NUREG-0714
Vols. 4 and 5

Occupational Radiation Exposure

Fifteenth and Sixteenth Annual Reports, 1982 and 1983

U.S. Nuclear Regulatory Commission

Office of Resource Management

B. Brooks, S. McDonald, E. Richardson

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Occupational Radiation Exposure

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PREVIOUS REPORTS IN THE SERIES

NUREG-0714 is the permanent identification number for the Occupational Radiation Exposure report series. The following is a list of all previous reports, along with their separate identification numbers that have been published in this series.

WASH1350-R1 through WASH1350-R6

First through Sixth Annual Reports of the Operation of the U.S. AEC's Centralized Ionizing Radiation Exposure Records and Reports 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, Oct. 1975.
NUREG-0119	Eighth Annual Occupational Radiation Exposure Report for 1975, U. S. Nuclear Regulatory Commission, Oct. 1976.
NUREG-0322	Ninth Annual Occupational Radiation Exposure Report for 1976, U. S. Nuclear Regulatory Commission, Oct. 1977.
NUREG-0463	Tenth Annual Occupational Radiation Exposure Report for 1977, U. S. Nuclear Regulatory Commission, Oct. 1978.
NUREG-0593	Eleventh Annual Occupational Radiation Exposure Report for 1978, U. S. Nuclear Regulatory Commission, Jan. 1981.
NUREG-0714, Vol. 1	Twelfth Annual Occupational Radiation Exposure Report for 1979, U. S. Nuclear Regulatory Commission, Aug. 1982.
NUREG-0714, Vols. 2 and 3	Occupational Radiation Exposure, Thirteenth and Fourteenth Annual Reports, 1980 and 1981, U.S. Nuclear Regulatory Commission, October 1983.

ABSTRACT

This report summarizes the occupational exposure data that is maintained in the U.S. Nuclear Regulatory Commission's Radiation Exposure Information and Reports System (REIRS). The bulk of the information contained in the report was extracted from the 1982 and 1983 annual statistical reports submitted by seven categories* of NRC licensees subject to the reporting requirements of 10 CFR § 20.407. These seven categories of licensees also submit personal identification and exposure information for terminating employees pursuant to 10 CFR § 20.408, and some analysis of this data is also presented in this report.

Annual reports were received from 482 NRC licensees in 1982 and from 467 licensees in 1983. Compilations of the reports for 1982 indicated that some 154,000 individuals were monitored, 94,000 of whom received a measurable dose. The collective dose incurred by these individuals was calculated to be 57,000 man-rems (man-cSv)†, and the average measurable dose was found to be 0.60 rem (cSv). These figures are about the same as those found in 1981.

Compilations of the reports for 1983 indicated that about 173,000 persons were monitored and that about 101,000 of them received a measurable dose. The collective dose was calculated to be some 61,000 man-rems (cSv), and the average measurable dose was 0.60 rem (cSv), the same as that found in 1982. In both 1982 and 1983, about 20% of the individuals monitored received doses greater than 0.50 rem (cSv) as had been the case in 1980 and 1981. However, the number of individuals receiving doses greater than five rems (cSv) decreased from 0.14% (203 persons) in 1981 to 0.09% (136 persons) in 1982.

In 1982, some 158,000 termination reports submitted to the NRC contained personal identification and exposure information for about 59,000 individuals who had completed their work assignment or employment with a covered category of NRC licensees. This is about 10,000 less than the number of persons terminating in 1981. The total number of monitored individuals for whom personal identification and exposure information has been incorporated into the Commission's Radiation Exposure Information and Reports System during the fifteen years that it has been operating is now about 300,000.

Information on occurrences involving personnel exposures to radiation or radioactive materials that exceeded certain control limits was obtained from reports submitted by all NRC licensees pursuant to 10 CFR § 20.403 and § 20.405. In 1982 the total number of individuals involved in such occurrences was 32, and in 1983 the number was 41. The number of overexposures reported by radiography firms continued to decline from previous years' values; only two occurrences involving radiographers were reported in 1983.

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*Commercial nuclear power reactors; industrial radiographers; fuel processors, fabricators, and reprocessors; manufacturers and distributors of byproduct material; independent fuel storage installations; facilities for land disposal of low-level waste; and geologic repositories for high-level waste.

†In the International System of Units the sievert (Sv) is the name given to the units for dose equivalent. One centisievert (cSv) equals one rem; therefore, man-rem becomes man-cSv.

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PREFACE

A number of NRC licensees have inquired how occupational radiation exposure data (from reports required by the NRC) are used by the NRC staff. This is a very appropriate inquiry that may be of importance to many affected licensees. 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, including individual and collective radiation doses from external sources as well as pertinent information on the inhalation of radioactive material (nuclides involved, bioassay results, exposure magnitude, etc.). These facts are used by the NRC staff as indicated below:

1. The data permit evaluation, from the viewpoint of trends, of the effectiveness of the overall NRC/licensee radiation protection and ALARA efforts by certain licensees. They also provide for the identification (and subsequent correction) of unfavorable trends.

2. The external-dose data permit evaluation of the radiological risk associated with certain categories of NRC-licensed activities, including the size of the workforce and the collective dose.

3. The data provide for governmental monitoring of the potential transient-worker problem.

4. The data are used in the establishment of priorities for the utilization of NRC health physics resources: research, standards development, and regulatory program development.

5. The data are considered in reviews of inspection frequencies that are programmed for various categories of licensees.

6. The data may influence licensing action decisions.

7. The data are used for comparative analyses of radiation protection performance: US/foreign, BWR's/PWR's, civilian/military, plant/plant, nuclear industry/other industries, etc.

8. The data are used for justification of the expenditure of resources in the annual budget process.

9. The data help provide facts for evaluating the adequacy of the current risk-limitation system (e.g., are individual lifetime dose limits, worker population collective dose limits, and requirements for optimization, needed).

10. The data permit comparisons of occupational radiation risks with potential public risks when action for additional protection of the public involves worker exposures.

11. The data help in the evaluation of the effectiveness of dose-reduction measures (e.g., methods for reducing individuals' doses that may increase the collective dose).

12. The data provide facts for answering Congressional and Administration inquiries and for responding to questions raised by public interest groups, special interest groups, labor unions, etc.

13. The data provide information which can be used in the planning of epidemiological studies.

With regard to routine work-place conditions, the annual statistical summary reports required by §20.407, the termination reports required by §20.408, and the annual dose data reported by work function in accordance with Subsection 6.9.1.5 of the standard technical specifications for nuclear power plants provide the only centralized data base available to assist the staff in the performance of its duties as listed above. It is to everyone's advantage if these duties are performed by a well-informed staff in the light of factual information.

Beginning with the next report in this series, we plan to expand the data analysis sections in an effort to provide for additional practical applications. Suggestions for advanced analysis of this type are invited.

R E Alexander

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Occupational Radiation Exposure
Thirteenth and Fourteenth Annual Reports, 1982 and 1983

1. INTRODUCTION

One of the basic purposes of the Atomic Energy Act and the implementing regulations in Title 10, Code of Federal Regulations, Chapter I, Part 20, is to protect the health and safety of the public, including the employees of the licensees conducting operations under those regulations. Among the regulations designed to ensure that the standards for protection against radiation set out in 10 CFR Part 20 are met is a requirement that licensees provide individuals likely to be exposed to radiation with devices to monitor their exposure. Each licensee is also required to maintain indefinitely records of the results of such monitoring. 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 Part 20 requiring the reporting of certain occupational radiation exposure information to a central repository at AEC Headquarters. This information was required of the four categories* of AEC licensees that were considered to involve the greatest potential for significant occupational doses and of AEC facilities and contractors exempt from licensing. A procedure was established whereby the appropriate occupational exposure data were extracted from these reports and entered into the Commission's Radiation Exposure Information Reporting System (REIRS), a computer system maintained at the Oak Ridge National Laboratory Computer Technology Center in Oak Ridge, Tennessee. The computerization of these data ensured that they would be kept indefinitely and facilitated 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 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. The annual reports published by the 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 Department of Energy (DOE), is collected and published by DOE's Division of Operational and Environmental Safety at Germantown, Maryland.

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*Commercial nuclear power reactors; industrial radiographers; fuel processors, fabricators, and reprocessors; and manufacturers and distributors of specified quantities of byproduct material.

On September 29, 1978, 10 CFR § 20.407 was amended to require that all NRC specific licensees submit annual radiation exposure reports for each of the calendar years 1978 and 1979. The reports were statistical summary reports exactly like those that had been required of the previously named four categories of NRC licensees. Therefore, the reports published for the years 1978 and 1979 (NUREG-0593 and NUREG-0713, Vol. 1) summarized the annual exposure data that had been submitted by all types of NRC licensees. In 1980 the applicability of the reporting requirements of §§20.407 and 20.408 reverted back to four types* of NRC licensees, and the annual report (NUREG-0714, Vols. 2 and 3) published for the years 1980 and 1981 contains exposure information pertaining to only those four categories of licensees.

In 1982 and 1983, paragraph 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 new categories are (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. Therefore, this document presents the exposure information that was reported by NRC licensees representing two of these new categories. (There are no geologic repositories for high-level waste currently licensed.)

2. LIMITATIONS OF THE DATA

All of the figures compiled in this report relating to exposures and 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 environment in which individuals work and is used in evaluating the radiation protection program.

Monitoring requirements are based, in general, on 10 CFR § 20.202 which requires licensees to monitor individuals who receive or are likely to receive a dose in any calendar quarter in excess of 25% of the applicable quarterly limits. For most adults the quarterly limit for the whole body is 1.25 rems, so that 0.312 rem per quarter is the level above which monitoring is required. Depending on the administrative policy of each licensee, persons such as visitors and clerical workers may also be provided with monitoring devices for identification or convenience, although the probability of their being exposed to measurable levels of radiation is extremely small. Licensees are given the option of reporting the dose distribution of only those individuals for whom monitoring is required, or the dose distribution of all those for whom monitoring is provided. Many licensees elect to report the latter; however, this may increase the number of individuals that one could consider to be radiation workers. In an effort to account for this, the number of individuals reported as having "no measurable exposure" has been subtracted from the total number of individuals monitored in order to calculate an average dose per individual receiving a measurable dose, as well as the average dose per monitored individual.

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*Commercial nuclear power reactors; industrial radiographers; fuel processors, fabricators, and reprocessors; and manufacturers and distributors of specified quantities of byproduct material.

One source of error that is present in the calculation of the annual collective dose (i.e., the summation of each monitored person's whole body dose) incurred by workers is the assumption that the midpoint of the dose range is the mean dose of the individuals reported in each dose range. This allows the collective dose to be calculated without knowing each person's actual annual dose by multiplying the number of individuals in each dose range by the midpoint of the range, and then summing these products. Past experience has shown that the actual mean dose of the individuals reported in each range is less than the midpoint. Thus, the collective doses presented in this report may be 10% higher than the sum of the actual individual doses.

The average dose per individual, as well as the dose distributions shown for groups of licensees, also could have been affected by the multiple reporting of individuals who were monitored by two or more licensees during the year. Since individuals are not identified in the annual reports, an individual who was monitored by five different licensees would have been counted once on each report. Therefore, when the data were summed to determine the total number of individuals monitored by a group of licensees, this person would be counted as five individuals rather than as one. This could also affect the distribution of doses because the individual has been counted five times in the lower dose ranges rather than one time in the higher range in which his actual accumulated dose (the sum of his doses incurred at each facility) would have placed him. This source of error has the greatest potential impact on the data reported by power reactor facilities since they employ many short-term workers. Further discussion of this is provided in Section 4.

Another fact that should be kept in mind before drawing any conclusions from the annual statistical data is that all of the personnel included in the reports may not have been monitored throughout the entire year. Many licensees such as radiography firms and nuclear power facilities 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 would receive if he were involved in that activity for the full year.

3. ANNUAL PERSONNEL MONITORING REPORTS - 10 CFR § 20.407

3.1 Annual Whole Body Dose Distributions

On February 4, 1974, 10 CFR § 20.407 was amended to require certain categories of licensees to submit an annual statistical report indicating the distribution of the whole body exposures incurred by their employees. In prior years the annual report was formatted differently and was not very useful as a basis for estimating the collective dose. Tables 1 and 2 are compilations of the statistical reports submitted for calendar years 1982 and 1983 by six categories* of licensees. For each category, they show the number of individuals that incurred an annual whole body dose that fell within one of the 18 dose ranges and the collective dose (man-rems) estimated to have been received by these individuals. The collective dose was calculated by assuming that each individual

*Commercial nuclear power reactors; industrial radiographers; fuel processors, fabricators and reprocessors; manufacturers and distributors of byproduct material; independent fuel storage installations; and facilities for land disposal of low-level radioactive waste.

Table 1
DISTRIBUTION OF ANNUAL WHOLE BODY DOSES BY LICENSE CATEGORY
1982

LICENSE CATEGORY	Number of Individuals with Whole Body Doses in the Following Ranges (Rems or cSv)																	Total Number Moni-tored	Number with Meas-urable Dose	Total Collective Dose Man-rems (man-cSv)
	No Meas-urable Exposure	Meas-urable but <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	6.0–7.0	7.0–8.0	8.0–9.0	9.0–10.0	10.0–12.0	> 12.0			
INDUSTRIAL RADIOGRAPHY																				
Single Location	1,035	587	190	89	27	18	20	10	1									1,977	942	187
Multiple Locations	2,040	2,017	789	790	481	286	564	195	65	21	5	3	0	0	0	2	0	7,258	5,218	2,811
Total	3,075	2,604	979	879	508	304	584	205	66	21	5	3	0	0	0	2	0	9,235	6,160	2,998
MANUFACTURING & DISTRIB.																				
Broad	2,718	979	337	168	90	54	164	65	22	11	1	1						4,610	1,892	821
Other	536	210	49	19	8	4	11	3	3									843	307	69
Total	3,254	1,189	386	187	98	58	175	68	25	11	1	1						5,433	2,199	890
LOW-LEVEL WASTE DISPOSAL																				
Total	429	168	41	14	5	9	14											680	251	53
INDEP. SPENT FUEL STORAGE																				
Total	3	9	7	9	7													35	32	9
FUEL FABRICATION																				
Uranium Fuel Process.	3,535	3,731	770	381	133	36	44	7	7	8								8,652	5,117	724
Decommiss. of U and Pu Fuel Facilities	840	198	43	22	8	7	24	14										1,156	316	107
Total	4,375	3,929	813	403	141	43	68	21	7	8								9,808	5,433	831
**COMMERCIAL POWER REACT.																				
Boiling Water Reactors	21,457	10,352	4,454	4,404	2,840	2,048	4,795	2,358	1,183	230	7							54,128	32,671	24,466
Press. Water Reactors	30,830	21,664	8,274	6,411	3,900	2,749	6,061	2,328	631	202	49	13	4	0	1			83,117	52,287	27,761
High Temp. Gas Reactors	978	22																1,000	22	0
Total	52,287	32,016	12,728	10,815	6,740	4,797	10,856	4,686	1,814	432	56	13	4	0	1			137,245	84,958	52,227
†Adjusted Total	49,751	30,100	11,618	10,073	6,295	4,459	10,259	4,699	2,043	579	89	30	4	0	1			130,000	80,249	52,227
†GRAND TOTALS	60,887	37,999	13,844	11,565	7,054	4,873	11,100	4,993	2,141	619	95	34	4	0	1	2	0	155,211	94,324	57,008

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

**Includes all reactors that reported although all of them may not have been in commercial operation for a full year.

†These values are adjusted to account for the multiple counting of transient reactor workers (see Section 4).

Table 2
DISTRIBUTION OF ANNUAL WHOLE BODY DOSES BY LICENSE CATEGORY
1983

LICENSE CATEGORY	Number of Individuals with Whole Body Doses in the Following Ranges (Rems or cSv)																	Total Number Moni-tored	Number with Meas-urable Dose	Total Collective Dose Man-rems (man-cSv)
	No Meas-urable Exposure	Meas-urable but <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	6.0–7.0	7.0–8.0	8.0–9.0	9.0–10.0	10.0–12.0	> 12.0			
INDUSTRIAL RADIOGRAPHY																				
Single Location	941	470	133	77	32	17	22	15	2	4	0	1						1,714	733	213
Multiple Locations	2,552	1,688	854	654	365	207	387	136	42	29	7	4	2	1				6,910	4,358	2,171
Total	3,593	2,158	969	731	397	224	409	151	44	33	7	5	2	1				8,624	5,131	2,384
MANUFACTURING & DISTRIB.																				
Broad	2,588	966	259	139	85	53	139	64	26	9	4							4,332	1,744	767
Other	460	187	43	11	5	2	7	1	1	0	0	2						719	259	57
Total	3,048	1,153	302	150	90	55	146	65	27	9	4	2						5,051	2,003	824
LOW-LEVEL WASTE DISPOSAL																				
Total	254	239	55	21	17	13	13											612	358	71
INDEP. SPENT FUEL STORAGE																				
Total	6	7	6	9	5													33	27	8
FUEL FABRICATION																				
Uranium Fuel Process.	3,694	3,035	1,074	442	99	42	26	9	2	17								8,440	4,746	748
Decommiss. of U and Pu Fuel Facilities	316	155	50	18	6	7	24	7										583	267	87
Total	4,010	3,190	1,124	460	105	49	50	16	2	17								9,023	5,013	835
**COMMERCIAL POWER REACT																				
Boiling Water Reactors	24,461	11,511	4,498	4,097	2,618	1,927	5,663	2,890	1,252	229	63	16	4					59,229	34,768	27,574
Press. Water Reactors	35,422	22,716	8,192	6,379	3,882	2,793	6,520	2,423	698	315	2							89,342	53,920	29,184
High Temp. Gas Reactors	965	48																1,013	48	1
† Total	60,848	34,275	12,690	10,476	6,500	4,720	12,183	5,313	1,950	544	65	16	4					149,584	88,736	56,759
GRAND TOTALS † (Unadjusted)	71,659	41,022	15,146	11,847	7,114	5,061	12,801	5,545	2,023	603	76	23	6	1				172,927	101,268	60,881

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

**Includes all reactors that reported although all of them may not have been in commercial operation for a full year.

†These values are unadjusted for the multiple counting of transient workers (see Section 4).

received an annual dose equal to the midpoint of the dose range in which he appears. The number of individuals in each dose range was multiplied by this midpoint, and then these products were summed. Overall, the tables show that about 40% of the total number of individuals monitored each year received exposures that were too small to be detected by personal radiation monitoring devices, as has been the case for the last six years. The collective dose increased slightly between 1982 and 1983 to a value of 60,900 man-rems (man-cSv) and is about 2,000 man-rems (man-cSv) more than that found for 1981.

The "Adjusted Total" shown in Table 1 for the dose distribution of individuals monitored by commercial power reactors in 1982 reflects corrections that were made to the compilation of the annual reports to account for the counting of transient workers more than one time. This adjusted total was also used in the calculation of the "Grand Total" at the bottom of Table 1. No adjustments were made to the distributions shown in Table 2 because the necessary data for transient workers has not yet been computerized. Further discussion of the data and methodology used in making these corrections is given in Section 4.

