NUREG-0463

OCCUPATIONAL RADIATION EXPOSURE

Tenth Annual Report

1977

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Manuscript Completed: October 1978
Date Published: October 1978

Division of Technical Support
Office of Management and Program Analysis
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

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ABSTRACT

This is a report by the U. S. Nuclear Regulatory Commission on the operation of the Commission's centralized repository of information on the exposure of personnel to radiation. The report is published annually and is available at all NRC public document rooms or may be purchased from the National Technical Information Service in Springfield, Virginia.

The bulk of the information summarized in the report was obtained from annual and termination reports (Sections I and II) submitted by four categories of NRC licensees: (1) operating nuclear power reactors; (2) industrial radiographers; (3) fuel fabricators and processors; and (4) commercial processors and distributors of specified quantities of byproduct materials, in accordance with the requirements set forth in Part 20.407 and Part 20.408 of Title 10, Chapter 1, Code of Federal Regulations. Annual reports were received from 457 covered licensees which indicated that 98,212 individuals, with an average annual exposure of 0.40 rems, were monitored during 1977. The number of termination reports submitted by these licensees continues to increase. Personal identification and exposure information has been taken from about 245,000 reports and incorporated into the repository during the ten years that it has been operating.

Information on incidents involving personnel overexposures to radiation or radioactive materials (Section III) was obtained from reports submitted by all NRC licensees pursuant to Parts 20.403 and 20.405 of Title 10, Chapter 1, Code of Federal Regulations. The total number of overexposures reported in 1977 decreased from the number reported in 1976, but is about the same as that reported in previous years. The number of incidents reported by radiography firms, however, is considerably less than last year's values. The more significant overexposures which occurred in 1977 are summarized in Appendix B.

TENTH ANNUAL
OCCUPATIONAL RADIATION EXPOSURE REPORT
1977

INTRODUCTION

On November 4, 1968, the U.S. Atomic Energy Commission (AEC) approved a program for the reporting of certain occupational radiation exposure information to a central repository. This information was to be required of four categories[1] of AEC licensees, as defined in 10 CFR 20.407, and of AEC facilities and contractors exempt from licensing. As of December 31, 1973, radiation exposure information on approximately 150,000 occupationally exposed persons had been incorporated into the repository. Annual reports for each of the years 1969 through 1973 summarized this information and were published as six separate documents (WASH-1350-R1 through WASH-1350-R6).

In January 1975, with the division 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 exposure information reported by facilities under its own jurisdiction. Beginning with the annual report for

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[1] Operating nuclear power reactors; industrial radiographers; fuel processors, fabricators and reprocessors; commercial processors and distributors of specified quantities of byproduct material.

calendar year 1974,[2] the NRC's publication no longer contains information pertaining to ERDA facilities or contractors. Comparable information for ERDA, now Department of Energy (DOE), facilities and contractors is collected by DOE's Division of Operational and Environmental Compliance at Germantown, Maryland.

[2]The annual occupational radiation exposure reports for NRC licensees for 1974, 1975 and 1976 are available from NTIS as NUREG 75/108, NUREG-0119, and NUREG-0322. The annual radiation exposure reports for DOE/ERDA contractors for 1974, 1975, and 1976 are available from NTIS as ERDA-76/119, ERDA-77-29, and DOE/EV-0011/9.

I. ANNUAL REPORTS - 10 CFR 20.407

Exposure Distributions

On February 4, 1974, 10 CFR 20.407 was amended to require the four categories of covered licensees to submit an annual statistical report indicating the distribution of the whole body exposures[1] incurred by their employees. In prior years the annual report was formatted differently and was not very useful as a basis for estimating man-rems. Table 1 is a compilation of the statistical reports submitted for calendar year 1977. It shows the number of individuals that incurred a cumulative annual whole body dose that fell within one of the 18 dose ranges, and the percentages of the total number monitored in each range. It also shows the cumulative dose (man-rems) estimated to have been received by these individuals. This number was obtained by assuming that each individual received an annual dose equal to the mid-point of the dose range in which he appears, and by then summing these doses. The table shows that 39% of the 98,212 individuals monitored during 1977 received exposures that were too small to be detected by personnel radiation monitoring devices, that 99.7% of the exposures were less than 5 rems, and that 94.8% of the total number of man-rems were accumulated by individuals with annual doses of less than 5 rems.

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[1] All of the figures compiled in this report relating to exposures and/or 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. However it may not be directly suitable for use in the assessment of risk to the individuals involved.

TABLE 1
DISTRIBUTION OF ANNUAL WHOLE BODY EXPOSURES
BY LICENSEE CATEGORY
1977

Category of NRC Licensee	Total No. Monitored	Exposure Ranges (Rems)																
		Less Than Measurable	Measurable <0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.0	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12
POWER REACTORS																			
No. of Individuals	71,904	27,671	15,523	6,750	5,179	3,300	2,500	6,174	2,838	1,130	569	141	66	36	21	6			
% in Range	100%	38%	22%	9%	7%	5%	3%	9%	4%	2%	<1%								
No. of Man-rems	32,731	0	776	1,181	1,942	2,062	2,188	9,261	7,095	3,955	2,560	776	429	270	179	57			
% in Range	100%		2%	4%	6%	6%	7%	28%	22%	12%	8%	2%	1%	1%	<1%	1%			
RADIOGRAPHY																			
No. of Individuals	10,569	4,372	2,488	1,084	812	512	357	644	192	63	30	12	1	1					1
% in Range	100%	41%	24%	10%	8%	5%	3%	6%	2%	<1%									
No. of Man-rems	3,159	0	124	190	305	320	312	966	480	220	135	66	6	8					27
% in Range	100%		4%	6%	10%	10%	10%	31%	15%	7%	4%	2%	<1%			1%			
FUEL FAB. & PROC.																			
No. of Individuals	11,496	4,492	4,533	1,057	571	315	179	205	91	28	25								
% in Range	100%	39%	39%	9%	5%	3%	2%	2%	1%										
No. of Man-rems	1,725	0	227	185	214	197	157	307	228	98	112								
% in Range	100%		13%	11%	12%	11%	9%	18%	13%	6%	7%								
MANUF. & DISTRIB.																			
No. of Individuals	4,243	1,784	1,271	394	215	144	91	153	76	47	34	16	14	4					
% in Range	100%	42%	30%	9%	5%	3%	2%	4%	2%	1%	<1%				<1%				
No. of Man-rems	1,329	0	63	69	81	90	80	229	190	165	153	88	91	30					
% in Range	100%		5%	5%	6%	7%	6%	17%	14%	12%	12%	7%	7%	2%					
TOTALS																			
No. of Individuals	98,212	38,319	23,815	9,285	6,777	4,271	3,127	7,176	3,197	1,268	658	169	81	41	21	6			1
% in Range	100%	39%	24%	10%	7%	4%	3%	7%	3%	1%	1%			1%					
No. of Man-rems	38,944	0	1,190	1,625	2,542	2,669	2,737	10,763	7,993	4,438	2,960	930	526	308	179	57			27
% in Range	100%		3%	4%	7%	7%	7%	28%	21%	11%	8%	2%	1%	1%	<1%				

It should be pointed out that very few of the annual exposures that exceed five rems are classified as personnel overexposures. Although 1.25 rems 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 per calendar quarter (up to 12 rems 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 where "N" equals the individual's age in years. Although there is no annual limit, annual exposures that exceed 12 rems indicate that an overexposure has occurred. Any quarterly whole body exposure in excess of the applicable quarterly limits are considered overexposures and must be reported. A discussion of various types of overexposures that have occurred is given in Section III.

A summary of the annual whole body exposures reported to the Commission by the four categories of NRC licensees required to submit reports during the past ten years is presented in Table 2. One can see that about 95% of the exposures have consistently remained less that two rems, and that the number of individuals receiving an annual exposure in excess of five rems is about one half of one percent of the total number of individuals monitored each year.

