is less than the midpoint of the range. For this reason, the resultant calculated collective doses shown in this report for these licensees may be approximately 10% higher than the sum of the actual individual doses. Care should be taken when comparing the actual collective dose calculated for 1994 to 2009 with the collective dose for years prior to 1994 because of this change in methodology.

In addition, prior to 1994, doses only included the external whole-body dose with no internal dose contribution. Although the contribution of internal dose to the TEDE is minimal for most licensees, it should be considered when comparing collective doses for 1994 and later with the collective dose for years prior to 1994. One noted exception is for fuel fabrication licensees where the committed effective dose equivalent (CEDE), in some cases, contributes the majority of the TEDE (see Section 3.3.5).

3.1.5 Average Individual Dose

The average individual dose is obtained by dividing the collective dose by the total number of monitored individuals. This figure is usually less than the average measurable dose because it includes the number of those individuals who received zero or less than measurable doses.

3.1.6 Average Measurable Dose

The average measurable dose is obtained by dividing the collective TEDE by the number of individuals with a measurable dose. This is the average most commonly used in this and other reports when examining trends and comparing doses received by individuals in various segments of the nuclear industry.

3.1.7 Collective TEDE Distribution by Dose Range

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2008 report, *Sources and Effects of Ionizing Radiation, United Nations Scientific Committee on the Effects of Atomic Radiation UNSCEAR 2008 Report to the General Assembly, Volume I* [Ref. 2], recommends the calculation of a parameter, SR_E (collective dose distribution ratio), to aid in the examination of the distribution of radiation exposure among individuals. SR is defined as the ratio of the annual collective dose incurred by individuals whose annual doses exceed a certain dose level to the total annual collective dose. UNSCEAR uses a subscript to denote the specific dose level in millisieverts. Therefore, SR_{15} is the notation for the collective dose for individuals who received more than 15 mSv (1.5 rem) in the year, divided by the total annual collective dose. The UNSCEAR 2008 report notes that the 1.5 rem dose level may not be useful where doses are consistently lower than this level, and UNSCEAR recommends that research organizations report SR values lower than 1.5 rem where appropriate. For this reason, NRC has adopted the policy of calculating and tracking the collective TEDE distribution by dose range at dose levels of 0.10, 0.25, 0.50, 1.0, and 2.0 rem.

The collective TEDE distribution by dose range values in this report was calculated by summing the TEDE to each individual who received a TEDE greater than or equal to the specified dose range divided by the total collective TEDE. In addition, the distribution is presented as a percentage rather than as a decimal fraction.

Figures 3.2, 3.3, 3.5, 3.6, 3.8, 3.10, and 3.11 show the collective TEDE distribution by dose range calculated in terms of percentage of the collective dose delivered above the specified dose levels for each of the categories of NRC licensees. Two properties of these graphs help to further reveal the nature of the distribution of dose and dose trends at NRC licensees. The first is that the percentage of dose in the higher dose ranges (i.e., above 0.50 rem) should be relatively small. This would indicate that fewer individuals are exposed at these higher levels of individual risk. The second property is the ability to track the shift in dose over time. For a given dose value, a reduction in the percentage from one year to the next indicates that less dose is being received by individuals above this value. Therefore, these graphs can be useful in qualifying the dose received in a given year and the trends in doses from year to year.

3.2 ANNUAL TEDE DOSE DISTRIBUTIONS

Table 3.2 provides a statistical compilation of the occupational dose reports by categories of licensees (see Section 3.3 for a description of each licensee category). The dose distributions are generated by summing the TEDE for each individual and counting the number of individuals in each dose range. In nearly every licensee category, a large number of individuals receive doses that are less than measurable, and very few doses exceed 4 rem. Ninety-two percent of the reported individuals with measurable doses (shown in Table 3.2) were monitored by commercial nuclear power facilities in 2009, where they received 84% of the total collective dose.

3.3 SUMMARY OF OCCUPATIONAL DOSE DATA BY LICENSE CATEGORY

3.3.1 Industrial Radiography Licenses, Fixed Locations and Temporary Job Sites

Industrial radiography licenses are issued to allow the use of sealed radioactive materials, usually in exposure devices or “cameras,” that primarily emit gamma rays for nondestructive testing of pipeline weld joints, steel structures, boilers, aircraft and ship parts, and other high-stress alloy parts. Some firms are licensed to conduct such activities in one location, usually in a permanent facility designed and shielded for radiography; others perform radiography at temporary job sites in the field. The radioisotopes most commonly used are cobalt-60 and iridium-192. As shown in Table 3.1, annual reports were received for 63 radiography licensees in 2009. Table 3.3 summarizes the reported data for the two types of industrial radiography licenses for 2009 and for the previous 2 years for comparison purposes.

The average measurable dose for individuals performing radiography at a fixed location ranged from 4% to 7% of the average measurable dose of individuals at temporary job sites over the past 3 years. This is because it is more difficult for individuals to avoid exposure to radiation at temporary job sites in the field, where conditions are not optimal and may

TABLE 3.2
Distribution of Annual Collective TEDE by License Category
2009

License Category (Number of sites reporting)	Number of Individuals with TEDE in the Ranges (rem) *													Total Number Monitored	Number with Meas. Dose	Total Collective Dose (TEDE) (person-rem)
	No meas.	Meas. <0.1	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1.00-2.00	2.00-3.00	3.00-4.00	4.00-5.00	5.00-6.00	6.00-12.00	>12			
INDUSTRIAL RADIOGRAPHY																
Fixed Locations (2)	35	43	2	–	–	–	–	–	–	–	–	–	–	80	45	1.805
Temporary Job Sites (61)	312	558	349	412	288	197	339	77	24	1	–	–	–	2,557	2,245	1,312.196
Total (63)	**347**	**601**	**351**	**412**	**288**	**197**	**339**	**77**	**24**	**1**	**–**	**–**	**–**	**2,637**	**2,290**	**1,314.001**
MANUFACTURING AND DISTRIBUTION																
Type "A" Broad (3)	213	278	116	71	36	8	16	–	–	–	–	–	–	738	525	103.094
Type "B" Broad and Other (3)	44	34	5	4	–	1	–	–	–	–	–	–	–	88	44	3.785
Nuclear Pharmacies (10)	290	643	113	41	9	3	3	4	1	–	–	–	–	1,107	817	72.343
Total (16)	**547**	**955**	**234**	**116**	**45**	**12**	**19**	**4**	**1**	**–**	**–**	**–**	**–**	**1,933**	**1,386**	**179.222**
INDEPENDENT SPENT FUEL STORAGE																
Total (2)	**38**	**30**	**3**	**1**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**72**	**34**	**1.465**
FUEL CYCLE **																
Total (10)	**5,136**	**1,897**	**584**	**311**	**128**	**38**	**7**	**–**	**–**	**–**	**–**	**–**	**–**	**8,101**	**2,965**	**372.666**
COMMERCIAL POWER REACTORS ***																
Boiling Water (35)	28,756	21,558	7,828	4,652	1,390	504	275	–	–	–	–	–	–	64,963	36,207	5,282.869
Pressurized Water (69)	65,871	31,112	9,589	3,700	771	237	138	–	–	–	–	–	–	111,418	45,547	4,741.935
Total (104)	**94,627**	**52,670**	**17,417**	**8,352**	**2,161**	**741**	**413**	**–**	**–**	**–**	**–**	**–**	**–**	**176,381**	**81,754**	**10,024.804**
GRAND TOTALS	**100,695**	**56,153**	**18,589**	**9,192**	**2,622**	**988**	**778**	**81**	**25**	**1**	**–**	**–**	**–**	**189,124**	**88,429**	**11,892.158**

* Dose values exactly equal to the values separating ranges are reported in the next higher range.
** This category includes fabrication, processing, and uranium enrichment plants (see Section 3.3.5).
*** This category includes all reactors in commercial operation for a full year during 2009. Although Brown's Ferry 1 was placed on administrative hold in 1985, it remains in the count of operating reactors and has resumed operation as of June, 2007. These values have not been adjusted for the multiple counting of transient reactor workers (see Section 5).

TABLE 3.3
Annual Exposure Information for Industrial Radiographers
2007-2009

Year	Type of License	Number of Licensees	Number of Monitored Individuals	Individuals with Measurable Dose	Collective Dose (person-rem)	Average Measurable Dose (rem)
2007	Fixed Location	5	59	20	0.623	0.03
	Temporary Job Sites	69	2,548	2,204	1,314.548	0.60
	Total	**74**	**2,607**	**2,224**	**1,315.171**	**0.59**
2008	Fixed Location	3	61	26	0.509	0.02
	Temporary Job Sites	58	2,906	2,561	1,460.248	0.57
	Total	**61**	**2,967**	**2,587**	**1,460.757**	**0.56**
2009	Fixed Location	2	80	45	1.805	0.04
	Temporary Job Sites	61	2,557	2,245	1,312.196	0.58
	Total	**63**	**2,637**	**2,290**	**1,314.001**	**0.57**

change daily. To view the contribution that each radiography licensee made to the total collective dose, see Appendix A which presents a summary of the information reported by each of these licensees in 2009.

High exposures in radiography can be directly attributable to the type and location of the radiography field work. For example, locations such as oil drilling platforms and aerial tanks offer the radiographer little available shielding. In these situations, there may not be an opportunity to use distance as a means of reducing exposure. Although these licensed activities usually result in average measurable doses that are higher than those received by other licensees, they involve a relatively small number of exposed individuals.

Figure 3.1 shows the number of individuals with measurable dose per licensee, the total collective dose per licensee, and the average measurable dose per individual for both types of industrial radiography licensees from 1994 through 2009. From 2008 to 2009, there was a 14% decrease in the number of individuals with measurable TEDE and a 13% decrease in the collective TEDE.

Figures 3.2 and 3.3 show the collective dose distribution by dose range (see Section 3.1.7) for fixed location and temporary job site radiography licensees. These graphs demonstrate that temporary job site licensees consistently have individuals receiving doses in the higher dose ranges and routinely have 20% to 25% of the collective dose delivered to individuals above 2 rem. It should be noted that the 2006 distribution for fixed location radiographers in Figure 3.2 has been adjusted in this report due to a change in status for a radiographer who was initially identified as a fixed location radiographer and who was later determined to be a temporary job site radiographer.

3.3.2 Manufacturing and Distribution Licenses, Type "A" Broad, Type "B" Broad, Other, and Nuclear Pharmacies

Manufacturing and distribution (M&D) licenses are issued to allow the manufacture and distribution of radionuclides in various forms for

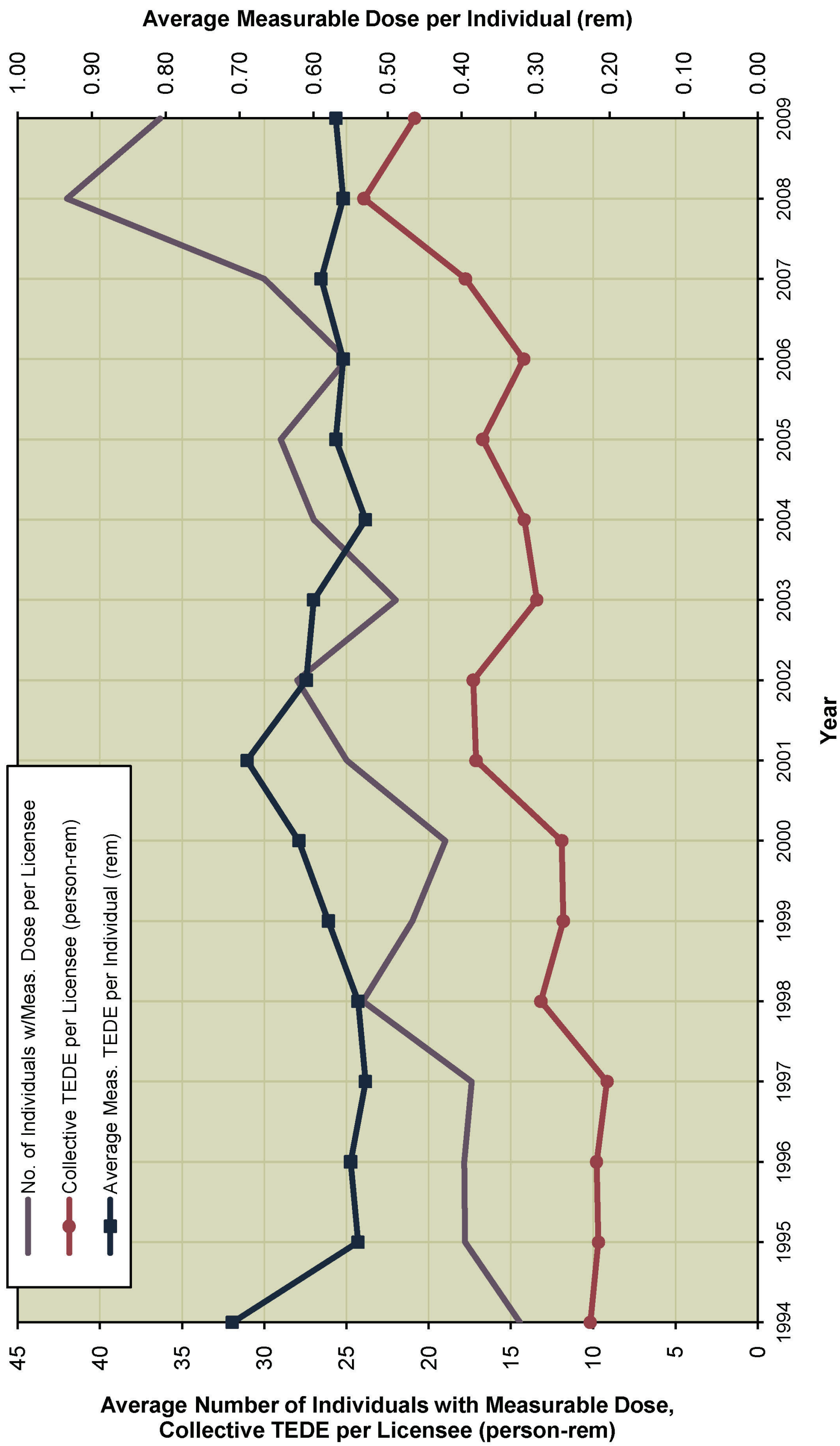

FIGURE 3.1. Average Annual Values for Industrial Radiography Licensees
1994–2009

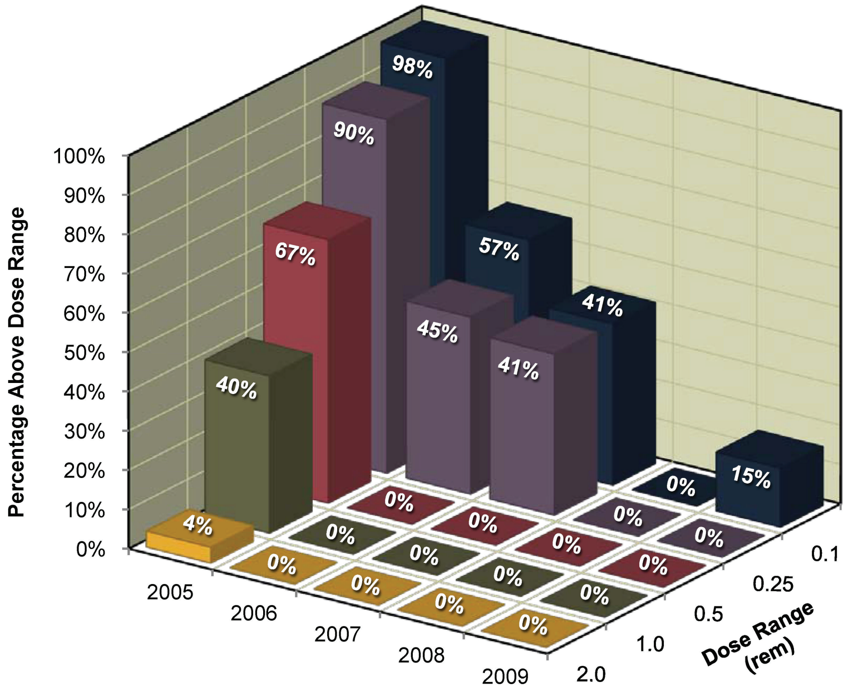

FIGURE 3.2. Collective TEDE Distribution by Dose Range
Industrial Radiographer—Fixed Location Licensees
2005–2009

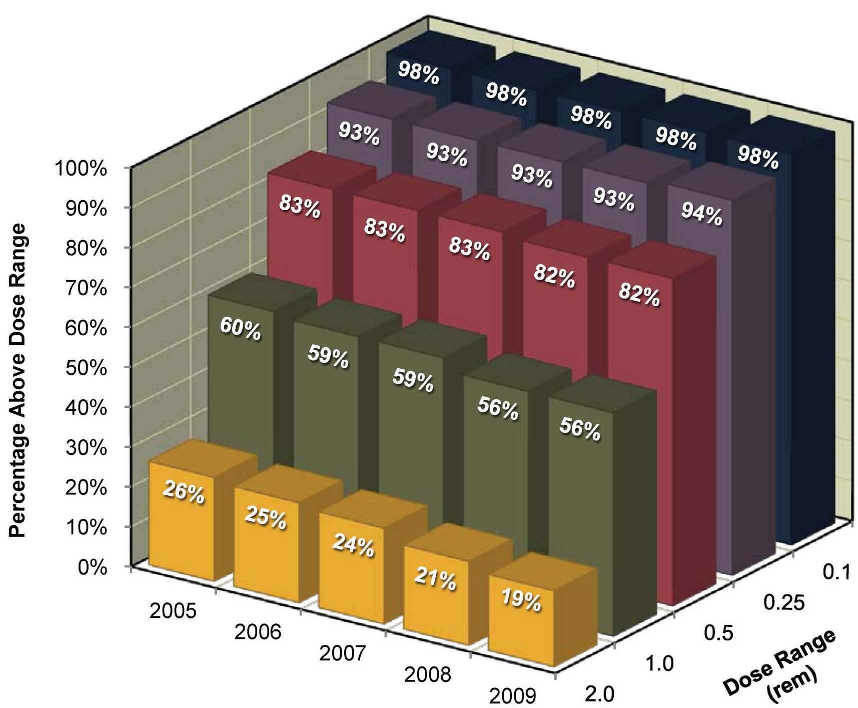

FIGURE 3.3. Collective TEDE Distribution by Dose Range
Industrial Radiographer—Temporary Job Site Licensees
2005–2009

a number of diverse purposes. The products are usually distributed to organizations/ companies specifically licensed by NRC or an Agreement State. Type “A” Broad licenses are issued to larger organizations that may use many different radionuclides in many different ways and that have a comprehensive radiation protection program. Some Type “A” Broad license firms are medical suppliers that process, package, or distribute such products as diagnostic test kits, radioactive surgical implants, and tagged radiochemicals for use in medical research, diagnosis, and therapy. Type “B” Broad and Other licenses are usually issued to smaller firms requiring a more restrictive license. These firms are suppliers of industrial radionuclides and are involved in the processing, encapsulation, packaging, and distribution of the radionuclides that they have purchased in bulk quantities from production reactors and cyclotrons. Major products include gamma radiography sources, cobalt irradiation sources, well-logging sources, sealed sources for gauges and smoke detectors, and radiochemicals for nonmedical research. Nuclear pharmacies are involved in the compounding and dispensing of radioactive materials for use in nuclear medicine procedures.