It should be pointed out that very few of the annual exposures that exceed five rems (cSv) are classified as personnel overexposures. Although 1.25 rems (cSv) is the quarterly limit set forth in paragraph (a) of 10 CFR § 20.101, paragraph (b) permits licensees, under certain conditions, to allow a worker to receive a whole body dose of three rems (cSv) per calendar quarter (up to 12 rems (cSv)) annually. The conditions are that (1) the licensee must have determined and recorded the worker's prior accumulated occupational dose to the whole body and that (2) the worker's whole body dose when added to his accumulated occupational dose does not exceed 5(N-18) rems (cSv) where "N" equals the individual's age in years. Although there is no annual limit, annual exposures that exceed 12 rems (cSv) indicate that an overexposure has occurred. Any quarterly exposure in excess of the applicable quarterly limits must be reported. A discussion of various types of occurrences in which the limits have been exceeded is given in Section 5.

A summary of the annual whole body exposures reported to the Commission by certain categories of NRC licensees required to submit reports pursuant to 10 CFR § 20.407 during the past sixteen years is presented in Table 3. About 95% of the exposures have consistently remained less than two rems (cSv), and the number of individuals receiving an annual exposure in excess of five rems (cSv) has remained at two tenths of one percent of the total number of individuals monitored each year for 1982 and 1983.

3.2 Summary of Occupational Exposure Data by License Category

As was previously explained, the statistical data contained in the annual reports required by 10 CFR § 20.407 provide the dose distribution of the workers monitored by each licensee and permit an estimate to be made of the collective dose incurred by these groups of individuals. This information was collated and summarized to yield the information shown in Table 4. Figures in the third column indicate the total number of individuals for whom monitoring was provided by the licensees in each category, and the fourth column gives the number of these individuals that received a measurable whole body dose (referred to as "workers" in this report). If one then divides the total collective dose (shown in the fifth column) by each of these figures, two average doses are found. The average dose per monitored individual is shown in the sixth column and is always smaller than the average dose per worker, shown in the seventh column. The

TABLE 3

SUMMARY OF ANNUAL WHOLE BODY EXPOSURES
FOR CERTAIN CATEGORIES OF LICENSEES

1968-1983

Year	Total Number of Monitored Persons Compiled Number	(Adjusted* Number)	Percent of Individuals With Doses <2 rems	Percent of Individuals With Doses >5 rems	Number of Individuals With Doses >12 rems
1968	36,836		97.2%	0.5%	3
1969	31,176		96.5%	0.5%	7
1970	36,164		96.1%	0.6%	0
1971	36,311		95.3%	0.7%	1
1972	44,690		95.7%	0.5%	8
1973	67,862		95.0%	0.5%	1
1974	85,097		96.4%	0.3%	1
1975	78,713		94.8%	0.5%	1
1976	92,773		95.0%	0.4%	3
1977	98,212	(93,438)	93.8%	0.4%	1
1978	105,893	(100,818)	94.6%	0.2%	3
1979	131,027	(125,316)	95.2%	0.2%	1
1980	159,177	(150,675)	94.6%	0.3%	0
1981	157,874	(149,314)	94.6%	0.2%	1
1982	162,456	(155,211)	94.9%	0.1%	0
1983	172,915	(N/A)	95.2%	0.1%	0

*The total number of monitored individuals after adjusting for the multiple counting of transient reactor workers (see Section 4).

TABLE 4

ANNUAL EXPOSURE DATA FOR CERTAIN CATEGORIES OF LICENSEES
1973 - 1983

LICENSE CATEGORY	Calendar Year	Number of Licensees Reporting	Number of Monitored Individuals	Number of Workers with Measurable Doses	Collective Dose (man-rems or man-cSv)	Average Dose per Monitored Individual (rems or cSv)	Average Measurable Dose per Worker (rems or cSv)	CR+
Industrial Radiography	1983	340	8,624	5,131	2,384	0.28	0.46	0.45
	1982	353	9,235	6,160	2,998	0.32	0.49	0.46
	1981	266	9,938	5,489	2,652	0.27	0.48	0.48
	1980	292	11,102	6,556	2,979	0.27	0.45	0.57
	1979	341	11,969	6,904	3,461	0.29	0.50	0.47
	1978	337	13,093	6,685	2,950	0.23	0.44	0.43
	1977	339	10,569	6,197	3,159	0.30	0.51	0.45
	1976	321	11,245	6,222	3,629	0.32	0.58	0.51
	1975	291	9,178	4,693	2,796	0.30	0.60	0.53
	1974	319	8,792	4,943	2,938	0.33	0.59	0.51
	1973	341	8,206	5,328	3,354	0.41	0.63	
Manufacturing and Distribution	1983	33	5,051	2,003	824	0.16	0.41	0.54
	1982	34	5,453	2,199	890	0.16	0.40	0.51
	1981	29	4,846	2,395	904	0.19	0.38	0.52
	1980	29	5,119	2,460	1,033	0.20	0.42	0.61
	1979	28	3,937	2,219	888	0.23	0.40	0.55
	1978	27	3,973	1,886	851	0.21	0.45	0.61
	1977	30	4,243	2,459	1,329	0.31	0.54	0.63
	1976	24	3,501	1,976	1,226	0.35	0.62	0.67
	1975	19	3,367	1,859	1,188	0.35	0.64	0.64
	1974	24	3,340	1,827	1,050	0.31	0.57	0.63
	1973	34	4,251	1,925	1,177	0.28	0.61	
Low-Level Waste Disposal	1983	1	612	358	71	0.12	0.20	0.14
	1982	1	680	251	53	0.08	0.21	0.20
Independent Fuel Storage	1983	1	33	27	8	0.24	0.30	0
	1982	1	35	32	9	0.26	0.28	0
Fuel Fabrication and Processing	1983	15	9,023	5,013	835	0.09	0.17	0.19
	1982	16	9,808	5,433	831	0.08	0.15	0.20
	1981	18	10,552	5,942	940	0.09	0.16	0.09
	1980	18	10,204	5,900	1,111	0.11	0.19	0.12
	1979	21	9,946	5,365	1,268	0.13	0.24	0.16
	1978	20	11,305	6,100	1,525	0.13	0.25	0.24
	1977	21	11,496	7,004	1,725	0.15	0.25	0.34
	1976	24	11,227	5,285	1,830	0.16	0.35	0.41
	1975	24	11,614	5,602	3,175	0.27	0.57	0.54
	1974	26	11,064	4,728	2,836	0.26	0.60	0.61
	1973	27	10,610	5,056	2,400	0.23	0.47	
**Commercial Light Water Reactors	1983	80	148,571	88,688	56,758	0.38	0.64	0.57
	1982	79	129,000*	80,227*	52,227	0.40	0.65	0.57
	1981	73	123,978*	80,664*	54,271	0.44	0.67	0.58
	1980	70	124,250*	77,903*	53,810	0.43	0.69	0.59
	1979	69	99,463*	62,316*	39,759	0.40	0.64	0.57
	1978	68	72,448*	45,474*	31,910	0.44	0.70	0.61
	1977	65	67,130*	42,867*	32,731	0.49	0.76	0.64
	1976	62	66,800	36,715	26,555	0.40	0.72	0.62
	1975	54	54,763	28,034	21,270	0.39	0.76	0.64
	1974	53	62,044	21,904	14,083	0.23	0.64	0.62
	1973	41	44,795	16,558	14,337	0.32	0.87	
Grand Totals and Averages	1983	467	171,914	101,220	60,880	0.35	0.60	0.56
	1982	482	154,211*	94,302*	57,008	0.37	0.60	0.56
	1981	385	149,314*	94,490*	58,767	0.39	0.62	0.56
	1980	410	150,675*	92,819*	58,933	0.39	0.63	0.57
	1979	459	125,316*	76,804*	45,376	0.36	0.59	0.55
	1978	453	100,819*	60,145*	37,236	0.37	0.62	0.59
	1977	455	93,438*	58,527*	38,944	0.42	0.67	0.62
	1976	428	92,773	50,198	33,240	0.36	0.66	0.60
	1975	388	78,922	40,188	28,429	0.36	0.71	0.62
	1974	422	85,240	33,402	20,907	0.25	0.63	0.60
	1973	443	67,862	28,867	21,268	0.31	0.74	

+CR is the ratio of the annual collective dose delivered at annual doses exceeding 1.5 rems to the total annual collective dose. (See Section 3.2).
*These figures are adjusted to account for the multiple counting of transient reactor workers (see Section 4).
**Includes all LWRs that reported, although all of them may not have been in commercial operation for a full year.

latter average is normally used for radiation workers because it deletes the minimal exposures of many individuals who are monitored for convenience or for identification purposes.

One of the parameters that the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) recommends be calculated for occupational dose distributions to aid in the comparison of exposure data is the ratio "CR." CR is defined to be the ratio of the annual collective dose incurred by individuals whose annual doses exceed 1.5 rems to the total annual collective dose. The latest UNSCEAR report [Ref. 1] states that normal values of CR should be between 0.05 and 0.50. This means that, usually, no more than 50% of the collective dose should be due to individual doses that exceed 1.5 rems. The last column in Table 4 shows the values of CR for the different types of licenses; one can see that CR is close to 0.50 for three of the groups and is much less than 0.50 for the remaining three groups.

3.2.1 Industrial Radiography Licenses, Single and Multiple Locations

These 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 plant, and others perform radiography at multiple sites in the field. As shown in Table 4, annual reports were received for 353 radiography licenses in 1982 and for 340 licenses in 1983. This means that more than 98% of the covered radiography licensees filed an annual report, and extrapolations to account for those not reporting were not necessary.

Table 5 summarizes the reported data for the two types of radiography licenses for 1982 and 1983 and shows that the number of workers receiving measurable doses reported by the single-location license decreased by 18% while the collective dose increased by 14% between 1982 and 1983. This resulted in the average measurable dose increasing from 0.20 rem (cSv) to 0.28 rem (cSv). The number of workers at firms having multiple-location licenses also decreased by about 16%, and the collective dose decreased even more (23%). This resulted in the average measurable dose decreasing to 0.50 rem (cSv). Overall, one finds that the average measurable dose for radiography workers continues to remain at about one-half of one rem (cSv), as it has for the last seven years, and that the average dose for workers performing radiography at a single location is usually less than half this amount. This is probably due to the fact that it is much more difficult for workers to avoid exposure to radiation in the field, where conditions are not the best and may change every day. In order to see the contribution that each radiography licensee made to the total collective dose, a summary of the information reported by each of these licensees in 1982 and in 1983 is presented, in alphabetical order, in Appendix A.

TABLE 5

ANNUAL EXPOSURE INFORMATION FOR INDUSTRIAL RADIOGRAPHERS
1982 and 1983

Type of License	Year	Number of Monitored Individuals	Workers with Measurable Doses	Collective Dose (manrems or man-cSv)	Average Measurable Dose (rems or cSv)
Single location	1982	1,977	942	187	0.20
Multiple locations	1982	7,258	5,218	2,811	0.54
Total	1982	9,235	6,160	2,998	0.49
Single location	1983	1,714	773	213	0.28
Multiple locations	1983	6,910	4,358	2,171	0.50
Total	1983	8,624	5,131	2,384	0.46

Since personnel monitoring data has frequently been found to have lognormal distributions [Ref. 2], trends in the data reported by radiography licensees may be observed from log probability plots* of the data.

Figure 1 displays such plots of the doses incurred by workers monitored by the two types of radiography licensees for each of the years 1982 and 1983. One can see that the plots of the dose distributions of workers at single location radiography facilities, where the workers receive doses that average about half of those received by workers at multiple-location facilities, form fairly straight lines and usually lie above those of the multiple location facilities. One feature of these types of graphs is that several comparisons of various dose distributions can be quickly made. For example, one can easily see that about 85% of the workers monitored by firms licensed for radiography at multiple locations received doses that were less than one rem (cSv), while some 96% of the workers monitored at single location radiography facilities received such doses. Also, the relative positions and curvature of the graphs are indicative of certain characteristics of the dose distributions.

Further examination of the plots of the dose distribution of workers at single location radiography facilities reveals that the position of the 1983 plot below that of the 1982 plot indicates an increase in the average dose and in CR (as shown at the bottom of the graph). This is due to the fact that six workers received doses that exceeded four rems (cSv) in 1983. Looking at the plots for the multiple location licensees for 1982 and 1983, one can quickly see that they are quite similar to each other, and one would expect to see similar average doses and values of CR.

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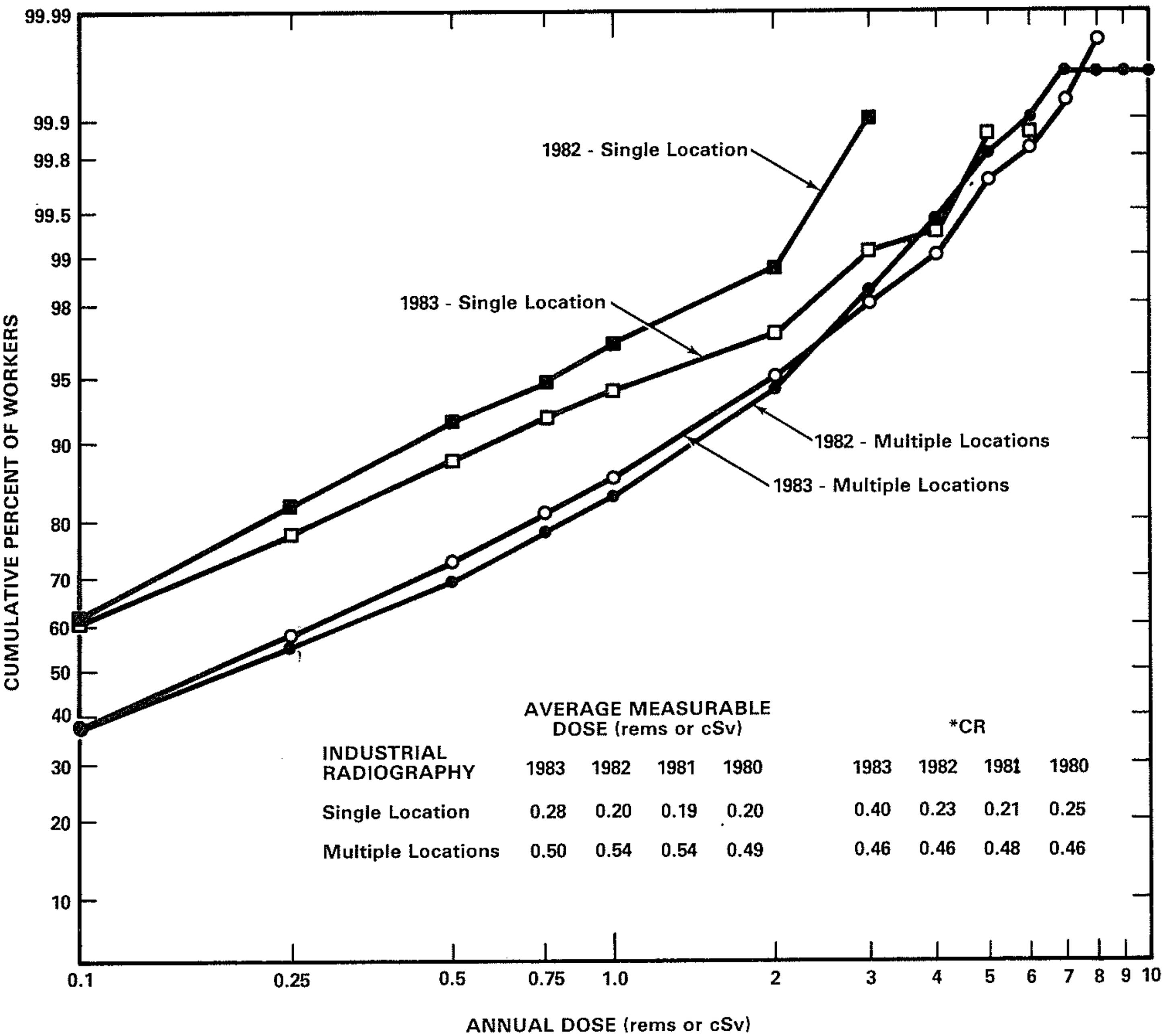
*If the data have a log normal distribution, the data points will form a straight line when plotted on log probability paper on which cumulative probabilities are laid off on the vertical axis at distances proportional to the corresponding number of standard deviations above or below the median, and the dose is plotted on the horizontal axis on a logarithmic scale.

FIGURE 1
ANNUAL DOSE DISTRIBUTION OF WORKERS
AT INDUSTRIAL RADIOGRAPHY FACILITIES
1982 & 1983



INDUSTRIAL RADIOGRAPHY	AVERAGE MEASURABLE DOSE (rems or cSv) 1983	1982	1981	1980	*CR 1983	1982	1981	1980
Single Location	0.28	0.20	0.19	0.20	0.40	0.23	0.21	0.25
Multiple Locations	0.50	0.54	0.54	0.49	0.46	0.46	0.48	0.46

*CR is the ratio of the annual collective dose delivered at individual doses exceeding 1.5 rems to the total annual collective dose.

Note: Each point on the curves represents the cumulative percentage of workers with measurable doses who received doses less than the indicated annual dose.

The tendency of the plots to curve upward for doses greater than one rem (cSv) is typical of distributions having several workers with doses in the higher dose ranges [Ref. 1, 3], and indicates that the entire distribution is not a log normal one. Another theoretical analysis of occupational dose distributions [Ref. 4] has found that these data may be fitted by a hybrid log normal distribution. At low doses, this distribution is log normal, but at higher doses, where radiation control programs very closely monitor each worker's total dose so that the frequency of doses approaching the dose limits is reduced, the distribution is normal.