TABLE 2

SUMMARY OF ANNUAL WHOLE BODY EXPOSURES
FOR COVERED LICENSEES

1968-1977

Year	Total Number Monitored	Percent of Exposures < 2 Rems	Percent of Exposures > 5 Rems	Number of Annual Exposures > 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	94.5%	0.3%	1

Man-Rems Per Licensee Type

As was previously explained, the statistical data contained in the annual reports required by 10 CFR 20.407 permit an estimate to be made of the man-rems accumulated by the individuals monitored by each licensee. The information submitted by each one was collated to yield the information shown in Table 3. There are two values indicating the average annual exposure per individual. The lower values were obtained by dividing the total number of man-rems by the total number of individuals monitored, and the higher values were obtained by dividing the same total number of man-rems by the number of those individuals reported as having received a measurable exposure (referred to as radiation workers). The 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. In 1977 the average exposure for workers continued to decline in every category except power reactors, where it remained about the same. The averages consistently remain less than one rem per worker.

Commercial Nuclear Power Facilities

The percentage of the total number of man-rems incurred by workers at power reactors has, during the last five years, increased from 67% to 84%. Therefore, this section of the report has been expanded to illustrate and discuss some of the factors contributing to this increase.

TABLE 3

MAN-REMS ACCUMULATED BY CATEGORY OF COVERED LICENSEES

Covered Categories of NRC Licensees	Calendar Year	Number of Licensees Reporting	Total No. Individuals Monitored	No. Individuals With Measurable Exposure	Total No. Man-rems	Average Dose (Rems) Per Individual (Based on Total Monitored)	Average Dose (Rems) Per Worker (Based on Measurable Exposure)
*Commercial Power Reactors	1977	65	71,904	44,233	32,731	0.46	0.74
	1976	62	66,800	36,715	26,555	0.40	0.72
	1975	54	54,763	28,034	21,270	0.39	0.76
	1974	53	62,044	21,904	14,083	0.23	0.64
	1973	41	44,795	16,558	14,337	0.32	0.87
Industrial Radiography	1977	339	10,569	6,197	3,159	0.30	0.51
	1976	321	11,245	6,222	3,629	0.32	0.58
	1975	291	9,178	4,693	2,796	0.30	0.60
	1974	319	8,792	4,943	2,938	0.33	0.59
	1973	341	8,206	5,328	3,354	0.41	0.63
Fuel Processing and Fabrication	1977	23	11,496	7,004	1,725	0.15	0.25
	1976	24	11,227	5,285	1,830	0.16	0.35
	1975	23	11,405	5,495	3,125	0.27	0.56
	1974	25	10,921	4,617	2,739	0.25	0.59
	1973	27	10,610	5,056	2,400	0.23	0.47
Processing and Distribution of Byproduct Material	1977	30	4,243	2,459	1,329	0.31	0.54
	1976	24	3,501	1,976	1,226	0.35	0.62
	1975	19	3,367	1,859	1,188	0.35	0.63
	1974	24	3,340	1,827	1,050	0.31	0.57
	1973	34	4,251	1,925	1,177	0.28	0.61
Totals and Overall Averages	1977	457	98,212	59,893	38,944	0.40	0.65
	1976	428	92,773	50,198	33,240	0.36	0.66
	1975	387	78,713	40,081	28,379	0.36	0.71
	1974	421	85,097	33,291	20,810	0.24	0.63
	1973	443	67,862	28,867	21,268	0.31	0.74

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

Table 4 summarizes the information contained in Appendix A, which was reported by each reactor site during the past five years. The data are presented for the two types of light water reactors--pressurized water reactors (PWR) and boiling water reactors (BWR)--that had been in commercial operation for at least one year as of December 31 of each of the years indicated.[2] Figures 1 and 2 serve to display some of this information graphically.

Figure 1 indicates that the total number of man-rems per year incurred by workers at nuclear power facilities continues to increase, while the number of reactors is leveling off. The average number of man-rems per reactor and the average number of workers per reactor also continues to increase each year. The average number of man-rems per megawatt-year, however, appears to have leveled off at about one, and the average dose to an individual worker remains a little less than one rem.

Figure 2 displays some of this same type of information for each of the two types of light water reactors. The cost, in terms of total man-rems and man-rems per megawatt-year of generated electricity continues to be greater for the operation of BWR's than for PWR's. The numbers of reactors, however, is still rather small, and the information reported by a few reactors where unusual conditions or problems may have occurred could

[2]Some of the figures shown for 1974 are different from those shown in the previous annual reports. The new values reflect corrections made in the dates that some of the reactors began commercial operation.

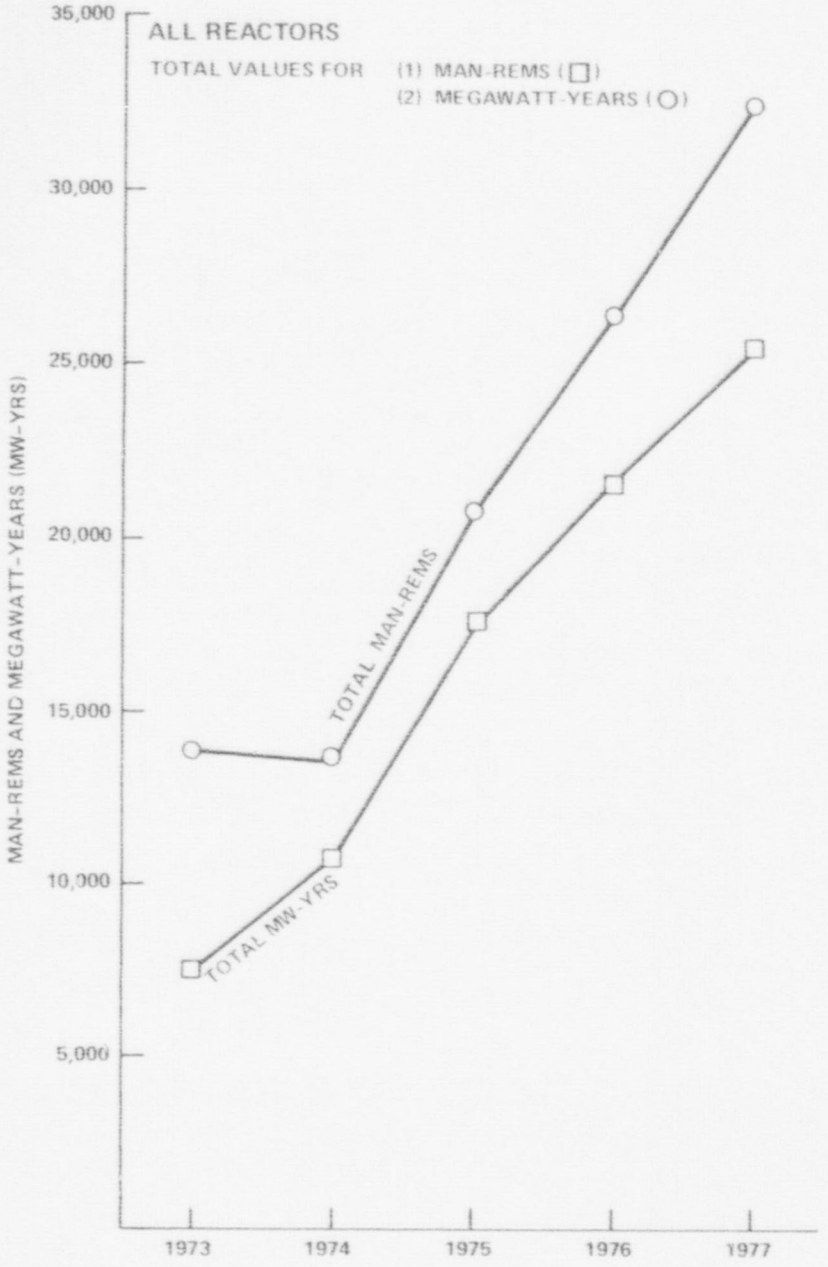
TABLE 4 *

SUMMARY OF ANNUAL EXPOSURES REPORTED BY NUCLEAR POWER FACILITIES 1973-1977

Year	Reactor Type	Number of Reactors Operating Full Year	Total Number of Man-Rems	No. of Workers With Measurable Exposure	Total Megawatt-Yrs. Generated	Average Annual Dose (Rems/Person)	Average No. of Man-Rems Per Reactor	Average No. of Workers Per Reactor	Man-Rems Per Megawatt-Yr.
1973	PWR	12	9,399	9,440	4,065	1.00	783	787	2.3
	BWR	12	4,564	5,340	3,344	0.85	380	445	1.4
	Total	24	13,963	14,780	7,409	0.94	582	616	1.9
1974	PWR	20	6,627	9,697	6,821	0.68	331	485	1.0
	BWR	14	7,095	8,769	4,042	0.81	507	626	1.8
	Total	34	13,722	18,466	10,863	0.74	404	543	1.3
1975	PWR	26	8,268	10,884	11,983	0.76	318	419	0.7
	BWR	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	PWR	30	13,807	17,588	13,251	0.79	460	586	1.0
	BWR	23	12,626	17,859	8,312	0.71	549	776	1.5
	Total	53	26,433	35,447	21,563	0.75	499	669	1.2
1977	PWR	34	13,469	20,878	16,481	0.65	396	614	0.8
	BWR	23	19,042	21,388	9,103	0.89	828	930	2.1
	Total	57	32,511	42,266	25,584	0.77	570	742	1.3

*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.