Table 3.4 presents the annual data that were reported by the three types of licensees for 2009 and the previous 2 years. Looking at the information shown separately for the Type “A” Broad licensees, it can be seen that the average measurable dose generally remains higher for the Type “A” Broad licensees. Only three Type “A” Broad licensees reported in 2009.

Figure 3.4 shows the number of individuals with measurable dose per licensee, the total collective dose per licensee, and the average measurable dose per individual for Type “A” Broad, Type “B” Broad, Other, and Nuclear Pharmacy licensees. The number of individuals with measurable dose per licensee increased by 16% because less nuclear pharmacies submitted 2009 annual data, while the collective TEDE per licensee decreased slightly in 2009. The average measurable dose decreased by 24% from 0.17 rem to 0.13 rem. The figures for Type “A” Broad licensees are primarily attributed to Mallinckrodt, Inc. and Covidien, which accounted for 88% of

TABLE 3.4

Annual Exposure Information for Manufacturing and Distribution 2007–2009

Year	Type of License	Number of Licensees	Number of Monitored Individuals	Individuals with Measurable Dose	Collective Dose (person-rem)	Average Measurable Dose (rem)
2007	M & D - Type "A" Broad	2	504	352	113.354	0.32
	M & D - Type "B" Broad and Other	3	83	58	5.447	0.09
	M & D - Nuclear Pharmacies	18	1,519	1,053	172.525	0.16
	Total	**23**	**2,106**	**1,463**	**291.326**	**0.20**
2008	M & D - Type "A" Broad	2	465	312	95.790	0.31
	M & D - Type "B" Broad and Other	4	205	114	8.421	0.07
	M & D - Nuclear Pharmacies	12	1,264	915	117.912	0.13
	Total	**18**	**1,934**	**1,341**	**222.123**	**0.17**
2009	M & D - Type "A" Broad	3	738	525	103.094	0.20
	M & D - Type "B" Broad and Other	3	88	44	3.785	0.09
	M & D - Nuclear Pharmacies	10	1,107	817	72.343	0.09
	Total	**16**	**1,933**	**1,386**	**179.222**	**0.13**

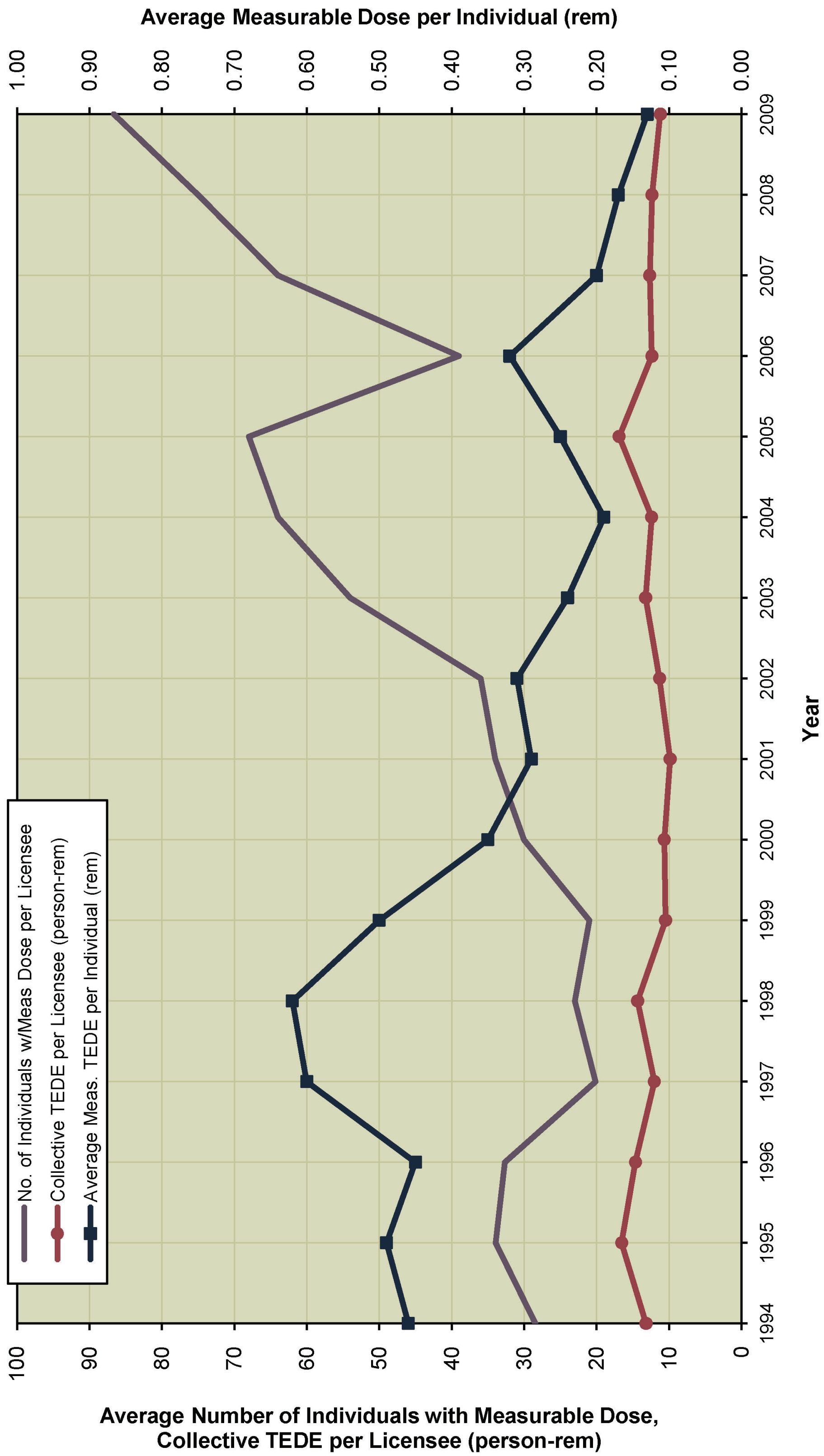

FIGURE 3.4. Average Annual Values for Manufacturing and Distribution Licensees
1994–2009

the collective dose in 2009 for this licensee category.

Figure 3.5 shows the collective dose distribution by dose range (see Section 3.1.8) for Type "A" Broad licensees and Figure 3.6 shows the collective dose distribution by dose range for Type "B" Broad, Other, and Nuclear Pharmacy licensees. These graphs show that, for 2005 through 2009, Type "B" Broad, Other, and Nuclear Pharmacy manufacturing and distribution licensees have more individuals receiving dose in the higher dose ranges.

For Type "B" Broad, Other, and Nuclear Pharmacy licensees, the decrease in values for 2005 through 2009 has been due to one licensee (IBA Molecular North America, Inc.) decreasing its collective TEDE by 45% from the 2007 value. Appendix A lists the contribution that each of these licensees made toward the total values of the number of individuals monitored, number of individuals, and collective dose for 2009.

3.3.3 Low-Level Waste Disposal Licenses

Low-level waste disposal licenses are issued to allow the receipt, possession, and disposal of low-level radioactive wastes at a land disposal facility. The licensee has the appropriate facilities to receive wastes from such places as hospitals and laboratories, store them for a short time, and dispose of them in a properly prepared burial ground. The licensees in this category are located in and licensed by Agreement States, which have primary regulatory authority over the licensees' activities. Since 1999, all licensees that have conducted these activities have been located in Agreement States; therefore, there are no NRC low-level waste licensees reporting radiation exposure data to REIRS.

3.3.4 Independent Spent Fuel Storage Installation Licenses

Independent spent fuel storage installation (ISFSI) licenses are issued to allow the possession of commercial nuclear power reactor spent fuel and other associated radioactive materials for the purpose of storage. The spent fuel, which has undergone at least one year of decay since being used as a source of energy in a commercial nuclear power reactor, is provided interim storage, protection, and safeguarding for a limited time, pending its final disposal.

The majority of ISFSI facilities are located onsite at commercial nuclear power reactors. Since the doses from these ISFSI facilities are usually included with the doses reported by the commercial nuclear power reactors, the doses from these ISFSI facilities are not reported separately to NRC. The doses from the two ISFSI licensees that are not associated with commercial nuclear power reactors are reported here for 2009. One is the GE Morris facility located in Illinois, and the second is the Trojan ISFSI. The Trojan commercial nuclear power reactor is no longer in commercial operation and has been decommissioned. However, the ISFSI facility at Trojan remains in operation and the occupational dose information is reported to NRC under the ISFSI license. Appendix A summarizes the occupational dose information reported by these licensees.

Figure 3.7 shows the number of individuals with measurable dose per licensee, the total collective dose per licensee, and the average measurable dose per individual for ISFSI facilities. The large increase in the collective dose per licensee and number of individuals

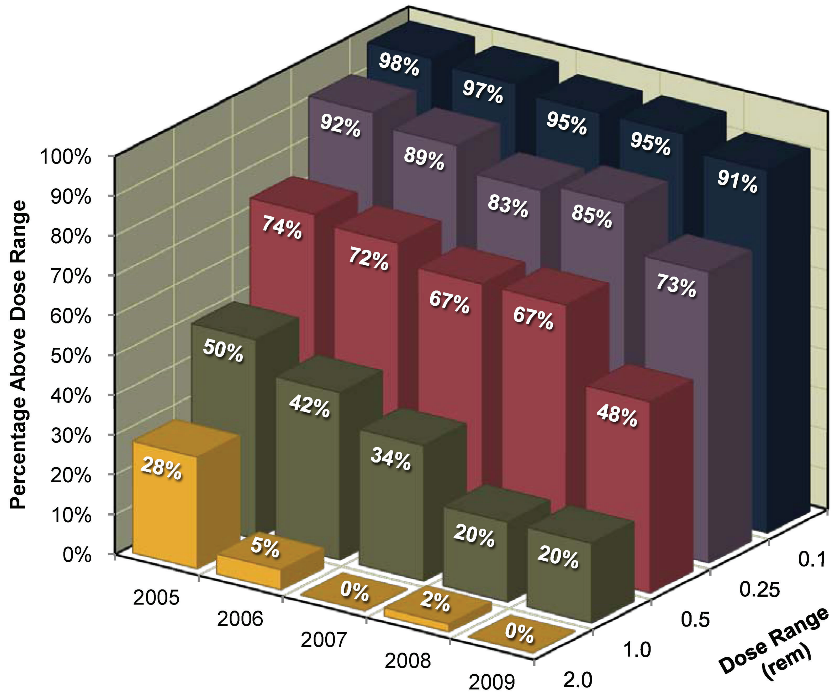

FIGURE 3.5. Collective TEDE Distribution by Dose Range
Type “A” Broad Manufacturing and Distribution Licensees
2005–2009

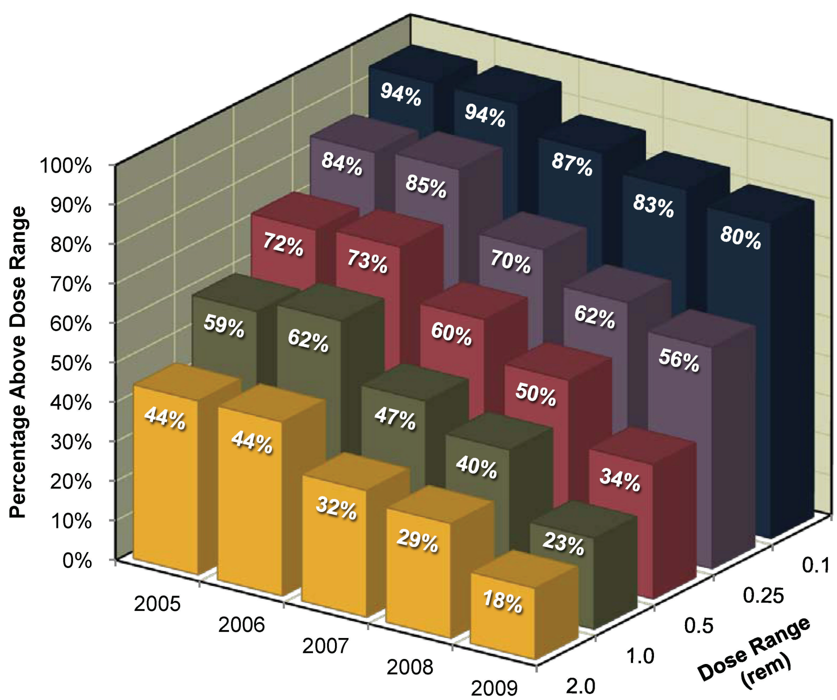

FIGURE 3.6. Collective TEDE Distribution by Dose Range
Type "B" Broad, Other, and Nuclear Pharmacy Licensees
2005–2009

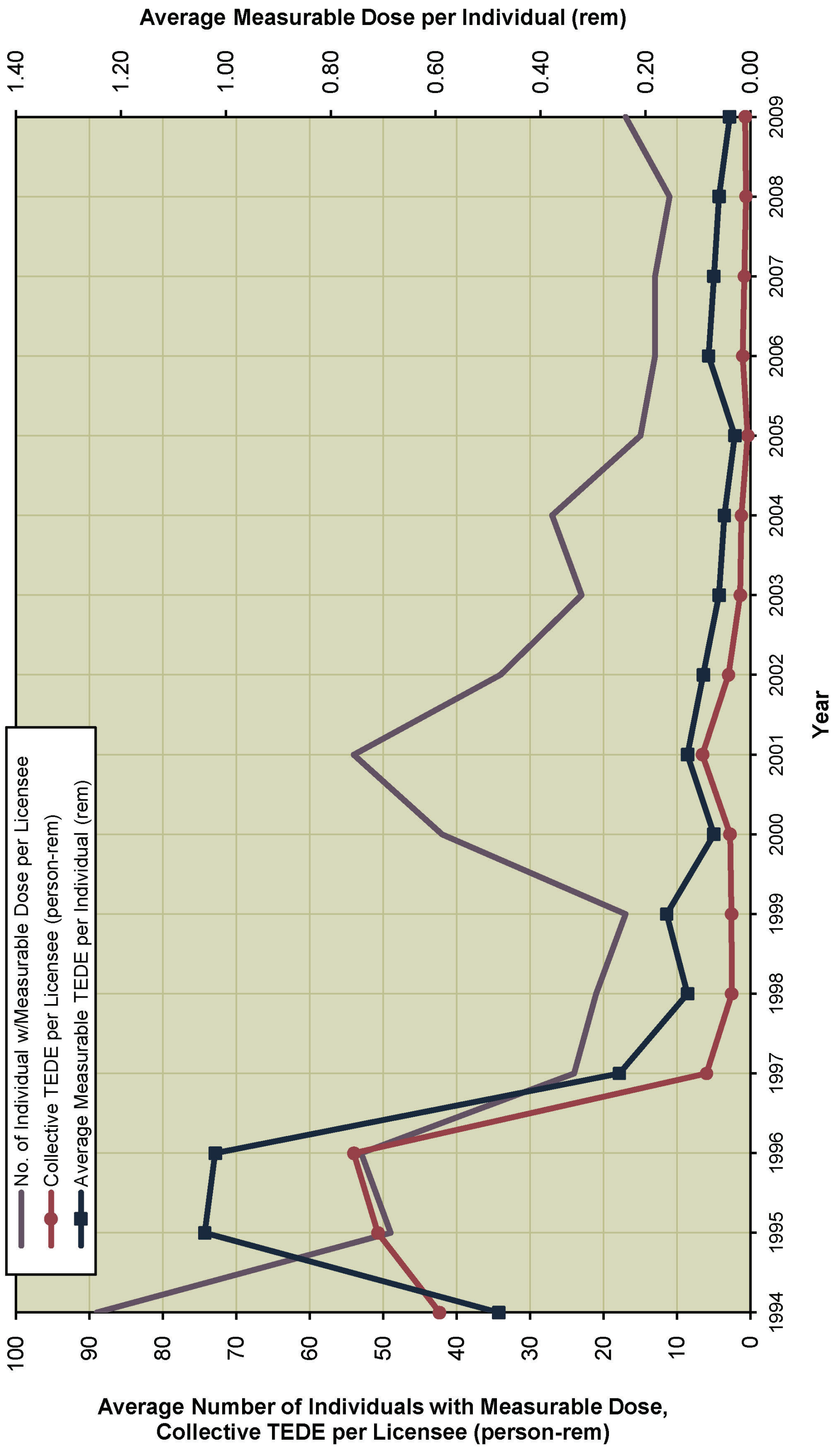

FIGURE 3.7. Average Annual Values for Independent Spent Fuel Storage Installations 1994–2009

per licensee in 1994 was mainly because only one licensee reported separately for 1994 through 1998, rather than the two licensees that reported in prior years. The number of individuals with measurable dose and collective TEDE per licensee both increased from 2008 to 2009. Figure 3.8 shows the collective dose distribution by dose range (see Section 3.1.7) for ISFSI licensees from 2005 to 2009.