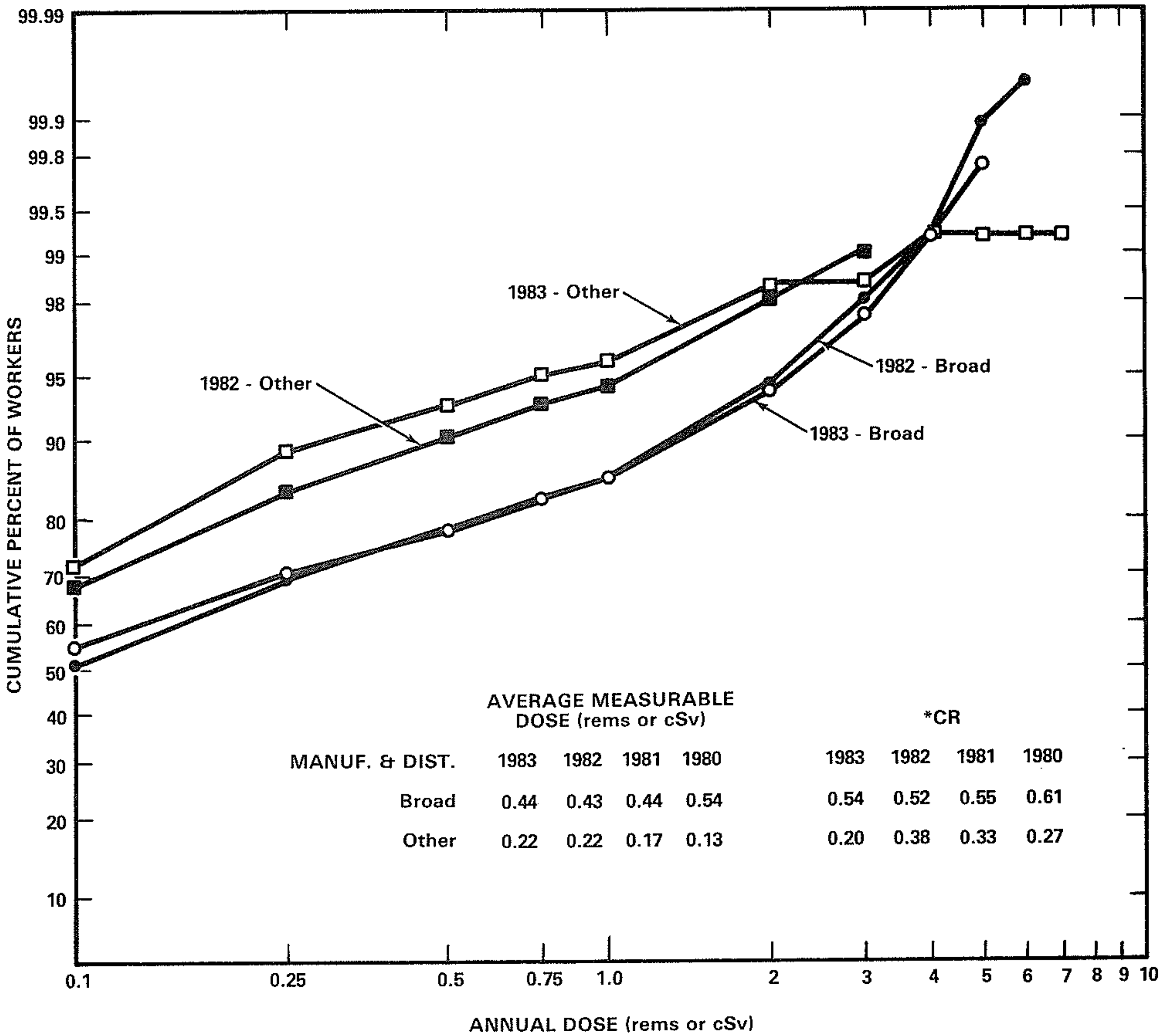
3.2.2 Manufacturer and Distributor Licenses, Broad and Other

These licenses are issued to allow the manufacture and distribution of radionuclides in various forms for a number of diverse purposes. Broad licenses are issued to large facilities having a comprehensive radiological protection program, and the other licenses are usually issued to smaller firms requiring a more restrictive license. Some 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. Other 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 non-medical research. However, only those NRC licensees (about 30) that possess or use at any one time specified quantities of the nuclides listed in Paragraph 20.408(a)(6) are required to submit annual (10 CFR § 20.407) and termination (10 CFR § 20.408) reports. As shown in Table 4, annual reports were received from 34 and 33 manufacturing and distribution licensees in 1982 and 1983, respectively.

Table 6 presents the annual data that were reported by the two types of licensees in 1982 and 1983. One can see that the total number of workers receiving measurable doses, as reported by these types of licensees decreased by about nine percent between 1982 and 1983, as did the collective dose. This resulted in the average dose remaining at about 0.41 rem (cSv). This is about the same as the average measurable doses found in 1980 and 1981. Looking at the information shown separately for the broad and other types of licensees, one can see that the values of all of the parameters remain higher for the broad licensees, probably because this type of license allows the possession of larger quantities of radioactive materials than do the other licenses. In order to see the contribution that each of these licensees made toward the total values of the number of persons monitored, number of workers, and collective dose, Appendix A lists the values of these parameters for each licensee in alphabetical order by licensee name for 1982 and 1983.

Figure 2 displays log probability plots of the doses incurred by workers under the two types of manufacturing and distribution licenses for the years 1982 and 1983. The position of the curves plotted for the other licenses above those plotted for the broad licenses indicates that a larger portion of the workers reported by the other licensees have lower doses than those reported by the broad licensees. For example, the graphs show that about 86% of workers monitored by the broad licensees received doses that were less than one rem (cSv),

Figure 2
ANNUAL DOSE DISTRIBUTION OF WORKERS
AT MANUFACTURING & DISTRIBUTION FACILITIES
1982 & 1983



MANUF. & DIST.	AVERAGE MEASURABLE DOSE (rems or cSv) 1983	1982	1981	1980	*CR 1983	1982	1981	1980
Broad	0.44	0.43	0.44	0.54	0.54	0.52	0.55	0.61
Other	0.22	0.22	0.17	0.13	0.20	0.38	0.33	0.27

*CR is the ratio of the annual collective dose delivered at individual doses exceeding 1.5 rems to the total annual collective dose.

Note: Each point on the curves represents the cumulative percentage of workers with measurable doses who received doses less than the indicated annual dose.

TABLE 6

ANNUAL EXPOSURE INFORMATION FOR MANUFACTURERS AND DISTRIBUTORS
1982 and 1983

Type of License	Year	Number of Monitored Individuals	Workers with Measurable Doses	Collective Dose (man-rems or cSv)	Average Measurable Dose (rems or cSv)
M & D-Broad	1982	4,610	1,892	821	0.43
M & D-Other	1982	843	307	69	0.22
Total	1982	5,453	2,199	890	0.40
M & D-Broad	1983	4,332	1,744	767	0.44
M & D-Other	1983	719	259	57	0.22
Total	1983	5,051	2,003	824	0.41

while about 98% of the workers monitored by the other licensees received such doses.

3.2.3 Low-Level Waste Disposal Licensees

These 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 equipment to pick up wastes from such places as hospitals, and laboratories, and transport them to a proper facility for storage and burial.

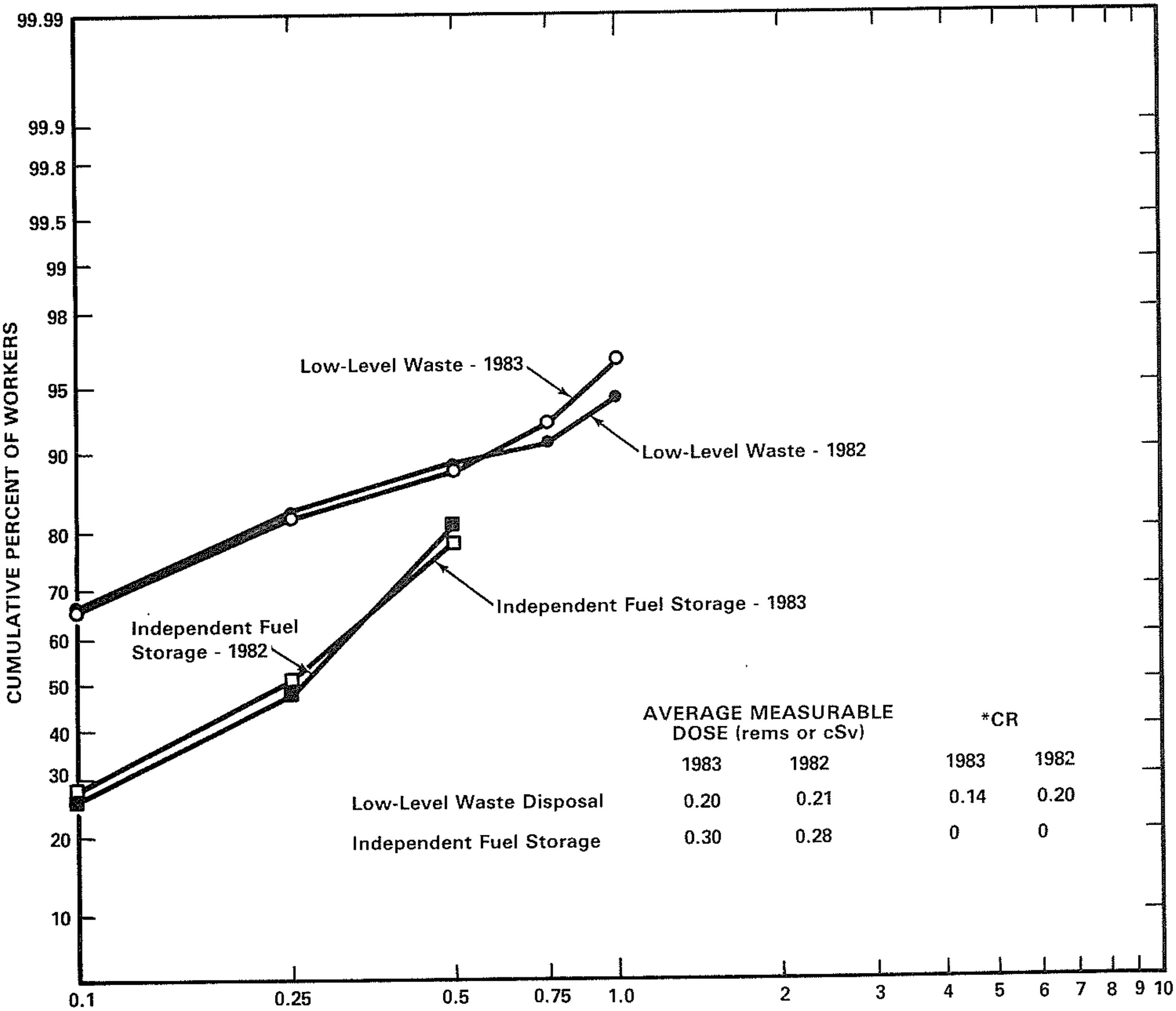
The requirement for this category of NRC licensee to file annual reports became effective in January 1983. The one licensee in this category submitted annual reports for 1982 and 1983, although the facility is located in and licensed by an Agreement State, which has primary regulatory authority over its activities. The licensee is an older company with a fairly large operation, and Table 4 summarizes the data reported for 1982 and 1983. One can see that the collective dose, although rather small, increased by about 30% from 1982 to 1983. However, the number of workers receiving measurable doses increased by some 40%, so that the average measurable dose remained at about 0.20 rem (cSv).

Figure 3 displays log probability plots of the doses incurred by workers at the low-level waste disposal facility during 1982 and 1983. One can quickly see that the distributions are quite similar, with all of the doses being less than two rems (cSv) and about 92% of the doses being less than 0.75 rem (cSv) each year. This resulted in the average measurable doses remaining at about 0.20 rem (cSv) each year and in rather low values of CR each year. Appendix A lists the exposure information reported by this licensee.

3.2.4 Independent Spent Fuel Storage Installation

These licenses are issued to allow the possession of power reactor spent fuel and other associated radioactive materials for the purpose of storage of such fuel in an independent spent fuel storage installation (ISFSI). Here, the spent fuel, which has undergone at least one year's decay since being used as a

Figure 3
ANNUAL DOSE DISTRIBUTION OF WORKERS AT LOW-LEVEL WASTE DISPOSAL FACILITIES AND AT AN INDEPENDENT FUEL STORAGE FACILITY
1982 & 1983



	AVERAGE MEASURABLE DOSE (rems or cSv)		*CR	
	1983	1982	1983	1982
Low-Level Waste Disposal	0.20	0.21	0.14	0.20
Independent Fuel Storage	0.30	0.28	0	0

*CR is the ratio of the annual collective dose delivered at individual doses exceeding 1.5 rems to the total annual collective dose.

Note: Each point on the curves represents the cumulative percentage of workers with measurable doses who received doses less than the indicated annual dose.

source of energy in a power reactor, is provided interim storage, protection, and safeguarding for a limited time, pending its ultimate disposal.

Table 4 summarizes the data submitted by the only licensed ISFSI for 1982 and 1983. Only about 35 individuals were monitored at the facility and a collective dose of 8 or 9 man-rems (man-cSv) was incurred each year. The average dose for the approximately 30 workers receiving measurable doses each year was found to be about 0.30 rem (cSv).

Figure 3 displays log probability plots of the doses incurred by workers at the ISFSI in 1982 and 1983. The plots are similar, with all doses being less than 0.75 rem so that the value of CR was zero each year. Appendix A lists the exposure data reported by this licensee.

3.2.5 Fuel Fabrication and Reprocessing Licenses

The fuel fabrication licenses are issued to allow the processing and fabrication of reactor fuels. In most uranium facilities, where light water reactor fuels are processed, uranium hexafuoride enriched in the isotope U-235 is converted to solid uranium dioxide pellets and inserted into zirconium tubes. The tubes are fabricated into fuel assemblies, which are shipped to nuclear power plants. Some facilities also perform chemical operations to recover the uranium from scrap and other off-specification materials. On a much smaller scale, fuel assemblies containing plutonium oxide pellets can be similarly fabricated and used in reactors for experimental purposes. However, there are no NRC licensees engaged in this activity at this time.

The number of facilities licensed by the NRC to fabricate fuel, especially plutonium fuel, has been decreasing for the last several years (Table 4). Therefore, a number of licensees (five in 1982 and four in 1983) are primarily engaged in decommissioning activities, and the information that they provided for 1982 and 1983 is shown as "Pu Decommissioning" in Table 7.

Table 7

ANNUAL EXPOSURE INFORMATION FOR FUEL FABRICATORS
1982 and 1983

Type of License	Year	Number of Monitored Individuals	Workers with Measurable Doses	Collective Dose (man-rems or man-cSv)	Average Measurable Dose(man-rems or man-cSv)
Uranium Fuel Fab	1982	8,652	5,117	724	0.14
Pu Decommissioning	1982	1,156	316	107	0.34
Total	1982	9,808	5,433	831	0.15
Uranium Fuel Fab	1983	8,440	4,746	748	0.16
Pu Decommissioning	1983	583	267	87	0.33
Total	1983	9,023	5,013	835	0.17

One can see that the collective dose incurred during decommissioning is much less than that incurred during fuel fabrication, but the small number of workers incurring the dose results in an average measurable dose that is about twice that received by the fuel fabrication workers. However, it should be pointed out that three of the eleven licensees primarily engaged in uranium fuel fabrication in 1982 and 1983 were also involved in the decommissioning of plutonium facilities, and the report submitted by each one covered both activities. Therefore, for comparison with data submitted for previous years, the data in the "Totals" row should be used because decommissioning activities were also being conducted during previous years and were not shown separately. Appendix A lists the number of persons monitored, the number of workers receiving measurable doses, and the collective dose for each of these licensees in alphabetical order by licensee name for 1982 and 1983.

Figure 4 consists of the log probability plots of the dose distributions of workers at fuel fabrication facilities for the years 1982 and 1983. One can see that the distributions are quite similar, with all doses being less than five rems (cSv) and about 99.3% of the doses being less than two rems (cSv) each year. The average dose and the value of CR were therefore about the same for each.

Fuel reprocessing licenses are issued to allow the separation of usable uranium and plutonium from spent nuclear fuel. There is only one licensed commercial facility that has ever reprocessed fuel, and it has been shut down since 1972. However, the licensee was still doing some decontamination work and storing radioactive waste at the facility, and the annual report that was submitted each year was usually grouped with those of the fuel fabricators. In February 1982, the Department of Energy assumed possession and control of the reprocessing facility to conduct waste solidification activities necessary for final decommissioning. During this period, the NRC license will, in effect, be suspended, and no reports will be filed with the NRC.

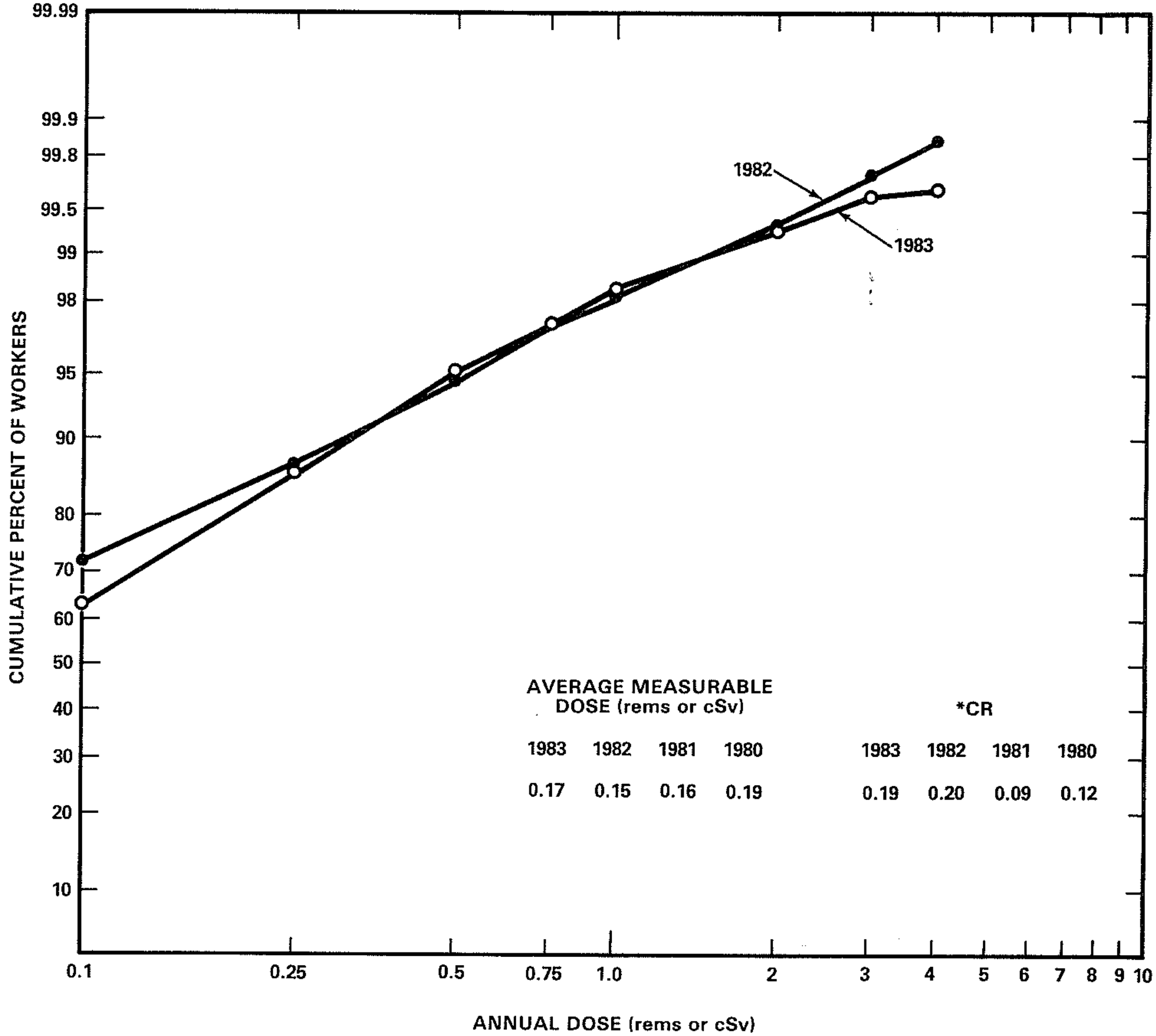
3.2.6 Water-Cooled Power Reactor Licenses

These licenses are issued to utilities to allow them to use special nuclear material in a reactor to produce heat to generate electricity to be sold to consumers. There are two major types of commercial reactors in the United States - pressurized water reactors and boiling water reactors - each of which uses water as the primary coolant.

