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Twentieth Annual Report

Radiation Exposures for DOE and DOE Contractor Employees - 1987

October 1989

Prepared for:
U.S. Department of Energy
Assistant Secretary for
Environment, Safety, and Health
Office of Safety Policy and Standards

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Under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

TWENTIETH ANNUAL REPORT
RADIATION EXPOSURES FOR DOE AND DOE CONTRACTOR EMPLOYEES
1987

PREFACE

This report is one of a series of annual reports provided by the U.S. Department of Energy (DOE) summarizing occupational radiation exposures received by DOE and DOE contractor employees. These reports provide an overview of radiation exposures received each year, as well as identification of trends in exposures being experienced over the years.

In 1968, the U.S. Atomic Energy Commission (AEC) established a program for reporting certain occupational radiation exposure information to a central radiation records repository. At the same time, a contract was established with Union Carbide Corporation at Oak Ridge, Tennessee, to computerize the processing of the radiation exposure reporting system. Annual summary reports were published from 1969 through 1973 (WASH-1350-R1 through WASH-1350-R6), which included information on AEC contractor employees and visitors, as well as employees and visitors of companies in the private sector licensed by the AEC.

In January 1975, with the separation of the 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. Former AEC licensees reported to the NRC while contractors reported to ERDA. At the same time, a contract was established with Union Carbide Corporation at Oak Ridge, Tennessee, to computerize the reporting and processing of both the ERDA and NRC radiation exposure reporting systems. On October 1, 1977, DOE was formed and assumed the responsibilities of ERDA. Processing and programming of exposure information continued at Oak Ridge until October 1978, when the management and further development of the DOE radiation exposure reporting system was assigned to the System Safety Development Center, EG&G Idaho, Inc.; the NRC system remained at Oak Ridge.

Radiation exposure data for ERDA and ERDA contractor employees and visitors for 1974 through 1976 were reported in ERDA 76/119, ERDA 77-29, and DOE/EV-0011/9. The DOE and DOE contractor radiation exposure data for 1977-1979 were presented in DOE/EV-0066/10, 11, and 12, respectively. A revised version of the 1979 report was issued as DOE/EP-0039. The data for 1980-1982 were presented in DOE/EP-0040, DOE/EP-0040/1, and DOE/EP-0040/2. The data for 1983-1986 were presented in DOE/PE-0072, DOE/EH-0011, DOE/EH-0036, and DOE/EH-0069, respectively. This report contains 1987 radiation exposure data for DOE and DOE contractor employees and visitors.

Previous reports for AEC/ERDA/DOE government and contractor employees and visitors may be obtained from the DOE Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830.

SUMMARY

All U.S. Department of Energy (DOE) and DOE contractors are required by Order DOE 5484.1, Chg 3, Chapter IV, to submit occupational radiation exposure records to a central repository. Data are required to be submitted for all employees who were required to be monitored in accordance with Order DOE 5480.1A, Chapter XI, and for all visitors who had a positive exposure. The data required include the external penetrating whole-body dose equivalent, the shallow dose equivalent, and a summary of internal depositions of radioactive material above specified limits. This report is a summary of the external penetrating whole-body dose equivalents and the internal depositions of radioactive material reported by DOE and DOE contractors for the year 1987.

A total of 81,028 DOE and DOE contractor employees were reported to have been monitored for whole-body ionizing radiation exposures in 1987. This represents 48.7% of all DOE and DOE contractor employees and is a substantial decrease (13,012) from the number of monitored employees reported for 1986. Much of this decrease is attributable to revised reporting requirements that took effect in 1987 and affected the reporting of the 1987 exposure data. In addition to the employees, 62,549 visitors were monitored.

Of all monitored employees reported, 57.4% received a dose equivalent that was less than measurable, 40.7% a measurable dose equivalent less than 1 rem, and 1.9% a dose equivalent greater than 1 rem. No employee received a dose equivalent greater than 4 rem. The dose equivalent received by 91.3% of the visitors to DOE facilities was less than measurable. Only 8.6% of the visitors received a measurable dose equivalent less than 1 rem, and 0.08% of the visitors received a dose equivalent greater than 1 rem. No visitor received a dose equivalent greater than 3 rem.

The collective dose equivalent for DOE and DOE contractor employees was 5,980 person-rem. The collective dose equivalent for visitors was 373 person-rem. The total dose equivalent for employees and visitors combined was 6,353 person-rem. The average dose equivalent for all monitored individuals (employees and visitors) reported was 44 mrem, and the average dose equivalent for all individuals reported who received a measurable exposure was 159 mrem. The highest average dose equivalent for all monitored individuals reported was observed at reactor facilities (167 mrem), and the lowest was observed for visitors (6 mrem) to DOE facilities. These averages are significantly less than the DOE 5-rem/year radiation protection standard for whole-body exposures.

Two cases of internal body depositions were reported in 1987 that exceeded 50% of the pertinent annual dose-equivalent standard as set forth in Order DOE 5480.1A, Chapter XI. Both occurred during 1987 and are considered new cases.

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TWENTIETH ANNUAL REPORT

RADIATION EXPOSURES FOR DOE AND DOE CONTRACTOR EMPLOYEES 1987

INTRODUCTION

One of the basic Department of Energy (DOE) radiation protection policy objectives is that radiation exposures be maintained as low as is reasonably achievable (ALARA) within the occupational exposure guidelines provided in Order DOE 5480.1A, Chapter XI (Table 1). Assurance that occupational exposures do not exceed the guidelines is not considered, in itself, sufficient for demonstrating achievement of this objective. All operations are to be conducted in a manner to assure that radiation exposures to employees and visitors are maintained at the lowest levels technically and economically practicable.

TABLE 1. Radiation Protection Standards for External and Internal Dose Equivalents for Individuals in Controlled Areas[a]

Type of Exposure	Exposure Period	Dose Equivalent (Dose or Dose Commitment)(rem)[b]
Whole body, head and trunk, gonads, lens of the eye,[d] red bone marrow, active blood-forming organs	Year	5[c]
	Calendar quarter	3
Unlimited areas of the skin (except hands and forearms), other organs, tissues, and organ systems (except bone)	Year	15
	Calendar quarter	5
Bone	Year	30
	Calendar quarter	10
Forearms[e]	Year	30
	Calendar quarter	10
Hands[e] and feet	Year	75
	Calendar quarter	25

(a) As of January 1, 1989, Order DOE 5480.1A, Chapter XI, was superseded by Order DOE 5480.11. However, because this report addresses 1987 exposure data, the requirements of the former Order are presented.

(b) To meet the dose commitment standards above, operations must be conducted in such a manner that it would be unlikely that an individual would assimilate in a critical organ, by inhalation, ingestion, or absorption, a quantity of radionuclide(s) that would commit the individual to an organ dose that exceeds the standards specified in this table.

(c) In special cases, with the approval of the Deputy Assistant Secretary for Safety, Health, and Quality Assurance, a worker may exceed 5 rem/year provided his/her average exposure per year since age 18 will not exceed 5 rem/year. This does not apply to emergency situations.

(d) A beta exposure below a maximum energy of 700 keV will not penetrate the lens of the eye; therefore, the applicable standard for these energies would be that for the skin (15 rem/year).

(e) All reasonable effort shall be made to limit exposure of forearms and hands to the standard for the skin.

To assist in the determination that doses to individuals are maintained at the lowest level reasonably achievable, DOE requires the submittal of occupational radiation exposure records to a central repository. The central data base also includes occupational radiation exposure information for the former Atomic Energy Commission (AEC) and former Energy Research and Development Administration (ERDA).

This report includes a summary of the data submitted for 1987 by DOE and DOE contractor facilities. Data from previous years are also included so that trends can be analyzed. Appendixes A, B, and C present whole-body exposure data for employees and visitors in 1987.

SUMMARY OF WHOLE-BODY IONIZING RADIATION DOSES

Monitoring is required by Order DOE 5480.1A, Chapter XI, where the potential exists for an individual to receive a dose or dose commitment in excess of 10% of the quarterly or annual occupational radiation exposure standards shown in Table 1. (As of January 1, 1989, Order DOE 5480.1A, Chapter XI, was superseded by Order DOE 5480.11. However, because this report addresses 1987 exposure data, the requirements of the former Order are presented.) Depending on the administrative policy of the contractor, monitoring may also be provided to individuals, such as clerical workers, for whom the exposure potential is extremely low.

On November 6, 1987, DOE promulgated revised reporting requirements in Order DOE 5484.1, Chg 3, which affected the reporting of occupational doses received during 1987. Before 1987, DOE contractors were required to report the number of individuals who received an occupational whole-body exposure in one of 16 dose-equivalent intervals ranging from "less than measurable" to "greater than 10 rem." Contractors were also required to report separately any uptake of radioactive material that resulted in a dose commitment to the critical organ in excess of 50% of the pertinent annual dose equivalent standards set forth in Order DOE 5480.1A, Chapter XI.