3.3.5 Fuel Cycle Licenses

Fuel cycle licenses are issued to allow the processing, enrichment, and fabrication of reactor fuels. In most uranium facilities where light water reactor (LWR) fuels are fabricated, enriched uranium hexafluoride is converted to solid uranium dioxide pellets and inserted into zirconium alloy tubes. The tubes are fabricated into fuel assemblies that are shipped to commercial nuclear power reactors. Some facilities also perform chemical operations to recover the uranium from scrap and other off-specification materials prior to disposal of these materials. In 1997, the regulatory oversight for the uranium enrichment facilities at Portsmouth, Ohio and Paducah, Kentucky was transferred from DOE to NRC and was added to the NRC's fuel cycle license category. In 2005, a third uranium enrichment facility, the United States Enrichment Corporation (USEC), Inc., was added to this category. In 2009, Louisiana Energy Services (LES) joined this category as the fourth uranium enrichment facility. It should be noted that LES was undergoing construction during 2009 and therefore did not significantly contribute to the collective radiation exposure for this licensee category.

Figure 3.9 shows the number of individuals with measurable dose per licensee, the total

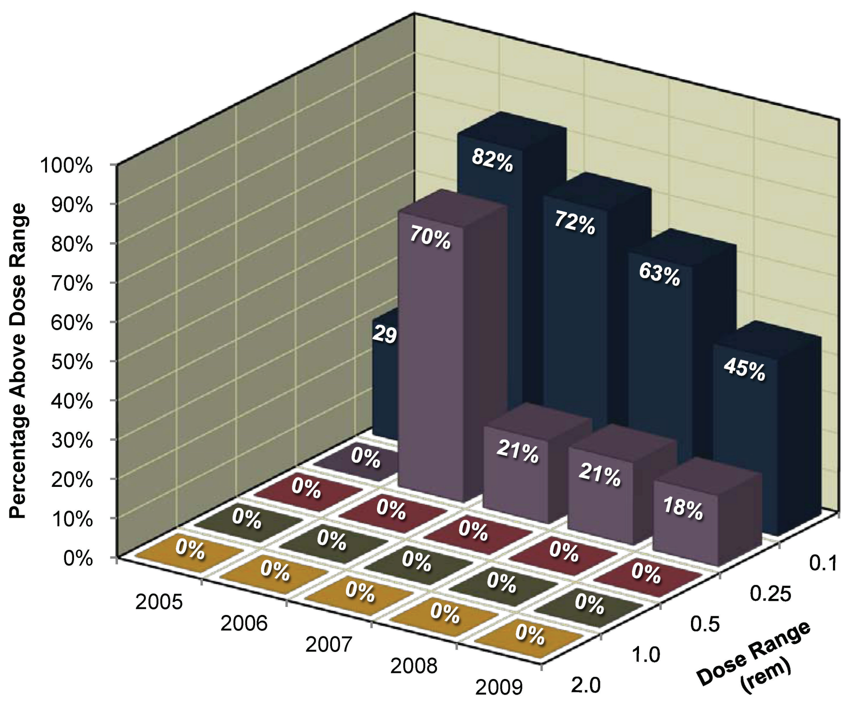

FIGURE 3.8. Collective TEDE Distribution by Dose Range Independent Spent Fuel Storage Installation Licensees 2005–2009

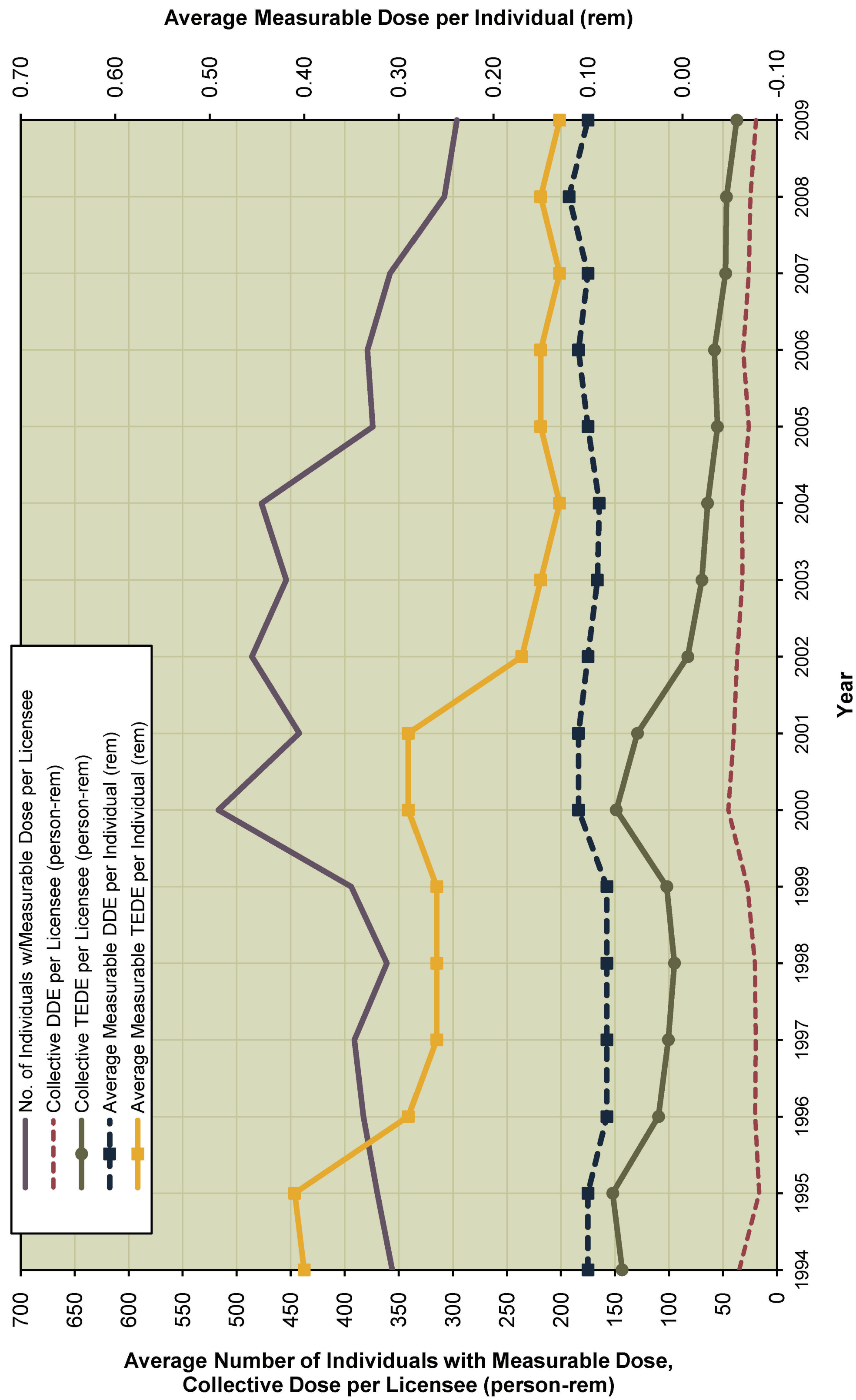

FIGURE 3.9. Average Annual Values for Fuel Cycle Licensees
1994–2009

collective dose per licensee, and the average measurable dose per individual for fuel cycle licensees. In addition to the collective TEDE and average measurable dose, the deep dose equivalent (DDE) collective dose and DDE average measurable dose are also shown since the CEDE is a significant contribution to the TEDE for fuel fabrication facilities.

Figure 3.10 shows the collective dose distribution by dose range (see Section 3.1.7) for fuel cycle licensees from 2005 to 2009. Over the past 3 years, the values have remained fairly constant.

As shown in Table 3.5, the collective TEDE, DDE and CEDE decreased by 11%, 12% and 11% respectively from 2008, even with the additional uranium enrichment facility.

Table 3.5 shows that there were ten licensed fuel cycle (fabrication and enrichment) facilities reporting in 2009. Appendix A lists each of the ten licensees with the number of individuals monitored, the number of individuals receiving measurable external doses, and the collective dose for each licensee.

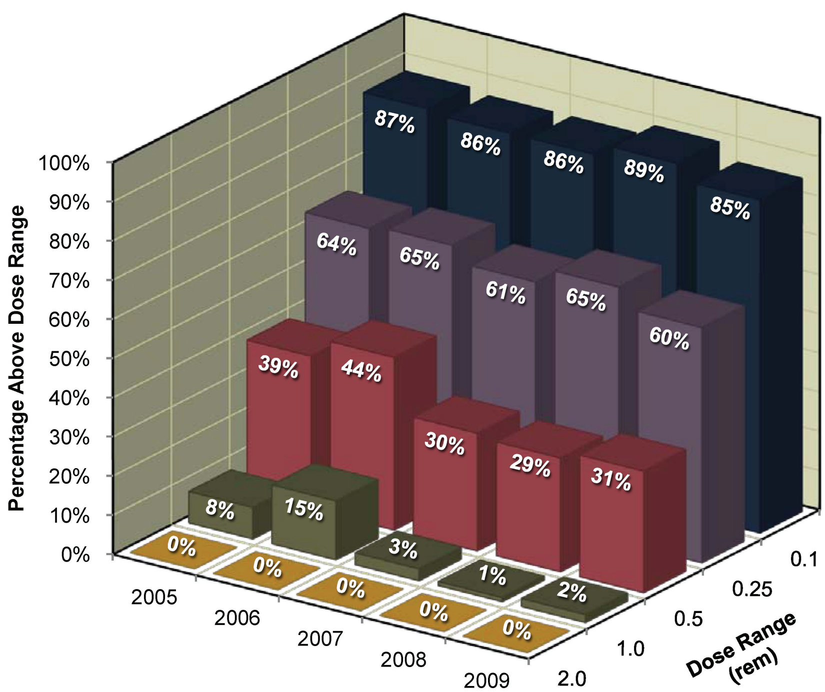

FIGURE 3.10. Collective TEDE Distribution by Dose Range
Fuel Cycle Licensees
2005–2009

TABLE 3.5
Annual Exposure Information for Fuel Cycle Licensees
2007–2009

Year	Type of License	Number of Licensees	Number of Monitored Individuals	Individuals with Meas. TEDE	Collective TEDE (person-rem)	Average Meas. TEDE (rem)	Individuals with Meas. DDE	Collective DDE (person-rem)	Average Meas. DDE (rem)	Individuals with Meas. CEDE	Collective CEDE (person-rem)	Average Meas. CEDE (rem)
2007	Fuel Cycle	9	7,536	3,225	429	0.13	2,254	230	0.10	1,983	199	0.10
2008	Fuel Cycle	9	7,184	2,770	421	0.15	1,849	221	0.12	1,786	200	0.11
2009	Fuel Cycle	10	8,101	2,964	373	0.13	1,994	194	0.10	1,955	179	0.09

3.3.6 Light Water Reactor Licenses

Light water reactor (LWR) licenses are issued to utilities to allow them to use special nuclear material in a reactor that produces heat to generate electricity to be sold to consumers. There are two major types of commercial LWRs in the United States, pressurized water reactors (PWRs) and boiling water reactors (BWRs), each of which uses water as the primary coolant.

Table 3.1 shows the number of licensees, number of monitored individuals, number of individuals with measurable dose, total collective dose, and average dose per individual for reactor facilities that were in commercial operation for at least one full year for each of the years 1999 through 2009. The values do not include reactors that have been permanently shut down or reactors that have not been in commercial operation for one full year. The figures for reactors have not been adjusted for the multiple counting of transient individuals (see Section 5).

The reported dose distribution of individuals monitored at each plant site for the year 2009 is presented in alphabetical order by plant name in Appendix B.

Figure 3.11 shows the collective dose distribution by dose range (see Section 3.1.7) for reactor licensees from 2005 to 2009. The distribution of collective dose has been fairly constant over the past 5 years, with a slight increase noted for 2009 in each dose range. The increase in the percentage of collective dose in each dose range is due to an increase in the number of individuals receiving doses from 1 rem to 2 rem in 2009. Outage hours at power reactors increased by 12% from 2008 to 2009 resulting in more activities performed in higher radiation fields, especially in the areas of refueling and maintenance.

More detailed presentations and analyses of the annual dose information reported by nuclear power facilities can be found in Sections 4 and 5.

3.3.7 Agreement State Licensees Reporting to NRC under Required Program Codes

Through the Agreement State Program, 37 states have signed formal agreements with the NRC, by which those states have assumed regulatory responsibility over certain byproduct, source, and small quantities of special nuclear material. NRC assists states intending to become Agreement States and reviews and approves new Agreements. NRC technical assistance to Agreement States continues after the Agreement

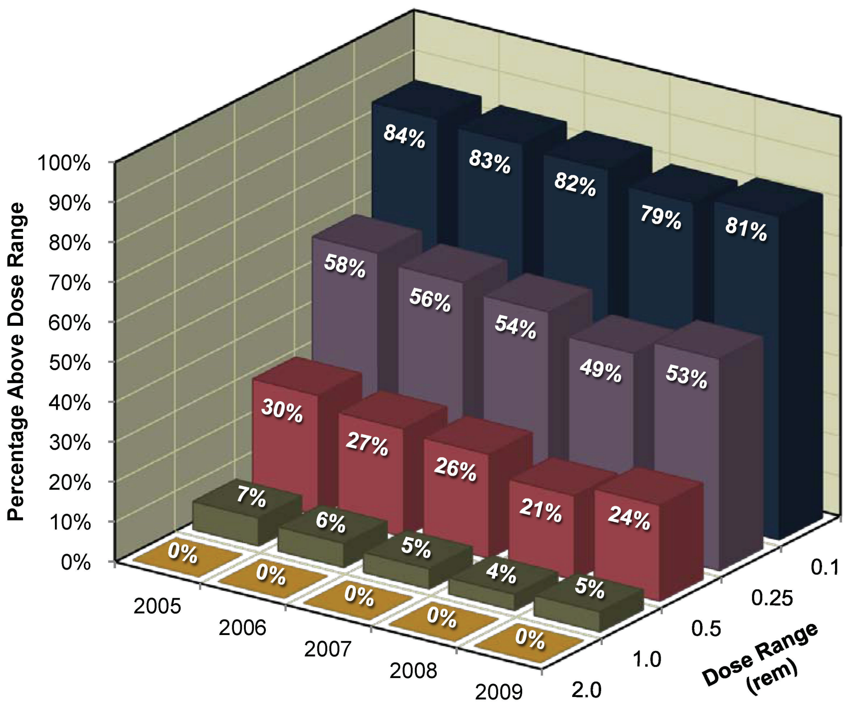

FIGURE 3.11. Collective TEDE Distribution by Dose Range
Reactor Licensees
2005–2009

is signed. NRC and Agreement States jointly develop new regulations, regulatory guidance and other regulatory initiatives.

A number of Agreement State licensees are not required to report to REIRS, but voluntarily report for convenient recordkeeping or because they have reported in the past and have decided to continue to do so – or in accordance with their state requirements. These licensees are listed in Appendix A, Tables A2 and A3, but are not included or analyzed within Section 3.

3.3.8 Other Facilities Reporting to NRC

Appendix A contains additional facilities that reported occupational radiation dose reports to NRC in 2009. These facilities are not among the seven categories of licensees required to report under 10 CFR 20.2206 (see Section 3.1.1) and are not included in the analysis presented in this report. However, these facilities may be of interest to researchers, and since they are not included in any other published reports, they are included here in the interest of completeness. The facility with the largest collective dose for these additional facilities reported under the category of uranium hexafluoride (UF_6) production plants.

3.4 SUMMARY OF INTAKE DATA BY LICENSEE CATEGORY

For each intake recorded, licensees are required to list the radionuclide that was taken into the body, pulmonary clearance class, intake mode, and amount of the intake in microcuries.

An NRC Form 5, or its equivalent paper document or an electronic format, containing this information is required to be completed and submitted to NRC under 10 CFR 20.2206. Tables 3.6 and 3.7 summarize the intake data reported to NRC during 2009. The data are categorized by licensee type and are listed in order of radionuclide and pulmonary clearance class or pulmonary solubility type. Table 3.6 lists the intakes where the mode of intake into the body was recorded as ingestion or other. These other modes of intake can include absorption through the skin and injection through a puncture or wound.

Table 3.7 lists the intakes where the mode of intake was inhalation from ambient airborne radioactive material in the workplace. The

TABLE 3.6
Intake by Licensee Category and Radionuclide Mode of Intake—*Ingestion and Other*
2009

Mode	Licensee Category	Program Code	Radionuclide	Number of Intake Records *	Collective Intake in Microcuries (sci. notation)
Ingestion	Fuel Fabrication	21210	U-234	**1**	**2.85E-04**
	Power Reactors	41111	AM-241	4	3.80E-07
		41111	CM-242	4	5.70E-07
		41111	CM-243	4	9.20E-07
		41111	CO-58	3	1.23E+02
		41111	CO-60	**5**	5.40E+02
		41111	CR-51	1	**1.91E+03**
		41111	CS-134	1	4.00E+01
		41111	FE-55	4	3.43E-02
		41111	FE-59	1	2.97E+02
		41111	MN-54	1	2.04E+02
		41111	NB-95	3	4.40E-02
		41111	NI-63	4	2.80E-03
		41111	PU-238	4	2.80E-07
		41111	PU-239	4	2.80E-07
		41111	PU-241	4	5.04E-05
		41111	ZN-65	1	3.18E+02
		41111	ZR-95	3	2.00E-02
Absorption	Power Reactors	41111	CO-58	1	5.84E-03
		41111	CO-60	1	**7.04E-02**
		41111	MN-54	1	2.81E-04
		41111	NB-95	1	4.72E-03
		41111	ZR-95	1	8.40E-03

NOTE: The data values shown bolded and in boxes represent the highest value in each category.
* An intake event may involve multiple nuclides, and individuals may incur multiple intakes during the year. The number of intake records given here indicates the number of separate intake reports that were submitted on NRC Form 5 reports under 10 CFR 20.2206.