As shown in Table 4, annual reports were received from nuclear power facilities for 79 licensed reactors where 129,000 individuals were monitored for exposure to radiation in 1982. Of this number 80,227 workers received a measurable dose and incurred a collective dose of 52,227 man-rems (man-cSv). These figures are about the same as those reported in 1981. In 1983, the collective dose increased somewhat to reach a high of 56,758 man-rems (man-cSv), while the average measurable dose remained about the same. Figure 5 provides plots of the total values of several of the parameters given in Table 4.

Table 8 shows the contribution made by the two major types of power reactors. One can see that the average dose per worker, collective dose per reactor, number of workers per reactor and collective dose per megawatt-year have been greater for boiling water reactors (BWRs) than that found for pressurized water

Figure 4
ANNUAL DOSE DISTRIBUTION OF WORKERS
AT FUEL FABRICATORS AND PROCESSORS
1982 & 1983



*CR is the ratio of the annual collective dose delivered at individual doses exceeding 1.5 rems to the total annual collective dose.

Note: Each point on the curves represents the cumulative percentage of workers with measurable doses who received doses less than the indicated annual dose.

Figure 5
TOTAL ANNUAL VALUES
AT LIGHT WATER COOLED REACTORS
1969 - 1983

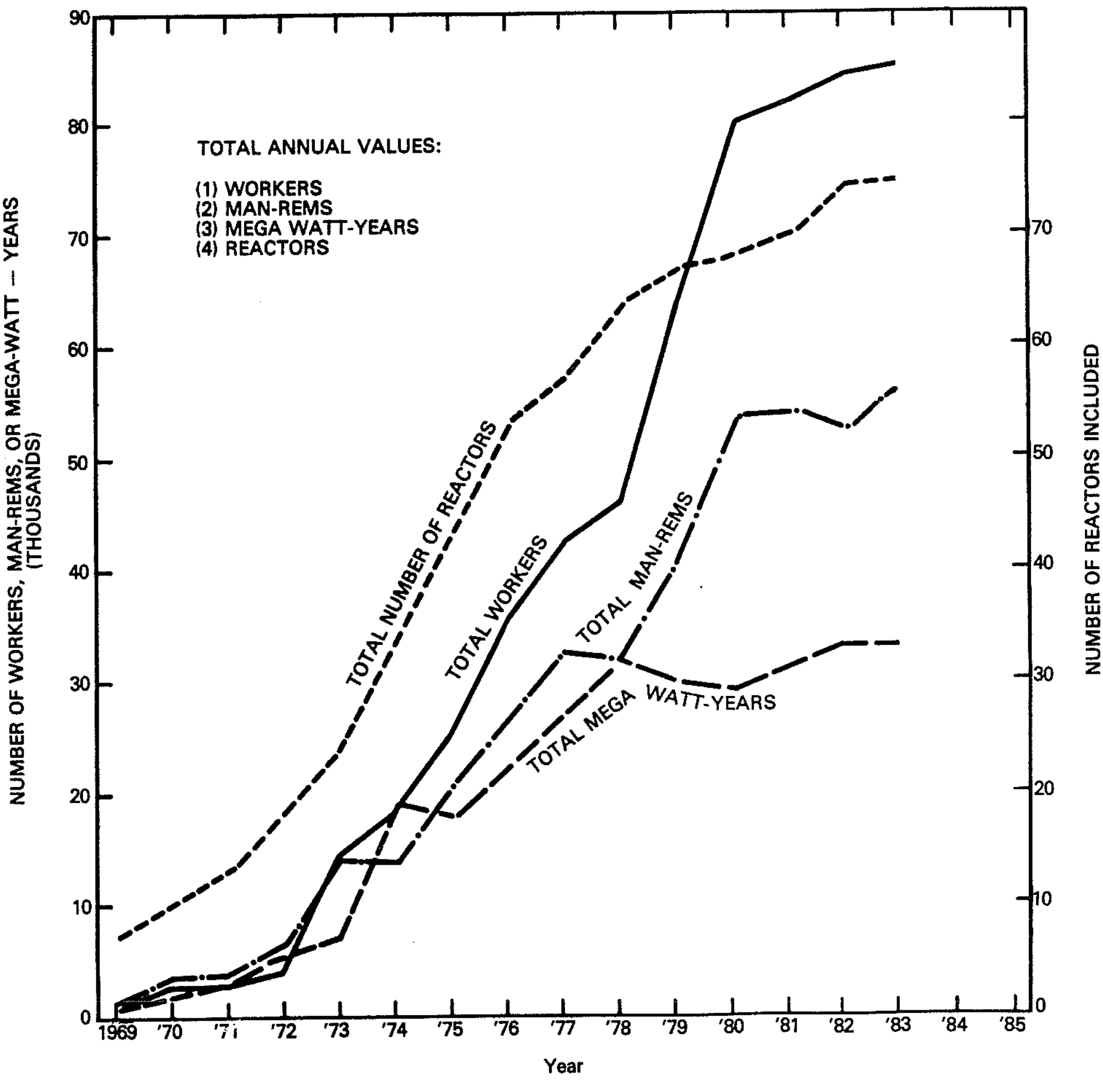


TABLE 8*

SUMMARY OF ANNUAL EXPOSURES
REPORTED BY NUCLEAR POWER FACILITIES
1973 - 1983

Year	Reactor Type	Number of Reactors Included	Total Number of Man-rems	**No. of Workers With Measurable Doses	Total Megawatt-yr. Generated	Average Annual Dose (rems/worker or cSv/worker)	Average Collective Dose per Reactor (man-rems or man-cSv)	Average No. of Workers Per Reactor	Collective Dose per Megawatt-yr.
1973	PWRs	12	9,399	9,440	3,770	1.00	783	787	2.5
	BWRs	12	4,564	5,340	3,394	0.85	380	445	1.3
	Total	24	13,963	14,780	7,164	0.94	582	616	1.9
1974	PWRs	20	6,627	9,697	6,824	0.68	331	485	1.0
	BWRs	14	7,095	8,769	4,059	0.81	507	626	1.7
	Total	34	13,722	18,466	10,883	0.74	404	543	1.3
1975	PWRs	26	8,268	10,884	11,983	0.76	318	419	0.7
	BWRs	18	12,611	14,607	5,786	0.86	701	812	2.2
	Total	44	20,879	25,491	17,769	0.82	475	579	1.2
1976	PWRs	30	13,807	17,588	13,325	0.79	460	586	1.0
	BWRs	23	12,626	17,859	8,586	0.71	549	776	1.5
	Total	53	26,433	35,447	21,911	0.75	499	669	1.2
1977	PWRs	34	13,469	20,878	17,346	0.65	396	614	0.8
	BWRs	23	19,042	21,388	9,098	0.89	828	930	2.1
	Total	57	32,511	42,266	26,444	0.77	570	742	1.2
1978	PWRs	39	16,713	25,720	19,840	0.65	429	659	0.8
	BWRs	25	15,096	20,278	11,774	0.74	604	811	1.3
	Total	64	31,809	45,998	31,614	0.69	497	719	1.0
1979	PWRs	42	21,437	38,828	18,249	0.55	510	924	1.2
	BWRs	25	18,322	25,245	11,671	0.73	733	1,010	1.6
	Total	67	39,759	64,073	29,920	0.62	593	956	1.3
1980	PWRs	42	24,266	46,237	18,287	0.52	578	1,101	1.3
	BWRs	26	29,530	34,094	10,868	0.87	1,136	1,311	2.7
	Total	68	53,796	80,331	29,155	0.67	791	1,181	1.8
1981	PWRs	44	28,671	47,351	20,552	0.61	652	1,076	1.4
	BWRs	26	25,471	34,832	10,899	0.73	980	1,340	2.7
	Total	70	54,142	82,183	31,451	0.66	773	1,174	1.7
1982	PWRs	48	27,753	52,147	22,141	0.53	578	1,086	1.3
	BWRs	26	24,437	32,235	10,655	0.76	940	1,240	2.3
	Total	74	52,190	84,382	32,795	0.62	705	1,139	1.6
1983	PWRs	49	29,016	52,173	23,196	0.56	592	1,065	1.3
	BWRs	26	27,455	33,473	9,730	0.82	1,056	1,287	2.8
	Total	75	56,471	85,646	32,926	0.66	753	1,142	1.7

*The figures on this table are based on the number of nuclear power reactors that had been in commercial operation for at least one year as of December 31 of each of the years indicated.

**Uncorrected for multiple counting of transient workers because the workers may be monitored by both BWRs and PWRs.

reactors (PWRs) for the last ten years. This can be easily seen in Figure 6 which plots the average values of the annual collective dose and number of workers for each year since 1969.

Figure 7 presents the log normal plot of the distribution of the whole body doses received by radiation workers at nuclear power facilities in 1982 and 1983. One can quickly see that about 73% of the workers receiving measurable doses at BWRs received doses that were less than one rem (cSv), while about 82% of the workers at PWRs received such doses. Also, departures from a straight line for doses that exceed one rem are again seen, and, according to the hybrid log normal method [Ref. 4] of analyzing these dose distributions, the sharpness of the departure indicates that a strong feedback mechanism operates when workers begin to incur large doses. Listed at the bottom of the figure are the values of CR for the last four years. These show that a larger portion of the collective dose (about 60%) at BWRs continues to be due to workers receiving doses greater than 1.5 rems (cSv) than at PWRs, where CR is usually about 0.50. More detailed presentations and analyses of the annual exposure information reported by nuclear power reactors can be found in the two annual reports, NUREG-0713, Vol. 4 [Ref. 5] and NUREG-0713, Vol. 5 [Ref. 6].

3.2.7 High Temperature Gas Cooled Power Reactor Licenses

A license to operate a power reactor is issued to utilities to allow them to use special nuclear material in a reactor to produce heat to generate electricity to be sold to consumers. However, in this type of a reactor, a gas, usually helium, is used as the primary coolant. Fort St. Vrain near Greeley, Colorado, is the only such reactor in operation in the U.S. As shown in Table 9, annual whole body doses incurred by workers at the plant have been minimal. For the last three years, everyone monitored has received a whole body dose that was less than 0.10 rem (cSv), and no one has ever exceeded an annual dose of 0.25 rem (cSv). The average dose per worker remains at about 0.03 rem (cSv) or less.

TABLE 9
ANNUAL EXPOSURE INFORMATION FOR FORT ST. VRAIN
1974 - 1983

Year	No. of Individuals with Annual Doses in Ranges (Rems or cSv)			Total No. of Individuals Monitored	Annual Collective Dose (man-rems or man-cSv)	Gross Electricity Generated (MW-yr.)	Average Measurable Dose Per Worker (rems or cSv)
	No Measurable Dose	Measurable Dose <0.10	0.10-0.25				
1974	1597	63	1	1,661	3.3	0.0	0.05
1975	1263	0	0	1,263	0.0	0.0	0.00
1976	1362	25	0	1,387	1.3	2.8	0.05
1977	946	55	1	1,002	2.9	29.8	0.05
1978	896	34	0	930	1.7	75.7	0.05
1979	1149	120	2	1,271	6.4	28.6	0.05
1980	902	57	1	960	3.0	83.2	0.05
1981	1096	31	0	1,127	1.0	93.6	0.03
1982	978	22	0	1,000	0.4	72.6	0.02
1983	965	48	0	1,013	1.0	94.4	0.02

Figure 6
COMMERCIAL LIGHT WATER COOLED REACTORS
1969 - 1983

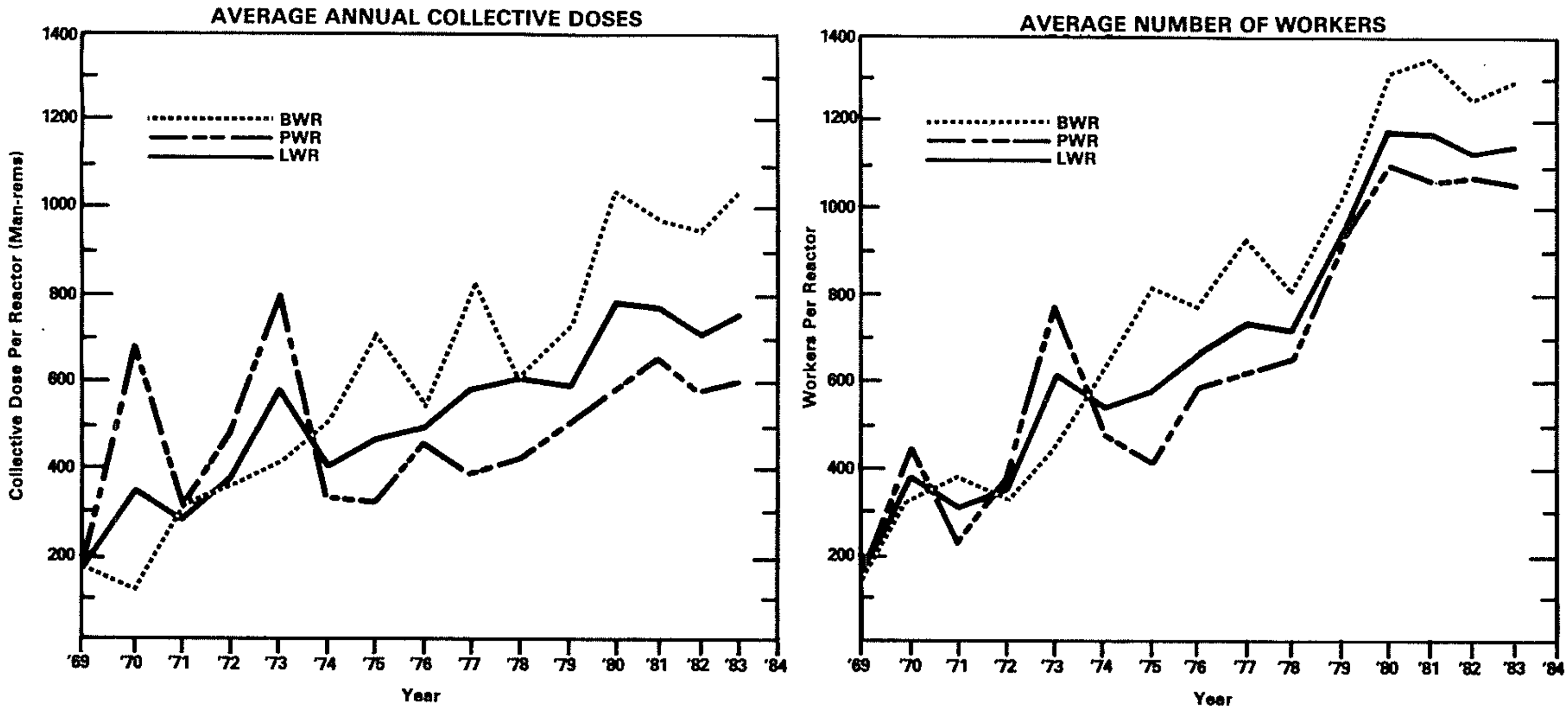
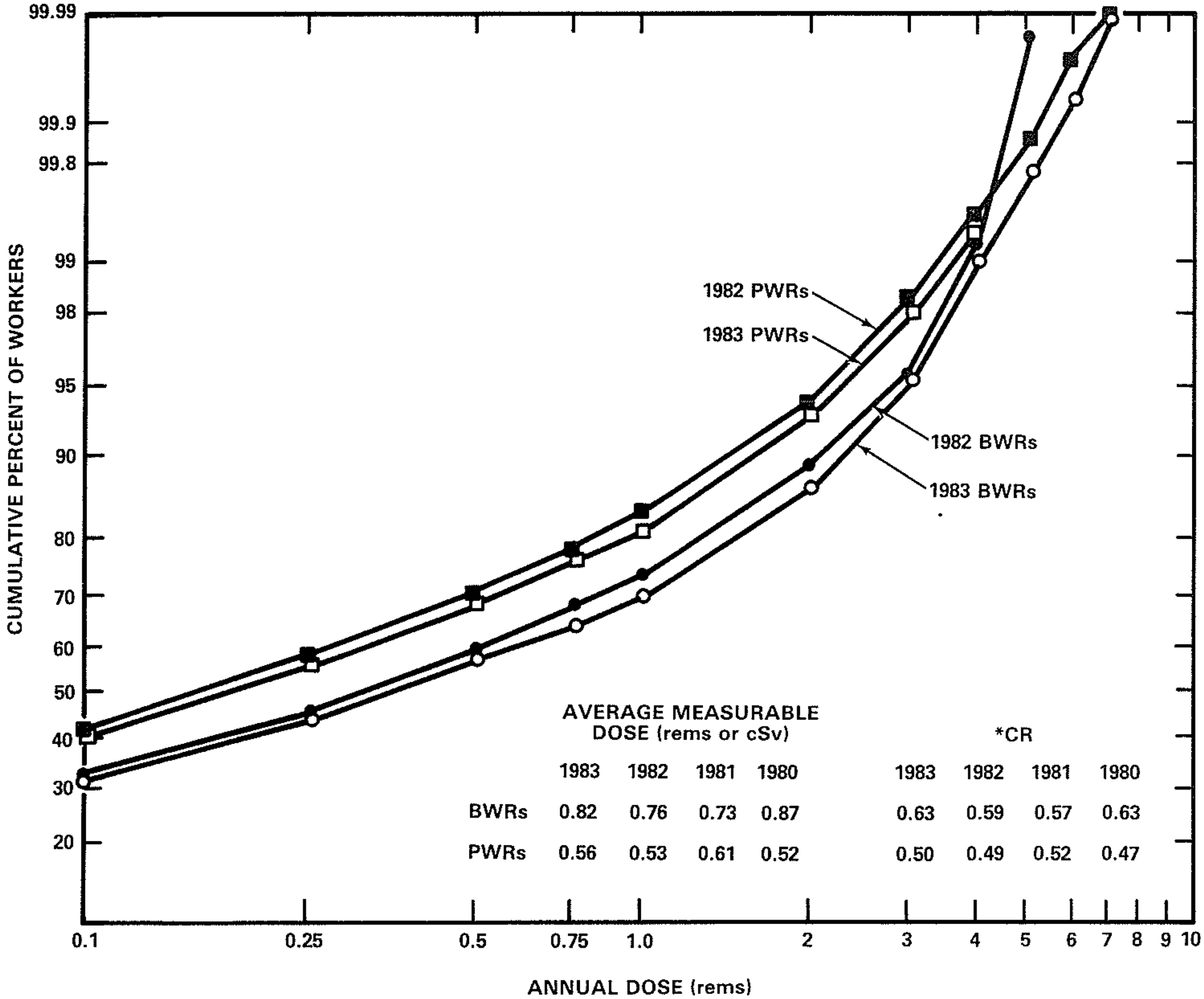


Figure 7
ANNUAL DOSE DISTRIBUTION OF WORKERS AT
LIGHT WATER REACTOR FACILITIES
1982 & 1983



	AVERAGE MEASURABLE DOSE (rems or cSv)				*CR			
	1983	1982	1981	1980	1983	1982	1981	1980
BWRs	0.82	0.76	0.73	0.87	0.63	0.59	0.57	0.63
PWRs	0.56	0.53	0.61	0.52	0.50	0.49	0.52	0.47

*CR is the ratio of the annual collective dose delivered at individual doses exceeding 1.5 rems to the total annual collective dose.