Currently, however, contractors are required by the revised reporting requirements to submit exposure data for individual employees and visitors. Data required to be submitted include total effective dose equivalent, external penetrating whole-body dose equivalent, internal effective dose equivalent, shallow dose equivalent and extremity dose equivalent. However, because the revised Order specifying radiation protection requirements for workers (DOE 5480.11) did not become effective until January 1, 1989, reporting of total effective dose equivalents, internal effective dose equivalents and extremity dose equivalents were not required for 1987 and 1988 exposure data. Consequently, this report is a summary of external penetrating dose equivalents received by DOE and DOE contractor employees and visitors in 1987. This report also summarizes uptakes of radioactive material that were required to be reported as described in the preceding paragraph. These reporting requirements for uptakes of radioactive material will remain in effect for the 1988 exposure data but will be superseded by the new reporting requirements that will become effective beginning with the 1989 exposure data.

One benefit of the revised reporting requirements is that calculation of collective dose equivalents received by DOE and DOE contractor employees and visitors will be more accurate than in the past. In previous reports, collective dose equivalents were calculated by multiplying the number of individuals who received dose equivalents in various dose equivalent ranges by the midpoint of those ranges and summing the products. For this report, however, this calculational method was not necessary because the actual doses received by individuals were reported by the contractors. This allowed the actual collective dose equivalents received by individuals to be determined. Analysis of the 1987 data indicated that using the midpoints of the dose equivalent ranges rather than the actual dose equivalents reported would have resulted in an overestimate of the collective dose equivalent received by all DOE and DOE contractor employees and visitors by 15.5%. Therefore, it is likely that the collective dose equivalents reported for previous years were overestimated by between 10% and 20%.

Another important change resulting from the revised reporting requirements is that the specific employees required to be reported has changed. Although both the former and current reporting requirements state that annual reports shall be submitted for all monitored DOE and DOE contractor workers, the current requirements define the term "monitored worker" whereas the former requirements did not. Monitored workers are defined by the current requirements as those employees who work with or near ionizing radiation or radioactive material and who are monitored in accordance with Order DOE 5480.1A. Therefore, the term "monitored worker" is generally considered to be synonymous with the term "radiation worker." As a result, some contractors chose not to report data for individuals who were not required to be monitored, especially those who received no measurable dose. This probably accounts for the significant decrease in the number of monitored employees reported for 1987 compared to previous years.

DISTRIBUTION BY DOSE INTERVAL

The number of employees and visitors who received a dose equivalent in each of 16 dose-equivalent ranges is presented in Table 2. No DOE or DOE contractor employee received a dose equivalent greater than the DOE radiation protection standard of 5 rem. A total of 81,028 DOE and DOE contractor employees were reported to have been monitored for whole-body ionizing radiation exposure in 1987. This represents 48.7% of all DOE and DOE contractor employees. In addition to the employees, 62,549 visitors were monitored at DOE facilities. Visitors may include radiation workers from another DOE facility present on a temporary basis.

For comparison, Table 2 lists both the actual collective dose equivalents reported for each dose-equivalent interval and the collective dose equivalents that would have been calculated had the midpoints of the dose equivalent ranges been multiplied by the number of persons in those ranges. The latter calculational method was used in previous reports because individual exposure data were not submitted to the central repository. The data indicate that almost 70% of the overestimate of the total collective dose equivalent using this method is attributable to the "Measurable to 0.1 rem" dose equivalent interval.

TABLE 2. Distribution of Whole-Body Ionizing Radiation Doses for DOE/DOE Contractor Employees and Visitors by Dose-Equivalent Interval, 1987

Dose-Equivalent Interval (rem)	Number of Persons			Collective Person-rem		
	Employees	Visitors	Total	Employees	Visitors	Total
<Measurable	46,512	57,116	103,628	0	0	0
Measurable to 0.10	24,163	4,697	28,860	665	99	764 (1,443)[a]
0.10 to 0.25	4,799	437	5,236	762	65	827 (916)
0.25 to 0.50	2,376	121	2,497	846	45	891 (936)
0.50 to 0.75	988	79	1,067	605	47	652 (667)
0.75 to 1.00	613	46	659	532	40	573 (577)
1 to 2	1,258	52	1,310	1,776	72	1,849 (1,965)
2 to 3	283	1	284	672	3	675 (710)
3 to 4	36	0	36	122	0	122 (126)
4 to 5	0	0	0	0	0	0
5 to 6	0	0	0	0	0	0
6 to 7	0	0	0	0	0	0
7 to 8	0	0	0	0	0	0
8 to 9	0	0	0	0	0	0
9 to 10	0	0	0	0	0	0
>10	0	0	0	0	0	0
TOTAL	81,028	62,549	143,577	5,980	373	6,353 (7,340)

(a) Numbers in parentheses indicate the collective dose equivalents that would have been calculated by multiplying the midpoints of the dose-equivalent ranges by the numbers of persons in those ranges.

A comparison of the number of DOE and DOE contractor employees, the number of monitored employees reported and the number of monitored employees reported who did not receive a measurable dose equivalent in the last eight years is presented in Figure 1. The number of monitored employees reported for 1987 decreased significantly from the number reported for previous years (Figure 1).[a]

Of the monitored employees reported for 1987, 57.4% received a dose equivalent that was less than measurable, 40.7% a measurable dose equivalent less than 1 rem, and 1.9% a dose equivalent greater than 1 rem (Figure 2). The dose equivalent received by 91.3% of the visitors to DOE facilities was less than measurable. Only 8.6% of the visitors received a dose equivalent between measurable and 1 rem, and 0.08% of the visitors received a dose equivalent greater than 1 rem (Figure 2).

(a) Much of this decrease is attributable to the revised reporting requirements as discussed on page 3.

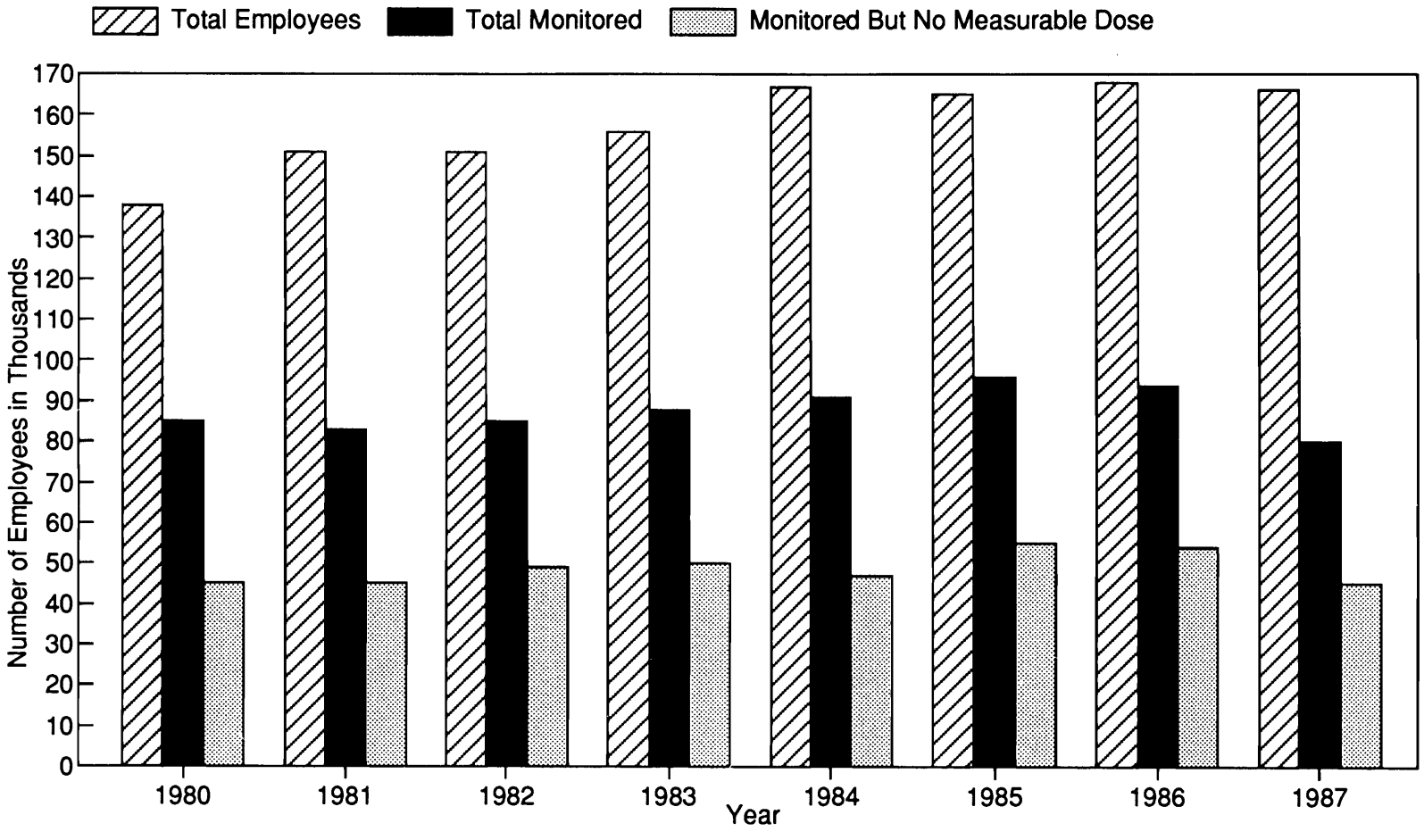

FIGURE 1. Comparison of Number of Employees, Number of Employees Monitored, and Number of Employees Monitored Who Received No Measurable Dose Equivalent, 1980-1987