TABLE 3.7
Intake by Licensee Category and Radionuclide Mode of Intake—*Inhalation*
2009

Licensee Category	Program Code	Radionuclide	Pulmonary Clearance Class or Solubility Type	Number of Intake Records *	Collective Intake in Microcuries (sci. notation)
Manufacturing and Distribution	03211	I-131	D	**3**	**6.20E-01**
Uranium Hexafluoride (UF_6) Production Plants	11400	UNAT	D	487	3.00E-01
	11400	UNAT	Y	**487**	**6.36E-01**
Uranium Enrichment	21200	TH-230	W	16	6.86E+01
	21200	U-234	D	**28**	1.75E+01
	21200	U-234	W	13	**7.67E+01**
	21200	U-234	Y	4	1.92E+01
Fuel Fabrication	21210	AM-241	M	23	7.43E-05
	21210	CO-60	Y	13	7.42E-02
	21210	PU-239	M	30	2.08E-04
	21210	RN-220	D	132	**1.65E+02**
	21210	RA-224	M	23	8.91E-05
	21210	SR-90	D	179	3.41E-02
	21210	SR-90	S	196	3.37E-01
	21210	TH-228	M	139	3.96E-04
	21210	TH-228	S	131	4.44E-04
	21210	TH-232	M	30	1.34E-04
	21210	TH-232	S	7	1.80E-05
	21210	U-232	F	120	2.07E-04
	21210	U-232	S	162	5.18E-04
	21210	U-232	Y	170	1.37E-03
	21210	U-234	D	384	2.69E-01
	21210	U-234	F	639	8.03E-02
	21210	U-234	M	654	3.55E-02
	21210	U-234	S	**1,531**	2.55E+00
	21210	U-234	W	70	3.56E-02
	21210	U-234	Y	894	3.39E+00
	21210	U-235	D	157	6.75E-03
	21210	U-235	F	120	5.92E-04
	21210	U-235	M	21	1.84E-05
	21210	U-235	S	599	6.99E-02
	21210	U-235	W	70	1.32E-03
	21210	U-235	Y	280	8.13E-02
	21210	U-236	D	157	2.82E-04
	21210	U-236	F	453	9.01E-03
	21210	U-236	M	21	2.29E-04
	21210	U-236	S	229	2.59E-02
	21210	U-236	W	70	5.56E-05
	21210	U-236	Y	280	3.51E-02
	21210	U-238	D	206	2.92E-02
	21210	U-238	F	42	4.30E-06
	21210	U-238	M	541	8.84E-03
	21210	U-238	S	454	2.41E-01
	21210	U-238	W	70	4.83E-03
	21210	U-238	Y	894	4.85E-01

NOTE: The data values shown bolded and in boxes represent the highest value in each category.
* An intake event may involve multiple nuclides, and individuals may incur multiple intakes during the year. The number of intake records given here indicates the number of separate intake reports that were submitted on NRC Form 5 reports under 10 CFR 20.2206.

TABLE 3.7
Intake by Licensee Category and Radionuclide Mode of Intake—*Inhalation* (continued)
2009

Licensee Category	Program Code	Radionuclide	Pulmonary Clearance Class or Solubility Type	Number of Intake Records *	Collective Intake in Microcuries (sci. notation)
Power Reactors	41111	AM-241	W	2	7.51E-05
	41111	CM-242	W	2	3.22E-05
	41111	CM-243	W	2	6.93E-05
	41111	CO-58	Y	2	2.47E+01
	41111	CO-60	Y	16	1.02E+02
	41111	CR-51	Y	1	**6.20E+02**
	41111	FE-55	D	1	9.30E-03
	41111	FE-59	Y	1	3.50E+01
	41111	I-131	D	**20**	6.83E+00
	41111	MN-54	W	1	8.60E-02
	41111	MN-54	Y	1	9.07E+01
	41111	NB-95	W	1	1.23E-02
	41111	NI-63	D	1	7.58E-04
	41111	PU-238	Y	1	1.44E-04
	41111	PU-238	W	1	7.00E-08
	41111	PU-239	Y	1	5.80E-05
	41111	PU-241	W	1	1.37E-05
	41111	RU-106	Y	1	6.43E+01
	41111	ZN-65	Y	**1**	3.63E+01
	41111	ZR-95	Y	1	5.61E-03

NOTE: The data values shown bolded and in boxes represent the highest value in each category.
* An intake event may involve multiple nuclides, and individuals may incur multiple intakes during the year. The number of intake records given here indicates the number of separate intake reports that were submitted on NRC Form 5 reports under 10 CFR 20.2206.

pulmonary clearance class or pulmonary solubility type is recorded as D, W, Y (days, weeks, years) or F, M, S (fast, medium, slow), respectively, corresponding to the clearance half-time from the pulmonary region of the lung into the blood and gastrointestinal tract. The pulmonary clearance class designation depends on whether the licensee is using the nomenclature in ICRP Publication 30, which is described in 10 CFR Part 20 (D, W, Y) [Ref. 13] or ICRP Publication 68 (F, M, S) [Ref. 14]. Licensees that use the methodology described in ICRP Publication 30 utilize D, W, and Y pulmonary classes to determine dose. Licensees that use the methodology described in ICRP Publication 68 utilize F, M, and S pulmonary solubility types to determine dose.

The amount of material taken into the body is given in microcuries, a unit of measure of the quantity of radioactive material. For each licensee category, the maximum number of intake records and the maximum intake are highlighted in the table in bold for ease of reference.

Table 3.8 lists the number of individuals with measurable CEDE, the collective CEDE, and the average measurable CEDE per individual for each licensee category. Fuel fabrication facilities have the majority of internal dose (99%) in 2009 and the highest average CEDE per individual. This is due to the individuals' exposure to uranium during the processing and fabrication of the uranium fuel.

TABLE 3.8
Collective and Average CEDE by Licensee Category
2009

Licensee Category	Licensee Name	License Number	Number with Meas. CEDE	Collective CEDE (person-rem)	Average Meas. CEDE (rem)
Manufacturing and Distribution					
02500	CARDINAL HEALTH	34-29200-01MD	**64**	**0.656**	**0.010**
02500	IBA MOLECULAR NORTH AMERICA, INC.	45-25221-01MD	5	0.042	0.008
03211	INTERNATIONAL ISOTOPES IDAHO INC.	11-27680-01	3	0.015	0.005
		Total	**72**	**0.713**	**0.010**
Uranium Enrichment					
21200	U. S. ENRICHMENT CORP. - PADUCAH	GDP-1	16	**0.081**	**0.005**
	U. S. ENRICHMENT CORP. - PORTSMOUTH	GDP-2	**22**	0.046	0.002
		Total	**38**	**0.127**	**0.003**
Fuel Fabrication					
21210	B & W NUCLEAR OPERATIONS GROUP	SNM-0042	198	14.685	0.074
	AREVA NP, INC. - LYNCHBURG	SNM-1168	30	1.108	0.037
	AREVA NP, INC. - RICHLAND	SNM-1227	238	**67.267**	**0.283**
	GLOBAL NUCLEAR FUEL - AMERICAS, LLC	SNM-1097	490	36.875	0.075
	NUCLEAR FUEL SERVICES, INC.	SNM-0124	**608**	8.002	0.013
	WESTINGHOUSE ELECTRIC COMPANY LLC	SNM-1107	353	50.912	0.144
		Total	**1,917**	**178.849**	**0.093**
Independent Spent Fuel Storage Installation					
23200	GENERAL ELECTRIC CO. - MORRIS OPER	SNM-2500	**4**	**0.398**	**0.100**
		Total	**4**	**0.398**	**0.100**
Power Reactors					
41111	ARKANSAS	DPR-51	1	0.010	0.010
	PILGRIM	DPR-35	4	0.104	0.026
	COLUMBIA GENERATING	NPF-21	1	0.011	0.011
	BRAIDWOOD	NPF-72	4	0.059	0.015
	OCONEE	DPR-38	1	0.013	0.013
	VOGTLE	NPF-68	18	**0.221**	0.012
	RIVER BEND	NPF-47	9	0.160	0.018
	DUANE ARNOLD	DPR-49	2	0.068	**0.034**
	THREE MILE ISLAND 1	DPR-50	1	0.011	0.011
	NINE MILE POINT	DPR-63	1	0.012	0.012
	FT CALHOUN	DPR-40	1	0.012	0.012
	DIABLO CANYON	DPR-80	1	0.015	0.015
	SUMMER	NPF-12	1	0.017	0.017
	BROWNS FERRY	DPR-33	**37**	0.130	0.004
	NORTH ANNA	NPF-04	4	0.009	0.002
		Total	**86**	**0.852**	**0.010**
Grand Totals			**2,117**	**180.939**	**0.085**

NOTE: The data values shown bolded and in boxes represent the highest value in each category.

Table 3.9 shows the distribution of internal dose (CEDE) from 1994 to 2009 for licensees required to report under 10 CFR 20.2206. For the purposes of this table, the definition of a "measurable CEDE" is any reported value greater than zero. As noted above, the vast majority of the internal doses are received by individuals working at fuel fabrication facilities. It should be noted that the collective CEDE has decreased every year since 2000.

TABLE 3.9
Internal Dose (CEDE) Distribution
1994–2009

Year	Number of Individuals with CEDE in the Ranges (rem) *										Total with Meas. CEDE	Collective CEDE (person-rem)	Average Meas. CEDE (rem)
	Meas. 0.020	0.020-0.100	0.100-0.250	0.250-0.500	0.500-0.750	0.750-1.000	1-2	2-3	3-4	4-5			
1994	3,425	577	287	351	196	138	293	69	2	-	5,338	1,033.688	0.194
1995	2,868	691	338	362	216	145	288	49	2	-	4,959	1,019.045	0.205
1996	3,096	598	305	317	190	121	185	22	2	2	4,838	741.373	0.153
1997	3,835	869	381	366	242	148	169	30	-	-	6,040	826.280	0.137
1998	3,310	932	426	355	230	140	153	21	2	-	5,569	779.148	0.140
1999	3,399	630	402	425	206	117	173	29	-	-	5,381	792.586	0.147
2000	3,248	891	514	373	214	98	224	58	7	1	5,628	969.792	0.172
2001	1,767	766	572	277	109	51	146	82	15	1	3,786	810.128	0.214
2002	1,759	739	555	370	95	20	23	3	-	-	3,564	377.016	0.106
2003	2,208	727	572	271	98	13	4	-	-	-	3,893	311.641	0.080
2004	1,987	738	440	252	90	14	3	-	-	-	3,524	274.606	0.078
2005	1,204	633	432	223	89	25	2	-	-	-	2,608	263.857	0.101
2006	1,294	583	383	245	80	13	3	-	-	-	2,601	245.743	0.094
2007	1,418	524	415	228	38	1	3	-	-	-	2,627	207.121	0.079
2008	900	547	411	254	29	3	1	-	-	-	2,145	205.475	0.096
2009	1,027	488	411	128	53	9	1	-	-	-	2,117	180.939	0.085

* Dose values exactly equal to the values separating ranges are reported in the next higher range.

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Section 4
COMMERCIAL LIGHT WATER REACTORS – FURTHER ANALYSIS

4.1 INTRODUCTION

General trends in occupational radiation exposures at commercial nuclear power reactors are best evaluated within the context of other pertinent information. In this section, some of the tables and appendices that summarize dose data also show the type, capacity, amount of electricity generated, and age of the reactor. Dose data are then presented as a function of these data.

4.2 DEFINITION OF TERMS AND SOURCES OF DATA

4.2.1 Number of Reactors

The number of reactors shown in Tables 4.1, 4.2, and 4.3 is the number of BWRs, PWRs, and LWRs, respectively, that had been in commercial operation for at least one full year as of December 31 of each of the indicated years. This is the number of reactors in which the average number of individuals with measurable dose and average collective dose per reactor is based. Excluded are reactors that have been in commercial operation for less than 12 months during the first year and reactors that have been permanently defueled. This technique yields conservative values for many of the averages shown in the tables. The date that each reactor was declared to be in commercial operation was taken from Ref. 15.

Three Mile Island Unit 2 (TMI-2) was included in the compilation of data for commercially operating reactors from 1975 through 1988 and has not been included in the data analysis since 1988. TMI-1 and TMI-2 reported data separately beginning in 1986.

There were no changes to the count of operating reactors in 2009. The number of operating BWRs remains the same as in 2008 at 35, and the number of operating PWRs remains the same at 69. The dose information for these reactors and for others that are no longer in commercial operation is listed at the end of Appendix B.

4.2.2 Electric Energy Generated

The electric energy generated in megawatt years (MW-yr) each year by each reactor is graphically represented in Appendix D. This number was obtained by dividing the megawatt hours of electricity annually produced by each facility by 8,760, the number of hours in the year, except for leap years, when the number is 8,784 hours. The number of megawatt hours of electricity produced each year was obtained from Ref. 15. For the years 1973 to 1996, the electricity generated is the gross electricity output of the reactor. For 1997 to 2009, the number reflects the net electricity produced, which is the gross electricity minus the amount the plant uses for operations. This change is the result of a change in NRC power generation reporting requirements. The electricity generated (in MW-yr) that is presented in Tables 4.1, 4.2, and 4.3 is the summation of electricity generated by the number of reactors included in each year. These sums are divided by the number of operating reactors included in each year to yield the average amount of electric energy generated per reactor, which is also shown in Tables 4.1, 4.2, and 4.3.

TABLE 4.1
Summary of Information Reported by Commercial Boiling Water Reactors
1994–2009

Year	Number of Reactors Included*	Annual Collective Dose (person-rem)	No. of Individuals with Measurable Dose**	Electricity Generated*** (MW-yr)	Average Measurable Dose per Individual (rem)**	Average Collective Dose per Reactor (person-rem)	Average No. Individuals with Measurable Doses per Reactor**	Average Collective Dose per MW-yr (person-rem/ MW-yr)	Average Electricity Generated per Reactor (MW-yr)	Average Maximum Dependable Capacity Net (MWe)	Maximum Dependable Capacity Achieved
1994	37	12,098	39,171	22,139.00	0.31	327	1,059	0.55	598	801	75%
1995	37	9,471	35,686	24,737.00	0.27	256	964	0.38	669	835	80%
1996	37	9,466	37,792	24,322.20	0.25	256	1,021	0.39	657	838	78%
1997	37	7,603	34,021	22,866.10	0.22	205	919	0.33	618	845	73%
1998	36	6,829.296	32,899	23,781.20	0.21	190	914	0.29	661	874	76%
1999	35	6,434.430	31,482	26,962.60	0.20	184	899	0.24	770	885	87%
2000	35	6,089.676	31,186	28,476.90	0.20	174	891	0.21	814	893	91%
2001	35	4,835.397	28,797	28,730.40	0.17	138	823	0.17	821	895	92%
2002	35	6,107.767	30,978	29,460.00	0.20	175	885	0.21	842	907	93%
2003	35	5,659.434	30,759	29,094.40	0.18	162	879	0.19	831	912	91%
2004	35	5,450.982	33,948	29,424.80	0.16	156	970	0.19	841	893	94%
2005	35	5,995.975	33,544	29,386.80	0.18	171	958	0.20	840	946	89%
2006	35	4,989.761	34,159	30,238.40	0.15	143	976	0.17	864	954	91%
2007	35	5,388.416	37,515	30,189.30	0.14	154	1,072	0.18	863	955	90%
2008	35	4,522.413	34,642	31,248.30	0.13	129	990	0.14	893	957	93%
2009	35	5,282.869	36,207	30,762.70	0.15	151	1,034	0.17	879	959	92%

* Includes only those reactors that had been in commercial operation for at least one full year as of December 31 of each of the indicated years.
** Figures are not adjusted for the multiple reporting of transient individuals (see section 5).
*** Beginning in 1997, the electricity reflects the net electricty generated.

TABLE 4.2
Summary of Information Reported by Commercial Pressurized Water Reactors
1994–2009

Year	Number of Reactors Included*	Annual Collective Dose (person-rem)	No. of Individuals with Measurable Dose**	Electricity Generated*** (MW-yr)	Average Measurable Dose per Individual (rem)**	Average Collective Dose per Reactor (person-rem)	Average No. Personnel with Measurable Doses per Reactor**	Average Collective Dose per MW-yr (person-rem/MW-yr)	Average Electricity Generated per Reactor (MW-yr)	Average Maximum Dependable Capacity Net (MWe)	Maximum Dependable Capacity Achieved
1994	70	9,574	44,283	52,397.6	0.22	137	633	0.18	749	928	81%
1995	70	11,762	49,985	54,138.2	0.24	168	714	0.22	773	929	83%
1996	72	9,417	46,852	55,337.8	0.20	131	651	0.17	769	935	82%
1997	72	9,546	50,690	48,985.3	0.19	133	704	0.19	680	943	72%
1998	69	6,358.096	38,586	53,288.7	0.16	92	559	0.12	772	942	82%
1999	69	7,231.281	43,938	56,235.0	0.16	105	637	0.13	815	942	86%
2000	69	6,562.006	42,922	57,529.9	0.15	95	622	0.11	834	943	88%
2001	69	6,273.155	38,773	58,822.4	0.16	91	562	0.11	852	946	90%
2002	69	6,018.423	42,264	59,369.7	0.14	87	613	0.10	860	947	91%
2003	69	6,296.136	44,054	57,920.6	0.14	91	638	0.11	839	949	88%
2004	69	4,916.915	35,901	60,398.7	0.14	71	520	0.08	875	943	93%
2005	69	5,459.832	44,583	59,790.9	0.12	79	646	0.09	867	955	91%
2006	69	6,031.425	46,106	59,751.3	0.13	87	668	0.10	866	960	90%
2007	69	4,731.597	42,015	61,955.6	0.11	69	609	0.08	898	961	93%
2008	69	4,673.527	44,808	60,586.0	0.10	68	649	0.08	878	964	91%
2009	69	4,741.935	45,547	60,467.9	0.10	69	660	0.08	876	966	91%

* Includes only those reactors that had been in commercial operation for at least one full year as of December 31 of each of the indicated years.
** Figures are not adjusted for the multiple reporting of transient individuals (see section 5).
*** Beginning in 1997, the electricity reflects the net electricty generated.