FIGURE 1


ALL REACTORS
TOTAL VALUES FOR (1) MAN-REMS (□)
(2) MEGAWATT-YEARS (○)
MAN-REMS AND MEGAWATT-YEARS (MW-YRS)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
TOTAL MAN-REMS
TOTAL MW-YRS
1973
1974
1975
1976
1977

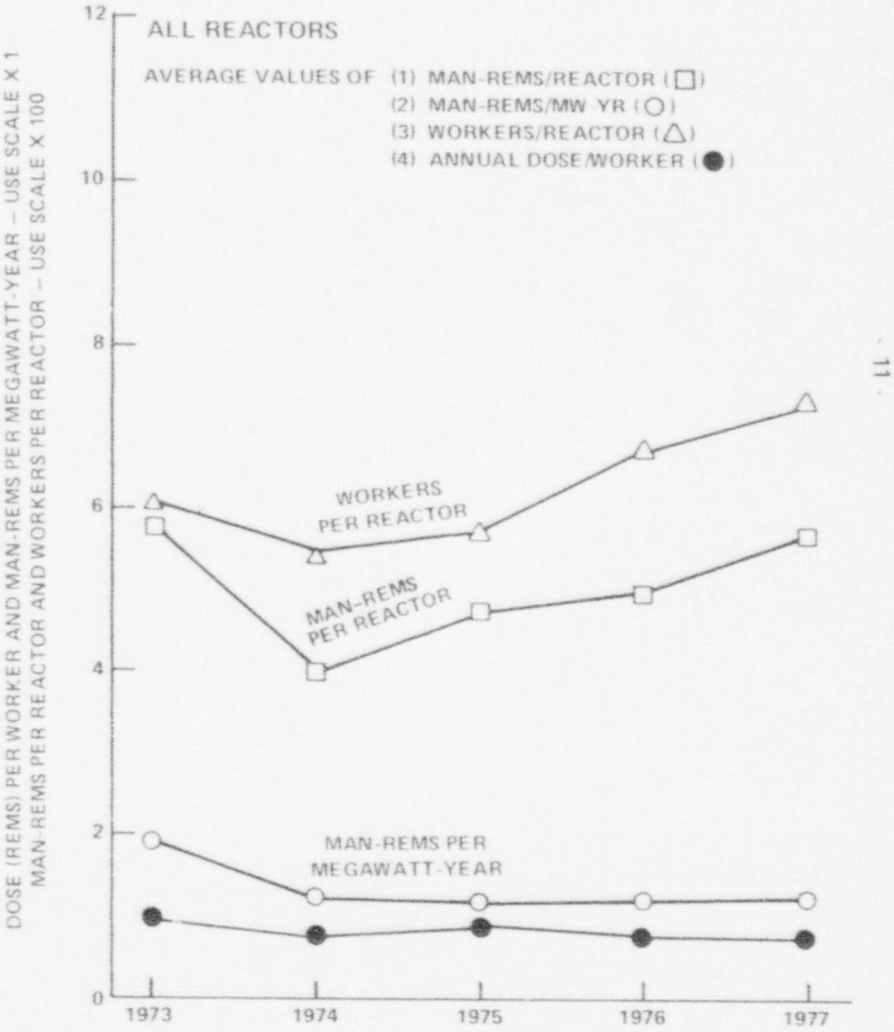
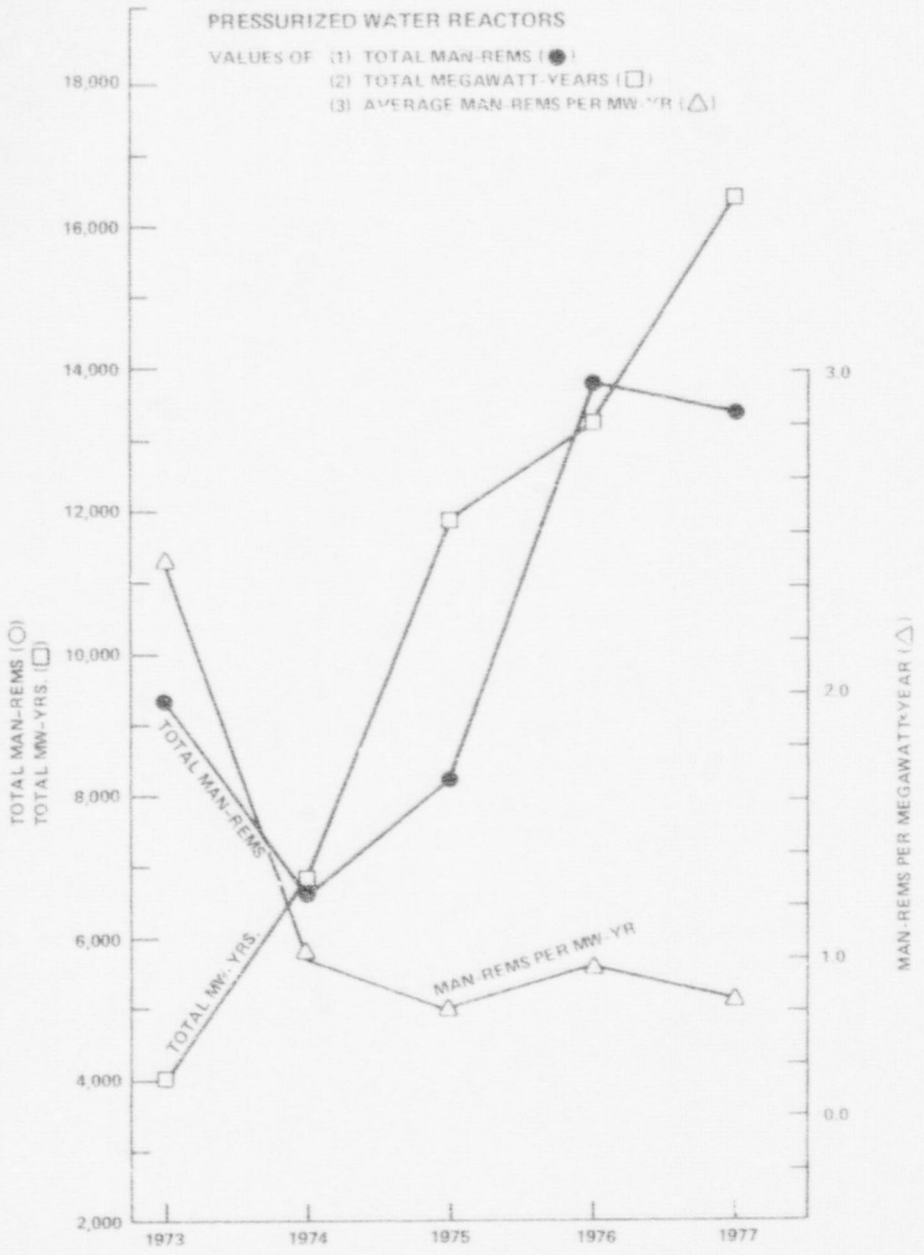
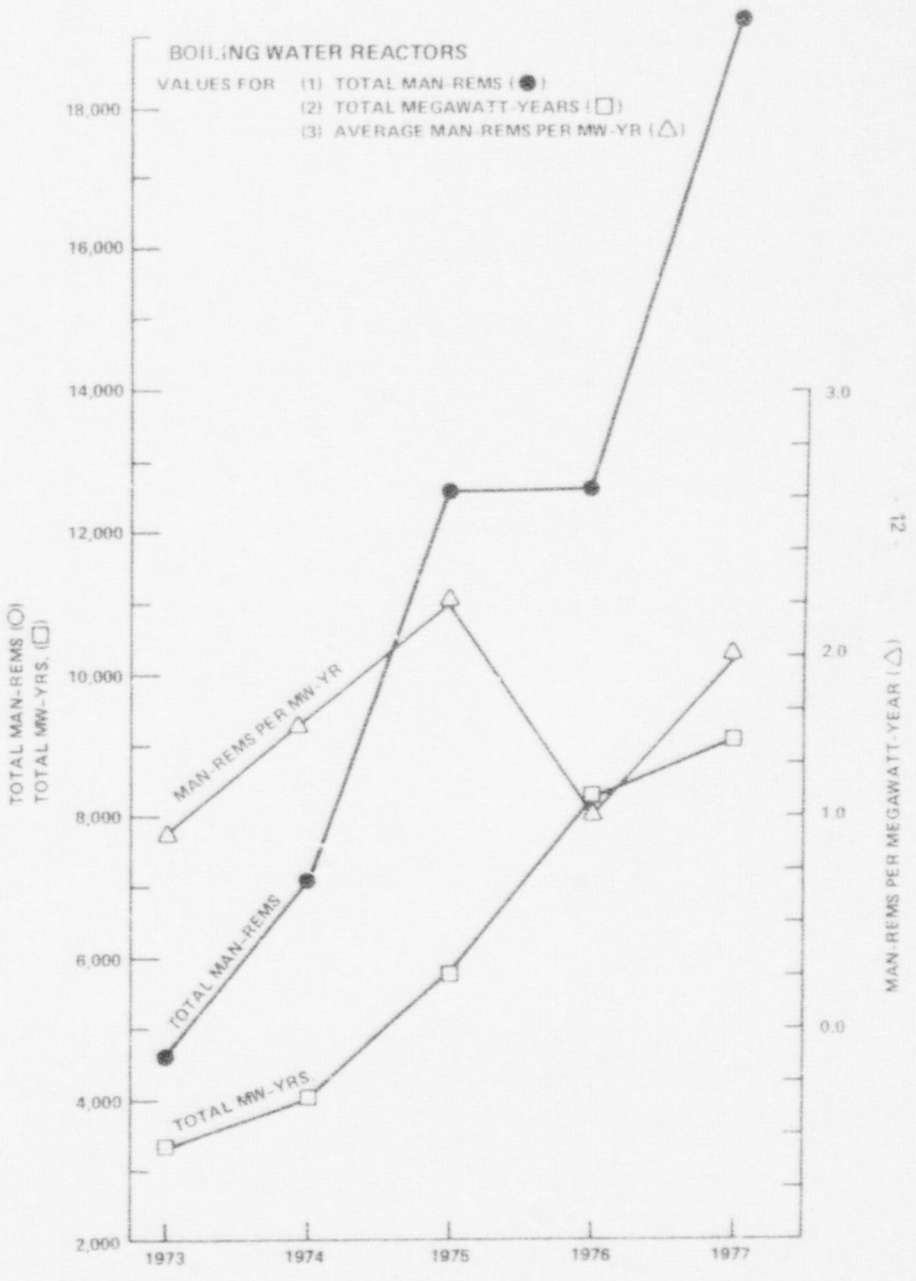