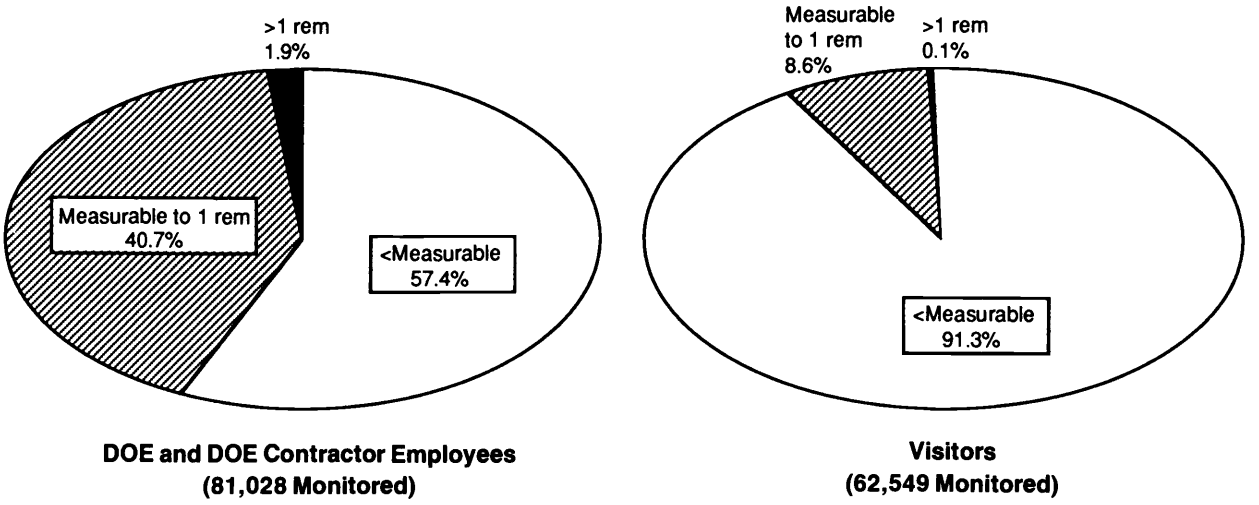

FIGURE 2. Percentage of Monitored Employees and Percentage of Monitored Visitors Who Received Dose Equivalents Less Than Measurable, Measurable to 1 rem, or Greater Than 1 rem, 1987

The collective whole-body dose equivalent was 5,980 person-rem for all DOE and DOE contractor employees, and 373 person-rem for visitors to DOE facilities, for a total collective dose equivalent of 6,353 person-rem. The contribution of the individuals in each dose-equivalent interval to the collective dose equivalent is shown in Figure 3. Individuals whose exposure was less than 1 rem contributed the greatest portion (58.4%) of the total person-rem.

The distribution of whole-body doses for the years 1965-1987 is presented in Table 3. As indicated in Table 3, the fraction of all monitored workers who received a dose equivalent greater than 1 rem has gradually declined since 1965, starting at about 5% and leveling off at about 2% for the last ten years. This general downward trend in occupational radiation exposures can be observed in Figure 4, which shows the collective dose equivalent for all individuals from 1965 to 1987 who received a dose equivalent greater than 1 rem. The collective dose equivalent for individuals who received an exposure less than 1 rem was not included because before 1974, less-than-measurable exposures were not distinguished from measurable exposures in the reporting system. This decrease in collective dose equivalent has been achieved even though some work was performed in older facilities which were not constructed using current design criteria. This trend reflects both changes in the nature of the work performed at DOE facilities and the required application of ALARA practices throughout all DOE operations.

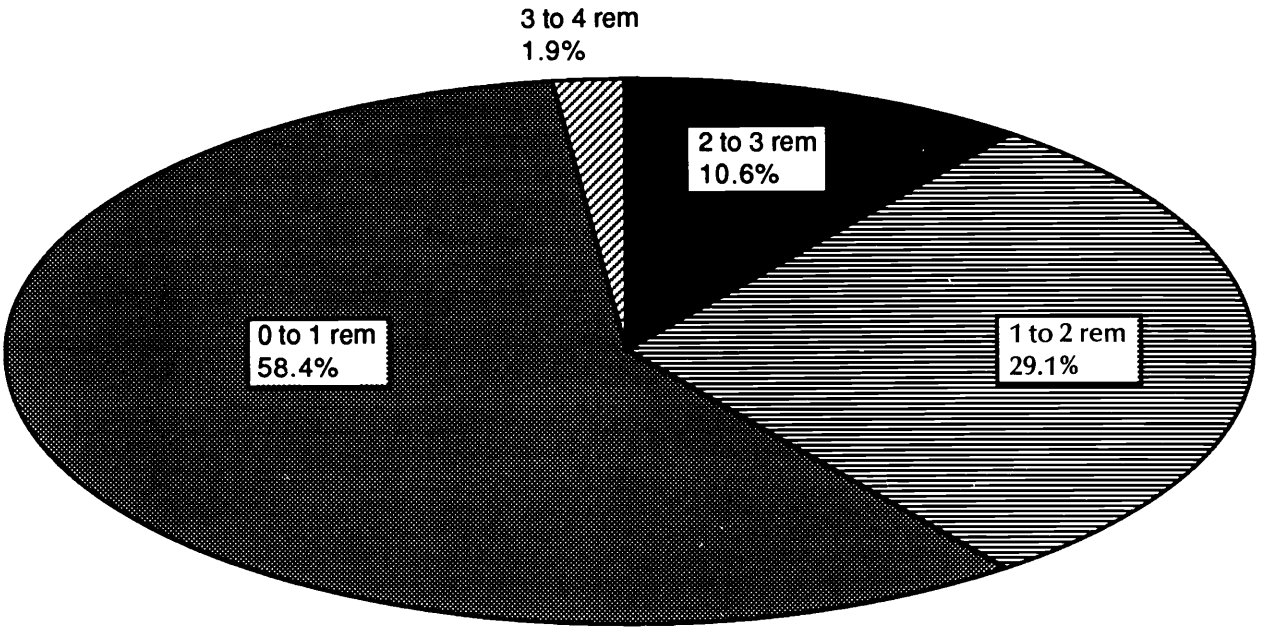

FIGURE 3. Contribution of Each Dose-Equivalent Interval to the Total Collective Dose Equivalent, 1987

TABLE 3. Distribution of Whole-Body Ionizing Radiation Doses for DOE/DOE Contractor Employees, 1965-1987

Year	Number of Employees Receiving Doses in Each Dose-Equivalent Range (rem)														Total Monitored
	0-1[a] <Meas.	Meas.-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12	
1965	128,360		4,158	1,704	515	294	70	32	26	25	22	6	2		135,214
1966	131,522		3,706	1,630	593	313	88	47	24	6	2			1	137,932
1967	102,510		3,472	1,572	555	168	35	29	23	17	4	1			108,386
1968	103,206		2,799	1,408	425	144	3	1							107,986
1969	98,625		2,554	1,313	335	86	4					1			102,918
1970	92,185		2,698	1,329	279	158	5	4	2		1				96,661
1971	90,640		2,380	888	275	118	8	3				1		2	94,315
1972	86,077		2,130	929	219	95	8	2							89,460
1973	89,071		1,944	727	172	60	2	1							91,977
1974	43,184	32,500	1,667	688	149	40	4								78,232
1975	43,310	42,141	1,846	753	232	142				1					88,425
1976	40,083	47,886	1,679	475	70	6	1								90,200
1977	43,017	49,948	1,579	545	103	23			1	2				2	95,220
1978	44,898	55,296	1,323	439	53	11									102,020
1979[b]	50,003	53,235	1,286	416	33	10	1							2	104,986
1980	45,054	38,895	1,113	387	16										85,465
1981[b]	45,224	36,561	967	263	29	5									83,049
1982	48,968	34,949	1,010	313	56	28									85,324
1983	49,871	36,768	1,270	294	49	31									88,283
1984[b]	47,327	42,696	1,226	312	31	11									91,603
1985	55,939	38,085	1,366	356	51	8				1					95,806
1986	54,581	37,774	1,298	349	35	1		1					1		94,040
1987	46,512	32,939	1,258	283	36										81,028

(a) Separation of data before 1974 is unavailable.

(b) The data differ slightly from those listed in previous reports because of errors reported by individual contractors after publication of the annual report.