TABLE 4.3
Summary of Information Reported by Commercial Light Water Reactors
1994–2009

Year	Number of Reactors Included*	Annual Collective Dose (person-rem)	No. of Individuals with Measurable Dose**	Electricity Generated*** (MW-yr)	Average Measurable Dose per Individual (rem)**	Average Collective Dose per Reactor (person-rem)	Average No. Personnel with Measurable Doses per Reactor**	Average Collective Dose per MW-yr (person-rem/MW-yr)	Average Electricity Generated per Reactor (MW-yr)	Average Maximum Dependable Capacity Net (MWe)	Maximum Dependable Capacity Achieved
1994	107	21,672	83,454	74,536.60	0.26	203	780	0.29	697	884	79%
1995	107	21,233	85,671	78,875.20	0.25	198	801	0.27	737	896	82%
1996	109	18,883	84,644	79,660.00	0.22	173	777	0.24	731	902	81%
1997	109	17,149	84,711	71,851.40	0.20	157	777	0.24	659	910	72%
1998	105	13,187.392	71,485	77,069.90	0.18	126	681	0.17	734	918	80%
1999	104	13,665.711	75,420	83,197.60	0.18	131	725	0.16	800	923	87%
2000	104	12,651.682	74,108	86,006.80	0.17	122	713	0.15	827	926	89%
2001	104	11,108.552	67,570	87,552.80	0.16	107	650	0.13	842	929	91%
2002	104	12,126.190	73,242	88,829.70	0.17	117	704	0.14	854	934	91%
2003	104	11,955.570	74,813	87,015.00	0.16	115	719	0.14	837	936	89%
2004	104	10,367.897	69,849	89,823.50	0.15	100	672	0.12	864	926	93%
2005	104	11,455.807	78,127	89,177.70	0.15	110	751	0.13	857	952	90%
2006	104	11,021.186	80,265	89,989.70	0.14	106	772	0.12	865	958	90%
2007	104	10,120.013	79,530	92,144.90	0.13	97	765	0.11	886	959	92%
2008	104	9,195.940	79,450	91,834.30	0.12	88	764	0.10	883	961	92%
2009	104	10,024.804	81,754	91,230.60	0.12	96	786	0.11	877	964	91%

* Includes only those reactors that had been in commercial operation for at least one full year as of December 31 of each of the indicated years.
** Figures are not adjusted for the multiple reporting of transient individuals (see section 5).
*** Beginning in 1997, the electricity reflects the net electricty generated.

As shown in Table 4.3, there was a 0.7% decrease in the net electricity generated at LWRs in 2009. Cook Unit 1, a PWR, continued an outage throughout 2009 from a failed turbine, contributing to the decrease in power generated. Perry, a BWR, refueled and had a forced outage and repairs related to the moisture separator and emergency service water cables. These plants experienced the largest decreases in power production (in MW-yr) from 2008 to 2009. In 2009, River Bend and Robinson, a BWR and PWR respectively, increased power production from 2008.

4.2.3 Collective Dose per Megawatt-Year

The number of MW-yr of electricity generated was used in determining the ratio of the average value of the annual collective dose (TEDE) to the number of MW-yr of electricity generated. The ratio was calculated by dividing the total collective dose in person-rem by the electric energy generated in MW-yr and is a measure of the dose incurred by individuals at commercial nuclear power reactors in relation to the electric energy produced. For the years 1973 to 1996, the electricity generated is the gross electricity output of the reactor. For 1997 to 2009, the number reflects the net electricity produced. This ratio, calculated by year for BWRs, PWRs, and LWRs is presented in Tables 4.1, 4.2, and 4.3. This ratio was also calculated for each reactor site (see Appendix C). The average collective dose per MW-yr for LWRs increased to a value of 0.11 rem/MW-yr in 2009 from a value of 0.10 rem/MW-yr in 2008 due to a combination of a 9% increase in the collective dose and a 0.6% decrease in power production.

4.2.4 Average Maximum Dependable Capacity

Average maximum dependable capacity as shown in Tables 4.1, 4.2, and 4.3 was calculated by dividing the sum of the net maximum dependable capacities of the reactors in megawatts (net MWe) by the number of reactors included each year. The net maximum dependable capacity is defined as the gross electrical output as measured at the output terminals of the turbine generator during the most restrictive seasonal conditions less the normal station service loads. This “capacity” of each plant was found in Ref. 15.

4.2.5 Percent of Maximum Dependable Capacity Achieved

The percent of maximum dependable capacity achieved is shown for all LWRs in Table 4.3. This parameter gives an indication of the overall power generation performance of LWRs as compared with the maximum dependable capacity that could be obtained in a given year. It is calculated by dividing the average electricity generated per reactor by the average maximum dependable capacity for each year.

From 1973 to 1978, this indicator exhibited an increasing trend as a number of new reactors began producing power at higher efficiencies. Following the accident at TMI, reactor operations personnel concentrated on improving safety systems and complying with the new regulations for these systems. During this time period, from 1979 to 1987, the percent of maximum dependable capacity remained around 61%. Following the completion of most of these mandated repairs, reactors increased the percent of maximum dependable capacity from 62% in 1987 to 81% in 1996, a gain of nearly 20% in 10 years. The decrease in maximum dependable capacity from 1996 to 1997 was due to the change from measuring the gross electricity generated to the net electricity generated. The percent of maximum dependable capacity for LWRs decreased to 91% in 2009 from 92% in 2008. This decrease in capacity was due to a 12% increase in outage hours from refueling and equipment outages in 2009, reducing the number of hours of power generation.

4.3 ANNUAL TEDE DISTRIBUTIONS

Table 4.4 summarizes the distribution of the annual TEDE doses received by individuals at all commercial LWRs during each of the years 1994 through 2009. This distribution is the sum of the annual dose distributions reported by each licensed LWR each year. As previously noted, the distribution reported by each LWR site for 2009 is shown in Appendix B.

Table 4.4 includes only those reactors in operation for one full year for each year presented in the table. In 2009, the total collective dose increased by 9% to a value of 10,025 person-rem. The PWR with the largest decrease in the collective dose was Davis-Besse. In 2009, TMI-1 experienced the highest increase in collective dose among PWRs, followed by Indian Point 3. Both of these units had refueling outages in 2009 and no outages in 2008. The BWR with the largest decrease in the collective dose was Oyster Creek, which had no refueling outages during 2009. Perry experienced the highest increase in collective dose among BWRs in 2009 and had a refueling outage and two forced outages requiring equipment repairs.

4.4 AVERAGE ANNUAL TEDE DOSES

Some of the data presented in Tables 4.1, 4.2, and 4.3 are graphically displayed in Figure 4.1, where it can be seen that the average collective dose and average number of individuals per BWR have been higher than those for PWRs since 1994. BWRs generally have higher collective doses due to the fact that the steam produced directly from the reactor is used to drive turbines to produce electricity. This results in radioactivity being present in both the reactor and power generation components of the systems, while PWR systems are designed to keep the radioactivity within the reactor vessel and steam generators, and not in the turbine systems. Between 1994 and 2009, the annual collective dose per LWR dropped by 53%. Most of this decrease occurred prior to 2001. Both BWR and PWR collective doses appear to have leveled off since 2001, after a long decreasing trend since the mid-1980's.

The average collective dose per reactor for PWRs increased by 1% to 69 person-rem and the average collective dose per reactor for BWRs increased by 17% to 151 person-rem from 2008 to 2009. The overall collective dose per reactor for LWRs increased by 9% from 88 person-rem in 2008 to 96 person-rem in 2009. This is the third year that the average collective dose per reactor for LWRs has been below 100 person-rem since tracking began in

TABLE 4.4
Summary Distribution of Annual Whole-Body Doses at Commercial Light Water Reactors*
1994–2009

Year	No Measurable Exposure	Measurable <0.1	Number of Individuals with Whole Body Doses in the Ranges (rem) **															Total Number Monitored	Number with Measurable Exposure	Collective Dose*** (person-rem)
			0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.0	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.0	6.0-7.0	7.0-8.0	8.0-9.0	9.0-10.0	10.0-12.0	>12			
1994	85,145	36,528	18,633	14,246	6,800	3,502	3,323	215	6	-	-	-	-	-	-	-	-	168,398	83,253	21,534.000
1995	81,032	38,575	20,245	15,279	6,884	3,336	3,077	125	5	-	-	-	-	-	-	-	-	168,558	87,526	21,674.000
1996	78,197	39,426	19,955	14,201	5,809	2,648	2,342	68	-	-	-	-	-	-	-	-	-	162,646	84,449	18,874.000
1997	80,163	41,759	19,951	13,396	5,394	2,240	1,671	59	3	-	-	-	-	-	-	-	-	164,636	84,473	17,136.000
1998	77,080	37,039	17,189	10,467	3,930	1,562	1,129	35	-	-	-	-	-	-	-	-	-	148,431	71,351	13,169.366
1999	74,867	39,663	18,063	10,964	3,994	1,569	1,141	24	2	-	-	-	-	-	-	-	-	150,287	75,420	13,665.711
2000	73,793	40,301	17,598	10,310	3,525	1,375	976	23	-	-	-	-	-	-	-	-	-	147,901	74,108	12,651.682
2001	73,206	37,461	16,078	9,231	2,930	1,060	747	63	-	-	-	-	-	-	-	-	-	140,776	67,570	11,108.552
2002	76,270	41,588	16,752	9,426	3,121	1,245	1,003	105	2	-	-	-	-	-	-	-	-	149,512	73,242	12,126.190
2003	77,889	42,720	17,231	9,589	3,139	1,233	864	37	-	-	-	-	-	-	-	-	-	152,702	74,813	11,955.570
2004	80,473	41,583	15,626	8,245	2,733	978	668	16	-	-	-	-	-	-	-	-	-	150,322	69,849	10,367.897
2005	82,574	46,444	17,754	9,191	2,934	1,104	683	17	-	-	-	-	-	-	-	-	-	160,701	78,127	11,455.807
2006	84,558	48,571	18,269	9,312	2,675	904	532	2	-	-	-	-	-	-	-	-	-	164,823	80,265	11,021.186
2007	84,551	49,998	17,672	8,294	2,329	824	402	11	-	-	-	-	-	-	-	-	-	164,081	79,530	10,120.013
2008	89,874	51,831	17,337	7,578	1,847	583	269	5	-	-	-	-	-	-	-	-	-	169,324	79,450	9,195.940
2009	94,627	52,670	17,417	8,352	2,161	741	413	-	-	-	-	-	-	-	-	-	-	176,381	81,754	10,024.804

* Summary of reports submitted in accordance with 10 CFR 20.407 or 20.2206 by BWRs and PWRs that had been in commercial operation for at least 1 full year as of December 31 of each of the indicated years. Figures shown have not been adjusted for the multiple reporting of transient individuals (see Section 5).
** Dose values exactly equal to the values separating ranges are reported in the next higher range.
*** The collective dose, when not reported by the licensee, was calculated by the NRC staff using methods described in Section 3.1.4.

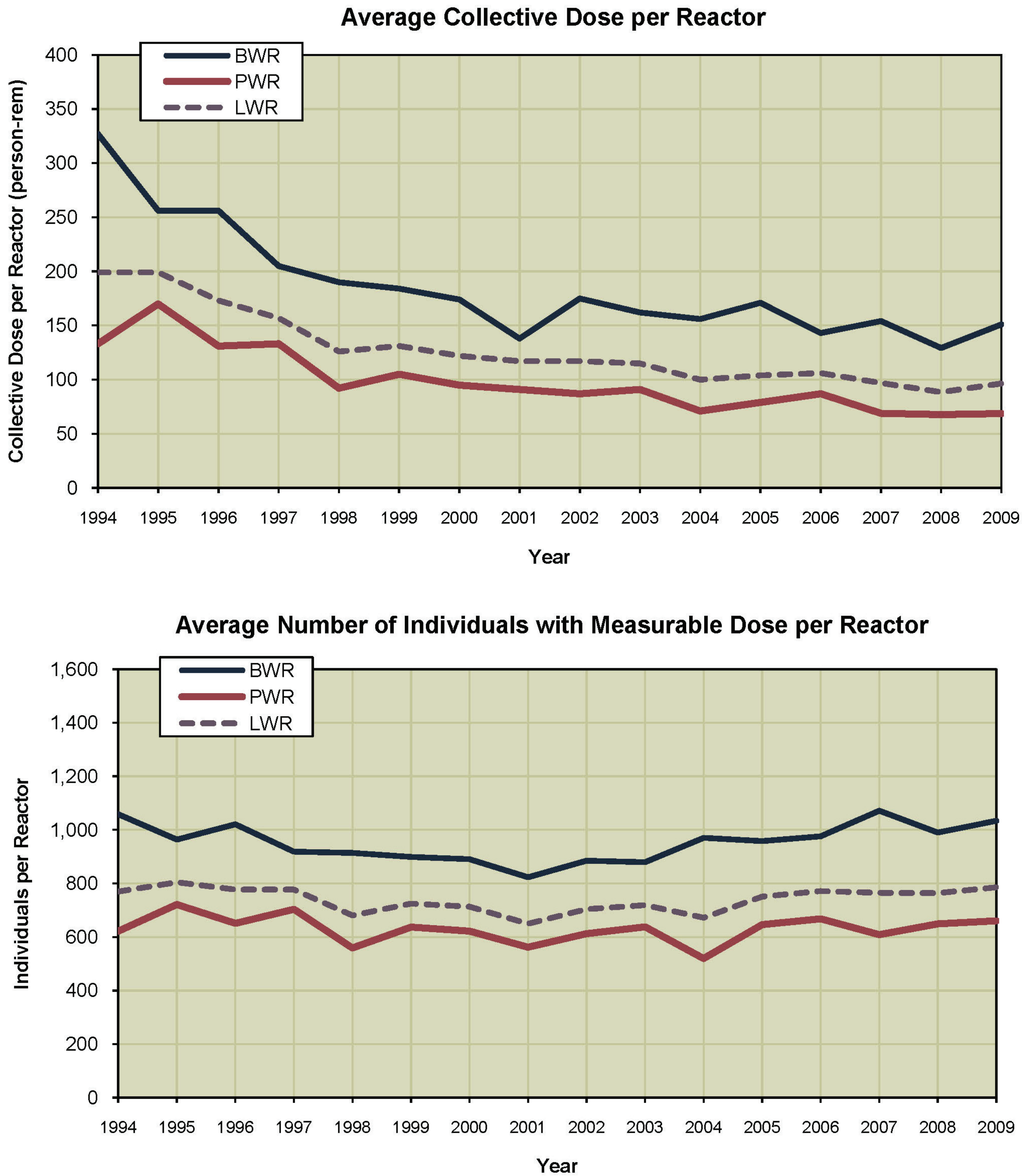


FIGURE 4.1. Average Collective Dose per Reactor and Number of Individuals with Measurable Dose per Reactor 1994–2009

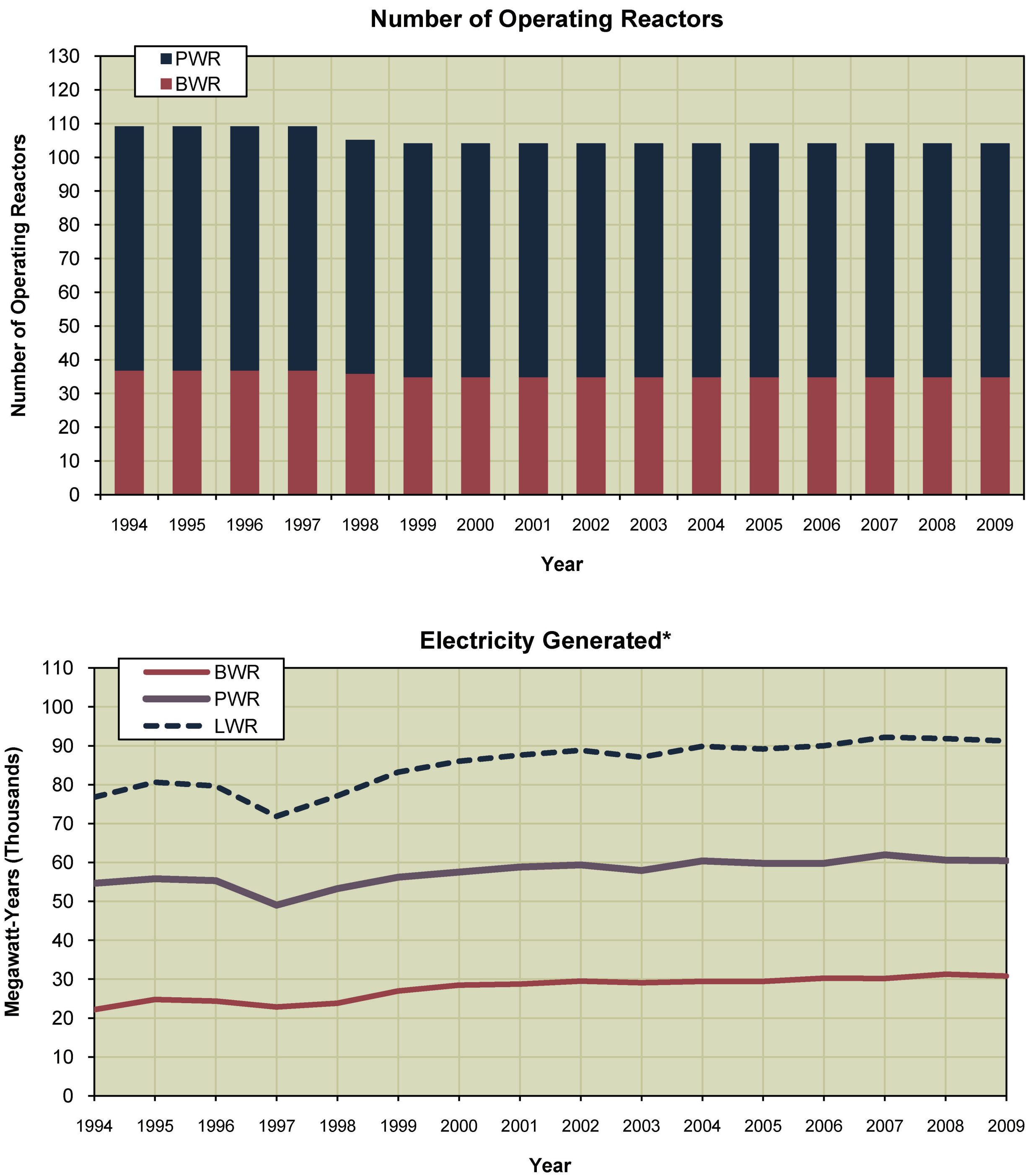
1973. The overall decreasing trend in average reactor collective doses since 1994 indicates that licensees are continuing to successfully implement ALARA dose reduction processes at their facilities. In 2009, the number of individuals with measurable dose per reactor increased to 660 for PWRs and increased to 1,034 for BWRs.