ALL REACTORS
AVERAGE VALUES OF (1) MAN-REMS/REACTOR (□)
(2) MAN-REMS/MW-YR (○)
(3) WORKERS/REACTOR (△)
(4) ANNUAL DOSE/WORKER (●)
DOSE (REMS) PER WORKER AND MAN-REMS PER MEGAWATT-YEAR — USE SCALE X 1
MAN-REMS PER REACTOR AND WORKERS PER REACTOR — USE SCALE X 100
12
10
8
6
4
2
0
WORKERS PER REACTOR
MAN-REMS PER REACTOR
MAN-REMS PER MEGAWATT-YEAR
1973
1974
1975
1976
1977

FIGURE 2


PRESSURIZED WATER REACTORS
VALUES OF (1) TOTAL MAN-REMS (●)
(2) TOTAL MEGAWATT-YEARS (□)
(3) AVERAGE MAN-REMS PER MW-YR (△)
TOTAL MAN-REMS (○)
TOTAL MW-YRS. (□)
MAN-REMS PER MEGAWATT-YEAR (△)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
3.0
2.0
1.0
0.0
1973
1974
1975
1976
1977
TOTAL MAN-REMS
TOTAL MW-YRS.
MAN-REMS PER MW-YR


BOILING WATER REACTORS
VALUES FOR (1) TOTAL MAN-REMS (●)
(2) TOTAL MEGAWATT-YEARS (□)
(3) AVERAGE MAN-REMS PER MW-YR (△)
TOTAL MAN-REMS (○)
TOTAL MW-YRS. (□)
MAN-REMS PER MEGAWATT-YEAR (△)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
3.0
2.0
1.0
0.0
1973
1974
1975
1976
1977
MAN-REMS PER MW-YR
TOTAL MAN-REMS
TOTAL MW-YRS.

drastically affect the figures. In an effort to identify these plants, Tables 5 and 6 list the PWR's and the BWR's in ascending order of man-rems per reactor. For example, one can see that in 1973 the doses incurred by 3,000 workers at one of the oldest PWR's, Indian Point 1, contributed more to the total number of man-rems than did all the other PWR's combined. This was due primarily to extensive repairs of the superheating system, and the plugging and testing of steam generator tubes. Thus, a high dose year at one particular plant can impact the averages significantly.

In general, one can see from the listings that the plants having the lowest values of the three parameters each year are usually the newer plants. Some of the older, smaller plants also appear near the top of the listings since they report a small number of man-rems; however, the ratio of their man-rems to the number of megawatt-years generated will be higher because of their limited power generation capacity. When a plant reports a high number of man-rems, and a large man-rems to megawatt-year ratio as well, it usually indicates that the plant was shut down for extensive maintenance or modification work. For PWR's, this work usually includes repair and inspection of leaking steam generator tubes, replacement of reactor coolant pump seals, and work on the control rod drive mechanisms. For BWR's, it can indicate maintenance of the reactor water cleanup system, detection and repair of cracks in the core spray system

TABLE 5
PRESSURIZED WATER REACTORS
LISTED IN ASCENDING ORDER OF MAN-REMS PER REACTOR
1973 THROUGH 1977

1973			
Site Name	[1]Man-Rems per Site	Dose per Worker (Rems)	Man-Rems per MW-Yr.
Turkey Point 3	78	0.17	0.19
Yankee Rowe	99	0.74	0.78
Maine Yankee	117	0.14	0.29
Surry 1	152	0.16	0.21
Ginna	224	0.70	0.55
Point Beach 1&2	588	1.17	0.85
San Onofre	354	0.62	1.29
Robinson 2	695	0.83	1.51
Haddam Neck	697	0.73	2.38
Palisades	1133	1.16	3.95
Indian Point 1	5262	1.75	[illegible]
Averages per Reactor	783	1.00	2.31

1974			
Site Name	[1]Man-Rems per Site	Dose per Worker (Rems)	Man-Rems per MW-Yr.
Prairie Island 1	18	0.12	0.10
Zion 1	56	0.18	0.13
Fort Calhoun	71	0.22	0.24
San Onofre	71	0.33	0.19
Point Beach 1&2	295	0.74	0.39
Haddam Neck	201	0.37	0.39
Yankee Rowe	205	0.84	1.85
Turkey Point 3&4	454	0.57	0.48
Oconee 1&2	517	0.61	0.79
Maine Yankee	420	0.68	0.97
Surry 1&2	884	0.52	1.23
Indian Point 1&2	911	0.89	1.64
Palisades	627	0.81	69.67
Robinson 2	672	0.79	1.16
Ginna	1225	1.39	4.82
Averages per Reactor	331	0.68	0.97