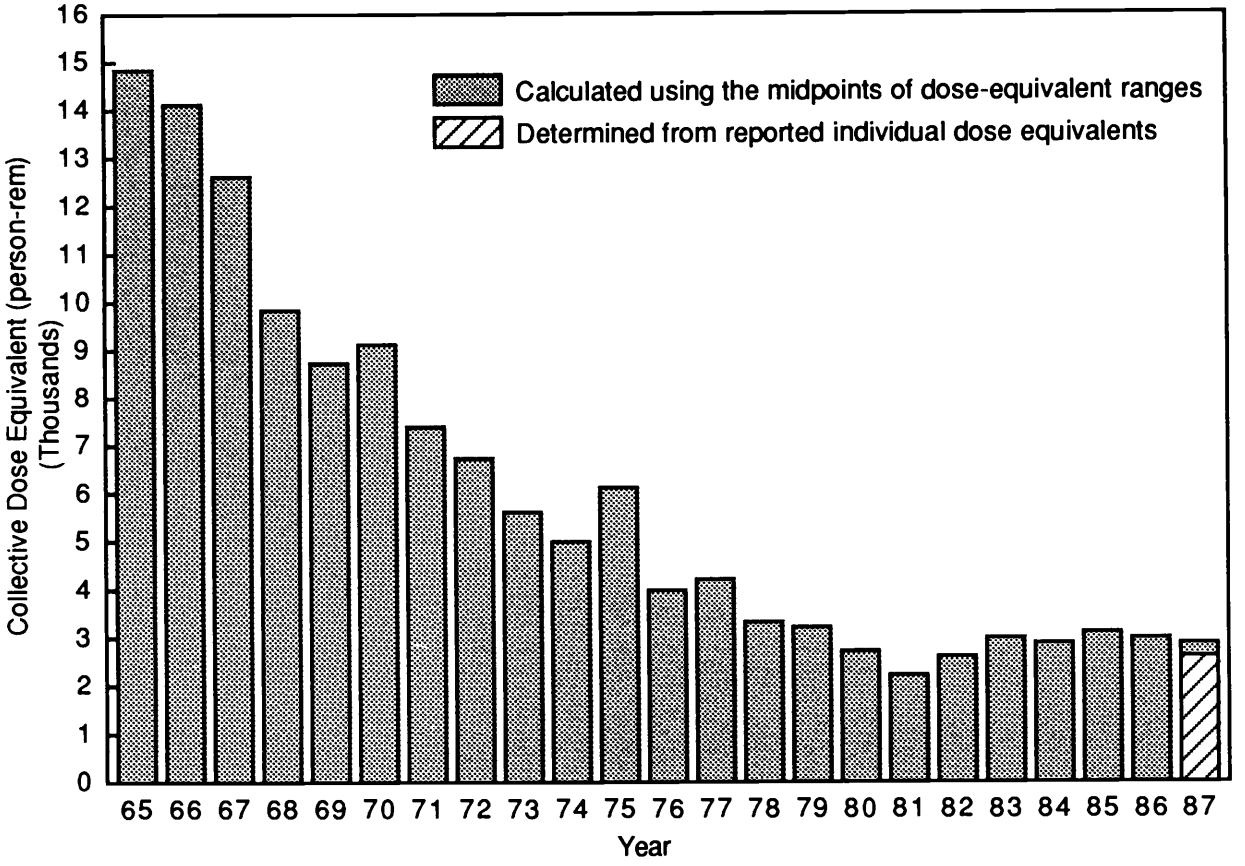

FIGURE 4. Total Collective Dose Equivalent for all DOE/DOE Contractor Employees Who Received a Dose Equivalent Greater Than 1 rem, 1965-1987

DISTRIBUTION BY FACILITY TYPE

The number of individuals and the distribution of the annual whole-body dose equivalents in each of 11 facility categories were reported to the central repository. The assignment of exposures to one of the 11 facility types (listed in Order DOE 5484.1, Chg 3) is a policy decision of each field organization. For this report, visitors and DOE offices were also considered a facility type. The contribution of each facility type to the collective dose equivalent is shown in Figure 5. The largest percentage of the total collective dose equivalent was in the category "Maintenance and Support." The smallest contribution was from DOE offices. A summary of the data is presented in Table 4.

The average dose equivalent by facility type per individual monitored and per individual monitored with a measurable dose equivalent is shown in Table 5. The average dose equivalent per individual monitored for all facilities combined was 44 mrem. The highest average dose equivalent per individual monitored was observed at reactor facilities (167 mrem), and the lowest was observed for visitors to DOE facilities (6 mrem). The average dose equivalent per individual monitored with a measurable dose equivalent was 159 mrem. The highest average dose equivalent for individuals monitored with a measurable dose equivalent was observed at fuel processing facilities (267 mrem), and the lowest was observed at DOE offices (30 mrem).

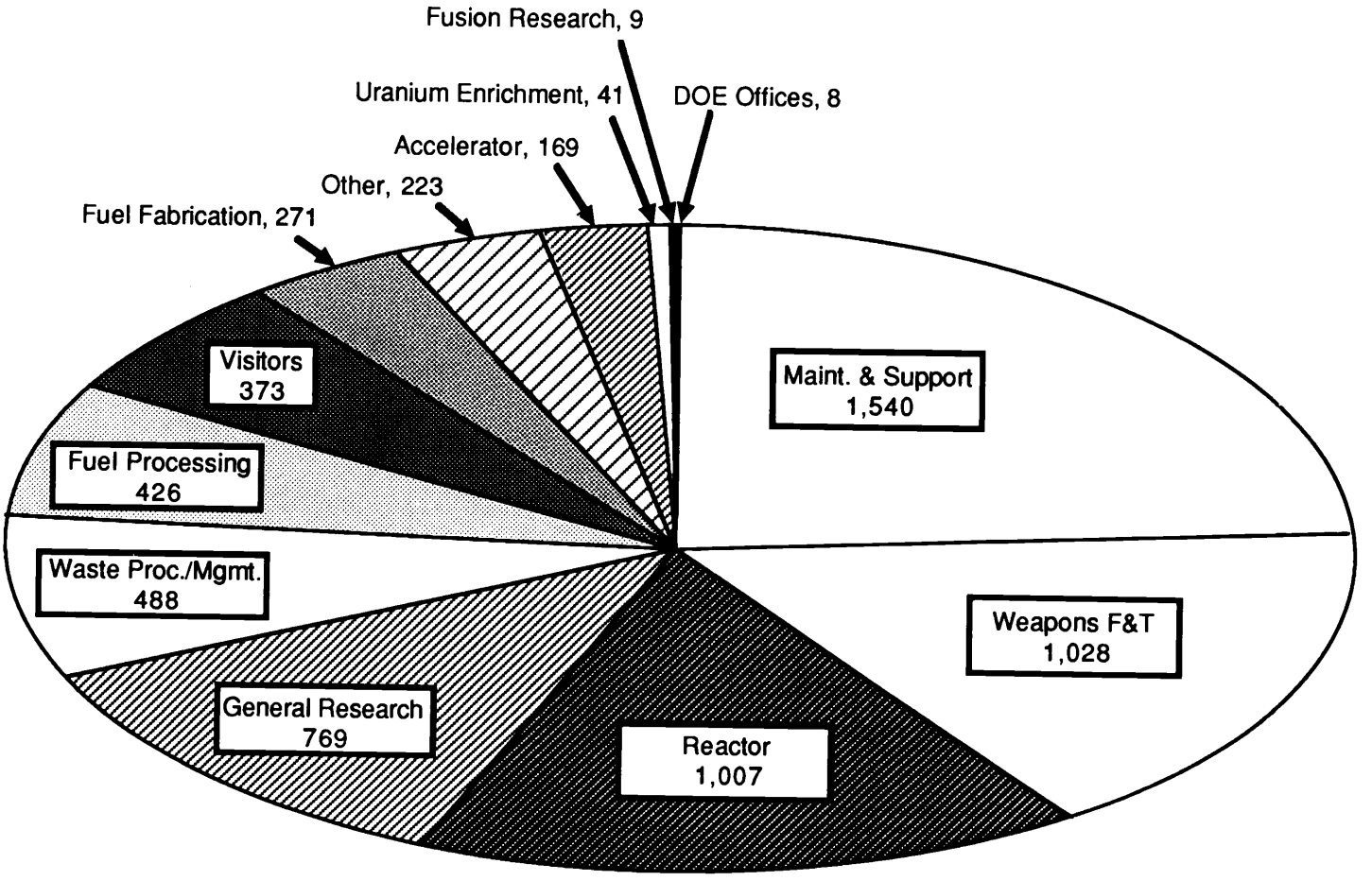

FIGURE 5. Contribution of Each Facility Type to the Total Collective Dose Equivalent, 1987

TABLE 4. Distribution of Annual Whole-Body Doses for DOE/DOE Contractor Employees and Visitors by Facility Type, 1987[a]

Facility Type	Total Persons Monitored	Number of Persons Receiving Dose Equivalents in Each Dose-Equivalent Range (rem)																Total Person-rem
		<Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	
Accelerator	3,636	1,909	1,379	198	78	28	16	27	1									169
Fuel/Uranium Enrichment	3,412	2,291	1,031	70	16	2	1	1										41
Fuel Fabrication	2,785	1,036	1,007	339	293	86	15	6	3									271
Fuel Processing	3,088	1,491	797	312	198	100	82	104	4									426
Maintenance and Support	18,394	10,207	5,988	978	452	203	109	311	123	23								1,540
Reactor	6,048	1,827	2,814	614	235	119	97	242	88	12								1,007
Research, General	20,760	15,630	3,719	656	335	121	107	165	26	1								769
Research, Fusion	1,346	1,150	177	17	1	1												9
Waste Processing/ Management	3,274	1,248	1,183	349	178	101	68	135	12									488
Weapons Fabrication and Testing	10,561	4,937	3,596	1,014	459	189	97	247	22									1,028
Other	6,429	3,763	2,213	241	129	38	21	20	4									223
Visitors	62,549	57,116	4,697	437	121	79	46	52	1									373
DOE Offices	1,295	1,023	259	11	2													8
TOTAL PERSONS	143,577	103,628	28,860	5,236	2,497	1,067	659	1,310	284	36								
TOTAL PERSON-REM			764	827	891	652	573	1,849	675	122								6,353

(a) Throughout this report there may be minor variations in collective dose-equivalent values because of rounding.