Note: Each point on the curves represents the cumulative percentage of workers with measurable doses who received doses less than the indicated annual dose.

For the ten years ending on December 31, 1983, the total collective dose for workers at the site is about 27 man-rems (man-cSv), and a total of 481 megawatt-years of electricity had been generated. This yields a ten-year average of about 0.04 man-rem (man-cSv) per megawatt-year which is a small fraction of the average value of this parameter found for LWRs (see Table 4).

3.3 Health Implications of Average Annual Doses

If any damage to health is caused by exposure to radiation in the work place, it would probably manifest itself as certain types of cancer in the exposed worker or, less likely, as inherited genetic damage in the first few generations of the workers' offspring. However, the likelihood of either cancer or genetic damage occurring as a result of occupational radiation exposure experienced by workers in the nuclear industry is small. A vast amount of scientific information is available from which estimates of these risks can be made. Much of this information, however, has been obtained from epidemiologic studies of human populations at levels of exposures considerably higher than those normally experienced in the work place. Complementary to this, information obtained from many animal and cell biology studies has greatly enhanced our knowledge and understanding. Although using this information to estimate risks in the work place introduces large uncertainties, these uncertainties can be dealt with in such a manner that the risk is not likely to be underestimated. Thus the discussion below is likely to overstate the health implications rather than understate them.

Cancer induction as a result of radiation exposure has been examined by many organizations having scientific and medical expertise in the subject. One of these, the National Academy of Sciences (NAS), completed a comprehensive review of the biological effects of ionizing radiation in 1980 [Ref. 8]. Based on this report, a large working population receiving one million man-rems (man-cSv) might suffer an estimated 100 to 200 additional cancer deaths over the remaining years of their lives. This risk estimate can be applied to the collective dose, 61,000 man-rems (man-cSv) and the population, 101,000 workers, receiving measurable exposures, presented in Table 4 of this report. The result is that, for the work force reported as being exposed in 1983, the expected number of cancer deaths that might result from occupational radiation dose received that year would be about ten. (Results derived from the 1982 data would be quite similar.) These deaths would occur many years following the exposure and would be in addition to the approximately 18,000 cancer deaths that occur normally in a population of 100,000 workers without exposure to this amount of radiation. Perhaps more meaningful to the individual workers are the health implications to the workers receiving the average dose of 0.60 rem (cSv) or the maximum dose of 25 rems (cSv) during 1983. The estimated increased cancer death risk is about one chance in 10,000 for the average dose and about four chances in 1,000 for the maximum dose. Should a worker receive 0.60 rem (cSv) per year continuously during his entire working career (working from age 20 until age 65) his risk of dying from cancer could increase by less than 2% over the normal risk of dying of cancer. These risks can be compared to the American Cancer Society's estimates of one chance in four of developing cancer and one chance in six of dying of cancer.

The potential genetic effects from a worker population receiving about 61,000 man-rems (man-cSv) is very small compared to the genetic damages that normally

occur spontaneously in a population of this size. Approximately 100,000 serious genetic defects occur normally in one million live births, i.e., an average of about one serious defect in every ten live births. Theoretically, the total genetic damage in the first generation children of the 101,000 workers would, according to the 1980 NAS report, be an increase of four or less cases (less than 0.05%) compared to the expected 10,000 cases that occur normally. No significant increase in the number of genetic defects has been observed in the children of individuals exposed to ionizing radiation at Hiroshima and Nagasaki, Japan.

4. TERMINATION DATA SUBMITTED PURSUANT TO 10 CFR § 20.408

4.1 Termination Reports, 1969-1983

In 1969, the Atomic Energy Commission (predecessor of the NRC) began requiring certain categories of licensees[†] to submit personal identification and exposure information upon the termination of each monitored person's employment or work assignment in the licensee's facility. The appropriate information on each report has been manually coded and entered into the Commission's computerized Radiation Exposure Information Reporting System (REIRS) for permanent retention. The data are retrievable by several criteria - social security number name, facility, etc. - which allows statistical analysis of the data as well as the tracing of individual dose histories. During the years that this information has been collected, some 1,100,000 termination records have been received for approximately 300,000 individuals who have been reported as having terminated their employment at facilities in one or more of the categories of covered licensees. The figures given for the number of reports and the number of individuals are different because numerous individuals have been terminated more than once over the years and because some individuals may have had external doses reported for more than one part of the body, as well as estimates of internal depositions of radioactive material, each of which is counted as one record. Table 10 provides a breakdown of this information for individuals terminating during each of fifteen years and, since the majority of termination reports are now submitted by nuclear power facilities, the number of records and individuals that they reported are displayed separately. One can see that the number of records continues to increase each year, primarily because of the growing need for workers at power reactors.

4.2 Limitations of the Termination Data

When examining or using the statistics that are based on the termination data, one should keep in mind that these data have various limitations: (1) some licensees submit a termination report for each monitored contractor employee at the end of each monitoring period rather than waiting until the individual

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*Assuming that, on the average, each exposed person will have one child in the future, i.e., 101,000 children born to this worker population.

†Commercial nuclear power reactors; industrial radiographers; fuel processors, fabricators, and reprocessors; and manufacturers and distributors of specified quantities of byproduct material.

TABLE 10

TERMINATION REPORTS SUBMITTED TO THE NRC
1969 - 1983**

	All Covered Categories*		Power Reactor Licensees	
YEAR	Number of Termination Records	Number of Terminating Individuals	Number of Termination Records	Number of Terminating Individuals
1969	5,009	3,992	790	727
1970	8,606	6,069	2,126	1,908
1971	12,955	8,874	2,246	2,197
1972	15,685	10,353	4,997	3,888
1973	19,985	15,588	11,525	9,071
1974	30,389	21,499	16,946	11,603
1975	44,676	27,415	38,376	22,627
1976	70,230	40,079	63,593	35,294
1977	88,295	42,183	81,074	36,864
1978	96,010	44,541	85,308	37,359
1979	133,470	58,913	118,218	48,305
1980	175,408	73,662	162,515	65,092
1981	185,841	71,780	177,832	66,902
1982**	158,316	59,147	153,390	56,491
1983**	88,188	35,766	86,223	34,563

*Commercial nuclear power reactors; industrial radiographers; fuel processors, fabricators, and reprocessors; manufacturers and distributors of specified quantities of byproduct materials; low-level waste disposal facilities; independent spent fuel storage installations; and geologic high-level waste respositories.

**The termination data for all individuals terminating during 1982 or 1983 have not been entered into the REIR System.

actually completes his work assignment at the facility, (2) the period(s) of exposure that are reported for terminating individuals may indicate the monitoring period during which he may have been exposed to radiation rather than the actual dates of exposure, (3) some licensees report cumulative periods of exposure and doses rather than the actual periods and dose incurred during each period, and (4) licensees having more than one licensed facility sometimes include in the termination report submitted when the individual leaves the second facility the dose that he incurred at the first facility, which may already have been reported. Although attempts have been made to correct for some of these problems, they are still an additional source of error in any statistics developed from the termination data.

4.3 Transient Workers per Calendar Quarter

One use that is being made of the information contained in the termination reports is the examination of the doses being received by short-term workers. Since nearly half of the termination reports indicated periods of exposure that were less than 90 days, it is possible that several thousand individuals could have been employed by two or more licensees during the same calendar quarter. Thus, in this report, a "quarterly transient" worker is defined to be an individual who began and terminated employment at two or more different licensed facilities within one calendar quarter. This allows one to examine the doses of those workers most likely to approach the quarterly limits without their employer's knowledge since they move so rapidly among facilities.

Table 11 displays some of the information gathered from these termination reports that were submitted by all covered licensees and by licensed nuclear power facilities, separately. One can quickly see that the vast majority of these individuals are monitored by nuclear power facilities. The number of these individuals increased more than twentyfold during the five years 1972 through 1976 but now appears to be increasing at a much smaller rate. They have comprised about two percent of the number of workers receiving a measurable dose (Table 4) for the last several years. This probably reflects the earlier rapid rate of growth of the nuclear power industry and its need for short-term workers. The table also shows that the average individual dose (which is close to being a quarterly dose for these workers) has tended to decrease during this time and has remained less than 0.5 rem during the last five years. Examinations of these records also revealed that some individuals have worked for as many as six different NRC licensees during one quarter. However, on the average, less than two instances per year have been found in which a worker exceeded his quarterly limit of three rems (cSv) as a result of his working at two or more different licensed facilities within one calendar quarter. In a few of these instances, the doses that the workers had received while employed by the first utility were revised upward later in the year. The underestimates resulted in quarterly doses that slightly exceeded three rems (cSv). A very few quarterly exposures exceeding three rems (cSv) may have gone undetected because a worker's dose was received over a period spanning more than one quarter and was reported for the entire period. When this happens, it is not possible to determine the portion of the dose received during each quarter. This method of reporting is considered by the NRC staff to be inconsistent with the requirements of 10 CFR 20.408, and licensees will be advised that such reports are not acceptable.

4.4 Transient Workers per Calendar Year

Since the number of transient workers per calendar quarter comprise only a small percentage of the total number of individuals terminating each year,

TABLE 11

TRANSIENT WORKERS PER CALENDAR QUARTER
1972-1983

Year	No. of Persons Terminated by Two or more Licensees Within One Quarter	Collective Dose (man-rems or man-cSv)	Average Individual Dose (rem or cSv)
All Covered Licensees			
1972	69	63	0.91
1973	157	138	0.88
1974	332	170	0.51
1975	709	508	0.72
1976	1299	904	0.70
1977	1481	870	0.59
1978	1570	720	0.46
1979	1809	836	0.46
1980	2355	1063	0.45
1981*	2344	955	0.41
1982**	1977	773	0.39
Power Reactor Facilities			
1972	57	57	1.00
1973	146	123	0.84
1974	285	158	0.55
1975	684	493	0.72
1976	1257	889	0.71
1977	1437	851	0.59
1978	1500	680	0.45
1979	1754	802	0.46
1980	2218	1033	0.47
1981*	2335	952	0.41
1982**	1922	771	0.40

*Revised according to latest compilations.

**Figures for 1982 may be incomplete because all of the 1982 termination data have not been computerized at this time.

it was decided to change the criteria so that the records of more workers would be examined. This was done by selecting the records of all individuals who began and terminated two or more periods of employment with at least two different reactor facilities within one calendar year and summing each worker's whole body doses. An examination of these data would allow one to determine the number and average dose for these "annual transients." Since more than 95% of these transients are reported by nuclear power facilities, only the termination records of these individuals were examined in detail. Table 12 summarizes the number and doses of the transients found among the individuals terminating during the six years 1977 through 1982. A similar collation has not been done for the 1983 data because not all of them have yet been computerized. One can see that the number of these workers increased from about 3,200 workers in 1977 to about 5,400 in 1980 and 1981. The 4,481 workers shown for 1982 may indicate a decreasing trend or may be due to the fact that all of the 1982 termination data have not yet been computerized. The average dose, however, remains at about 1 rem (cSv). More details about these annual transients and a discussion of the impact that the inclusion of these individuals in each of two or more licensee's annual dose distribution reports had on the annual compilation of the reports submitted by all of the nuclear power facilities are presented in the NRC reports designated as NUREG-0713, Vols. 4 and 5 [Refs. 6 and 7].

TABLE 12

TRANSIENT WORKERS PER CALENDAR YEAR
AT NUCLEAR POWER FACILITIES
1977-1982

Year	No. of Commercial Reactors	No. of Individuals Terminated by Two or More Licensees	Collective Dose (man-rems or man-cSv)	Average Dose (rems or cSv)
1977	57	3,161	3,776	1.29
1978	64	3,202	3,231	1.01
1979	67	4,022	3,891	0.97
1980	69	5,463	6,028	1.10
1981*	73	5,425	5,381	0.99
1982**	75	4,481	4,954	1.11

*Revised according to latest compilations.
**Figures for 1982 may be incomplete because all of the 1982 termination data have not been computerized at this time.

5. PERSONNEL OVEREXPOSURES - 10 CFR § 20.403 and 10 CFR § 20.405

5.1 Control Levels

One requirement of the above-referenced sections of Part 20, Title 10, Chapter I, Code of Federal Regulations, is that all persons licensed by the NRC must submit reports of all occurrences involving personnel radiation exposures that exceed certain control levels, thus providing for investigations and corrective actions as necessary. The term "overexposure" is not necessarily intended to indicate that a worker has been subjected to an unacceptable biological risk. Based on the magnitude of the exposure, the occurrence may be placed into one of three categories:

Category A

10 CFR § 20.403(1) - Exposure of the whole body of any individual to 25 rems or more; exposure to the skin of the whole body of any individual to 150 rems or more; or exposure of the extremities (feet, ankles, hands or forearms) of any individual to 375 rems or more. The Commission must be notified immediately of these events.

Category B

10 CFR § 20.403(b) - Exposure of the whole body of any individual to 5 rems or more; exposure of the skin of the whole body of any individual to 30 rems or more; or exposure of the extremities to 75 rems or more. The Commission must be notified within 24 hours of these events.

Category C

10 CFR § 20.405 - Exposure of an individual to radiation or concentrations of radioactive material that exceeds any applicable quarterly limit in Part 20 or in the licensee's license but is less than the values given above. This includes reports of whole body exposures that exceed 1.25 rems, or that exceed 3 rems, as discussed in Section 3.1. Reports of skin exposures that exceed 7.5 rems and extremity exposures that exceed 18.75 rems are included, and reports of exposures of individuals to concentrations in excess of the levels given in 10 CFR § 20.103 and Appendix B usually fall into this category as well. These reports must be submitted to the Commission within 30 days of the occurrence.

A short description of the seven occurrences reported in 1982 and 1983 that resulted in individuals receiving exposures of the magnitudes indicated in Category A or B is given in Sections 5.2.1 and 5.2.2.

5.2 Summary of Overexposures

Table 13 summarizes all of the occupational overexposures to external sources of radiation as reported by Commission licensees pursuant to § 20.403 and § 20.405 during the years 1977 through 1983. For 1982 and 1983, it shows the number of individuals that exceeded various limits while employed by one of several types of licensees. For the years 1977 through 1980, only the overexposures reported by licensed industrial radiography firms are shown separately. Most of the occurrences included in the "All Others" category come from research

TABLE 13

PERSONNEL OVEREXPOSURES TO EXTERNAL RADIATION
1977 - 1983

Year	License Category	Persons and Doses (rems or cSv)	Types of Overexposures and Doses: Whole Body (rems or cSv) <5.00	Whole Body ≥5 <25	Whole Body ≥25	Skin (rems or cSv) >7.5<30	Skin ≥30<150	Skin ≥150	Extremity (rems or cSv) >18.75<75	Extremity ≥75<375	Extremity >375
	Industrial Radiography	No. of Persons	1								1
		Sum of Doses	4.7								650
	Power Reactor	No. of Persons	7								
		Sum of Doses	13.2								
1983	Medical Facilities	No. of Persons	2								
		Sum of Doses	3.5								
	Marketing & Manufact.	No. of Persons		1[a]					2		
		Sum of Doses		25					49.5		
	Others	No. of Person							25	2	
		Sum of Doses							837	228	
	Industrial Radiography	No. of Persons	6	3							
		Sum of Doses	16.1	20.7							
	Power Reactors	No. of Persons	1	1							
		Sum of Doses	5.0	9.4							
1982	Medical Facilities	No. of Persons	2								
		Sum of Doses	1.9								
	Marketing	No. of Persons	1[b]								
1982	& Manufact.	Sum of Doses	1.3								
	All Others	No. of Persons	1						15	2	
		Sum of Doses	4.3						569	206	
	Industrial	No. of Persons	7	1							
1981	Radiography	Sum of Doses	12.2	7.1							
	All Others	No. of Persons	10	2[c]		1			4		
		Sum of Doses	24.1	30.9		8.1			102.9		
	Industrial	No. of Persons	4	1					1		
1980	Radiography	Sum of Doses	23.6	7.7					56.0		
		No. of Persons	84						3		3
	All Others	Sum of Doses	285.4						73.5		33,000
	Industrial	No. of Persons	8[d]	3							
1979	Radiography	Sum of Doses	25.9	34.6							
	All Others	No. of Persons	30	3[e]		7	1	2[f]	15	1[g]	
		Sum of Doses	65.0	39.0		125.7	40.0	327	468.1	147	
	Industrial	No. of Persons	4	1						1	
1978	Radiography	Sum of Doses	15.3	21.6						150	
		No. of Persons	12	4	1	2			2		
	All Others	Sum of Doses	36.0	51.9	27.3	18.2			49.2		
	Industrial	No. of Persons	7	2[h]							1
1977	Radiography	Sum of Doses	23.7	23.2							630
		No. of Persons	38		1	3[i]			10		
	All Others	Sum of Doses	75.0		220	40.0			224		

[a]This person simultaneously received an extremity overexposure of 61 rems (cSv) that is not shown.
[b]This person simultaneously received a skin overexposure of 15.2 rems (cSv) that is not shown.
[c]One of these persons simultaneously received an extremity overexposure of 21 rems (cSv) that is not shown.
[d]One of these persons simultaneously received an extremity overexposure of 46 rems (cSv) that is not shown.
[e]One of these persons simultaneously received an extremity overexposure of 45 rems (cSv) that is not shown.
[f]These two persons simultaneously received extremity overexposures of 82 and 38 rems (cSv) that are not shown.
[g]This person simultaneously received a skin overexposure of 13 rems (cSv) that is not shown.
[h]This person simultaneously received an extremity overexposure of 18 rems (cSv) that is not shown.
[i]This person simultaneously received an extremity overexposure of 26.9 rems (cSv) that is not shown.

facilities and universities. In 1980 the total number of individuals reported as being overexposed was 96, a considerable increase over the numbers reported for other years. This increase was due to the overexposure of some 67 individuals at one nuclear power facility during steam generator repair work. They received doses between three and five rems. In 1982, the total number of overexposed individuals was 32, and the highest whole body dose was 9.4 rems (cSv). In 1983, the number of individuals involved in such occurrences increased to 40, and the highest whole body dose was 25 rems (cSv). In 1980, 1979, 1978, and 1977, the highest whole body doses were 7.7, 17.0, 27.3 and 220 rems (cSv), respectively.

There were no instances in 1982 or 1983 in which the estimated intake of radioactive material exceeded the quarterly intake limit, equivalent to exposure for 520 hours at the maximum permissible concentrations (MPC-hours). There were thirteen reports of personnel exposures to airborne concentrations of soluble uranium in excess of the applicable limit equivalent to exposure for 40 hours at the maximum permissible concentration in 1982. Ten of these (all less than 100 MPC-hours) occurred at two uranium milling facilities during non-routine cleanup operations, and bioassay results indicated that protective devices had prevented physical uptake of the material. One of these mills shutdown in the fall of 1982. There were no reported exposures to excessive concentrations in 1983.