1975			
Site Name	[1]Man-Rems per Site	Dose per Worker (Rems)	Man-Rems per MW-Yr.
Arkansas 1	21	0.14	0.04
Kewaunee	28	0.27	0.07
Prairie Island 1&2	123	0.26	0.15
Zion 1&2	127	0.29	0.11
Three Mile Island 1	73	0.56	0.11
Yankee Rowe	116	0.47	0.80
Oconee 1,2&3	497	0.60	0.27
Point Beach 1&2	459	1.35	0.57
San Onofre	292	0.69	0.75
Fort Calhoun	294	0.63	1.17
Palisades	306	0.62	1.01
Maine Yankee	319	0.73	0.59
Indian Point 1*&2	705	0.79	0.60
Turkey Point 3&4	876	0.74	0.88
Ginna	538	0.78	1.47
Haddam Neck	703	0.88	1.42
Surry 1&2	1649	0.85	1.56
Robinson 2	1142	1.34	2.27
Averages per Reactor	315	0.76	0.69

*Indian Point 1 was defueled in 1975.

1976			
Site Name	[1]Man-Rems per Site	Dose per Worker (Rems)	Man-Rems per MW-Yr.
Rancho Seco	58	0.19	0.22
Yankee Rowe	59	0.39	0.42
Calvert Cliffs 1	74	0.15	0.10
Maine Yankee	85	0.35	0.12
Cook 1	116	0.29	0.14
Millstone Point 2	168	0.27	0.32
Point Beach 1&2	370	1.18	0.43
Prairie Island 1&2	447	0.55	0.62
Kewaunee	270	0.71	0.67
Zion 1&2	571	0.74	0.50
Three Mile Island 1	286	0.35	0.54
Arkansas 1	289	0.61	0.62
Fort Calhoun	313	0.61	1.18
Oconee 1,2&3	1026	0.84	0.66
Haddam Neck	449	0.70	0.93
Turkey Point 3&4	1184	0.72	1.22
Ginna	636	0.84	2.56
Palisades	696	0.93	2.01
Robinson 2	715	1.20	1.22
San Onofre	880	0.66	2.96
Indian Point 1*&2	1950	1.23	7.14
Surry 1&2	3165	1.15	3.41
Averages per Reactor	460	0.79	0.99

1977			
Site Name	[1]Man-Rems per Site	Dose per Worker (Rems)	Man-Rems per MW-Yr.
Beaver Valley	87	0.26	0.27
Palisades	100	0.30	0.17
Kewaunee	140	0.45	0.35
Prairie Island 1&2	300	0.42	0.71
St. Lucie	152	0.34	0.25
Trojan	174	0.29	0.23
Point Beach 1&2	430	1.03	1.02
Millstone Point 2	243	0.36	0.49
Maine Yankee	245	0.48	0.42
Arkansas 1	256	0.43	0.42
Fort Calhoun	297	0.56	0.89
Cook 1	300	0.37	0.55
Yankee Rowe	356	0.49	3.04
Indian Point 1*,2&3	1071	0.77	0.87
Three Mile Island 1	360	0.32	0.58
Rancho Seco	391	0.76	0.58
Ginna	401	0.76	1.16
Oconee 1,2&3	1329	0.83	0.89
Robinson 2	455	0.72	0.92
Zion 1&2	1004	1.28	0.78
Turkey Point 3&4	1036	0.79	1.12
Calvert Cliffs 1	547	0.24	0.98
Haddam Neck	642	0.72	1.40
San Onofre	847	0.86	3.18
Surry 1&2	2307	1.24	2.13
Averages per Reactor	396	0.65	0.82

[1]For Those Sites With More Than One Operating Reactor, the Numbers of Man-rems per Reactor is Obtained by Dividing the Number of Man-rems Reported by the Site by the Number of Reactors.

TABLE 6
BOILING WATER REACTORS
LISTED IN ASCENDING ORDER OF MAN-REMS PER REACTOR
1973 THROUGH 1977

1973

Site Name	[1]Man-Rems per Site	Dose per Worker (Rems)	Man-Rems per MW Yr.
Vermont Yankee	85	0.34	0.38
Pilgrim	126	0.54	0.26
Monticello	176	0.43	0.52
La Crosse	221	1.40	9.21
Humboldt Bay	266	1.26	5.32
Big Rock Point	285	1.18	5.56
Dresden 1,2&3	939	0.70	0.84
Nine Mile Point	567	1.03	1.38
Millstone Point 1	663	0.56	2.95
Oyster Creek	1236	1.58	2.91
Averages per Reactor	380	0.85	1.36

1974

Site Name	[1]Man-Rems per Site	Dose per Worker (Rems)	Man-Rems per MW Yr.
La Crosse	139	1.21	3.66
Vermont Yankee	216	0.61	0.71
Quad Cities 1&2	482	0.71	0.50
Big Rock Point	276	0.98	6.73
Humboldt Bay	318	1.07	7.39
Monticello	349	0.41	1.00
Pilgrim 1	415	0.90	1.77
Dresden 1,2,3	1662	1.04	1.90
Nine Mile Point	824	1.11	2.13
Oyster Creek	984	1.05	2.27
Millstone Point 1	1430	0.55	3.33
Averages per Reactor	507	0.81	1.76

1975

Site Name	[1]Man-Roms per Site	Dose per Worker (Rems)	Man-Rems per MW Yr.
Peach Bottom 2&3	228	0.23	0.19
Cooper Station	117	0.20	0.26
Vermont Yankee	153	0.54	0.36
Big Rock Point	180	0.60	5.15
La Crosse	234	1.42	7.31
Browns Ferry 1	325	0.14	2.01
Humboldt Bay	339	1.28	7.53
Nine Mile Point	681	1.05	1.90
Pilgrim 1	798	1.69	2.59
Quad Cities 1&2	1618	1.49	1.55
Oyster Creek	1140	0.94	3.05
Dresden 1,2&3	3423	1.48	4.83
Monticello	1353	1.00	3.92
Millstone Point 1	2022	0.78	4.35
Averages per Reactor	701	0.86	2.18

1976

Site Name	[1]Man-Rems per Site	Dose per Worker (Rems)	Man-Rems per MW Yr.
Duane Arnold	105	0.30	0.35
La Crosse	110	0.93	5.23
Brown Ferry 1&2	234	0.11	0.69
Hatch	134	0.21	0.27
Fitzpatrick	202	0.34	0.41
Monticello	263	0.81	0.55
Big Rock Point	289	0.59	9.97
Brunswick 2	326	0.26	1.10
Cooper Station	350	0.46	0.81
Vermont Yankee	411	0.50	1.06
Peach Bottom 2&3	840	0.39	0.61
Nine Mile Point	428	1.09	0.89
Dresden 1,2&3	1680	0.96	3.95
Humboldt Bay	683	1.31	29.70
Quad Cities 1&2	1651	1.35	1.74
Oyster Creek	1078	0.68	2.37
Millstone 1	1194	0.87	2.66
Pilgrim 1	2468	2.01	9.23
Averages per Reactor	547	0.71	1.52

1977

Site Name	[1]Man-Rems per Site	Dose per Worker (Rems)	Man-Rems per MW Yr.
Cooper Station	198	0.63	0.37
La Crosse	225	1.59	20.36
Vermont Yankee	258	0.40	0.61
Duane Arnold	299	0.56	0.84
Big Rock Point	334	0.72	7.59
Millstone Point 1	394	0.37	0.68
Browns Ferry 1&2	863	0.46	0.65
Hatch 1	465	0.36	1.04
Quad Cities 1&2	1031	1.14	1.06
Dresden 1,2&3	1694	0.91	1.50
Monticello	1000	1.16	2.34
Peach Bottom 2&3	2037	0.72	1.94
Fitzpatrick	1080	0.78	2.34
Brunswick 2	1120	0.74	3.86
Nine Mile Point	1383	1.27	3.99
Oyster Creek	1614	0.96	4.18
Humboldt Bay	1935	1.75	[illegible]
Pilgrim 1	3142	1.67	9.91
Averages per Reactor	828	0.89	2.1

[1]For Those Sites With More Than One Operating Reactor, the Numbers of Man-rems per Reactor is Obtained by Dividing the Number of Man-rems Reported by the Site by the Number of Reactors.

and in the reactor vessel feedwater nozzles and spargers and, in older plants, extensive seismic and emergency core cooling system modifications. More details on the activities conducted by each nuclear power facility for each year since 1973 can be found in the reports titled Nuclear Power Plant Operating Experience, (OOE-ES-004, NUREG-0227, NUREG-0366 and NUREG-0483, to be published).