Figures 4.2 and 4.3 are plots of most of the other information that is given in Tables 4.1, 4.2, and 4.3. Figure 4.2 shows that in 2009 the net electricity generated decreased slightly to 91,231 MW-yr while the number of operating reactors has remained constant for the past 11 years. Figure 4.3 shows that the value for the total collective dose per megawatt-year for all LWRs increased by 9% from a value of 9,196 person-rem in 2008 to 10,025 person-rem in 2009. The average measurable dose per individual remained the same at 0.12 rem in 2009 (not adjusted for transient individuals).

The fluctuations in the parameters for the years following the accident at the TMI plant in 1979 may reflect some of the impact that this incident had on the nuclear power industry. The decrease seen in dose trends since 1983 may be attributable to several factors. Utilities have completed the tasks initiated as a result of the lessons learned from the TMI accident, and they are increasing efforts to avoid and reduce exposure. The importance of exposure control and the concept of keeping exposures to ALARA levels are continually being stressed, and most utilities have established programs to collect and share information relative to tasks, techniques, and exposures.

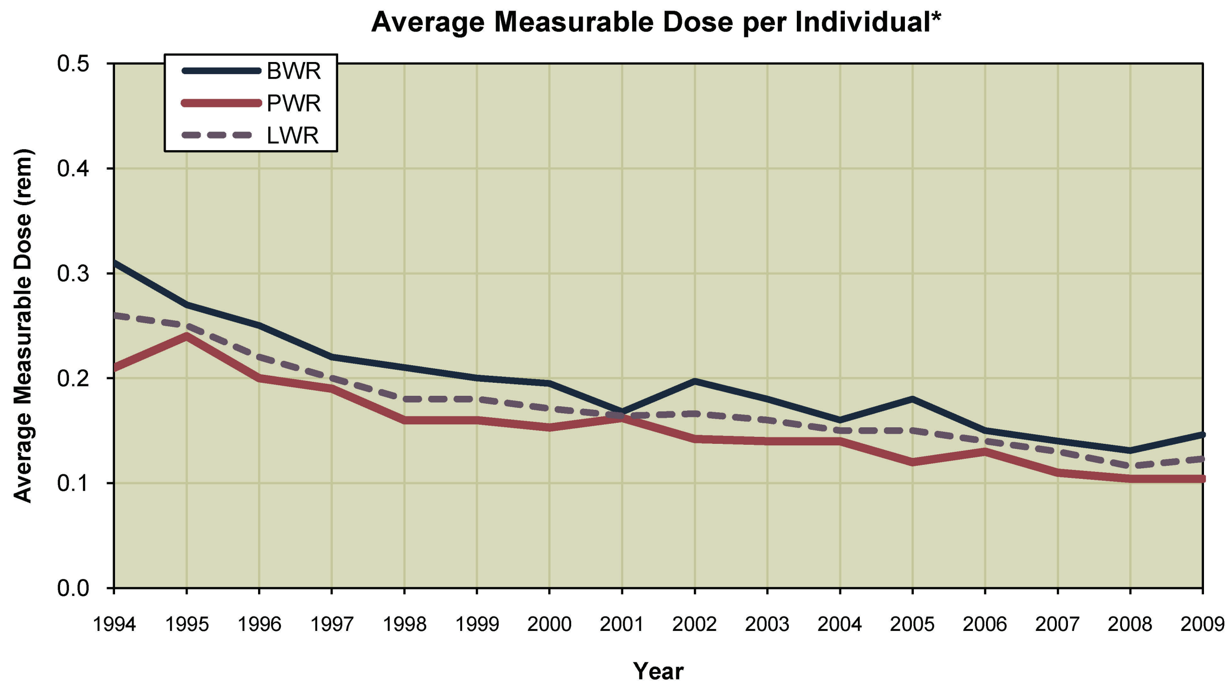
To further assist in the identification of any trends that might exist, Figure 4.4 displays the average and median[7] values of the collective dose per reactor for BWRs and for PWRs for the years 1994 through 2009. The ranges of the values reported each year are shown by the vertical lines with a small bar at each end marking the two extreme values. The rectangles indicate the range of values of the collective dose exhibited by those plants ranked in the 25th through the 75th percentiles. The median collective dose for PWRs decreased from 63 person-rem in 2008 to 56 person-rem in 2009. The median collective dose for BWRs increased from 109 person-rem in 2008 to 133 person-rem in 2009. Figure 4.4 also shows that, in 2009, 50% of the PWRs reported collective doses between 40 and 83 person-rem, while 50% of the BWRs reported collective doses between 116 and 159 person-rem. These values are based on an annual average, not the 3-year rolling average that is presented in Section 4.5. Nearly every year the median collective dose is less than the average, which indicates that the median collective dose for most plants is less than the average collective dose per reactor (the value that is widely quoted).

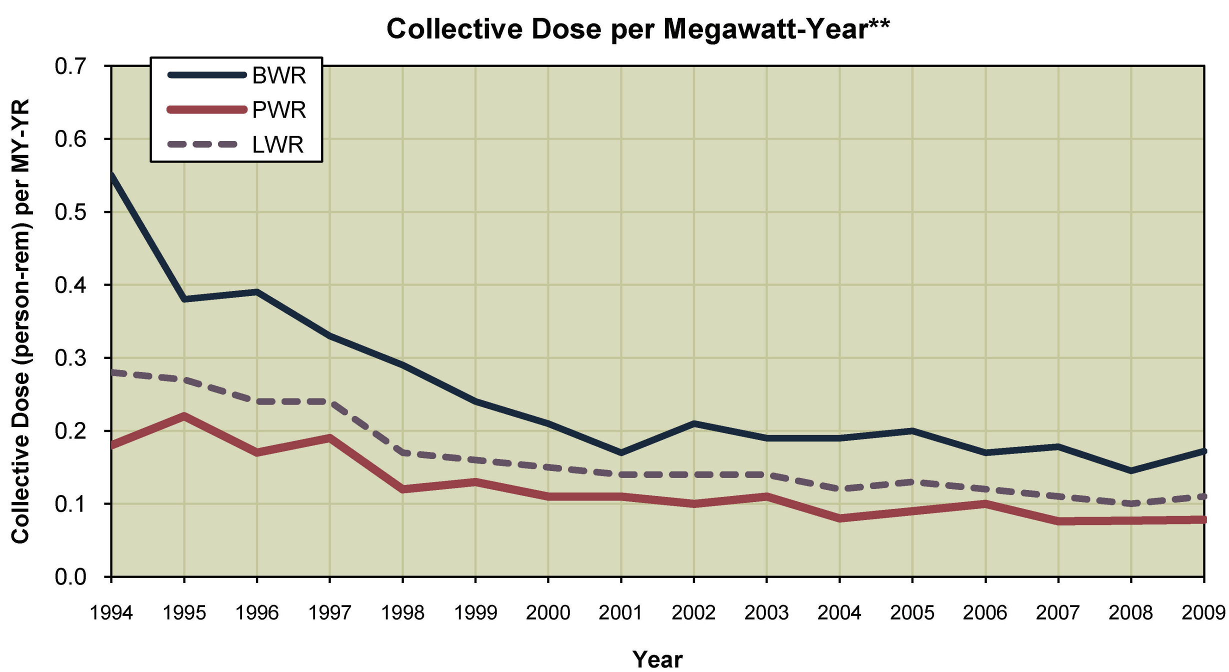
[7] The median is the value at which 50% of the reactors reported greater collective doses and the other 50% reported smaller collective doses.



* Gross electricity is shown for 1994–1996, net electricity is shown for 1997–2009.

FIGURE 4.2. Number of Operating Reactors and Electricity Generated 1994–2009





* Not adjusted for transient workers. See Section 5.

** Gross electricity is shown for 1994–1996, net electricity is shown for 1997–2009.

FIGURE 4.3. Average Measurable Dose per Individual and Collective Dose per Megawatt-Year 1994–2009

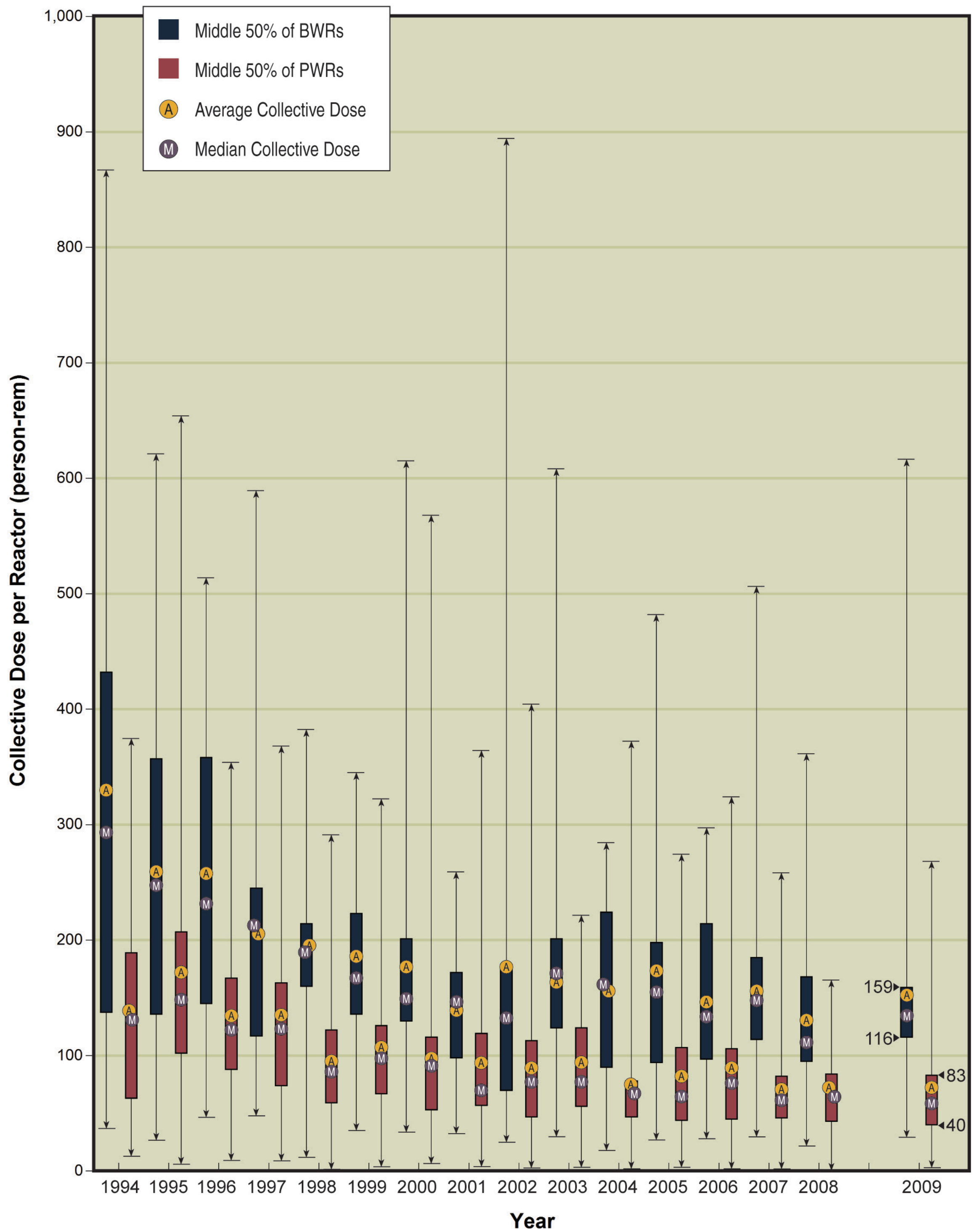


FIGURE 4.4. Average, Median, and Extreme Values of the Collective Dose per Reactor 1994–2009

4.5 THREE-YEAR AVERAGE COLLECTIVE TEDE PER REACTOR

The 3-year average collective dose per reactor is one of the metrics that the NRC uses in the Reactor Oversight Program to evaluate the effectiveness of the licensee's ALARA program. Tables 4.5 and 4.6 list the sites that had been in commercial operation for at least 3 years as of December 31, 2009, and show the values of several parameters for each of the sites. These tables also give averages for the two types of reactors.

TABLE 4.5

Three-Year Totals and Averages Listed in Ascending Order of Collective TEDE per BWR
2007–2009

Plant Name*	Reactor Years	Collective TEDE per Reactor Year	Collective TEDE per Site	Number of Workers with Measurable TEDE	Avgerage TEDE per Worker	Total MW-Yrs	Average TEDE per MW-Yr
HATCH 1,2	6	85.453	512.719	4,048	0.127	4627.0	0.11
FITZPATRICK	3	92.877	278.632	2,443	0.114	2396.3	0.12
CLINTON	3	94.571	283.713	2,126	0.133	3036.8	0.09
OYSTER CREEK	3	98.598	295.794	2,357	0.125	1679.0	0.18
LIMERICK 1,2	6	101.445	608.671	4,569	0.133	6566.3	0.09
DUANE ARNOLD	3	116.001	348.002	2,298	0.151	1651.3	0.21
DRESDEN 2,3	6	117.590	705.538	6,549	0.108	4925.5	0.14
SUSQUEHANNA 1,2	6	120.418	722.510	6,154	0.117	6494.4	0.11
LASALLE 1,2	6	123.767	742.599	6,341	0.117	6453.4	0.12
GRAND GULF	3	125.488	376.464	4,114	0.092	3398.1	0.11
FERMI 2	3	126.024	378.071	3,441	0.110	2892.5	0.13
HOPE CREEK 1	3	131.647	394.940	3,089	0.128	3179.8	0.12
MONTICELLO	3	136.266	408.799	2,661	0.154	1507.0	0.27
QUAD CITIES 1,2	6	140.465	842.789	6,376	0.132	4932.3	0.17
NINE MILE POINT 1,2	6	144.781	868.683	4,673	0.186	4946.6	0.18
VERMONT YANKEE	3	148.662	445.985	2,985	0.149	1706.2	0.26
PEACH BOTTOM 2,3	6	151.342	908.053	5,754	0.158	6409.5	0.14
BROWNS FERRY 1,2,3**	9	153.855	1,384.698	7,848	0.176	8190.7	0.17
BRUNSWICK 1,2	6	165.775	994.652	7,415	0.134	5057.3	0.20
PILGRIM	3	175.770	527.309	3,085	0.171	1868.6	0.28
RIVER BEND 1	3	220.839	662.516	4,918	0.135	2443.4	0.27
COOPER STATION	3	221.287	663.860	4,083	0.163	2095.2	0.32
COLUMBIA GENERATING	3	222.188	666.563	4,820	0.138	2738.1	0.24
PERRY	3	390.713	1,172.138	3,996	0.293	3004.8	0.39
Totals and Averages	**105**		**15,193.698**	**106,143**	**0.143**	**92,200.1**	**0.16**
Average per Reactor-Year		**144.702**		**1,011**		**878.1**	

* Sites where not all reactors had completed three full years of commercial operations as of December 31, 2008, are not included.
** Although Brown's Ferry 1 was placed on administrative hold in 1985, it remains in the count of operating reactors and has resumed operation as of June, 2007.