TABLE 5. Collective Dose Equivalents for DOE/DOE Contractor Employees and Visitors by Facility Type, 1987[a]

Facility Type	No. Individuals Monitored	No. Individuals with a Measurable Dose	Collective Dose Equivalent (Person-rem)	Average Dose Equivalent (mrem) Per Individual Monitored	Average Dose Equivalent (mrem) Per Individual Monitored with a Measurable Dose
Accelerator	3,636	1,727	169	46	98
Fuel/Uranium Enrichment	3,412	1,121	41	12	37
Fuel Fabrication	2,785	1,749	271	97	155
Fuel Processing	3,088	1,597	426	138	267
Maintenance and Support	18,394	8,187	1,540	84	188
Reactor	6,048	4,221	1,007	167	239
Research, General	20,760	5,130	769	37	150
Research, Fusion	1,346	196	9	6	43
Waste Processing/ Management	3,274	2,026	488	149	241
Weapons Fabrication and Testing	10,561	5,624	1,028	97	183
Other	6,429	2,666	223	35	84
Visitors	62,549	5,433	373	6	69
DOE Offices	1,295	272	8	6	30
TOTAL	143,577	39,949	6,353	44	159

(a) Throughout this report there may be minor variations in collective dose-equivalent values because of rounding.

DISTRIBUTION BY FIELD ORGANIZATION

For each field organization, the number of monitored individuals reported, the number of individuals having a measurable dose and the collective dose equivalent are shown in Table 6. Differences in the collective dose equivalent at each field organization reflect differences in the nature of the work performed and the administrative policy concerning whether the dose distribution is reported for all monitored employees or only for those for whom monitoring is required. Table 7 provides an indication of the work performed at each field organization by showing the fraction of the collective dose equivalent at each field organization attributed to each facility type.

Table 8 presents collective dose equivalents for each field organization from 1980 to 1987. As indicated by the 1987 data, the practice of using the midpoints of dose-equivalent ranges to calculate collective dose equivalent overestimates the actual collective dose equivalent. This practice was necessary for pre-1987 data because of the lack of a requirement to report individual exposure data. For 1987, this practice would have resulted in overestimates in collective dose equivalents ranging from 7% (Richland) to 68% (Pittsburgh). The collective dose equivalent for all DOE and DOE contractor employees and visitors would have been overestimated by 15.5%. Therefore, it is likely that the collective dose equivalents reported for the years 1980 to 1986 were overestimated by between 10% and 20%. Applying a value of 15.5% for the 1986 data, the actual collective dose equivalent would have been 7,327 rem. Comparing this value to the actual collective dose equivalent for 1987 (6,353 rem), the total collective dose equivalent for DOE and DOE contractor employees and visitors decreased by over 13% from 1986 to 1987.

TABLE 6. Collective Dose Equivalents for DOE/DOE Contractor Employees and Visitors by Field Organization, 1987

Field Organization	No. Individuals Monitored	No. Individuals with Measurable Doses	Collective Dose Equivalent (Person-rem)	Average Dose Equivalent (mrem) Per Individual Monitored	Average Dose Equivalent (mrem) Per Individual Monitored with a Measurable Dose
Albuquerque	21,601	8,647	1,363	63	158
Chicago	14,002	3,889	348	25	90
Idaho	7,317	1,972	318	43	161
Nevada	7,579	98	8	1	80
Oak Ridge	15,997	4,185	517	32	123
Pittsburgh Naval Reactor	2,203	1,726	78	36	45
Richland	23,734	6,843	2,477	104	362
San Francisco	29,630	1,078	78	3	73
Savannah River	18,454	9,245	945	51	102
Schenectady Naval Reactor	3,060	2,266	220	72	97
TOTAL	143,577	39,949	6,353	44	159

TABLE 7. Percent of Collective Dose Equivalent for DOE/DOE Contractor Employees and Visitors Attributed to a Facility Type Within Each Field Organization, 1987

Field Organization	Facility Type												
	Accel.	Fuel Enrich.	Fuel Fab.	Fuel Proc.	Maint. Support	Reactor	Research, General	Research, Fusion	Waste Proc./Man.	Weapon F&T	Other	Visitors	DOE Offices
Albuquerque					1.7		25.9		< 0.1	67.0	1.3	3.9	0.2
Chicago	38.8		0.1		8.2	11.2	19.6	1.6	1.2		0.5	18.7	0.2
Idaho				43.4	3.1	24.8	0.7		1.3		25.2	1.3	0.1
Nevada					9.1		0.4		1.3	86.2		3.0	
Oak Ridge		7.7	38.6	1.5			28.3		< 0.1	17.9		6.0	
Pittsburgh N.R.						42.6	56.8					0.5	
Richland	< 0.1		0.6	0.6	44.3	31.3	4.2		14.8		3.8	0.4	<0.1
San Francisco	42.5	1.8			16.0		19.6	3.6	< 0.1	5.8	0.5	10.0	0.2
Savannah River			6.0	28.2	38.9	5.3	3.2		11.9	1.2	3.1	2.0	0.3
Schenectady N.R.						14.0	2.8				< 0.1	83.2	
ALL FIELD ORGANIZATIONS COMBINED	2.7	0.7	4.3	6.7	24.2	15.9	12.1	0.1	7.7	16.2	3.5	5.9	0.1

TABLE 8. Collective Dose Equivalent for DOE/DOE Contractor Employees and Visitors by Field Organization, 1980-1987 (person-rem)

Field Organization	1980	1981[a]	1982	1983	1984[a]	1985	1986	1987	
Albuquerque	1,700	2,024	2,285	2,332	2,738	2,900	2,388	1,363	(1,591)[b]
Chicago	918	758	587	623	615	502	408	348	(438)
Idaho	593	302	363	353	441	420	685	318	(362)
Nevada	50	36	29	25	24	34	65	8	(9)
Oak Ridge	604	437	401	371	419	353	611	517	(610)
Pittsburgh Naval Reactor	186	185	194	220	180	180	143	78	(131)
Richland	2,256	2,093	2,272	2,458	2,399	2,548	2,321	2,477	(2,646)
San Francisco	240	171	289	267	195	187	108	78	(101)
Savannah River	1,391	1,401	1,310	1,293	1,283	1,394	1,498	945	(1,162)
Schenectady Naval Reactor	79	76	147	217	130	165	238	220	(290)
TOTAL	[8,024][c]	[7,483]	[7,879]	[8,158]	[8,423]	[8,684]	[8,465]	6,353	(7,340)

(a) The data differ slightly from those listed in previous reports because of errors reported by individual contractors after publication of the annual report.

(b) Numbers in parentheses indicate the collective dose equivalents that would have been calculated by using the midpoints of the dose equivalent ranges to calculate collective dose equivalent as was done for the 1980-1986 data. 1987 was the first year for which actual individual dose equivalents were reported. The data suggest that the actual collective dose equivalent received by DOE/DOE contractor employees and visitors was lower in 1987 than in any of the previous years in this decade.

(c) Total collective dose equivalents are shown in brackets for the years 1980-1986 because these values were calculated from incomplete data. Data for 1987 suggest that the calculational method used could have overestimated the actual total collective dose equivalents by approximately 15%.

SUMMARY OF INTERNAL EXPOSURES

Internal body depositions of radioactive material result from accidental, not planned, exposures. A report of internal body deposition of radioactive materials is required when:

1. any uptake of radioactive material occurred during the reporting year that either independently or when added to a current burden was estimated to result in a dose commitment to the critical organ in excess of 50% of the pertinent annual dose-equivalent standard set forth in Order DOE 5480.1A, Chapter XI; or when

2. any previously unreported uptake of radioactive material was determined to have been reportable according to the above criteria by reason of the most recent dose-equivalent estimates.

Two cases of internal body depositions were reported in 1987 that exceeded 50% of the pertinent annual dose-equivalent standard as set forth in Order DOE 5480.1A, Chapter XI. Both occurred during 1987 and are considered new cases.

Table 9 lists only those cases occurring since 1980 and identifies each by the first year known in which the dose equivalent exceeded 50% of the annual standard. Also listed are the radionuclide(s) involved, the organ showing the highest percent of the annual standard, and the number of individuals in each dose-equivalent range. Revisions to previously reported cases are included.