Table 7 presents the distribution of the cumulative doses (man-rems) among the major work functions of the personnel employed at power reactor facilities during the last four years. This table is based on information submitted by nuclear reactors pursuant to Regulatory Guide 1.16. Special and routine maintenance continue to contribute approximately 70% of the total man-rems. A breakdown of the information in Table 7 into the distributions for the PWR's and BWR's, separately, would show that, in 1977, 48% of the total man-rems at BWR's was incurred during special maintenance activities, as compared to 33% at PWR's. This is another indication of the impact that the performance of an unusually large number of non-routine operations at BWR's had on the number of man-rems that they reported. The document NUREG-0482, Occupational Radiation Exposures at Light Water Cooled Power Reactors, which is to be published at a later date, will contain more detailed information on nuclear power reactor facilities.

TABLE 7

PERCENTAGES OF PERSONNEL DOSE BY WORK FUNCTION

WORK FUNCTION	PERCENT OF DOSE			
	1974	1975	1976	1977
REACTOR OPERATIONS AND SURVEILLANCE	14.0%	10.8%	10.2%	10.6%
ROUTINE MAINTENANCE	45.4%	52.6%	31.0%	28.9%
IN-SERVICE INSPECTION	2.7%	3.0%	6.0%	6.6%
SPECIAL MAINTENANCE	20.4%	19.0%	40.0%	41.4%
WASTE PROCESSING	3.5%	6.9%	5.0%	5.9%
REFUELING	14.0%	7.7%	7.9%	6.6%

Industrial Radiography Operations

Annual occupational radiation exposure reports for CY 1977 were received from 339 companies using licensed radioactive sources for the purpose of conducting industrial radiography. The number of workers reported as having received some measurable exposure (6,197) is nearly the same as that reported in 1976; however, the total number of man-rems decreased by about 450. This resulted in an average dose per worker of 0.51 rems, the lowest reported in the last five years. The 74 firms having an average dose per worker that exceeded 0.51 rems are listed in Table 8 in ascending order of average dose per worker.

Fuel Processors and Fabricators

Annual occupational radiation exposure reports for CY 1977 were received from 20 facilities that had more than five kilograms of licensed special nuclear material (including plutonium, uranium-233, and uranium enriched in the isotopes 233 or 235) for use in fuel processing, fabrication, or reprocessing. The total number of man-rems incurred by workers engaged in these activities also decreased from last year's values, with the average dose per worker at 0.25 rems, the lowest value reported in the last five years. Table 9 lists these facilities in ascending order of average annual dose per worker, and shows the activity codes for each license. These may be interpreted as follows:

TABLE 8
RADIOGRAPHY FIRMS LISTED IN ASCENDING ORDER OF AVERAGE DOSE PER WORKER

Licensee Name & Number(s)	No. of Workers With Measurable Exposure	Total Man-rems	Average Dose Per Worker (Rems)	Licensee Name & Number(s)	No. of Workers With Measurable Exposure	Total Man-rems	Average Dose Per Worker (Rems)
Naval Electronics Systems Command 08-00038-16	10	5.31	0.53	Daniel International Corp. 39-01261-02	34	21.44	0.63
Froehling & Robertson Inc. 45-08890-01	11	6.06	0.55	Herron Testing Laboratories Inc. 34-00681-03	9	5.69	0.63
X-Ray Engineering Company 04-00616-04	257	141.47	0.55	Associated Piping & Engineering Co. 04-02409-02	8	5.14	0.64
Astrotech Inc. 37-09928-01	7	4.02	0.57	Dept. of Navy, Naval Weapons Ctr. 04-01757-01	9	5.90	0.66
Crane Company 24-00563-02	16	9.14	0.57	Midwest Inspection Service, Ltd. 48-16296-01	10	6.57	0.66
El Paso Natural Gas Company 42-03201-02	4	2.29	0.57	Branch Radiographic Labs., Inc. 29-03405-02	16	10.69	0.67
Clark Inspection Service Co. 35-11615-01	11	6.42	0.58	Universal Testing Company 43-11213-01	14	9.49	0.68
General Dynamics Corporation 06-01781-08	306	179.49	0.59	Arnold Greene Testing Labs, Inc. 20-01074-02	26	17.86	0.69
Tulsa Gamma Ray, Inc. 35-17178-01	8	4.72	0.59	Bill Miller X-Ray, Inc. 35-15112-01	122	83.79	0.69
Superior Industrial X-Ray Co. 12-02370-01	21	12.68	0.60	Nuclear Energy Service, Inc. 42-16559-01	172	121.73	0.71
Virginia Dept. of Highways & Transportation 45-13380-02	3	1.80	0.60	Richmond Engineering Co., Inc. 45-02884-01	15	10.59	0.71
Metaspec, Inc. 43-17142-01	9	5.45	0.61	Pittsburgh Testing Laboratory 37-00276-25	229	163.94	0.72
B & M Welding & Testing Co., Inc. 24-17183-01	1	0.62	0.62	H.P. and Associates, Inc. 35-16517-01	18	13.13	0.73
Charles F. Guyon, Inc. 29-06872-02	1	0.62	0.62	Naval Submarine Support Facility, New London 06-07150-01	15	11.22	0.75
P.X. Engineering Company, Inc. 20-15102-01	2	1.24	0.62	Industrial Inspection Industries, Inc. 34-14071-01	76	56.97	0.75
Stone & Webster Engineering Corp. 20-05600-02	644	401.39	0.62	Thayer Inspection Service 35-11239-01	26	19.86	0.76
Texas Pipe Bending Co. of Puerto Rico, Inc. 52-13632-01	3	1.86	0.62	Quality Assurance Lab. Inc. 18-10634-01	4	3.09	0.77
Venegas Industrial Testing Laboratories, Inc. 28-14847-02	2	1.24	0.62	Heat Treating & Metallurgical Co. 13-06147-04	9	7.07	0.79
Columbia Gas Transmission Corp. 47-16060-01	2	1.25	0.63	Sooner X-Ray & Mag, Inc. 35-17259-01	3	2.37	0.79

TABLE 8 (Continued)