TABLE 4.6
Three-Year Totals and Averages Listed in Ascending Order of Collective TEDE per PWR
2007–2009

Plant Name*	Reactor Years	Collective TEDE per Reactor Year	Collective TEDE per Site	Number of Workers with Measurable TEDE	Avgerage TEDE per Worker	Total MW-Yrs	Average TEDE per MW-Yr
PRAIRIE ISLAND 1,2	6	31.098	186.589	1,750	0.107	2,881.3	0.06
SUMMER 1	3	35.944	107.832	1,465	0.074	2,569.6	0.04
FARLEY 1,2	6	37.067	222.400	2,552	0.087	4,693.5	0.05
HARRIS	3	38.855	116.565	1,804	0.065	2,580.6	0.05
DAVIS-BESSE	3	39.104	117.312	1,289	0.091	2,525.9	0.05
CALLAWAY 1	3	41.265	123.795	1,972	0.063	3,307.6	0.04
PALO VERDE 1,2,3	9	45.164	406.475	5,773	0.070	9,888.8	0.04
WATTS BAR 1	3	46.303	138.908	1,868	0.074	3,125.2	0.04
POINT BEACH 1,2	6	48.219	289.314	2,259	0.128	2,750.1	0.11
GINNA	3	49.406	148.217	1,720	0.086	1,633.7	0.09
ROBINSON 2	3	51.925	155.776	1,804	0.086	2,012.0	0.08
INDIAN POINT 2	3	52.261	156.783	2,319	0.068	2,812.4	0.06
KEWAUNEE	3	53.431	160.292	1,338	0.120	1,542.9	0.10
CALVERT CLIFFS 1,2	6	53.873	323.240	2,827	0.114	4,973.2	0.06
SEABROOK	3	55.565	166.696	2,879	0.058	3,299.5	0.05
VOGTLE 1,2	6	56.303	337.816	3,067	0.110	6,315.4	0.05
BRAIDWOOD 1,2	6	57.214	343.286	3,890	0.088	6,691.5	0.05
WOLF CREEK 1	3	57.647	172.941	2,506	0.069	3,153.0	0.05
INDIAN POINT 3	3	58.335	175.004	2,464	0.071	2,812.4	0.06
BYRON 1,2	6	58.842	353.049	3,779	0.093	6,606.7	0.05
COOK 1,2	6	59.216	355.296	2,974	0.119	4,646.0	0.08
SOUTH TEXAS 1,2	6	59.766	358.595	3,200	0.112	7,423.9	0.05
TURKEY POINT 3,4	6	61.863	371.175	3,511	0.106	3,796.1	0.10
SEQUOYAH 1,2	6	62.341	374.046	3,572	0.105	6,309.5	0.06
BEAVER VALLEY 1,2	6	65.751	394.505	3,450	0.114	4,933.5	0.08
SAN ONOFRE 2,3	6	65.833	394.996	3,667	0.108	5,492.1	0.07
CATAWBA 1,2	6	66.451	398.707	3,894	0.102	6,307.6	0.06
MCGUIRE 1,2	6	66.929	401.575	4,153	0.097	6,125.3	0.07
ARKANSAS 1,2	6	67.348	404.089	4,317	0.094	5,117.8	0.08
OCONEE 1,2,3	9	68.904	620.139	5,669	0.109	7,032.0	0.09
FORT CALHOUN	3	70.354	211.063	1,809	0.117	1,323.0	0.16
COMANCHE PEAK 1,2	6	73.343	440.055	3,591	0.123	6,640.4	0.07
NORTH ANNA 1,2	6	74.728	448.366	3,121	0.144	4,975.2	0.09
SALEM 1,2	6	91.259	547.551	5,976	0.092	6,409.7	0.09
SURRY 1,2	6	91.850	551.102	3,421	0.161	4,537.8	0.12
MILLSTONE 2,3	6	99.279	595.676	3,633	0.164	5,542.3	0.11
ST. LUCIE 1,2	6	109.176	655.053	4,713	0.139	4,359.1	0.15
DIABLO CANYON 1,2	6	114.122	684.731	5,924	0.116	5,956.5	0.11
THREE MILE ISLAND 1	3	119.401	358.202	3,349	0.107	2,269.7	0.16
WATERFORD 3	3	136.478	409.434	3,216	0.127	3,184.3	0.13
CRYSTAL RIVER 3	3	141.003	423.008	3,122	0.135	2,173.6	0.19
PALISADES	3	182.468	547.405	2,312	0.237	2,142.5	0.26
Totals and Avgs	**207**		**14,147.059**	**131,919**	**0.107**	**182,873.2**	**0.08**
Avg per Reactor-Year		**68.343**		**637**		**883.4**	

* Sites where not all reactors had completed three full years of commercial operation as of December 31, 2008, are not included.

Based on the 105 reactor-years of operation accumulated over a three-year period by the 35 BWRs listed, the average 3-year collective TEDE per reactor was found to be 145 person-rem, the average measurable TEDE per individual was 0.14 rem, and the average collective TEDE per MW-yr was 0.16 person-rem per MW-yr. All values increased slightly or remained the same from 2008 to 2009.

Based on the 207 reactor-years of operation accumulated over a three-year period at the 69 PWRs listed, the average annual collective TEDE per reactor, average measurable TEDE per individual, and average collective TEDE per MW-yr were found to be 68 person-rem, 0.11 rem, and 0.08 person-rem per MW-yr, respectively. For PWRs from 2008 to 2009, all values either decreased slightly or remained the same.

In addition to the listings provided in Tables 4.5 and 4.6, considerable attention is paid to the quartile ranking of reactors for the 3-year average dose per reactor. The quartile ranking is used by the NRC as a factor in planning the number of inspection hours assigned per reactor. For this reason, Tables 4.7 and 4.8 have been included in the 2009 annual report for BWRs and PWRs respectively. These tables show the plant name, 3-year collective TEDE per reactor, the percent change in the 3-year average from the previous 3-year period, and the quartile ranking from the previous period if the ranking has changed.

TABLE 4.7

Three-Year Collective TEDE per Reactor-Year for BWRs
2007-2009

	Plant Name	Three-Year Coll. TEDE per Reactor Year 2007-2009	Percent Change From 2006-2008	2006-2008 Quartile (if changed)
1st Quartile	HATCH 1,2	85.453	-13% ▼	
	FITZPATRICK	92.877	-42% ▼	3
	COLUMBIA GENERATING	94.571	-32% ▼	2
	OYSTER CREEK	98.598	-34% ▼	3
	LIMERICK 1,2	101.445	7% ▲	
	BROWNS FERRY 1,2,3	116.001	-38% ▼	4
2nd Quartile	DUANE ARNOLD	117.590	49% ▲	1
	SUSQUEHANNA 1,2	120.418	13% ▲	1
	LASALLE 1,2	123.767	7% ▲	
	GRAND GULF	125.488	-7% ▼	
	FERMI 2	126.024	-8% ▼	
	HOPE CREEK 1	131.647	10% ▲	
3rd Quartile	MONTICELLO	136.266	52% ▲	1
	QUAD CITIES 1,2	140.465	-22% ▼	4
	Average 144.7			
	NINE MILE POINT 1,2	144.781	1% ▲	
	VERMONT YANKEE	148.662	3% ▲	
	PEACH BOTTOM 2,3	151.342	7% ▲	
	BRUNSWICK 1,2	153.855	0% ▼	
4th Quartile	CLINTON	165.775	-6% ▼	
	PILGRIM	175.770	72% ▲	1
	RIVER BEND 1	220.839	1% ▲	
	DRESDEN 2,3	221.287	74% ▲	2
	COOPER STATION	222.188	-2% ▼	
	PERRY	390.713	88% ▲	
	Average per Reactor-Year	**144.702**	**2% ▲**	

TABLE 4.8
Three-Year Collective TEDE per Reactor-Year for PWRs
2007-2009

	Plant Name	Three-Year Coll. TEDE per Reactor Year 2007-2009	Percent Change From 2006-2008	2006-2008 Quartile (if changed)
1st Quartile	PRAIRIE ISLAND 1,2	31.098	-31% ▼	
	SUMMER 1	35.944	-5% ▼	
	FARLEY 1,2	37.067	-10% ▼	
	HARRIS	38.855	-28% ▼	2
	DAVIS-BESSE	39.104	-63% ▼	4
	CALLAWAY 1	41.265	-1% ▼	
	PALO VERDE 1,2,3	45.164	-12% ▼	
	WATTS BAR 1	46.303	-65% ▼	4
	POINT BEACH 1,2	48.219	23% ▲	
	GINNA	49.406	-2% ▼	
	ROBINSON 2	51.925	2% ▲	
2nd Quartile	INDIAN POINT 2	52.261	-64% ▼	4
	KEWAUNEE	53.431	-10% ▼	
	CALVERT CLIFFS 1,2	53.873	-25% ▼	3
	SEABROOK	55.565	7% ▲	1
	VOGTLE 1,2	56.303	-10% ▼	
	BRAIDWOOD 1,2	57.214	-14% ▼	
	WOLF CREEK 1	57.647	-12% ▼	
	INDIAN POINT 3	58.335	61% ▲	1
	BYRON 1,2	58.842	-13% ▼	
	COOK 1,2	59.216	-43% ▼	4
3rd Quartile	SOUTH TEXAS 1,2	59.766	-16% ▼	2
	TURKEY POINT 3,4	61.863	5% ▲	2
	SEQUOYAH 1,2	62.341	-17% ▼	
	BEAVER VALLEY 1,2	65.751	-27% ▼	4
	SAN ONOFRE 2,3	65.833	-26% ▼	
	CATAWBA 1,2	66.451	-10% ▼	
	MCGUIRE 1,2	66.929	-7% ▼	
	ARKANSAS 1,2	67.348	-9% ▼	
	OCONEE 1,2,3	68.904	-6% ▼	
	FORT CALHOUN	70.354	-46% ▼	4
4th Quartile	COMANCHE PEAK 1,2	73.343	-2% ▼	3
	NORTH ANNA 1,2	74.728	-1% ▼	3
	SALEM 1,2	91.259	2% ▲	
	SURRY 1,2	91.850	-7% ▼	
	MILLSTONE 2,3	99.279	-2% ▼	
	ST. LUCIE 1,2	109.176	2% ▲	
	DIABLO CANYON 1,2	114.122	60% ▲	2
	THREE MILE ISLAND 1	119.401	195% ▲	1
	WATERFORD 3	136.478	55% ▲	3
	CRYSTAL RIVER 3	141.003	106% ▲	2
	PALISADES	182.468	5% ▲	
	Average per Reactor-Year	**68.343**	**-8% ▼**	

Average 68.3

4.6 DECONTAMINATION AND DECOMMISSIONING OF COMMERCIAL NUCLEAR POWER REACTORS

The NRC regulates the decontamination and decommissioning (D&D) of commercial nuclear power reactors. The purpose of the NRC's Decommissioning Program is to ensure that NRC-licensed sites are decommissioned in a safe, timely, and effective manner so that they can be returned to beneficial use and to ensure that stakeholders are informed and involved in the process, as appropriate.

The NRC's Office of Federal and State Materials and Environmental Management Programs (FSME) has project management responsibilities for decommissioning commercial nuclear power reactors. NRC commercial nuclear power reactor decommissioning activities include project management, technical review of licensee submittals in support of decommissioning, process of licensing amendments and exemptions in support of the progressive stages of decommissioning, inspections of decommissioning activities, support for the development of rulemaking guidance, public outreach efforts, international activities, and participation in industry conferences and workshops. FSME staff regularly coordinates with other offices on issues affecting all commercial nuclear power reactors, both operating and decommissioning, and specifically with staff in the Office of Nuclear Material Safety and Safeguards (NMSS) regarding the ISFSIs at reactor sites undergoing decommissioning. [Ref. 16]

4.6.1 Decommissioning Process

The decommissioning process begins when a licensee decides to permanently cease operations. The major steps that comprise the commercial nuclear power reactor decommissioning process are: notification of cessation of operations; submittal and review of the post-shutdown decommissioning activities report (PSDAR); submittal, review and approval of the license termination plan (LTP); implementation of the LTP; and completion of decommissioning. The flowchart in Figure 4.5 illustrates the D&D process.

4.6.1.1 Notification

When a licensee has decided to permanently cease operations, the licensee is required to submit a written notification to NRC. In addition, the licensee is required to notify the NRC in writing once fuel has been permanently removed from the reactor vessel.

4.6.1.2 Post-Shutdown Decommissioning Activities Report (PSDAR)

Before, or within 2 years after cessation of operations, the licensee must submit a PSDAR to the NRC and a copy to the affected State(s). The PSDAR must include: a description and schedule for the planned decommissioning activities; an estimate of the expected costs; and a discussion of the means for concluding that the environmental impacts associated with site-specific decommissioning activities will be bounded by appropriate, previously issued environmental impact statements. The NRC will notice receipt of the PSDAR in the *Federal Register* and make the PSDAR available for public comment. In addition, the NRC will hold a public meeting in the vicinity of the licensee's facility to discuss the PSDAR.

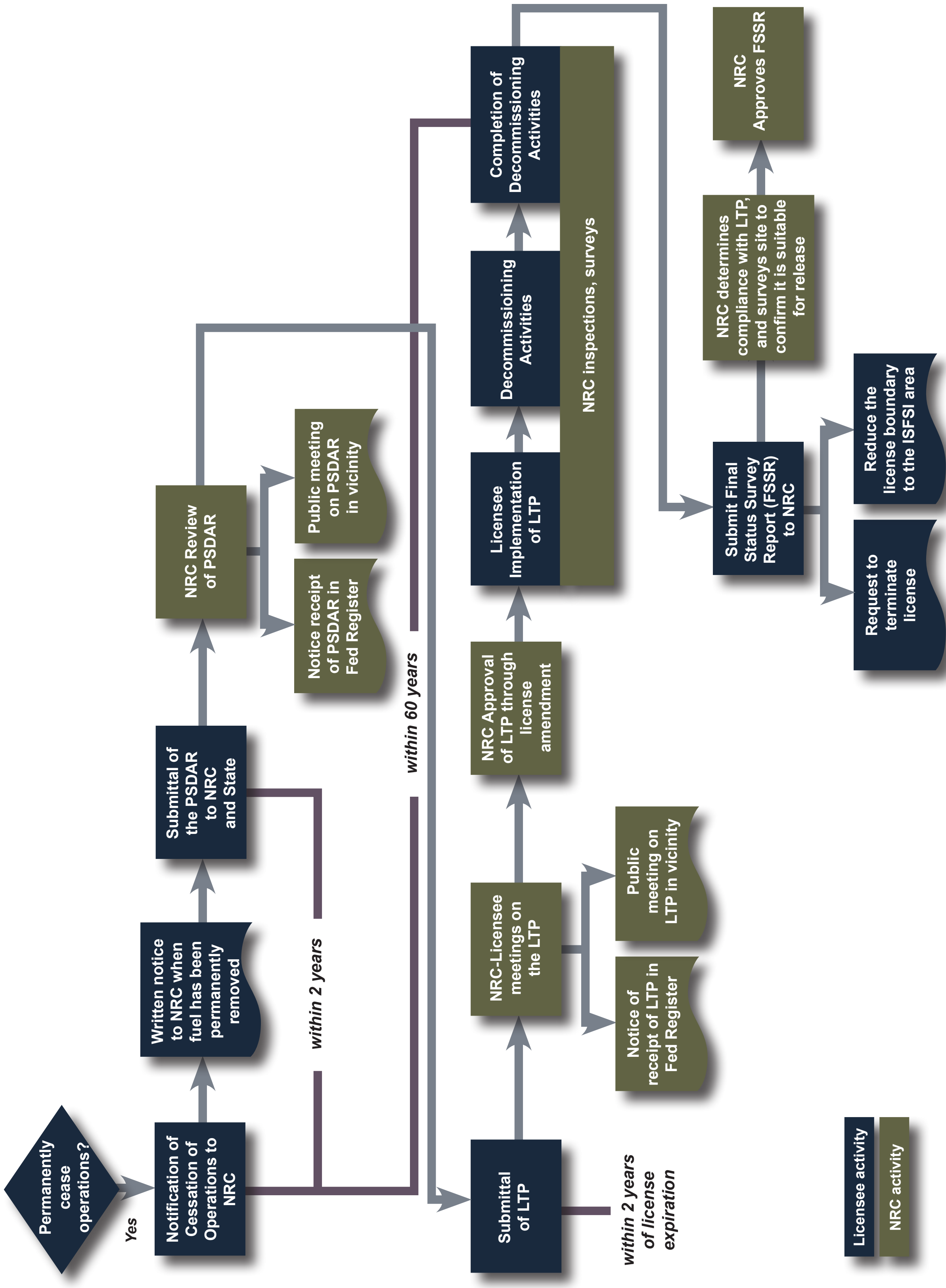


FIGURE 4.5. D&D Process Flowchart

4.6.1.3 License Termination Plan (LTP)

Each commercial nuclear power reactor licensee must submit an application for termination of its license. An LTP must be submitted at least 2 years before the license termination date. The NRC and licensee hold pre-submittal meetings to agree on the format and content of the LTP. These meetings are intended to improve the efficiency of the LTP development and review process. The LTP must include the following: a site characterization; identification of remaining dismantlement activities; plans for site remediation; detailed plans for the final radiation survey; description of the end use of the site, if restricted; an updated site-specific estimate of remaining decommissioning costs; and a supplement to the environmental report describing any new information or significant environmental change associated with the licensee's proposed termination activities. In addition, the licensee must demonstrate that it will meet the applicable requirements of the License Termination Rule in 10 CFR Part 20, Subpart E, "Radiological Criteria for License Termination."

The NRC will notice receipt of the LTP and make the LTP available for public comment. In addition, the NRC will hold a public meeting in the vicinity of the licensee's facility to discuss the LTP and the LTP review process. The NRC staff use 3 technical reports to guide them in the review of the LTP and approve the LTP through a license amendment.

4.6.1.4 Implementation of the License Termination Plan

After approval of the LTP, the licensee or responsible party must complete decommissioning in accordance with the approved LTP. The NRC staff will periodically inspect the decommissioning operations at the site to ensure compliance with the LTP. These inspections will normally include in-process and confirmatory radiological surveys.

Decommissioning must be completed within 60 years of permanent cessation of operations, unless otherwise approved by the Commission.

4.6.1.5 Completion of Decommissioning

At the conclusion of decommissioning activities, the licensee will submit a Final Status Survey Report (FSSR) which identifies the final radiological conditions of the site and requests that the NRC either: (1) terminate the 10 CFR Part 50 license or, (2) reduce the 10 CFR Part 50 license boundary to the footprint of the ISFSI. For decommissioning commercial nuclear power reactors with no ISFSI, or an ISFSI holding a specific license under 10 CFR Part 72, completion of reactor decommissioning will result in the termination of the 10 CFR Part 50 license. The NRC will approve the FSSR and the licensee's request if it determines that the licensee has met both of the following conditions: the remaining dismantlement has been performed in accordance with the approved LTP, and the final radiation survey and associated documentation demonstrate that the facility and site are suitable for release in accordance with the License Termination Rule.

4.6.2 Status of Decommissioning Activities at Commercial Nuclear Power Reactors

While 104 commercial nuclear power reactors are currently in commercial operation, several have undergone the process of D&D. As more commercial nuclear power reactors reach the end of their operating license, there will be a commensurate increase in activities involving radiation exposure related to D&D. For this reason, there is an increased need to provide further information on plants undergoing D&D.