TABLE 9. Dose Distributions for Cases of Internal Body Depositions, 1980-1987

Year	Radionuclide	Critical Organ	Dose-Equivalent Interval (rem)					
			7.5-10	10-15	15-25	25-50	50-100	100-200
1980	^{238}Pu	Bone			2	2		
	^{234}U, ^{235}U, ^{238}U	Lung	1					
1981	^{238}Pu, ^{239}Pu, ^{240}Pu	Bone		1	1			
	^{238}Pu, ^{239}Pu, ^{240}Pu	Lung	1					
	^{234}U, ^{235}U, ^{238}U	Lung	3					
1982	^{238}Pu	Bone			3	1		
	^{238}Pu, ^{239}Pu, ^{240}Pu	Bone						1
1983	^{239}Pu, ^{240}Pu, ^{241}Am	Bone			1			
	^{234}U, ^{235}U	Lung	4					
1984	^{239}Pu, ^{241}Am	Lung					1	
1985	^{234}U, ^{235}U, ^{238}U	Lung	2					
	^{239}Pu, ^{241}Am	Lung	1					
1986	None							
1987	^{238}Pu	Liver	1	1				

APPENDIX A

DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES BY FACILITY TYPE FOR EACH DOE FIELD ORGANIZATION, 1987

TABLE A.1
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES BY FACILITY TYPE
ALBUQUERQUE FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Facility Type	Total Monitored	< Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Accelerator																		
Fuel/Uran. Enrich.																		
Fuel Fabrication																		
Fuel Processing																		
Maint. & Support	1,701	693	990	11	6	1												23
Reactor																		
Research, Gen.	5,880	4,916	505	145	79	49	51	113	21	1								353
Research, Fusion																		
Waste Proc./Mgmt.	15	4	11															1
Weapons Fab. & Test.	7,591	2,834	3,208	643	366	176	96	246	22									913
Other	1,520	871	629	16	4													18
Visitors	4,335*	3,155*	1,037	112	22	7	2											53
DOE Offices	559	481	72	4	2													3
TOTAL	21,601*	12,954*	6,452	931	479	233	149	359	43	1								
TOTAL PERSON-REM			160	150	169	145	130	508	98	3								1,363

* Includes 2,439 visitors reported separately.

TABLE A.2
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES BY FACILITY TYPE
CHICAGO FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Facility Type	Total Monitored	< Meas.	Meas.- <0.10	0.10- 0.25	0.25- 0.50	0.50- 0.75	0.75- 1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Accelerator	2,752	1,513	968	145	61	26	14	24	1									135
Fuel/Uran. Enrich.																		
Fuel Fabrication	36	27	8	1														
Fuel Processing																		
Maint. & Support	737	466	222	28	10	2	1	7	1									28
Reactor	396	139	139	76	28	5	8	1										39
Research, Gen.	2,617	2,018	433	85	49	14	14	4										68
Research, Fusion	913	751	153	8	1													6
Waste Proc./Mgmt.	6				1	2	3											4
Weapons Fab. & Test.																		
Other	41	2	33	4	2													2
Visitors	6,389*	5,095*	1,141	129	11	4	4	5										65
DOE Offices	115	102	12	1														1
TOTAL	14,002*	10,113*	3,109	477	163	53	44	41	2									
TOTAL PERSON-REM			84	73	58	32	37	59	4									348

* Includes 4,209 visitors reported separately.

TABLE A.3
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES BY FACILITY TYPE
IDAHO FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Facility Type	Total Monitored	< Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Accelerator																		
Fuel/Uran. Enrich.																		
Fuel Fabrication																		
Fuel Processing	1,841	1,259	317	105	74	30	24	28	4									138
Maint. & Support	303	186	93	12	12													10
Reactor	1,590	1,124	279	94	52	16	9	16										79
Research, Gen.	35	26	6	1			1	1										2
Research, Fusion																		
Waste Proc./Mgmt.	94	67	13	6	7	1												4
Weapons Fab. & Test.																		
Other	1,839	1,161	460	124	63	19	12											80
Visitors	1,524*	1,444*	73	3	2	1	1											4
DOE Offices	91	78	13															
TOTAL	7,317*	5,345*	1,254	345	210	67	47	45	4									
TOTAL PERSON-REM			42	56	72	41	40	58	8									318

* Includes 1,432 visitors reported separately.

TABLE A.4
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES BY FACILITY TYPE
NEVADA FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Facility Type	Total Monitored	< Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Accelerator																		
Fuel/Uran. Enrich.																		
Fuel Fabrication																		
Fuel Processing																		
Maint. & Support	14	8	3	2	1													1
Reactor																		
Research, Gen.	1		1															
Research, Fusion																		
Waste Proc./Mgmt.	13	10	3															
Weapons Fab. & Test.	303	225	60	12	4	2												7
Other	2	2																
Visitors	7,246*	7,236*	10															
DOE Offices																		
TOTAL	7,579*	7,481*	77	14	5	2												
TOTAL PERSON-REM			3	2	2	1												8

* Includes 7,234 visitors reported separately.

TABLE A.5
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES BY FACILITY TYPE
OAK RIDGE FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Facility Type	Total Monitored	< Meas.	Meas.- <0.10	0.10- 0.25	0.25- 0.50	0.50- 0.75	0.75- 1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Accelerator																		
Fuel/Uran. Enrich.	2,608	1,502	1,020	68	15	1	1	1										40
Fuel Fabrication	1,745	603	550	282	235	62	10	3										199
Fuel Processing	133	33	76	20	3	1												8
Maint. & Support																		
Reactor																		
Research, Gen.	5,560	5,031	172	179	91	35	28	24										146
Research, Fusion																		
Waste Proc./Mgmt.	103	98	5															
Weapons Fab. & Test.	704	138	147	329	81	7	1	1										92
Other																		
Visitors	5,144*	4,407*	670	49	11	4	1	1	1									31
DOE Offices																		
TOTAL	15,997*	11,812*	2,640	927	436	110	41	30	1									
TOTAL PERSON-REM			71	148	157	63	36	39	3									517

* Includes 1,250 visitors reported separately.

TABLE A.6
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES BY FACILITY TYPE
PITTSBURGH NAVAL REACTOR FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Facility Type	Total Monitored	< Meas.	Meas.- <0.10	0.10- 0.25	0.25- 0.50	0.50- 0.75	0.75- 1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Accelerator																		
Fuel/Uran. Enrich.																		
Fuel Fabrication																		
Fuel Processing																		
Maint. & Support																		
Reactor	686	36	557	76	9	7	1											33
Research, Gen.	1,230	224	864	100	38	3	1											45
Research, Fusion																		
Waste Proc./Mgmt.																		
Weapons Fab. & Test.																		
Other	44	44																
Visitors	243	173	69	1														
DOE Offices																		
TOTAL	2,203	477	1,490	177	47	10	2											
TOTAL PERSON-REM			28	27	16	6	2											78

TABLE A.7
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES BY FACILITY TYPE
RICHLAND FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Facility Type	Total Monitored	< Meas.	Meas.- <0.10	0.10- 0.25	0.25- 0.50	0.50- 0.75	0.75- 1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Accelerator	13	2	11															
Fuel/Uran. Enrich.																		
Fuel Fabrication	23	3	6	7	1			3	3									14
Fuel Processing	26		10	4	1	2	2	7										14
Maint. & Support	4,204	1,643	1,498	259	164	121	88	286	122	23								1,098
Reactor	1,495	228	493	167	115	89	78	225	88	12								776
Research, Gen.	1,462	555	737	79	43	14	9	20	5									103
Research, Fusion																		
Waste Proc./Mgmt.	2,396	821	972	255	119	60	49	108	12									367
Weapons Fab. & Test.																		
Other	763	433	169	54	55	19	9	20	4									94
Visitors	13,204*	13,120*	66	11	4	2	1											10
DOE Offices	148	86	59	3														1
TOTAL	23,734*	16,891*	4,021	839	502	307	236	669	234	35								
TOTAL PERSON-REM			120	132	183	191	207	965	561	119								2,477

* Includes 13,120 visitors reported separately.

TABLE A.8
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES BY FACILITY TYPE
SAN FRANCISCO FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Facility Type	Total Monitored	< Meas.	Meas.- <0.10	0.10- 0.25	0.25- 0.50	0.50- 0.75	0.75- 1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Accelerator	870	393	400	53	17	2	2	3										33
Fuel/Uran. Enrich.	804	789	11	2	1	1												1
Fuel Fabrication																		
Fuel Processing																		
Maint. & Support	4,428	4,319	87	12	5		1	4										13
Reactor																		
Research, Gen.	1,970	1,705	230	17	15	2	1											15
Research, Fusion	433	399	24	9		1												3
Waste Proc./Mgmt.	54	53	1															
Weapons Fab. & Test.	1,614	1,542	59	11	1	1												5
Other	411	401	9	1														
Visitors	18,945*	18,853*	72	13	6	1												8
DOE Offices	101	98	3															
TOTAL	29,630*	28,552*	896	118	45	8	4	7										
TOTAL PERSON-REM			28	18	15	5	4	9										78

* Includes 18,802 visitors reported separately.