Licensee Name & Number(s)	No. of Workers With Measurable Exposure	Total Man-rems	Average Dose Per Worker (Rems)	Licensee Name & Number(s)	No. of Workers With Measurable Exposure	Total Man-rems	Average Dose Per Worker (Rems)
Consumers Power Company 21-08606-03	11	8.94	0.81	Calumet Engineering Services 13-16347-01	7	7.67	1.10
H.R. Inspection Service 15-06209-01	11	8.86	0.81	Advex Corporation 45-16452-01	7	7.79	1.11
Magnaflux Corporation 12-00622-08	358	294.58	0.82	Twin City Testing & Engineering Lab., Inc. 22-01376-02	22	25.37	1.15
Eastern Testing & Inspection, Inc. 29-09814-01	17	14.32	0.84	Atlantic Research Corporation 45-02808-04	4	4.87	1.22
The H.C. Nutting Company 34-14924-01	2	1.67	0.84	American X-Ray & Inspection, Inc. 21-15455-01	6	7.42	1.24
Consolidated X-Ray Service Corp. 42-08456-02	288	252.58	0.88	Inspection Service Corp. of Pa. 37-11636-01	8	9.91	1.24
Industrial Laboratories Inc. 41-04226-02	7	6.27	0.90	Catalytic, Inc. 37-12931-02	6	7.52	1.25
McCorkle Machine Shop 47-16182-01	4	3.62	0.91	Trans-Eastern Inspection, Inc. 37-14855-01	35	49.44	1.41
Yuba Industries, Inc. 35-13735-01	7	6.49	0.93	Combustion Engineering, Inc. 35-02325-02	14	20.79	1.49
Briggs Engineering & Tesonics Co., Inc. 20-16401-01	5	4.84	0.97	St. Louis Testing Lab., Inc. 24-00188-02	10	14.92	1.49
X-Ray, Inc. 46-03414-03	45	43.75	0.97	Industrial Gamma Inspection 35-16760-01	1	1.50	1.50
Advanced Radiation Service 29-14171-01	5	5.10	1.02	Word Industries Pipe Fabricating 35-15458-01	6	9.22	1.54
Cleveland X-Ray Inspection, Inc. 35-15205-01	33	34.59	1.05	Teledyne Ohiocast 34-00412-03	5	7.87	1.57
Nondestructive Inspection Service, Inc. 47-11883-01	10	10.46	1.05	Newport News Industrial Corporation 45-11589-01	5	8.05	1.61
Globe X-Ray Services, Inc. 35-15194-01	45	47.75	1.06	Twin Ports Testing, Inc. 22-15932-01	9	16.39	1.82
McManus Inspection Service 48-14158-01	2	2.12	1.06	Colby & Thielmeier Testing Co., Inc. 24-13737-01	4	7.37	1.84
Capital X-Ray Service 35-11114-01	31	33.68	1.09	J.G. Sylvester Associates 20-00302-02	21	41.15	1.96
Metils, Inc. 42-16534-01	11	12.02	1.09	ITT Grinnell Industrial Piping, Inc. 32-17346-01	7	15.72	2.25

TABLE 9

FUEL FABRICATORS AND PROCESSORS LISTED IN ASCENDING ORDER OF AVERAGE DOSE PER WORKER

Licensee Name & Number(s)	Activity Code(s)	No. of Workers With Measurable Exposure	Total Man-rems	Average Dose Per Worker (Rems)
United Nuclear Corporation SNM-777	21220	57	3.10	0.05
United Nuclear Corporation SNM-368	21230	59	3.32	0.06
Kerr-McGee Corporation [1] SNM-928 SNM-1174	21220 21110	11	0.92	0.08
Nuclear Fuel Services, Inc. SNM-124	21110 & 21300	186	15.12	0.08
Babcock & Wilcox Inc. SNM-42	21230	1,989	176.79	0.09
Combustion Engineering, Inc. SNM-33	21210	34	2.95	0.09
Exxon Nuclear Company, Inc. SNM-1227	21210 & 21120	1,386	1, 3.62	0.10
Texas Instruments, Inc. SNM-23	21230 & 22120	26	3.57	0.14
U.S. Nuclear, Inc. SNM-1315	21230	82	12.32	0.15
Babcock & Wilcox Co. SNM-1168	21230 & 11300	124	19.44	0.16
Nuclear Materials & Equipment Corporation SNM-145	21220	39	7.55	0.19
Atomics International SNM-21	21230 & 21300	436	91.03	0.21
General Atomic Company SNM-696	21230	244	50.21	0.21
General Electric Company SNM-1097	21210 & 22110	690	155.77	0.23
Nuclear Fuel Services, Inc. [2] CSF-1	43110	56	15.44	0.28
Combustion Engineering Co. SNM-1067	21230 & 22110	128	45.99	0.36
Westinghouse Electric Corporation SNM-1120	21110 & 21120	52	24.04	0.46
Westinghouse Electric Corporation SNM-1107	21210	542	347.45	0.64
Nuclear Materials & Equipment Corporation SNM-414 37-04456-03	21120 03211	164	111.34	0.68
General Electric Company SNM-960 TR-1 DR-10	21120 21300 42140	699	504.64	0.72

[1] Fuel Fabrication Operations Have Ceased. Present Licensed Activity is for Storage Only.

[2] Fuel Reprocessing Operations Have Ceased. Present Licensed Activity is for Possession of Irradiated Material.

21110 - Plutonium in fuel fabrication and scrap recovery
21120 - Plutonium in fuel fabrication
21210 - Uranium in UF_6 conversion, fuel fabrication and scrap recovery
21220 - Uranium in fuel fabrication and scrap recovery
21230 - Uranium in fuel fabrication
21300 - Uranium-233 uses, other than those given above
22110 - Plutonium, unencapsulated uses
22120 - Plutonium, neutron sources
23200 - Special nuclear material, storage only
42140 - Test reactors
43110 - Fuel reprocessing plants

Manufacturers and Distributors

Annual occupational radiation exposure reports were received from 30 licensees that had quantities of radioactive material in excess of the values given in 10 CFR 20.407(a)(4) for purposes of processing or manufacturing them for distribution. The number of licensees and the number of workers receiving measurable exposures increased by about 24% over the number reported in 1976. The total number of man-rems, however, increased by only 8%, resulting in the average dose per worker falling to 0.54 rems. The eight companies having an average dose per worker that exceeded the 0.54 rems average are listed in Table 10 in ascending order of average dose per worker.

TABLE 10

MANUFACTURERS AND DISTRIBUTORS LISTED IN ASCENDING ORDER OF AVERAGE DOSE PER WORKER

Licensee Name & Number(s)	No. of Workers With Measurable Exposure	Total Man-rems	Average Dose Per Worker (Rems)
New England Nuclear Corporation 20-00320-09	16	12.43	0.78
Minnesota Mining & Manufacturing Co. 22-00057-06	51	49.25	0.96
New England Nuclear Corporation 20-11868-01	195	195.62	1.00
Mallinckrodt/Nuclear 24-04206-01	341	385.15	1.13
Mallinckrodt, Inc. 29-13564-01	77	125.03	1.62
New England Nuclear Corporation 20-00320-13	152	274.60	1.81
Automation Industries, Inc. 37-00611-09	5	9.92	1.99
Picker Corporation 34-07225-14	6	17.18	2.86

II. TERMINATION REPORTS - 10 CFR 20.408

Terminations - 1969-1977

During the years the repository has been in operation, approximately 245,000 reports of terminations have been received for employees of covered licensees. These reports provide information for about 135,000 individuals. The difference in the figures given for the number of reports and for the number of individuals indicates that several thousand of these individuals have terminated more than once over the years. For the last few years, more than 75% of the termination reports have been for individuals that worked at nuclear power facilities.

Transient Workers

Since nearly 50% of the termination reports submitted have indicated periods of employment less than 90 days, it is possible that several thousand individuals could have been employed by two or more licensees during the same quarter. The exposures of these "transient workers" (i.e., individuals who began and terminated two or more employments with different employers within the same calendar quarter) are periodically examined to determine whether or not individual cumulative doses have been exceeding regulatory limits. Table 11 shows that the number of transient workers has been increasing during the last few years. This is due primarily to the requirement for short-term workers in the nuclear power plants. The values of the average

TABLE 11

TRANSIENT WORKERS

	1969	1970	1971	1972	1973	1974	1975	1976	1977*
Number of Workers Terminating Employment with Two or More Employers in One Quarter	8	29	11	69	157	354	714	1311	384
Total Number of Man-rems	5.4	14.6	2.8	61.3	135.5	175.9	507.1	909.9	201.0
Average Individual Dose (Rems)	0.67	0.50	0.25	0.89	0.86	0.50	0.71	0.69	0.52

*Data for 1977 is incomplete. Projections of this limited data to the end of the year indicate that these figures for 1977 will be about the same as for 1976.

individual transient worker's exposure shown in Table 11 appear to be nearly the same as that given in Table 4. This is not necessarily the case, however, since the average exposure shown in Table 11 is an average quarterly exposure for 95% of the transient workers, while the values in Table 4 indicate average annual exposures. However, the average exposure of these workers continues to be less than 20% of the quarterly limit of three rems, and fewer than 10 of these individuals have ever incurred exposures that exceeded three rems in one quarter.