5.2.1 Personnel Overexposures - 1982

Radiography Company - License Number 35-16191-01

On October 4, 1982, while working on a pipeline in Indiana, a radiographer and his assistant received whole body doses of 5.3 and 6.5 rems (cSv), respectively. After completing a radiograph, they failed to make adequate surveys to ensure that the radioactive source, iridium-192, was properly secured within the exposure device, and they waited in close proximity to the device until they noticed that their self-reading pocket dosimeters were off scale. Although the doses are in excess of NRC limits, they are below the level where observable medical effects would be expected.

Nuclear Power Facility - License Number DPR-39

On March 25, 1982, a shift engineer at the Zion nuclear power plant received a whole body dose of about 5 rems (cSv) when he entered the Unit 1 reactor cavity to check for water leakage. The incore instrumentation thimbles had been retracted and were significant sources of radiation in the reactor cavity. Several problems that contributed to the overexposure included inadequate preplanning, surveys, and training and a shortage of calibrated high-range portable survey instruments.

Nuclear Power Facility - License Number DPR-26

On June 1, 1982, a contractor employee at the Indian Point plant received a whole body dose of 8.7 rems (cSv) to bring his dose for the second quarter of 1982 to 9.4 rems (cSv). The exposure occurred when the employee, a diver, swam in the vicinity of a misplaced spent fuel assembly while assisting in the installation of new fuel racks. Several factors that contributed to the overexposure were instrument malfunctions that did not allow the proper detection of the radiation field in the area of the spent fuel bundle by either the diver or the health physics personnel.

Shielding Manufacturer - License Number SMB-179

In May 1983, the licensee, a company that fabricates kinetic energy penetrators and shielding from depleted uranium, discovered higher radiation doses to foundry workers' hands than had previously been measured. It was estimated that extremity overexposures ranging from 20 to 127 rems (cSv) had been received by fifteen foundry workers during the fourth quarter of 1982, extremity doses between 21 and 143 rems (cSv) were received by fourteen workers during the first quarter of 1983, and extremity doses from 20 to 40 rems (cSv) were received by thirteen workers during the second quarter of 1983. The overexposures occurred when the inside of the workers' leather gloves became contaminated with depleted uranium, and the skin of the palms of the hands received larger doses than anticipated. No visible damage to the workers' hands were found.

Radiography Company - License Number 42-19788-01

During an inspection of the licensee's activities conducted by the NRC staff on January 4-5, 1983, records were found that indicated that two radiographers apparently received whole body doses of 8.9 and 3.6 rems (cSv) during the month of October 1982. Although a specific event or incident was not identified that could have caused the overexposures, the exposures indicated a need for the licensee to strengthen his radiation safety program, particularly for field operations.

5.2.2 Personnel Overexposures - 1983

Radiography Company - License Number 37-15445-02

On June 7, 1983, the licensee was conducting radiography at a temporary job site in Hoboken, New Jersey. An iridium-192 source became disconnected from the drive cable of the radiography device, and the licensee was unable to return the source to its safe shielded position. The licensee requested assistance from a company that manufactures iridium-192 sources. The employee of the second company retrieved the iridium-192 source the next day, but he received a calculated dose of 650-1100 rems (cSv) to his thumb and index finger because an adequate survey was not conducted prior to the recovery attempt. The exposed individual was examined by a physician who did not identify any physical effects nor did he expect any subsequent health effects.

Gauge Manufacturer - License Number 12-11184-01

During the third quarter of 1983, an employee of a company that makes, distributes, and repairs industrial gauges containing sealed radiation sources received an apparent whole body dose of 25 rems (cSv) and a 60 rem (cSv) dose to the hands. He was also involved in loading and unloading sealed radioactive sources into source holders. Although the doses received by the individual are in excess of NRC limits, they are still below the level where observable medical effects would be expected. However, there were further indications of inadequacies in the licensee's radiation protection program, and on August 15, 1983, the NRC suspended the company's license. The suspension was rescinded on September 16, 1983, after NRC inspections determined that the licensee had taken adequate corrective actions.

REFERENCES

1. United Nations, "Report of the Scientific Committee on the Effects of Atomic Radiation," Annex H, General Assembly of Official Records, 1982, United Nations, New York.

2. Brodsky, A., R. Specht, B. Brooks, et. al., "Lognormal Distributions of Occupational Exposure in Medicine and Industry," presented at the 9th Midyear Topical Symposium of the Health Physics Society, 1976.

3. B. G. Brooks, "Occupational Radiation Exposure Twelfth Annual Report 1979," USNRC Report NUREG-0714, Vol. 1, August 1982.

4. Kumazawa, S. and T. Numakunai, "A New Theoretical Analysis of Occupational Dose Distributions Indicating the Effect of Dose Limits," Health Physics, Vol. 41, No. 3, 1981.

5. B. G. Brooks, "Occupational Radiation Exposure at Commercial Nuclear Power Reactors 1982," USNRC Report NUREG-0713, Vol. 4, 1984.

6. B. G. Brooks, "Occupational Radiation Exposure at Commercial Nuclear Power Reactors 1983," USNRC Report NUREG-0713, Vol. 5, 1985.

Appendix A

Alphabetical Listing of Annual Reports Filed by Certain NRC Licensees

APPENDIX A

INDUSTRIAL RADIOGRAPHERS

Licensee Name	License Number	1982 Total Individuals Monitored	1982 Workers with Measurable Dose	1982 Collective Dose (man-rems)	1982 Average Meas'ble Dose (rems)	1983 Total Individuals Monitored	1983 Workers with Measurable Dose	1983 Collective Dose (man-rems)	1983 Average Meas'ble Dose (rems)
ABC TESTING	20-19778-01	13	10	.95	.09	12	8	1.37	.17
ABEX CORPORATION	29-01208-02	7	0	.00	.00	6	0	.00	.00
ABEX CORPORATION - RPG	29-01208-03	0	0	.00	.00	0	0	.00	.00
ADVANCED RADIATION SERVICE INC.	29-14171-01	4	4	3.55	.89				
ADVEX CORPORATION	45-16452-01	14	12	13.65	1.14	11	9	11.42	1.27
AIR FORCE, DEPARTMENT OF THE	09-15149-01	6	6	.30	.05	6	5	.25	.05
AIR PRODUCTS AND CHEMICALS	37-05105-05	12	8	2.07	.26	12	3	.40	.13
ALASKA INDUSTRIAL X-RAY	50-16084-01	11	11	7.65	.69	8	7	2.15	.31
ALASKA WELDING CENTER	50-19202-01	37	30	21.40	.71	73	64	69.75	1.09
ALLIED INSPECTION SERVICES INC.	21-18428-01	11	9	10.02	1.11	14	11	9.85	.89
ALLIS CHALMERS	37-16280-01	51	22	1.10	.05	50	35	2.00	.06
ALLIS CHALMERS CORPORATION	37-16280-02	51	22	1.10	.05	50	35	2.00	.06
ALLIS-CHALMERS CORPORATION	37-16280-03	30	1	.05	.05	20	2	.10	.05
ALLOY CRAFTS COMPANY	13-17511-01	8	4	.57	.14	9	3	.15	.05
AM-X CORPORATION	49-16670-01	128	128	64.92	.51	104	56	34.95	.62
AMERICAN AIRLINES INC.	35-13964-01	47	9	.45	.05	43	8	.52	.07
AMERICAN OIL COMPANY	13-00155-10	22	10	.62	.06	23	14	.70	.05
AMERICAN SHIP BUILDING COMPANY	34-11422-01	0	0	.00	.00	0	0	.00	.00
AMERICAN TESTING & INSPECTION	12-21101-01	4	4	.70	.17	5	5	2.17	.43
AMOCO OIL COMPANY	12-06708-01	3	0	.00	.00	3	0	.00	.00
AMOCO OIL COMPANY	45-01378-02	13	4	.20	.05	13	2	.10	.05
AMPCO-PITTSBURGH CORPORATION	37-07219-01	0	0	.00	.00	4	2	.92	.46
ANCHOR/DARLING VALVE COMPANY	37-15476-01	8	3	.27	.09	6	2	.10	.05
ARMY, DEPARTMENT OF THE	02-09128-01	7	0	.00	.00				
ARMY, DEPARTMENT OF THE	13-18235-01	126	11	.92	.08	0	0	.00	.00
ARMY, DEPARTMENT OF THE	29-00047-06	110	56	6.27	.11	132	35	1.75	.05
ARMY, DEPARTMENT OF THE	30-02405-05	5	5	.62	.12	6	6	.30	.05
ARNOLD GREENE TESTING LAB.	20-01074-02	40	20	3.50	.17	36	22	2.70	.12
ARROW TANK & ENGINEERING CO.	22-13253-01	5	2	.10	.05	7	1	.05	.05
ASSOCIATED PIPING & ENGINEER.	43-15119-01	8	4	2.42	.61	7	5	1.72	.34
ASTROTECH INC.	37-09928-01	13	8	3.00	.37	13	8	1.55	.19
ATLANTIC RESEARCH CORPORATION	45-02808-04	10	10	3.40	.34	14	10	3.82	.38
BABCOCK & WILCOX CO.	34-02160-04	197	51	10.50	.21	93	31	4.87	.16
BABCOCK & WILCOX COMPANY	34-02160-03	46	0	.00	.00	44	44	2.97	.07
BABCOCK AND WILCOX COMPANY	34-13454-01	7	3	.27	.09				
BAKER TESTING SERVICES INC.	20-19067-01	7	4	.65	.16	4	2	.22	.11
BASIN INDUSTRIAL X-RAY, INC.	42-19906-01	0	0	.00	.00	6	6	7.35	1.22
BATH IRON WORKS CORPORATION	18-00828-04	16	4	.32	.08	17	5	.50	.10
BELOIT CORPORATION	48-02412-02	17	10	.82	.08	2	0	.00	.00
BENJAMIN F. SHAW COMPANY	39-13318-01	5	5	1.55	.31	2	2	.42	.21
BILL MILLER INC.	35-19048-01	64	60	47.10	.78	24	17	8.87	.52
BORG-WARNER CORPORATION	37-16828-01	34	0	.00	.00	28	0	.00	.00
BRANCH RADIOGRAPHIC LAB.	29-03405-02	43	43	11.92	.28	38	38	10.27	.27

APPENDIX A (cont.)
INDUSTRIAL RADIOGRPHERS

Licensee Name	License Number	1982 Total Individuals Monitored	1982 Workers with Measurable Dose	1982 Collective Dose (man-rems)	1982 Average Meas'ble Dose (rems)	1983 Total Individuals Monitored	1983 Workers with Measurable Dose	1983 Collective Dose (man-rems)	1983 Average Meas'ble Dose (rems)
BRAND EXAMINATION SERVICES	06-17156-01					18	12	19.15	1.60
BRIGGS ENGINEERING & TESTING	20-16401-01	6	6	.55	.09	5	5	1.47	.29
BRISTOL STEEL AND IRON WORKS	45-16947-01	6	4	.77	.19	7	5	1.95	.39
BUCKEYE INTERNATIONAL	34-06627-01	5	1	.05	.05	4	0	.00	.00
BUCYRUS-ERIE CO.	48-06390-01	3	0	.00	.00	3	0	.00	.00
BOOTHE-TWINING,INC.	04-19522-01	132	111	78.50	.71	100	82	56.42	.69
C & R LABORATORIES	53-19179-01	4	4	.20	.05	4	4	.20	.05
CALUMET TESTING SERVICES INC.	13-16347-01	44	34	23.02	.68	37	24	19.87	.83
CAPITAL X-RAY SERVICE	35-11114-01	39	39	70.25	1.80	24	24	47.35	1.97
CAPITOL STEEL CORPORATION	35-18365-01	3	2	.10	.05	3	2	.35	.17
CARROLL ENGINEERS	20-13042-01	5	2	.10	.05	5	1	.05	.05
CATALYTIC INC.	37-12931-02	0	0	.00	.00	0	0	.00	.00
CATERPILLAR TRACTOR COMPANY	12-00013-02	3	2	.22	.11	15	4	.32	.08
CATERPILLAR TRACTOR COMPANY	12-18023-01	11	0	.00	.00	9	0	.00	.00
CERTIFIED TESTING LABORATORIES	29-14150-01	10	10	7.65	.76	6	6	.30	.05
CHERNE CONTRACTING CORPORATION	22-18342-01	17	17	2.97	.17	15	11	2.35	.21
CHICAGO BRIDGE AND IRON CO.	12-05639-01	11	2	.10	.05	8	1	.37	.37
CHICAGO BRIDGE AND IRON CO.	42-13553-02	522	385	251.62	.65	344	196	74.10	.38
CHICAGO BRIDGE AND IRON CO.	43-05337-02	14	7	1.42	.20	20	12	2.37	.20
CLARK EQUIPMENT COMPANY	21-02872-01	4	0	.00	.00				
CLARK INSPECTION SERVICE INC.	35-11615-01	13	12	4.15	.35	15	15	7.77	.52
CLEVELAND X-RAY INSPECTION INC	35-15205-01	93	87	92.95	1.07	33	32	26.95	.84
COLBY AND THIELMEIER TESTING	24-13737-01	6	6	4.80	.80	5	5	3.22	.64
COLONIAL GAS CO.	20-15003-01	5	0	.00	.00	5	0	.00	.00
COLT INDUSTRIES OPERATING CO.	48-02387-03	5	0	.00	.00	5	2	.10	.05
COLUMBIA GAS TRANSMISSION CO.	47-16060-01	5	4	1.42	.36	6	4	.97	.24
COMBUSTION ENGINEERING	35-02325-02	14	11	8.47	.77	12	9	6.30	.70
COMBUSTION ENGINEERING INC.	06-04154-01	45	28	3.75	.13	32	21	4.07	.19
CONSECO INC.	48-16774-01	2	2	.22	.11	0	0	.00	.00
CONSOLIDATED TESTING LABS	31-01545-03					5	3	.60	.20
CONSOLIDATED X-RAY SERVICE	29-21452-01					47	46	12.45	.27
CONSOLIDATED X-RAY SERVICE CO.	42-08456-02	187	177	138.97	.78	125	115	55.72	.48
CONSTRUCTION ENGINEERING	37-18456-01	0	0	.00	.00	24	14	4.25	.30
CONSUMERS POWER COMPANY	21-08606-03	20	20	15.35	.77	22	21	3.45	.16
COPES-VULCAN	37-19530-01	1	1	.17	.17	1	1	.37	.37
CRANE COMPANY	24-00563-02	10	10	3.47	.35	13	9	4.62	.51
CRANE COMPANY - INDIAN ORCHARD	20-00518-02	6	0	.00	.00	5	0	.00	.00
CRUCIBLE STEEL CASTING COMPANY	34-04657-02	0	0	.00	.00				
CTL ENGINEERING INC.	34-08331-01	2	2	1.25	.62	2	2	.75	.37
D & S TESTING, INC.	34-21458-01					4	4	1.75	.44
DANIEL INTERNATIONAL CORP.	39-01261-02	72	66	30.72	.47	65	40	17.77	.44
DAY AND ZIMMERMANN INC.	42-15051-02	4	3	.15	.05	3	3	.15	.05

APPENDIX A (cont.)

INDUSTRIAL RADIOGRAPHERS

Licensee Name	License Number	1982 Total Individuals Monitored	1982 Workers with Measurable Dose	1982 Collective Dose (man-rems)	1982 Average Meas'ble Dose (rems)	1983 Total Individuals Monitored	1983 Workers with Measurable Dose	1983 Collective Dose (man-rems)	1983 Average Meas'ble Dose (rems)
DAYTON MALLEABLE IRON COMPANY	34-06927-02	3	3	.97	.32				
DAYTON X-RAY COMPANY	34-06943-01	19	15	3.92	.26	14	11	1.57	.14
DEPT. OF ARMY, MCALESTER ARMY	35-19189-02	45	0	.00	.00	31	0	.00	.00
DEPT. OF NAVY, MARE ISLAND NAV	04-00364-06	38	34	4.15	.12	48	43	5.62	.13
DEPT. OF NAVY, NAVAL EXPLOSIVE	19-00318-03	21	1	.05	.05				
DEPT. OF NAVY, USS AJAX (AR-6)	04-17872-01	12	1	.87	.87	16	0	.00	.00
DEPT. OF NAVY, USS DIXON (AS-3	04-17976-01	24	23	1.15	.05	19	19	1.07	.06
DEPT. OF NAVY, USS HECTOR (AR-	04-18130-01	16	7	1.62	.23	26	1	.05	.05
DEPT. OF NAVY, USS JASON (AR-8	04-17765-01	17	3	.40	.13	20	5	.95	.19
DEPT. OF NAVY, USS PRAIRIE (AD	04-18013-01	14	0	.00	.00	15	1	.05	.05
DEPT. OF NAVY, USS PROTEUS (AS	04-18041-01	17	11	.55	.05	22	21	1.67	.08
DEPT. OF NAVY, USS SPERRY (AS-	04-18083-01	12	12	.60	.05				
DEPT. OF THE NAVY, USS SIERRA	09-19770-01	16	0	.00	.00	26	2	.10	.05
DODGE FOUNDRY AND MACHINE COMP	37-15324-01	5	5	.37	.07	4	4	.45	.11
DRAVO CORPORATION	34-00850-02	7	4	.85	.21	6	6	.67	.11
DUNCAN FOYNDRY & MACHINE WORKS	12-09687-01	1	0	.00	.00	1	0	.00	.00
DUQUESNE LIGHT COMPANY	37-17507-01	14	14	3.77	.27	17	17	3.32	.20
DURALOY COMPANY (THE)	37-02279-02	9	6	1.12	.19	9	5	1.02	.20
DURIRON COMPANY INCORPORATED	34-06398-01	6	5	.82	.16	3	3	.40	.13
E. I. DU PONT DE NEMOURS & COM	07-00455-30	5	2	.10	.05	5	1	.05	.05
E. L. CONWELL & COMPANY	37-17637-01	8	6	.62	.10	0	0	.00	.00
EASTERN TESTING AND INSPECTION	29-09814-01	23	20	15.50	.77	22	19	18.82	.99
EBASCO SERVICES INC.	29-07056-03	54	35	12.67	.36	62	52	14.30	.27
EG & G FLORIDA, INC.	09-21233-01	11	8	.90	.11	17	13	3.10	.24
ELPASO NATURAL GAS COMPANY	42-03201-02	4	4	1.10	.27	7	7	2.32	.33
EMPIRE STEEL CASTINGS, INC.	37-02448-01	3	1	.05	.05	4	2	.42	.21
ENERGY INCORPORATED	11-19475-01	5	5	4.55	.91				
ENVIRONMENTAL PROTECTION AGENC	22-13390-01	17	16	.92	.06	17	4	.20	.05
EQUITABLE GAS COMPANY	37-17491-01	7	4	.32	.08	7	2	.42	.21
EXAM COMPANY	35-16191-01	409	409	155.90	.38	420	68	24.87	.37
EXXON COMPANY U. S. A.	25-03375-02	6	1	.05	.05	7	0	.00	.00
FACTORY MUTUAL RESEARCH CORPOR	20-04007-02	7	1	.05	.05	6	2	.10	.05
FINLAY TESTING LABORATORIES	53-17854-01	12	12	4.52	.38	12	12	4.47	.37
FOSTER WHEELER ENERGY CORPORAT	29-03369-03	36	18	3.80	.21	35	12	5.67	.47
FRANKLIN RESEARCH CENTER	37-00637-11	16	0	.00	.00	12	0	.00	.00
FROEHLING & ROBERTSON INC.	45-08890-01	13	13	4.45	.34	13	9	2.47	.27
GAMMA FIELD RADIOGRAPHIC FACIL	12-13858-01	3	2	.10	.05	8	6	3.42	.57
GAMMA SCAN COMPANY	07-19528-01	0	0	.00	.00	0	0	.00	.00
GENERAL DYNAMICS CORPORATION	06-01781-08	98	98	22.27	.23	107	99	26.80	.27
GENERAL DYNAMICS CORPORATION	20-11915-01	16	6	1.72	.29	15	3	.40	.13
GENERAL ELECTRIC COMPANY	18-12518-01	13	8	.77	.10				

APPENDIX A1 (cont.)