Appendix B contains a list of the plants that are no longer in commercial operation along with the dose distribution and collective dose for these plants. It should be noted that these plants may be in different stages of D&D, so that a comparison of dose at one plant versus another would not be meaningful. In addition, Appendix B lists the plant units that are no longer in commercial operation but report along with other units at the site. Under the licensing conditions and reporting requirements, it is permitted to report this information together in one report. Table 4.9 lists the plants that have ceased operation and have changed the operational status as of the date shown. [Ref. 17] In addition, Appendix E provides descriptions of the decommissioning activities currently underway at these commercial nuclear power reactors as well as the total collective TEDE for each plant, from the year megawatt production stopped through 2009.

TABLE 4.9
Plants No Longer in Operation
2009

Plant Name	Date of First Commercial Operation	Plant Shutdown/ Notification to NRC	License Termination Plan Approved by NRC	PDSAR Submitted	Plant Status	Completion of Decommissioning
DRESDEN 1	8/1/1960	10/1978	9/1993	6/1998	SAFSTOR*	2036
FERMI 1	5/10/1963	9/1972		12/1975	DECON	2012
HUMBOLDT BAY 3	8/1/1963	7/1976	4/1987	2/1998	DECON**	2014
INDIAN POINT 1	3/26/1962	10/1974	1/1996		SAFSTOR	2026
LACROSSE	11/1/1969	4/1987	8/1991		SAFSTOR	2026
MILLSTONE 1	12/28/1970	7/1998		6/1999	SAFSTOR	2056
PEACH BOTTOM 1	1/24/1966	10/1974		6/1998	SAFSTOR	2034
RANCHO SECO	4/17/1975	6/1989	3/1995		DECON	2009
SAN ONOFRE 1	1/1/1968	11/1992	11/1994	12/1998	DECON	2030
THREE MILE ISLAND 2	12/30/1978	3/1979		2/1979	Post-Defueling Monitored Storage	2036
ZION 1	12/31/1973	2/1997		2/2000	SAFSTOR	2018
ZION 2	9/17/1974	9/1996		2/2000	SAFSTOR	2018

* SAFSTOR - (often considered 'delayed DECON'): a nuclear facility that is maintained and monitored in a condition that allows the radioactivity to decay; afterwards, it is dismantled.
** DECON - (immediate dismantlement): soon after the nuclear facility closes, equipment, structures, and portions of the facility containing radioactive contaminants are removed or decontaminated to a level that permits release of the property and termination of the NRC license.

4.7 GRAPHICAL REPRESENTATION OF DOSE TRENDS IN APPENDIX D

Each page of Appendix D presents a graph of selected dose performance indicators from 1973 through 2009. The dose and performance indicators illustrate the history of the collective dose per reactor for the site, the rolling 3-year average collective dose per reactor, and the electricity generated at the site. These data are plotted, beginning with each plant's first full year of commercial operation and continuing through 2009. Data for years when a plant was not in commercial operation have been included when available. However, any data reported prior to 1973 are not included. The 3-year average collective dose per reactor data are included because they provide an overall indication of each plant's general trend in collective dose. The 3-year average collective dose per reactor is also one of the metrics used by NRC in the Reactor Oversight Program to evaluate a licensee's ALARA program. This average is determined by summing the collective dose for the current year and the previous 2 years and then dividing this sum by the number of reactors reporting during those years. Depicting dose trends by using a 3-year average reduces the sporadic effects on annual doses of refueling operations (usually an 18- to 24-month cycle) and occasional high-dose maintenance activities and provides a more representative depiction of collective dose trends over the life of a plant. The annual average collective dose per reactor for all reactors of the same type is also shown on the graph.

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Section 5
TRANSIENT INDIVIDUALS AT NRC-LICENSED FACILITIES

5.1 TRANSIENT INDIVIDUALS AT NRC FACILITIES

The following analysis examines the individuals who had more than one Form 5 dose record at more than one NRC-licensed facility during the monitoring year. These individuals are defined as "transient" because they worked at more than one facility during the monitoring year.

The term "monitoring year" is used here in accordance with the definition of a year given in 10 CFR 20.1003, which defines a year as "the period of time beginning in January used to determine compliance with the provisions of 10 CFR Part 20. The licensee may change the start date of the monitoring year used to determine compliance provided that the change is made at the beginning of the monitoring/calendar year and that no day is omitted or duplicated in consecutive years."

Examination of the data reported for individuals who began and terminated two or more periods of employment with two or more different facilities within one monitoring year is useful in many ways. For example, the number of transients and the individual doses received by them can be determined from examining these data.

Additionally, the distribution of the doses received by transient individuals can be useful in determining the impact that the inclusion of these individuals in each of two or more licensees' annual reports has on the annual summary (as reported in Appendix B) for all nuclear power facilities and all NRC licensees combined (one of the issues mentioned in Section 2). Table 5.1 shows the actual distribution of transient individual doses as determined from the NRC Form 5 termination reports and compares it with the reported distribution of the doses of these individuals as they would have appeared in a summation of the annual reports submitted by each of the licensees.

In 2009, over 99% of the transient individuals were reported by nuclear power facilities. For this reason, these data are shown separately in Table 5.1.

Table 5.1 illustrates the impact that the multiple reporting of these transient individuals had on the summation of the dose reports for 2009. Each licensee reports the radiation dose received by individuals monitored at their facility. Many of these individuals are monitored at more than one facility during the year. When these dose records are summed up for all licensees, they appear to be separate individuals reported by each facility. If the individual visited five facilities during a year, he would appear in the summation to be five different people with five individual doses at each location. When these dose records are summed per individual, these records appear as one person, with a total annual dose that accurately represents the dose received for the entire monitoring year. Thus, while the total collective dose would remain the same, the number of individuals, their dose

TABLE 5.1
Effects of Transient Workers on Annual Statistical Compilations
2009

License Category	Number of Individuals with TEDE in the Ranges (rem) *												Total Number Monitored	Number with Measurable TEDE	Collective TEDE (person-rem)	Average Meas. TEDE (rem)
	No Measurable Exposure	Measurable <0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.0	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.0	>6				
POWER REACTORS																
(1) Form 5 Summation	94,627	52,670	17,417	8,352	2,161	741	413						176,381	81,754	10,024.804	0.12
(2) Transients, As Reported	36,334	25,117	10,267	5,004	1,305	464	247						78,738	42,404	5,877.745	0.14
(3) Transients, Actual	8,014	8,320	5,169	3,966	1,708	897	978	68	4				29,124	21,110	5,877.745	0.28
Corrected Distribution (1-[2-3])	**66,307**	**35,873**	**12,319**	**7,314**	**2,564**	**1,174**	**1,144**	**68**	**4**				**126,767**	**60,460**	**10,024.804**	**0.17**
ALL LICENSEES																
(1) Form 5 Summation	100,695	56,153	18,589	9,192	2,622	988	778	81	25	1			189,124	88,429	11,892.158	0.13
(2) Transients, As Reported	36,939	25,347	10,339	5,056	1,329	478	260	7	4				79,759	42,820	5,970.884	0.14
(3) Transients, Actual	8,031	8,351	5,189	3,997	1,731	912	1,005	73	4				29,293	21,262	5,970.884	0.28
Corrected Distribution (1-[2-3])	**71,787**	**39,157**	**13,439**	**8,133**	**3,024**	**1,422**	**1,523**	**147**	**25**	**1**			**138,658**	**66,871**	**11,892.158**	**0.18**

* Dose values exactly equal to the values separating ranges are reported in the next higher range.

distributions, and average doses would be affected by this multiple reporting. This was found to be true because too few individuals were reported in the higher dose ranges.

For example, in 2009, Table 5.1 shows that the summation of annual reports for reactor licensees indicated that no individual received a dose greater than 2 rem. After accounting for those individuals who were reported more than once, the corrected distribution indicated that there were 72 transient individuals who received doses greater than 2 rem. Four of these workers received doses greater than 3 rem. Correcting for the multiple counting of individuals also has a significant effect on the average measurable dose for these individuals. The corrected average measurable dose for transient individuals is twice as high as the value calculated by the summation of licensee records. The transient individuals represent 32% of the workforce that receives measurable dose. The correction for the transient individuals increases the average measurable dose by a factor of 2 from 0.14 rem to 0.28 rem for the transient workforce for all licensees. It should be noted that this analysis of transient individuals does not include individuals who may have been exposed at facilities that are not required to report to the NRC REIRS database (see Section 1), such as Agreement State licensees or DOE facilities.

One purpose of the REIRS database, which tracks occupational radiation exposures at NRC-licensed facilities, is to identify individuals who may have exceeded the occupational radiation dose limits because of multiple exposures at different facilities throughout the year. The REIRS database stores the radiation dose information for an individual by his/her unique identification number and identification type [Ref. 12, Section 1.5] and sums the dose for all facilities during the monitoring year. An individual exceeding the 5 rem per year regulatory limit (TEDE) would be identified in Table 5.1 in one of the dose ranges >5 rem. In 2009, there were no individuals reported by NRC licensees that exceeded this limit.

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Section 6
EXPOSURES TO PERSONNEL IN EXCESS OF REGULATORY LIMITS

6.1 REPORTING CATEGORIES

Doses in excess of regulatory limits are sometimes referred to as “overexposures.” The phrase “doses in excess of regulatory limits” is preferred to “overexposures” because the latter suggests that an individual has been subjected to an unacceptable biological risk, which may or may not be the case.

The implementation date for the revised 10 CFR Part 20 was January 1, 1994. 10 CFR Part 20 includes requirements for summing internal and external dose equivalents to yield TEDEs and to implement a similar limitation system for organs and tissues (such as the gonads, red bone marrow, bone surfaces, lung, thyroid, and breast). 10 CFR 20.1201 limits the TEDE of individuals to ionizing radiation from licensed material and other sources of radiation within the licensee’s control. 10 CFR Part 20 no longer contains quarterly dose limits but has reporting requirements for planned special exposures (PSEs).[8] The annual occupational dose limit (TEDE) for adults is 5 rem.

10 CFR 20.2202 and 10 CFR 20.2203 require that all licensees submit reports of all occurrences involving personnel radiation doses that exceed certain control levels, thus providing for investigations and corrective actions as necessary. Based on the magnitude of the dose, the occurrence may be placed into one of three categories as follows:

1. Category A
   10 CFR 20.2202(a)(1)— a TEDE to any individual of 25 rem or more, a lens dose equivalent of 75 rem or more, or a shallow-dose equivalent to the skin or extremities of 250 rads or more. The Commission must be notified immediately of these events.

2. Category B
   10 CFR 20.2202(b)(1)— In a 24-hour period, the Commission must be notified of the following events: a TEDE to any individual exceeding 5 rem, a lens dose equivalent exceeding 15 rem, or a shallow-dose equivalent to the skin or extremities exceeding 50 rem.

3. Category C
   10 CFR 20.2203—In addition to the notification required by 10 CFR 20.2202 (Category A or B events), each licensee must submit a written report within 30 days after learning of any of the following occurrences:

   a. Any incident for which notification is required by 10 CFR 20.2202

   b. Doses that exceed the limits in §20.1201, §20.1207, §20.1208, or §20.1301 (for adults, minors, the embryo/fetus of a declared pregnant individual, and the public, respectively), or any applicable limit in the license

[8] See 10 CFR Parts 20.1206, 20.2204, and Regulatory Guide 8.35 for more information on PSEs and their reporting requirements.

c. Levels of radiation or concentrations of radioactive material that exceed any applicable license limit for restricted areas or that, for unrestricted areas, are in excess of 10 times any applicable limit set forth in 10 CFR Part 20 or in the license (whether or not involving dose of any individual in excess of the limits in §20.1301)

d. For licensees subject to the provisions of the Environmental Protection Agency's generally applicable environmental radiation standards in 40 CFR 190, levels of radiation or releases of radioactive material in excess of those standards or license conditions related to those standards

6.2 LIMITATIONS OF THE DATA

It is important to note that this summary of events includes only

- Occupational radiation doses in excess of the regulatory limits
- Events at NRC-licensed facilities
- Final dose of record assigned to an individual

It **does not** include

- Medical events as defined in 10 CFR 35
- Doses in excess of the regulatory limits to the general public
- Agreement State-licensed activities or DOE facilities
- Other radiation-related violations, such as high dose-rate areas or effluent limits
- Exposures to dosimeters that, upon evaluation, have been determined to be high dosimeter readings only and are not assigned to an individual as the dose of record by the licensee

Care should be taken when comparing the summary information presented here with other reports and analyses published by NRC or other agencies. Various reports may include other types of "overexposure" events; therefore, the distinctions should be noted.

The analysis and summary of incidents presented here involving doses in excess of regulatory limits represent the status of events as of the publication of this report.

Exposure events of this type typically undergo a long review and evaluation process by the licensee, the NRC inspector for the regional office, and NRC Headquarters. Preliminary dose estimates submitted by licensees are often conservatively high and do not represent the final (record) dose assigned for the event. It is, therefore, not uncommon for a dose in excess of a regulatory limit event to be reassessed and the final assigned dose to be categorized as not having been in excess of the regulatory limits. In other cases, the exposure event may not be identified until a later date, such as during the next scheduled audit or inspection of the licensee's exposure event records.

For these reasons, an attempt is made to keep the exposure events summary presented here current. An event that has been reassessed and determined not to be a dose in excess of the regulatory limits is not included in this report. In addition, events that occurred in prior years are added to the summary in the appropriate year of occurrence. The reader should note that the summary presented here represents a snapshot of the status of events as of the publication date of this report. Previous or future reports may not correlate in the exact number of events because of the review cycle and reassessment of the events.

6.3 SUMMARY OF OCCUPATIONAL RADIATION DOSES IN EXCESS OF NRC REGULATORY LIMITS

In 2009, there were no category A, B, or C occurrences reported under the licensed activities included in this report.

Under the regulatory limits in 10 CFR 20.1201, an annual TEDE greater than 5 rem, for an adult occupational individual, is a dose that exceeds the regulatory limits.

Table 6.1 gives a summary of the annual occupational dose records reported to NRC, as required by 10 CFR 20.2206, by certain categories of NRC licensees. Table 6.1 shows that for the past 11 years, the percentage of individuals with <2 rem has been greater than 99%. The number of individuals receiving an annual dose greater than 5 rem has been <0.01% since 1998. No individual monitored at any of the five NRC licensee categories included in this report received a dose above the 5 rem annual regulatory limit (TEDE) during the past 6 years.

TABLE 6.1
Summary of Annual Dose Distributions for Certain* NRC Licensees
1999–2009

Year	Total Number of Monitored Individuals		Percent of Individuals with Doses <2 TEDE rem ***		Percent of Individuals with Doses <5 TEDE rem ***		Number of Individuals with Doses >12 TEDE rem ***
	Reported Number	Corrected Number **					
1999	166,084	129,117	99.6%	(534)	>99.99%	(1)	0
2000	163,073	125,026	99.5%	(573)	>99.99%	(3)	0
2001	154,717	118,150	99.4%	(734)	>99.99%	(1)	0
2002	162,381	119,694	99.5%	(582)	>99.99%	(1)	0
2003	165,941	122,213	99.7%	(419)	>99.99%	(1)	1
2004	164,017	122,975	99.7%	(368)	100%	(0)	0
2005	174,021	126,627	99.7%	(370)	100%	(0)	0
2006	176,071	126,726	99.8%	(258)	100%	(0)	0
2007	176,367	125,869	99.8%	(243)	100%	(0)	0
2008	181,368	129,796	99.9%	(167)	100%	(0)	0
2009	189,124	138,658	99.9%	(173)	100%	(0)	0

* Licensees required to submit radiation exposure reports to the NRC under 10 CFR 20.2206.
** This column lists the actual number of persons who may have been counted more than once because they worked at more than one facility during the calendar year (see Section 5).
*** Data for 1999–2009 are based on the distribution of individual doses after adjusting for the multiple counting of transient individuals (see Section 5). The number of people exceeding both 2 and 5 rem are shown in parentheses from 1999–2009.

6.4 MAXIMUM OCCUPATIONAL RADIATION DOSES BELOW NRC REGULATORY LIMITS

Because few doses exceed the NRC occupational radiation dose limits, certain researchers have expressed an interest in a listing of the maximum doses received at NRC licensees that do not exceed the regulatory limits. This would allow an examination of doses that approach, but do not exceed, the regulatory limits. Table 6.2 shows the maximum doses for each dose category required to be reported to the NRC. In addition, the number of doses in certain dose ranges is shown to reflect the number of doses that approach NRC regulatory limits. As shown in Table 6.2, few doses exceed half of the NRC occupational annual limits. In 2009, three individuals exceeded 75% of the TEDE dose limit, but no individual exceeded the 5 rem TEDE annual limit or any other annual limit.

TABLE 6.2
Maximum Occupational Doses for Each Exposure Category*
2009

Dose Category**	Annual Dose Limit 10CFR20***	Maximum Dose Reported (rem)	Max Dose Percent of the Limit	Number of Individuals with Measurable Dose	Numer of Individuals >25% of the Limit	Number of Individuals >50% of the Limit	Number of Individuals >75% of the Limit	Number of Individuals >95% of the Limit	Number of Individuals > Limit
SDE-ME	50 rem	45.790	92%	61,948	111	18	9	0	0
SDE-WB	50 rem	6.576	13%	66,873	0	0	0	0	0
LDE	15 rem	4.378	29%	65,032	5	0	0	0	0
CEDE		1.085		2,117					
CDE		9.021		2,224					
DDE		4.352		65,841					
TEDE	5 rem	4.352	87%	66,871	962	81	3	0	0
TODE	50 rem	9.251	19%	66,605	0	0	0	0	0

* Only records reported by licenssees required to report under 10 CFR 20.2206 are included. Numbers have been adjusted for the multiple reporting of transient individuals.

** SDE-ME = shallow dose equivalent to the maximally exposed extremity
SDE-WB = shallow dose equivalent to the whole body
LDE = lens dose equivalent to the lens of the eye
CEDE = committed effective dose equivalent
CDE = committed dose equivalent
DDE = deep dose equivalent
TEDE = total effective dose equivalent
TODE = total organ dose equivalent

*** Shaded boxes represent dose categories that do not have specific dose limits defined in 10 CFR 20.

Section 7
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