TABLE A.9
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES BY FACILITY TYPE
SAVANNAH RIVER FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Facility Type	Total Monitored	< Meas.	Meas.- <0.10	0.10- 0.25	0.25- 0.50	0.50- 0.75	0.75- 1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Accelerator																		
Fuel/Uran. Enrich.																		
Fuel Fabrication	981	403	443	49	57	24	5											57
Fuel Processing	1,088	199	394	183	120	67	56	69										267
Maint. & Support	7,007	2,892	3,095	654	254	79	19	14										368
Reactor	989	245	577	149	16	1	1											50
Research, Gen.	1,047	636	337	45	20	4	2	3										30
Research, Fusion																		
Waste Proc./Mgmt.	593	195	178	88	51	38	16	27										112
Weapons Fab. & Test.	349	198	122	19	7	3												11
Other	1,780	831	902	42	5													29
Visitors	4,339*	3,432*	889	13	4	1												19
DOE Offices	281	178	100	3														3
TOTAL	18,454*	9,209*	7,037	1,245	534	217	99	113										
TOTAL PERSON-REM			195	196	191	132	85	146										945

* Includes 2,922 visitors reported separately.

TABLE A.10
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES BY FACILITY TYPE
SCHENECTADY NAVAL REACTOR FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Facility Type	Total Monitored	< Meas.	Meas.- <0.10	0.10- 0.25	0.25- 0.50	0.50- 0.75	0.75- 1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Accelerator	1	1																
Fuel/Uran. Enrich.																		
Fuel Fabrication																		
Fuel Processing																		
Maint. & Support																		
Reactor	892	55	769	52	15	1												31
Research, Gen.	958	519	434	5														6
Research, Fusion																		
Waste Proc./Mgmt.																		
Weapons Fab. & Test.																		
Other	29	18	11															
Visitors	1,180	201	670	106	61	59	37	46										183
DOE Offices																		
TOTAL	3,060	794	1,884	163	76	60	37	46										
TOTAL PERSON-REM			33	25	29	36	32	64										220

APPENDIX B

DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES TO PERSONNEL FOR EACH DOE FIELD ORGANIZATION, 1987

TABLE B.1
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES TO PERSONNEL
ALBUQUERQUE FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Contractor	< Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Allied Signal (Bendix Div.)																	
Employees	19	21															
Visitors																	
Total	19	21															
EG&G Mound																	
Employees	9	2,256	27	8	2												52
Visitors	2	433	7														6
Total	11	2,689	34	8	2												59
General Electric Co.—Pinellas																	
Employees	200	35	4	1													2
Visitors																	
Total	200	35	4	1													2
Inhalation Toxicology																	
Employees	295	26	2														1
Visitors																	
Total	295	26	2														1
Jacobs—Weston Team																	
Employees	42																
Visitors	5																
Total	47																
Los Alamos National Lab.																	
Employees	4,393	479	143	79	49	51	113	21	1								352
Visitors	21	206	47	16	6	1											24
Total	4,414	685	190	95	55	52	113	21	1								376
MK-Ferguson Co.—UMTRA																	
Employees	34	8															
Visitors																	
Total	34	8															
MK-Ferguson Subcontractors —UMTRA																	
Employees	450	99	1														3
Visitors																	
Total	450	99	1														3

TABLE B.1 (Continued)
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES TO PERSONNEL
ALBUQUERQUE FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Contractor	< Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Mason & Hanger (Amarillo, TX)																	
Employees	938	95	45	29	8	2	5										35
Visitors	30	14	2														1
Total	968	109	47	29	8	2	5										36
Mason & Hanger (Los Alamos, NM)																	
Employees	353	14															
Visitors																	
Total	353	14															
Pan-Am World Services, Inc.																	
Employees	117	6	1	4													2
Visitors																	
Total	117	6	1	4													2
Rockwell International																	
Employees	1,679	2,136	589	333	167	94	241	22									858
Visitors	647	384	56	6	1	1											21
Total	2,326	2,520	645	339	168	95	241	22									879
Ross Aviation, Inc.																	
Employees	88	9	1														
Visitors																	
Total	88	9	1														
Sandia National Laboratory																	
Employees	557																
Visitors	11																
Total	568																
TOTAL ALBUQUERQUE	9,890	6,221	925	476	233	149	359	43	1								1,358

TABLE B.2
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES TO PERSONNEL
CHICAGO FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Contractor	< Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Ames Laboratory—(Iowa St.)																	
Employees		69															1
Visitors																	
Total		69															1
Argonne National Lab.																	
Employees	1,884	334	138	50	16	17	3										80
Visitors	1	66	9														3
Total	1,885	400	147	50	16	17	3										84
Battelle Memorial Institute —Columbus																	
Employees	77	20	4	5	2	1	7	1									18
Visitors		10	2														
Total	77	30	6	5	2	1	7	1									19
Brookhaven National Lab.																	
Employees	885	706	112	76	25	19	25	1									133
Visitors	284	588	49	8	4	3	5										37
Total	1,169	1,294	161	84	29	22	30	1									170
Chicago Misc. Subcontractors																	
Employees	18	35	10	3	1		1										6
Visitors																	
Total	18	35	10	3	1		1										6
Fermi National Lab.																	
Employees	1,003	594	66	15	4	3											35
Visitors	404	452	67	3		1											24
Total	1,407	1,046	133	18	4	4											58

TABLE B.2 (Continued)
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES TO PERSONNEL
CHICAGO FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Contractor	< Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Massachusets Institute of Technology																	
Employees	243	37	8	2	1												4
Visitors		2															
Total	243	39	8	2	1												4
Notre Dame Radiation Lab.																	
Employees	32	3	1														
Visitors	3																
Total	35	3	1														
Princeton Plasma Physics Lab.																	
Employees	728	153	8	1													6
Visitors	177	23	2														1
Total	905	176	10	1													7
Solar Energy Research Inst.																	
Employees	15	2															
Visitors																	
Total	15	2															
TOTAL CHICAGO	5,754	3,094	476	163	53	44	41	2									348

TABLE B.3
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES TO PERSONNEL
IDAHO FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Contractor	< Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Catalytic Inc.																	
Employees		1															
Visitors																	
Total		1															
EG&G Idaho, Inc.																	
Employees	1,253	364	109	69	16	10	16										91
Visitors	1	5	1														
Total	1,254	369	110	69	16	10	16										91
Idaho Office Subcontractors																	
Employees	202	70	15	13	8	6	8	4									39
Visitors		28															1
Total	202	98	15	13	8	6	8	4									40
MK-Ferguson Subcontractors																	
Employees	20	18	1	1	1		1										4
Visitors	11	39	2	2	1	1											3
Total	31	57	3	3	2	1	1										7
Protection Technology-INEL																	
Employees	365	38															1
Visitors																	
Total	365	38															1
Ralph M. Parsons Co.																	
Employees	11	2															
Visitors																	
Total	11	2															
Rockwell-INEL																	
Employees	372	99	8	1	1												5
Visitors																	
Total	372	99	8	1	1												5

TABLE B.3 (Continued)
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES TO PERSONNEL
IDAHO FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Contractor	< Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
UNC-GEO Technical Services																	
Employees	115	103	2														3
Visitors		1															
Total	115	104	2														3
West Valley Nuclear																	
Employees	404	222	113	61	17	12											70
Visitors																	
Total	404	222	113	61	17	12											70
Westinghouse Idaho Nuclear																	
Employees	996	240	94	63	23	18	20										100
Visitors																	
Total	996	240	94	63	23	18	20										100
TOTAL IDAHO	3,750	1,230	345	210	67	47	45	4									317

TABLE B.4
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES TO PERSONNEL
NEVADA FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Contractor	< Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Computer Sciences Corp.																	
Employees				1													
Visitors		1															
Total		1		1													
EG&G, Kirtland																	
Employees	56	8															
Visitors																	
Total	56	8															
EG&G, Los Alamos																	
Employees	22	10	1		1												1
Visitors	2	3															
Total	24	13	1		1												1
Fenix & Scisson, Inc.																	
Employees	40	17	4	1													2
Visitors		1															
Total	40	18	4	1													2
Holmes & Narver, Inc.																	
Employees	15	9	5	1													1
Visitors																	
Total	15	9	5	1													1
Reynolds Elec. & Eng. Co.																	
Employees	82	22	3	2													2
Visitors		1															
Total	82	23	3	2													2
TOTAL NEVADA	217	72	13	5	1												7

TABLE B.5
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES TO PERSONNEL
OAK RIDGE FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Contractor	< Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
M. M. Portsmouth Subcontractors																	
Employees																	
Visitors	107	246															3
Total	107	246															3
Martin Marietta/ORGDP																	
Employees	368	45	5	1	1		1										5
Visitors																	
Total	368	45	5	1	1		1										5
Martin Marietta/ORNL																	
Employees	5,026	142	178	91	35	28	24										146
Visitors	1,050	25	6	1													2
Total	6,076	167	184	92	35	28	24										148
Martin Marietta/Paducah																	
Employees	18	8	30	9													9
Visitors																	
Total	18	8	30	9													9
Martin Marietta/Portsmouth																	
Employees	1,116	967	33	5		1											27
Visitors																	
Total	1,116	967	33	5		1											27
Martin Marietta/Y-12																	
Employees	138	147	329	81	7	1	1										92
Visitors			17	4	2	1	1	1									11
Total	138	147	346	85	9	2	2	1									103