INDUSTRIAL RADIOGRAPHERS

Licensee Name	License Number	1982 Total Individuals Monitored	1982 Workers with Measurable Dose	1982 Collective Dose (man-rems)	1982 Average Meas'ble Dose (rems)	1983 Total Individuals Monitored	1983 Workers with Measurable Dose	1983 Collective Dose (man-rems)	1983 Average Meas'ble Dose (rems)
GENERAL ELECTRIC COMPANY	20-00815-05	12	12	1.47	.12	12	10	.75	.07
GENERAL ELECTRIC COMPANY	34-00499-10	3	1	.05	.05	3	0	.00	.00
GENERAL MOTORS CORP.	21-08678-04	0	0	.00	.00	4	0	.00	.00
GENERAL MOTORS CORPORATION	12-02251-01	3	3	.15	.05	3	3	.15	.05
GENERAL MOTORS CORPORATION	12-08050-01	12	2	.10	.05	8	0	.00	.00
GENERAL MOTORS CORPORATION	21-02392-01	4	0	.00	.00	3	0	.00	.00
GENERAL MOTORS CORPORATION	34-15315-02	12	0	.00	.00	23	0	.00	.00
GEO CONSTRUCTION TESTING	04-00616-04	347	276	97.00	.35	283	198	67.42	.34
GLADSTONE LABS. INC.	34-01764-02	7	3	.15	.05	7	3	.15	.05
GLOBE X-RAY SERVICES INC.	35-15194-01	32	32	49.72	1.55	20	20	36.62	1.83
GORSIRA X-RAY, INC.	21-19339-01	0	0	.00	.00	0	0	.00	.00
GREAT LAKES TESTING CORP.	13-21306-01					0	0	.00	.00
GREDE FOUNDRIES INCORPORATED	48-02844-01	3	1	.17	.17	3	3	.15	.05
GRINNELL COMPANY, INC.	38-02839-01	58	19	7.77	.41	39	21	3.17	.15
H. C. NUTTING CO.	34-14924-01	2	2	.22	.11	5	3	.27	.09
H. R. INSPECTION SERVICE INC.	15-06209-01	11	9	11.60	1.29	7	7	4.40	.63
H&H X-RAY SERVICES INC.	17-19236-01	20	20	31.25	1.56	11	11	10.42	.95
HARDY ASSOCIATES LTD.	50-19946-01	6	4	.85	.21	13	10	3.42	.34
HARRISON STEEL CASTINGS CO.	13-02141-01	7	7	.80	.11	6	6	1.85	.31
HERRON TESTING LABORATORY INC.	34-00681-03	6	4	1.15	.29	7	5	1.15	.23
HESS OIL VIRGIN ISLAND CORP	55-15533-02	9	4	1.15	.29	11	6	1.07	.18
HIGH STEEL STRUCTURES INC.	37-17534-01	8	5	.37	.07	8	4	.20	.05
HOWMET CORPORATION	48-01094-03	6	6	1.07	.18				
HUTCHINSON AREA VO-TECH INST.	22-15554-01	169	29	1.57	.05	294	28	2.10	.07
INDEPENDENT INSPECTION	42-19441-01	4	4	5.55	1.39	3	2	1.87	.94
INDEPENDENT TESTING LAB.	03-15991-02	26	18	3.40	.19	33	30	17.37	.58
INDUSTRIAL FABRICATING CO.	35-16466-01	6	6	1.32	.22	4	4	.90	.22
INDUSTRIAL GAMMA INSPECTION	24-19850-01	1	1	.37	.37	1	1	.05	.05
INDUSTRIAL INSPECTION INDUS.	34-14071-01	146	131	93.85	.72	81	61	41.57	.68
INDUSTRIAL LABORATORIES INC.	41-04226-02	8	8	13.67	1.71	5	4	7.12	1.78
INDUSTRIAL NDT COMPANY	45-19494-01	9	9	2.90	.32	13	10	3.37	.34
INDUSTRIAL NDT SERVICES	13-06147-04	8	7	1.00	.14	9	4	.85	.21
INDUSTRIAL RADIOGRAPHIC SER.	55-16734-01	0	0	.00	.00	0	0	.00	.00
INDUSTRIAL TESTING LABORATORY	37-16406-01	17	1	.05	.05	14	1	.05	.05
INGERSOLL-RAND COMPANY	29-02015-02	3	2	.55	.27	3	3	.52	.17
INSPECTION & TESTING COMPANY	11-19921-01	27	22	17.60	.80	30	28	21.17	.76
INSPECTION SERVICE CORP OF PEN.	37-11636-01	8	6	10.10	1.68	8	5	4.10	.82
INSPECTION SERVICE, INC.	41-21154-01	36	36	27.87	.77	39	39	34.20	.88
INTEC INSPECTION, INC.	35-19767-01	94	91	53.97	.59	32	32	11.77	.37
INTERIOR, DEPARTMENT OF THE	24-02619-02	8	4	.20	.05	6	5	.25	.05
INTERIOR, DEPARTMENT OF THE	36-01142-03	8	0	.00	.00	6	1	.17	.17
INTERMOUNTAIN TESTING COMPANY	05-07872-01	37	37	43.32	1.17	26	25	30.42	1.22

APPENDIX A (cont.)
INDUSTRIAL RADIOGRAPHERS

Licensee Name	License Number	1982 Total Individuals Monitored	1982 Workers with Measurable Dose	1982 Collective Dose (man-rems)	1982 Average Meas'ble Dose (rems)	1983 Total Individuals Monitored	1983 Workers with Measurable Dose	1983 Collective Dose (man-rems)	1983 Average Meas'ble Dose (rems)
INTERNATIONAL TESTING LABS. IN	29-14027-01	8	0	.00	.00	8	2	.67	.34
ITT GRINNEL INDUSTRIA PIPING	32-17346-01	7	7	6.87	.98	7	7	2.32	.33
J. G. SYLVESTER ASSOCIATES INC	20-00302-02	12	3	.27	.09	14	10	2.90	.29
J.T. CULLEN COMPANY INC.	12-15025-01	11	8	5.70	.71	9	7	3.82	.55
JACKSONVILLE SHIPYARDS INC.	09-15611-01	9	6	.87	.15	8	5	1.40	.28
JAN X-RAY SERVICES INC.	21-16560-01	9	9	4.57	.51	8	7	4.02	.57
JOHN DEERE FOUNDRY	12-09111-01	5	3	.15	.05	3	0	.00	.00
KAST METALS CORPORATION	14-07206-01	3	0	.00	.00	3	0	.00	.00
KELSEY-HAYES COMPANY INCORPORA	12-02360-02	5	1	.17	.17	4	1	.17	.17
LABARGE INC.	35-15514-01	7	7	.92	.13	4	3	.40	.13
LAKEHEAD TESTING LABORATORY IN	22-14897-01	7	0	.00	.00	0	0	.00	.00
LAW ENGINEERING TESTING COMPAN	10-00346-03	184	158	34.47	.22	247	152	27.90	.18
LEHIGH TESTING LABORATORIES IN	07-01173-03	11	11	6.22	.57	10	9	4.77	.53
LOCKHEED SHIPBUILDING & CONSTR	46-06926-02	12	8	1.77	.23	12	4	1.10	.27
LUKENS STEEL COMPANY	37-02827-01	11	1	.37	.37	10	0	.00	.00
LYNCHBURG FOUNDRY COMPANY	45-17464-01	7	2	.10	.05	9	2	.22	.11
MAGNA CHEK INC.	21-19111-01	22	16	3.05	.19	24	15	2.40	.16
MAGNAFLUX CORPORATION	12-00622-07	475	359	233.65	.65	456	364	324.95	.89
MARATHON OIL COMPANY	34-01541-02	46	22	1.10	.05	50	18	1.02	.06
MASON & HANGER-SILAS MASON COM	16-17692-01	64	5	.25	.05	81	4	.20	.05
MASSACHUSETTS MATERIALS RESEAR	20-19130-01	1	1	.05	.05	3	2	.22	.11
MASSILLON STEEL CASTING COMPAN	34-02605-01	3	0	.00	.00				
MATERIALS TESTING LABORATORY O	45-17151-01	11	11	9.22	.84	11	11	9.60	.87
MAYNARD ELECTRIC STEEL CASTING	48-07080-01	6	4	1.17	.29	4	3	1.12	.37
MCMANUS INSPECTION SERVICE	48-14158-01	1	1	.17	.17	1	1	.17	.17
MERTZ TESTING & INSPECTION, IN	26-19994-01	4	4	1.17	.29				
MET LAB INC	45-09963-01	8	4	3.05	.76	5	5	3.17	.63
MET-CHEM ENGINEERING LAB	43-19662-01	27	25	28.25	1.13	40	34	24.32	.71
MET-CHEM ENGINEERING LABORATOR	43-11213-02	15	15	7.92	.52	12	11	5.30	.48
METALSALES INC.	43-17142-01	7	7	7.27	1.03	11	11	8.35	.76
METILS INC.	42-16534-01	21	20	38.62	1.93	35	31	53.27	1.72
MICHIGAN TESTING ENGINEERS INC	21-14810-01	22	5	.37	.07				
MIDLAND-ROSS CORPORATION	34-01115-02	5	0	.00	.00				
MIDWEST INSPECTION SERVICE LTD	48-16296-01	15	10	6.50	.65	15	9	5.65	.63
MINNEAPOLIS ELECTRIC STEEL CAS	22-05572-02	2	0	.00	.00	2	0	.00	.00
MINNOTTE MANUFACTURING CORPORA	37-11460-01	1	0	.00	.00	1	0	.00	.00
MISSOURI STEEL CASTINGS COMPAN	24-15152-01	4	0	.00	.00	4	0	.00	.00
MONROE X-RAY CO.	17-12201-02					5	5	6.87	1.37
MONTANA X-RAY INC.	25-21134-01	1	1	1.50	1.50	1	1	1.50	1.50
MORRISON-KNUDSEN COMPANY INC	11-15946-01	0	0	.00	.00	15	15	6.10	.41
NATIONAL AERONAUTICS AND SPACE	34-00507-04	58	16	1.50	.09	56	20	3.57	.18

APPENDIX A (cont.)

INDUSTRIAL RADIOGRPHERS

Licensee Name	License Number and Program Type	1982 Total Individuals Monitored	1982 Workers with Measurable Dose	1982 Collective Dose (man-rems)	1982 Average Meas'ble Dose (rems)	1983 Total Individuals Monitored	1983 Workers with Measurable Dose	1983 Collective Dose (man-rems)	1983 Average Meas'ble Dose (rems)
NATIONAL AERONAUTICS AND SPACE	45-08886-02	6	6	.42	.07	6	1	.05	.05
NATIONAL ANNEALING BOX COMPANY	37-06044-01	6	2	.10	.05	6	6	.42	.07
NATIONAL GALLERY OF ART	08-10422-02					0	0	.00	.00
NATIONAL VALVE AND MANUFACT.	37-02895-03	8	3	.40	.13				
NAVY, DEPARTMENT OF USS F.	31-18014-01	9	9	1.35	.15	9	8	1.50	.19
NAVY, DEPARTMENT OF USS H.	31-17677-01	12	12	4.80	.40	15	15	2.10	.14
NAVY, DEPARTMENT OF USS L.	31-17970-01	14	14	1.32	.09	13	13	1.15	.09
NAVY, DEPARTMENT OF USS O.	31-18096-01	14	2	.10	.05	10	10	.50	.05
NAVY, DEPARTMENT OF USS P.	31-17928-01	19	6	.30	.05	11	0	.00	.00
NAVY, DEPARTMENT OF USS S.	31-17803-01	13	0	.00	.00				
NAVY, DEPARTMENT OF USS V.	31-17968-01	0	0	.00	.00	9	4	.32	.08
NAVY, DEPARTMENT OF USS Y.	31-17802-01	12	1	.05	.05	9	1	.05	.05
NAVY, DEPARTMENT OF THE	04-01757-01	43	10	.50	.05				
NAVY, DEPARTMENT OF THE	04-01757-12	0	0	.00	.00				
NAVY, DEPARTMENT OF THE	04-03141-01	30	3	.27	.09	33	3	.15	.05
NAVY, DEPARTMENT OF THE	04-06145-01	46	10	.50	.05				
NAVY, DEPARTMENT OF THE	04-09369-01	86	2	.10	.05	104	11	.55	.05
NAVY, DEPARTMENT OF THE	04-13252-01	23	0	.00	.00	15	1	.05	.05
NAVY, DEPARTMENT OF THE	06-07150-01	10	10	2.30	.23	14	13	4.27	.33
NAVY, DEPARTMENT OF THE	28-01012-02	44	40	4.05	.10	45	43	3.22	.07
NAVY, DEPARTMENT OF THE	37-00314-06	56	25	1.50	.06	59	17	1.22	.07
NAVY, DEPARTMENT OF THE	39-06126-01	68	61	5.90	.10	69	62	9.25	.15
NAVY, DEPARTMENT OF THE	39-19047-01	6	1	.05	.05	7	0	.00	.00
NAVY, DEPARTMENT OF THE	45-02757-01	3	3	.15	.05	17	11	.55	.05
NAVY, DEPARTMENT OF THE	45-04052-03	100	72	6.77	.09	79	74	5.67	.08
NAVY, DEPARTMENT OF THE	45-07740-02	108	93	8.77	.09				
NAVY, DEPARTMENT OF THE	45-15650-02	10	1	.05	.05	11	0	.00	.00
NAVY, DEPARTMENT OF THE	45-17845-01	6	0	.00	.00	9	0	.00	.00
NAVY, DEPARTMENT OF THE	46-03078-01	81	78	11.52	.15	85	82	12.37	.15
NAVY, DEPARTMENT OF THE	46-09611-01	3	0	.00	.00	3	0	.00	.00
NAVY, DEPARTMENT OF THE	46-19259-01	12	12	1.22	.10	19	19	.95	.05
NAVY, DEPARTMENT OF THE	53-06007-01	20	18	1.27	.07	24	23	2.55	.11
NAVY, DEPARTMENT OF THE	53-10226-01	14	0	.00	.00	16	1	.37	.37
NAVY, DEPT. OF THE, USS C	09-19932-01	16	15	2.60	.17	22	22	2.82	.13
NAVY, DEPT. OF THE, USS C.	04-19646-01					12	12	.60	.05
NAVY, DEPT. OF THE, USS M.	04-19966-01	10	8	.40	.05	15	15	.75	.05
NAVY, DEPT. OF THE, USS C.	04-21246-01	0	0	.00	.00	13	1	.05	.05
NAVY, DEPT. OF, USS F.	31-19283-01	10	8	.65	.08	13	10	1.97	.20
NDE SERVICES, INC.	05-19821-01	16	16	11.55	.72	14	14	7.02	.50
NDT CORROSION & CONTROL SER.	42-21135-01					0	0	.00	.00
NEW YORK TESTING LABORATORIES	31-02933-01	6	5	.62	.12	7	6	1.32	.22
NEWPORT NEWS INDUSTRIAL CORP.	34-16805-01	7	7	2.70	.39	7	6	.75	.12

APPENDIX A (cont.)

INDUSTRIAL RADIOGRAPHERS

Licensee Name	License Number	1982 Total Individuals Monitored	1982 Workers with Measurable Dose	1982 Collective Dose (man-rems)	1982 Average Meas'ble Dose (rems)	1983 Total Individuals Monitored	1983 Workers with Measurable Dose	1983 Collective Dose (man-rems)	1983 Average Meas'ble Dose (rems)
NEWPORT NEWS INDUSTRIAL CORP.	45-11589-01	4	4	.32	.08	6	5	.37	.07
NEWPORT NEWS SHIPBUILDING	45-09428-02	130	118	33.65	.28	85	85	34.77	.41
NILES STEEL TANK COMPANY	21-04741-01	5	1	.05	.05	5	1	.05	.05
NONDESTRUCTIVE INSPECTION SER.	47-11883-01	11	11	6.12	.56	9	9	7.45	.83
NONDESTRUCTIVE TESTING CORP.	29-19742-01	21	15	4.40	.29	22	15	4.85	.32
NOOTER CORPORATION	24-03783-01	20	15	1.00	.07	17	14	1.07	.08
NORFOLK SHIPBUILDING AND DRY.	45-12042-01	16	15	1.90	.13	17	10	1.07	.11
NORTHEASTERN RESEARCH & TEST.	29-18006-01	0	0	.00	.00	0	0	.00	.00
NORTHWEST AIRLINES INC.	22-12080-01	15	3	.15	.05	18	2	.22	.11
NUCLEAR ENERGY SERVICE INC.	42-16559-01	217	159	136.77	.86	176	119	65.05	.55
NUCLEAR WELDING INC.	12-17506-01	6	4	.77	.19	7	5	1.85	.37
OKLAHOMA STEEL CASTINGS CO.	35-21159-01	5	1	.05	.05	4	3	.27	.09
OKLAHOMA TRSTING LABORATORIES	35-10577-01	23	14	5.75	.41	17	2	.80	.40
OKLAHOMA X-RAY INC.	35-17961-01	1	1	.05	.05	1	1	.05	.05
OLD DOMINION IRON & STEEL CORP.	45-15581-01	7	7	3.97	.57	5	5	1.15	.23
OMAHA NONDESTRUCTIVE AND METAL.	26-11669-01	10	4	8.00	2.00	15	8	4.07	.51
OZARK AIR LINES, INC.	24-13591-01	27	3	2.60	.87	26	5	.25	.05
P. X. ENGINEERING COMPANY INC.	20-15102-01	3	2	.42	.21	2	1	.17	.17
PANHANDLE EASTERN PIPE LINE CO.	15-17729-01	9	9	.95	.11	9	9	1.07	.12
PARKER INDUSTRIAL X-RAY LAB.	06-01337-03	21	8	2.65	.33	18	11	4.05	.37
PATZIG TESTING LABS INC.	14-18897-02	0	0	.00	.00	15	12	2.82	.23
PDM LATIN AMERICA, LTD.	10-19980-01	14	5	.90	.18	3	2	.35	.17
PELTON CASTEEL INC.	48-02669-02	2	2	.10	.05	2	2	.10	.05
PENN INSPECTION CO.	35-21144-01	6	5	1.07	.21	6	5	3.92	.78
PENNSYLVANIA SHIPBUILDING CO.	37-21067-03	11	3	.15	.05	9	5	.25	.05
PHOTON FIELD INSPECTION, INC.	21-21010-01					9	1	.05	.05
PITTSBURGH DES MOINES STEEL CO.	14-01837-04	16	9	3.00	.33	12	8	2.40	.30
PITTSBURGH DES MOINES STEEL CO.	37-02607-02	21	15	3.10	.21	12	11	1.50	.14
PITTSBURGH TESTING LABORATORY	37-00276-25	246	147	39.67	.27	569	332	205.55	.62
PLANT INSPECTION CO.	04-21032-01	35	25	9.45	.38	32	20	5.60	.28
PORTABLE ATOMIC X-RAY COMPANY	35-07488-03	2	1	.62	.62				
POWER PIPING COMPANY	37-09945-01	12	8	1.75	.22	5	5	.75	.15
PROFESSIONAL SERVICES INDUS.	12-21531-01					8	5	.50	.10
PROGRESS SERVICES,INC.	34-19592-01	9	4	.32	.08	10	5	.57	.11
PULLMAN INC.	42-16573-01	8	5	1.15	.23	3	3	.40	.13
PULLMAN POWER PRODUCTS	37-08042-01	71	37	10.42	.28	97	47	9.87	.21
Q.C. LABORATORIES INC.	09-11579-03	21	15	5.80	.39	20	17	6.00	.35
QUAD CITY TESTING LABORATORY	14-17989-01	9	6	4.17	.70	11	9	4.60	.51
QUAKER ALLOY CASTING COMPANY	37-03671-01	28	25	2.57	.10	22	18	1.97	.11
QUALITY ASSURANCE LABORATORIES	18-19078-01	7	6	1.97	.33	6	4	.97	.24

APPENDIX A (cont.)