TABLE B.5 (Continued)
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES TO PERSONNEL
OAK RIDGE FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Contractor	< Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Morrison-Knudsen																	
Employees	37	5															
Visitors	36	3															
Total	73	8															
Oak Ridge Assoc. Univ.																	
Employees	5	30	1														1
Visitors																	
Total	5	30	1														1
Oak Ridge Office Subcontractors																	
Employees	57																
Visitors	195	6															
Total	252	6															
RMI Company																	
Employees	33	76	20	3	1												8
Visitors	597	84															1
Total	630	160	20	3	1												9
Westinghouse Materials Co. of Ohio																	
Employees	603	549	282	235	62	10	3										199
Visitors	721	59	6														2
Total	1,324	608	288	235	62	10	3										201
Westinghouse of Ohio Subcontractors																	
Employees		1															
Visitors	451	247	20	6	2												12
Total	451	248	20	6	2												2
TOTAL OAK RIDGE	10,558	2,640	927	436	110	41	30	1									517

TABLE B.6
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES TO PERSONNEL
PITTSBURGH NAVAL REACTOR FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Contractor	< Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Westinghouse Electric/BAPL																	
Employees	213	645	18	21	3	1											20
Visitors	173	60															
Total	386	705	18	21	3	1											21
Westinghouse Electric/NRF																	
Employees	38	758	158	26	7	1											57
Visitors		9	1														
Total	38	767	159	26	7	1											58
Westinghouse Plant Apparatus Div.																	
Employees	43																
Visitors																	
Total	43																
TOTAL PITTSBURGH	467	1,472	177	47	10	2											78

TABLE B.7
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES TO PERSONNEL
RICHLAND FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Contractor	< Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
General Electric Co./ Shippingport																	
Employees	174	59	43	39	16	6	17	4									75
Visitors																	
Total	174	59	43	39	16	6	17	4									75
Hanford Environ. Health Foundation																	
Employees	31	8															
Visitors																	
Total	31	8															
Kaiser Engineers Hanford—Arch./Eng.																	
Employees	579	415	141	100	92	73	266	115	23								950
Visitors		4	1														
Total	579	419	142	100	92	73	266	115	23								950
Pacific Northwest Laboratory																	
Employees	496	673	67	34	11	8	20	4									91
Visitors		7	2														1
Total	496	680	69	34	11	8	20	4									92
Westinghouse Hanford Co.																	
Employees	2,322	2,710	571	325	185	148	366	111	12								1,349
Visitors		53	8	4	2	1											8
Total	2,322	2,763	579	329	187	149	366	111	12								1,357
Westinghouse Hanford Subcontractors																	
Employees	83	31	3		1												2
Visitors		2															
Total	83	33	2		1												2
TOTAL RICHLAND	3,685	3,962	836	502	307	236	669	234	35								2,476

TABLE B.8
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES TO PERSONNEL
SAN FRANCISCO FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Contractor	< Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Energy Tech. Engineering Center																	
Employees	3	4	1														
Visitors																	
Total	3	4	1														
LLNL Plant Services																	
Employees	450	15															
Visitors																	
Total	450	15															
LLNL Security																	
Employees	317	6															
Visitors																	
Total	317	6															
LLNL Subcontractors																	
Employees																	
Visitors	27	62	13	6	1												7
Total	27	62	13	6	1												7
Lawrence Berkeley Laboratory																	
Employees	5	519	48	17	1		1										30
Visitors																	
Total	5	519	48	17	1		1										30
Lawrence Livermore Nat'l Lab. —Nevada																	
Employees	109	8	1														1
Visitors																	
Total	108	8	1														1
Lawrence Livermore Nat'l Lab.																	
Employees	8,353	217	46	17	4	1	4										28
Visitors	1																
Total	8,354	217	46	17	4	1	4										28

TABLE B.8 (Continued)
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES TO PERSONNEL
SAN FRANCISCO FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Contractor	< Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Los Angeles Lab of Biomedical and Environment																	
Employees	77	14			1	1	2										4
Visitors																	
Total	77	14			1	1	2										4
Rockwell International, Atomics Int'l																	
Employees		1		3	1	1											3
Visitors		10															
Total		11		3	1	1											3
Stanford Linear Accelerator Center																	
Employees	203	37	9	2		1											4
Visitors																	
Total	203	37	9	2		1											4
U. of Cal./Davis, Radiobiology Lab - LEHR																	
Employees	42																
Visitors	23																
Total	65																
U. of Cal. SAN - Lab of Radiobiology																	
Employees	42																
Visitors																	
Total	42																
TOTAL SAN FRANCISCO	9,652	893	118	45	8	4	7										78

TABLE B.9
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES TO PERSONNEL
SAVANNAH RIVER FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Contractor	< Meas.	Meas.- <0.10	0.10- 0.25	0.25- 0.50	0.50- 0.75	0.75- 1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Diversco																	
Employees	156	100	1														2
Visitors																	
Total	156	100	1														2
E. I. Du Pont/Construction																	
Employees	1,630	2,178	503	154	37	6	4										235
Visitors																	
Total	1,630	2,178	503	154	37	6	4										235
E. I. Du Pont/Production																	
Employees	2,503	2,631	639	351	175	91	106										630
Visitors	510	889	13	4	1												19
Total	3,013	3,520	652	355	176	91	106										649
E. I. Du Pont/Research																	
Employees	636	337	45	20	4	2	3										30
Visitors																	
Total	636	337	45	20	4	2	3										30
E. I. Du Pont/Subcontractors																	
Employees	220	161		1													3
Visitors																	
Total	220	161		1													3
Industrial Phases-SR																	
Employees	6																
Visitors																	
Total	6																

TABLE B.9 (Continued)
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES TO PERSONNEL
SAVANNAH RIVER FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Contractor	< Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Southern Bell Tel.																	
Employees	17	21															
Visitors																	
Total	17	21															
Univ. of Georgia Ecology Lab.																	
Employees	59	38	2	1													2
Visitors																	
Total	59	38	2	1													2
Wackenhut Services, Inc.																	
Employees	372	582	39	3													21
Visitors																	
Total	372	582	39	3													21
TOTAL SAVANNAH RIVER	6,109	6,937	1,242	534	217	99	113										943

TABLE B.10
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES TO PERSONNEL
SCHENECTADY NAVAL REACTOR FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Contractor	< Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
General Electric/KAPL-Kesselring																	
Employees	51	633	33	9	1												22
Visitors	143	561	79	38	29	27	41										137
Total	194	1,194	112	47	30	27	41										159
General Electric/KAPL-Knolls																	
Employees	508	428	5														6
Visitors	15	30	1														
Total	523	458	6														6
General Electric/KAPL-Knolls Subcontractors																	
Employees	19	11															
Visitors																	
Total	19	11															
General Electric/KAPL-Windsor																	
Employees	3	133	19	6													9
Visitors	43	79	26	23	30	10	5										46
Total	46	212	45	29	30	10	5										55
TOTAL SCHENECTADY	782	1,875	163	76	60	37	46										220

APPENDIX C

DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES FOR DOE GOVERNMENT EMPLOYEES AND VISITORS BY DOE FIELD ORGANIZATION, 1987

TABLE C.1
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES FOR DOE GOVERNMENT EMPLOYEES AND VISITORS BY DOE FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Organization	< Meas.	Meas.- <0.10	0.10- 0.25	0.25- 0.50	0.50- 0.75	0.75- 1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Albuquerque Operations	337	127	1	2													2
Amarillo Area Office	35																
Dayton Area Office		28															
Kansas City Area Office		1															
Los Alamos Area Office	114	7	4	1													1
Pinellas Area Office	4	3															
Rocky Flats Area Office	32	22	1														1
UMTRA Project Office	103	43															1
SUBTOTAL	625	231	6	3													6
Chicago Operations	49	5															
Environmental Meas. Lab.	31	3															
New Brunswick Lab.	70	7	1														
SUBTOTAL	150	15	1														1
Idaho Operations Office	153	23															
U.S. Geological Survey	10	1															
SUBTOTAL	163	24															
DNA-Kirtland AFB	7	4	1		1												1
EPA (NERC)	23	1															
SUBTOTAL	30	5	1		1												1

TABLE C.1 (Continued)
DISTRIBUTION OF ANNUAL WHOLE-BODY DOSES FOR DOE GOVERNMENT EMPLOYEES AND VISITORS BY DOE FIELD ORGANIZATION
1987

Dose-Equivalent Ranges (rem)

Organization	< Meas.	Meas.-<0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	>10	Total Person-rem
Oak Ridge Operations Office	4																
SUBTOTAL	4																
Pittsburgh Naval Reactors Office	10	18															
SUBTOTAL	10	18															
Richland Operations Office	86	59	3														1
SUBTOTAL	86	59	3														1
San Francisco Operations Office	98	3															
SUBTOTAL	98	3															
Savannah River Forest Station	36	11	1														
Savannah River Operations Office	142	89	2														2
SUBTOTAL	178	100	3														3
Schenectady Naval Reactors Office	12	9															
SUBTOTAL	12	9															
TOTAL DOE	52,764*	464	14	3	1												12

* Includes 51,408 visitors reported separately.

UNITED STATES
DEPARTMENT OF ENERGY
WASHINGTON, D.C. 20545

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