INDUSTRIAL RADIOGRAPHERS

Licensee Name		1982 Total Individuals Monitored	1982 Workers with Measurable Dose	1982 Collective Dose (man-rems)	1982 Average Meas'ble Dose (rems)	1983 Total Individuals Monitored	1983 Workers with Measurable Dose	1983 Collective Dose (man-rems)	1983 Average Meas'ble Dose (rems)
QUALITY TESTING INC.	34-17799-01	6	3	.80	.267				
RAMSEY CONSTRUCTION & FAB.	35-19433-01	12	10	8.02	.80	2	1	.17	.17
REACTOR CONTROLS INC.	04-15365-01	10	9	.57	.06	13	10	.75	.07
REFINERY PRODUCTS CORP.	48-03665-02	4	4	2.30	.57	5	4	2.00	.50
RELIANCE TESTING LABORATORIES	19-17176-01	18	11	5.62	.51	23	15	4.37	.29
RICHARD KRUEGEL, DBA	34-09037-01	5	5	3.37	.67	5	5	3.37	.67
RICHMOND ENGINEERING COMPANY	45-02884-01	8	2	.55	.27	8	2	.35	.17
S & S INSPECTION COMPANY	12-19780-01	5	5	10.50	2.10	9	9	6.92	.769
SAWBROOK STEEL CASTINGS CO.	34-06664-02	0	0	.00	.00	0	0	.00	.00
SAWYER RESEARCH PRODUCT INC	34-02044-01	7	0	.00	.00	7	0	.00	.00
SHAFER VALVE CO.	34-21198-01					4	0	.00	.00
SIVYER STEEL CASTING CO.	14-02407-01	2	2	.22	.11	2	2	.22	.11
SMITH-EMERY COMPANY	04-19467-01	16	16	4.62	.289	13	13	5.50	.42
SOUTHWEST X-RAY CORP.	42-19788-01	43	43	69.57	1.618	24	24	28.40	1.18
SOUTHWESTERN ENGINEERING CO.	24-19500-01	0	0	.00	.00	2	2	.55	.27
SPACE SCIENCE SERVICES INC	09-07550-01	50	40	18.90	.47	39	28	14.50	.518
SPECTRUM LABORATORIES INC.	29-07266-01	6	1	.05	.05	7	3	.15	.05
SSW INSPECTION SERVICES	14-19899-01	2	2	.80	.40				
ST. LOUIS STEEL CASTING, INC.	24-01587-01	3	3	.15	.05	3	3	.15	.05
ST. LOUIS TESTING LABORATORIES	24-00188-02	14	14	19.10	1.36	14	13	11.72	.90
STONE & WEBSTER ENGINEERING CO.	20-05600-02	80	49	14.97	.306	84	55	13.92	.25
STRUTHERS WELLS CORPORATION	37-11152-01	14	1	.17	.17	13	2	.22	.11
SUN RAY TESTING INTERNATIONAL	04-19810-01	0	0	.00	.00	0	0	.00	.00
SUPERIOR INDUSTRIAL X-RAY CO.	12-02370-01	25	20	18.12	.906	23	12	6.67	.556
TAYLOR AND FENN COMPANY	06-02024-01	3	0	.00	.00	3	0	.00	.00
TELEDYNE OHIOCAST	34-00412-03	16	13	8.20	.63	7	7	1.12	.16
TENNECO INC	42-09073-02	25	23	3.65	.159	0	0	.00	.00
TENNESSEE VALLEY AUTHORITY	41-06832-06	62	26	8.90	.34	44	21	5.30	.25
TEREX CORPORATION	34-19607-01	8	1	.05	.05	7	0	.00	.00
THAYER INSPECTION SERVICE INC.	35-11239-01	22	21	6.62	.31				
THIOKOL CHEMICAL CORPORATION	01-00856-02	9	0	.00	.00	9	0	.00	.00
THIOKOL CHEMICAL CORPORATION	43-03227-01	7	5	1.07	.21	18	2	.35	.17
THIOKOL CORPORATION	17-16380-01	32	8	.40	.05	45	16	.80	.05
TOWNSEND AND BOTTUM INC.	21-17095-01	0	0	.000	.00	0	0	.00	.00
TRANS WORLD AIRLINES INC	24-05151-05	17	7	.47	.068	18	3	.15	.05
TRANS-EASTERN INSPECTION SER.	37-14855-01	112	102	63.40	.62	132	98	115.20	1.176

APPENDIX A (cont.)

INDUSTRIAL RADIOGRAPHERS

Licensee Name	License Number	1982 Total Individuals Monitored	1982 Workers with Measurable Dose	1982 Collective Dose (man-rems)	1982 Average Meas'ble Dose (rems)	1983 Total Individuals Monitored	1983 Workers with Measurable Dose	1983 Collective Dose (man-rems)	1983 Average Meas'ble Dose (rems)
TRI-STATE INSPECTION & CONSULT.	37-19640-01	0	0	.00	.00	0	0	.00	.00
TRUTOM (U.S.) LTD.	44-18008-01	16	11	2.52	.23	17	11	3.27	.30
TULSA GAMMA RAY INC.	35-17178-01	35	34	49.47	1.45	13	13	15.57	1.20
TWIN CITY TESTING AND ENGINEER.	22-01376-02	36	25	15.47	.62	27	19	13.30	.70
TWIN PORTS TESTING INC.	22-15932-01	19	17	23.42	1.38	15	11	8.77	.80
U.S.A. WORTHINGTON PUMP CORP.	29-02210-02	4	0	.00	.00	4	0	.00	.00
UNION BOILER COMPANY	47-16182-01	16	12	9.70	.81	21	14	10.05	.72
UNITED EXAMINATIONS, INC.	37-21270-01					4	4	.45	.11
UNITED STATES PIPE AND FOUNDRY	29-07262-01	5	1	.05	.05	3	0	.00	.00
UNITED STATES TESTING COMPANY	37-15445-02	103	46	10.00	.22	103	52	7.40	.14
UNITED TECHNOLOGIES CORP.	06-07522-05	14	0	.00	.00	0	0	.00	.00
UNIVERSAL TECHNICAL TESTING L.	37-00453-03	14	11	5.22	.47	16	9	3.67	.41
UNIVERSAL TESTING LABORATORIES	29-16397-01	38	16	1.62	.10	26	10	.75	.07
VENEGAS INDUSTRIAL TESTING LAB	28-14847-02	6	5	2.60	.52	5	4	1.90	.47
VIRGINIA DEPARTMENT OF HIGHWAY	45-13380-02	3	1	2.50	2.50	3	3	.27	.09
VIRGINIA ELECTRIC & POWER CO.	45-13670-07	0	0	.00	.00				
VOLLRATH COMPANY (THE)	48-05395-01	8	3	.27	.09	7	1	.17	.17
WALWORTH COMPANY	29-02282-02	3	1	.05	.05	2	1	.05	.05
WAUKESHA FOUNDRY COMPANY INC.	48-13776-01	11	7	.35	.05	9	5	.25	.05
WEATHERLY FOUNDRY AND MANUFACT.	37-09859-01	2	0	.00	.00	2	0	.00	.00
WEHR STEEL COMPANY	48-02005-02	5	5	.70	.14	3	2	.22	.11
WELDERS TESTING LABORATORIES	02-19728-01	32	30	12.30	.41	65	60	38.80	.65
WELDING INSTITUTE OF ALASKA	50-17446-01	4	3	.80	.27	3	3	1.42	.47
WESTERN INDUSTRIAL X-RAY	04-21380-01					51	39	34.82	.89
WESTERN X-RAY COMPANY	35-19993-01	6	6	4.67	.78	13	13	17.47	1.34
WESTERN ZIRCONIUM	43-18296-01	23	23	1.15	.05	12	12	.60	.05
WESTINGHOUSE ELECTRIC CORP.	37-03632-01	21	10	1.75	.17	19	10	.75	.07
WESTINGHOUSE ELECTRIC CORP.	37-05809-02	6	1	.05	.05	6	3	.15	.05
WHITING CORPORATION	12-04921-01	7	7	.35	.05	6	3	.15	.05
WILLIAM POWELL COMPANY	34-02963-01	2	1	.05	.05	6	5	.25	.05
WILSON INSPECTION SERVICES,	35-19632-01	3	3	.47	.15	3	1	.62	.62
WISCONSIN CENTRIFUGAL INC.	48-11641-01	4	4	1.27	.32	4	4	1.42	.36
WISCONSIN INDUSTRIAL TESTING	48-17480-01	63	44	37.52	.85	41	27	21.02	.78
WORD INDUSTRIES PIPE FABRICAT.	35-15458-01	4	4	6.10	1.52	4	2	5.00	2.50
X-R-I TESTING OF MICHIGAN	21-05472-01	51	27	6.45	.24	55	28	4.40	.16
X-RAY, INC.	46-03414-03	49	46	30.97	.67	33	31	19.40	.63
X-SCAN INSPECTION COMPANY	35-19507-01	3	3	6.87	2.29	4	4	3.92	.98
YUBA HEAT TRANSFER CORP.	35-13735-01	8	7	8.92	1.27	5	5	2.27	.45

APPENDIX I A (cont.)

MANUFACTURERS AND DISTRIBUTORS

Licensee Name	License Number	Program Type	1982 Total Individuals Monitored	1982 Workers with Measurable Dose	1982 Collective Dose (man-rems)	1982 Average Meas'ble Dose (rems)	1983 Total Individuals Monitored	1983 Workers with Measurable Dose	1983 Collective Dose (man-rems)	1983 Average Meas'ble Dose (rems)
ABBOTT LABORATORIES	12-00621-03	BROAD	1015	145	12.025	.083	1294	199	22.200	.112
ACCURAY CORPORATION	34-00255-03	BROAD	342	278	27.375	.098	361	197	14.600	.074
AIRCO INCORPORATED	29-02085-01	OTHER	36	3	.800	.267	28	2	.225	.113
AMERICAN NUCLEAR PRODUCTS	24-16379-02	BROAD	1	1	.175	.175	1	1	.175	.175
AMERSHAM CORPORATION	12-12836-01	BROAD	187	74	19.550	.264	189	81	28.375	.350
AMERSHAM CORPORATION	12-12836-04	OTHER					Combined with a report for another license.			
ATOMIC ENERGY OF CANADA LIM.	12-18482-01	OTHER	84	66	12.700	.192	94	55	6.125	.111
AUTOMATION INDUSTRIES INC.	37-00611-09	OTHER	9	9	2.050	.228				
BAIRD-ATOMIC, INCORPORATED	20-01481-04	BROAD	32	4	.325	.081				
BAKER INDUSTRIES INC.	29-08864-03	BROAD	109	0	.000	.000	181	34	1.825	.054
CANBERRA INDUSTRIES	06-15099-01	BROAD	98	25	4.300	.172	27	15	2.025	.135
CETRON ELECTRONIC CORPORATION	12-09745-01	OTHER	4	1	.050	.050	4	0	.000	.000
COMBUSTION ENGINEERING INC.	06-00217-06	BROAD	269	99	10.000	.101	210	92	8.000	.087
COOK ELECTRIC COMPANY	12-02203-12	OTHER	7	0	.000	.000	7	0	.000	.000
E. R. SQUIBB AND SONS INC.	29-00139-02	BROAD	444	164	42.050	.256	405	172	42.100	.245
FIFE CORP	35-15511-01	OTHER	58	3	.275	.092				
FORT WAYNE MEDICAL LABORATORY	13-16080-01	OTHER	8	4	.325	.081	11	4	.200	.050
IMMUNO ASSAY CORPORATION	21-17915-01	OTHER	6	4	.200	.050	5	4	.200	.050
MALLINCKRODT/NUCLEAR	24-04206-01	BROAD	343	343	266.275	.776	357	346	223.050	.645
MEDI-PHYSICS INC.	12-13813-01	BROAD	64	61	102.800	1.685	78	74	143.550	1.940
NEW ENGLAND NUCLEAR CORP.	20-00320-09	BROAD	123	75	5.700	.076	105	37	3.425	.093
NEW ENGLAND NUCLEAR CORP.	20-00320-13	BROAD	446	266	170.225	.640	409	205	118.750	.579
NEW ENGLAND NUCLEAR CORP.	20-11868-01	BROAD	921	257	137.650	.536	526	199	143.300	.720
OHMART CORPORATION	34-00639-01	BROAD	83	68	14.575	.214	90	65	8.550	.132
PITTWAY CORPORATION	12-15023-01	BROAD	48	2	.100	.050	42	3	.275	.092
RADIATION MANAGEMENT CORP.	37-13129-01	OTHER	61	50	2.750	.055	58	33	2.350	.071
RAMSEY ENGINEERING CO.	42-01485-04	OTHER	122	77	24.600	.319	86	66	29.700	.450
SEAMAN NUCLEAR CORPORATION	48-12016-01	OTHER	21	17	19.000	1.118	18	16	12.475	.780
SOILTEST INCORPORATED	12-13793-01	BRD/OTH	13	0	.000	.000	13	1	.050	.050
TECHNICAL OPERATIONS INC.	20-00277-03	BROAD	72	30	8.300	.277	57	24	7.050	.294
TEST EQUIPMENT DISTRIBUTORS	21-18220-01	OTHER	20	5	.250	.050	27	4	.200	.050
TRAVENOL LABORATORIES INC.	20-13881-01	OTHER	114	16	1.750	.109	133	34	2.650	.078
TRAVENOL LABORATORIES INC.	20-13881-03	OTHER	Combined with report for another license.							
VARIAN ASSOCIATES	20-02237-04	OTHER	15	0	.000	.000				
WESTINGHOUSE ELECTRIC CO.	37-05809-01	OTHER	278	52	4.450	.086				

APPENDIX A (cont.)

FUEL FABRICATORS AND PROCESSORS

Licensee Name	License Number	1982 Total Individuals Monitored	1982 Workers with Measurable Dose	1982 Collective Dose (man-rems)	1982 Average Meas'ble Dose (rems)	1983 Total Individuals Monitored	1983 Workers with Measurable Dose	1983 Collective Dose (man-rems)	1983 Average Meas'ble Dose (rems)
ATOMICS INTERNATIONAL	SNM-0021	1159	604	135.15	.22	957	336	146.85	.44
BABCOCK & WILCOX CO.	SNM-0414	32	32	19.42	.61	6	5	.50	.10
BABCOCK AND WILCOX	SNM-1168	212	150	20.22	.13	216	206	31.25	.15
BABCOCK AND WILCOX INC	SNM-0042	2243	959	66.57	.07	2256	1136	82.95	.07
COMBUSTION ENGINEERING INC.	SNM-1067	264	159	27.82	.17	238	119	11.40	.10
COMBUSTION ENGINEERING, INC.	SNM-0033	83	64	11.62	.18	79	54	6.02	.11
EXXON NUCLEAR COMPANY INC.	SNM-1227	962	367	59.52	.16	957	405	65.57	.16
GENERAL ATOMIC COMPANY	SNM-0696	780	367	66.17	.18	834	249	35.17	.14
GENERAL ELECTRIC CO.	SNM-1097	1095	862	126.90	.15	1170	1014	192.07	.19
GENERAL ELECTRIC CO	SNM-0960	972	194	80.75	.42	481	234	84.10	.36
NUCLEAR FUEL SERVICES INC.	SNM-0124	1161	1014	59.77	.06	944	591	35.37	.06
TEXAS INSTRUMENTS INC.	SNM-0023	14	0	.00	.00				
UNITED NUCLEAR CORP.	SNM-0777	71	71	4.17	.06	48	1	.05	.05
UNITED NUCLEAR CORPORATION	SNM-0368	104	31	2.12	.07	113	27	1.92	.07
WESTINGHOUSE ELECTRIC CORP	SNM-1107	589	540	147.00	.27	676	607	140.47	.23
WESTINGHOUSE ELECTRIC CORP	SNM-1120	67	19	3.45	.18	48	27	1.97	.07
LOW-LEVEL WASTE DISPOSAL FACILITY									
CHEM-NUCLEAR SYSTEMS, INC.	46-19524-02	680	251	52.82	.21	612	358	70.95	.20
INDEPENDENT SPENT FUEL STORAGE INSTALLATION									
GENERAL ELECTRIC CO.	SMN-2500	35	32	9.42	.30	33	27	7.90	.29

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16. ABSTRACT *(200 words or less)*

This report summarizes the occupational radiation exposure information that has been reported to the NRC by certain categories of NRC licensees during the years 1973 through 1983. The bulk of the data presented in the report was obtained from annual radiation exposure reports submitted in accordance with the requirements of 10 CFR 20.407. Data on workers terminating their employment at certain NRC licensed facilities were obtained from reports submitted pursuant to 10 CFR 20.408. The annual reports submitted by nearly 500 licensees indicated that approximately 154,000 individuals were monitored in 1982 and about 173,000 individuals were monitored in 1983. They incurred average annual doses of 0.37 rem (cSv) and 0.35 rem (cSv) respectively. Termination radiation exposure reports required to be submitted pursuant to 10 CFR 20.408 were analyzed to reveal that about 59,000 individuals completed their employment with one or more of the 500 covered licensees during 1982*. Some 56,000 of these individuals terminated from power reactor facilities, when about 4,500 of them were considered to be transient workers who received an average dose of 1.11 rems (cSv).

*The most recent year for which most of the termination data are available for analysis.

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