Career Doses

The termination data also permit estimation of accumulated whole body dose that workers have received during their total period of employment in the nuclear industry. This was done by summing each individual's periods of employment and each corresponding whole body dose to give the cumulative occupational dose that the individual has received during his career. The data, however, are limited in the following ways:

(1) Termination information is submitted to the repository only for those individuals that are employed by the types of NRC licensees previously described on page 1. (2) It is not always known whether the dates given in the termination reports indicate the individual's complete period of employment or just the period

that he was monitored while he was assigned to work in radiation areas. It is believed, however, that for the majority of the individuals, the two periods are identical. (3) The exposure information is obtained from the readings of personnel monitoring devices used in routine monitoring programs. The results are sufficient to characterize the radiation environment of the worker, but they may not be directly suitable for use in the assessment of risk to individuals.

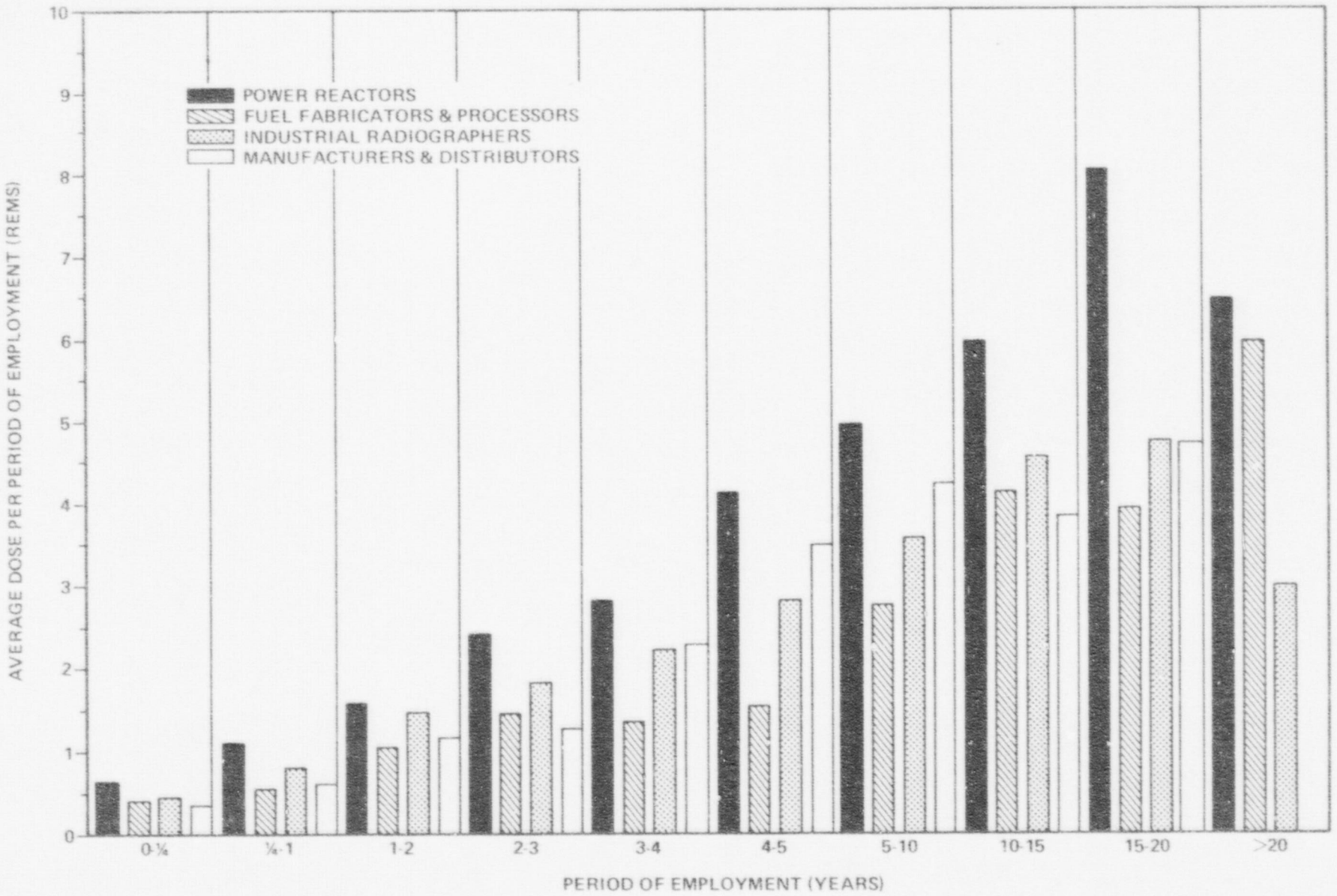
We have examined the termination information currently available for the four types of covered licensees (power reactors, fuel fabricators and processors, industrial radiographers and manufacturers and distributors) for 98,846 individuals. The periods of employment and whole body doses were summed as described above, and were broken down into ten ranges of employment periods: 0 - 90 days; 90 days - 1 year; 1 - 2 years; 3 - 4 years; 4 - 5 years; 5 - 10 years; 10 - 15 years; 15 - 20 years; and greater than 20 years. Appendix C lists the number of individuals whose total period of employment fell within these ranges, the total number of man-rems received, and the average career dose per individual. We have subtracted the number of these individuals who received no measurable exposure from the total number of individuals monitored to show the number of workers having measurable doses. Since these workers are more likely to be routinely

employed in radiation areas, the average doses shown in Appendix C were calculated by dividing the total number of man-rems by the number of workers with measurable doses.

Figure 3 shows the average career doses for workers employed by the four categories of covered licensees. The average career doses for workers in the nuclear power industry continue to be higher than for workers in the other three fields. In every instance, however, the average dose is less than the career dose limit specified for radiation workers, 5(N-18) rems, where "N" is the individual's age in years.

FIGURE 3

CAREER DOSES



III. PERSONNEL OVEREXPOSURES - 10 CFR 20.403 and 10 CFR 20.405

Types of Overexposures

One requirement of the above-referenced sections of Part 20, Title 10, Chapter 1, Code of Federal Regulations, is that all persons licensed by the NRC must submit reports of all incidents involving personnel radiation exposures that exceed certain levels. Based on the magnitude of the exposure, the reports may be placed into one of three categories:

A. 10 CFR 20.403(a) - 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.

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.

C. 10 CFR 20.405 - Exposure of an individual to radiation or concentrations of radioactive material in excess of any applicable quarterly limit in Part 20 or in the licensee's license. This includes reports of whole body exposures that exceed 1.25 rems, or that exceed 3

rems, as previously discussed on page 5. It also includes reports of skin exposures that exceed 7.5 rems, extremities exposures that exceed 18.75 rems. Reports of exposures of individuals to concentrations in excess of the levels given in 10 CFR 20, Appendix B, usually fall into this category. These reports must be submitted to the Commission within 30 days of the occurrence.

A short description of the four incidents occurring in 1977 that resulted in exposures of the magnitude described for category A or B is included in Appendix B of this report.

Summary of Overexposures

Table 12 summarizes all of the personnel overexposures to external sources of radiation as reported by Commission licensees pursuant to 10 CFR 20.403 and 20.405 during each of the years 1971 through 1977. It shows the number of individuals that incurred various types of overexposures while employed by one of several types of licensees. Most of the overexposures included in the "All Others" category come from test reactors, universities and facilities with large irradiator sources. The total of these figures for each of the last seven years indicates that the total number of individuals reported as having incurred overexposures to some part of the body has ranged between 46 and 66, with the exception of 1974 when 40 workers at one power reactor slightly exceeded the quarterly limit. The

TABLE 12

SUMMARY OF OVEREXPOSURES TO EXTERNAL SOURCES OF RADIATION

TYPE OF LICENSEE	1971 PART(S) OF BODY OVEREXPOSED				1972 PART(S) OF BODY OVEREXPOSED				1973 PART(S) OF BODY OVEREXPOSED				1974 PART(S) OF BODY OVEREXPOSED			
	Whole Body	Skin of W. Body	Extremity	W. Body & Extremity	Whole Body	Skin of W. Body	Extremity	W. Body & Extremity	Whole Body	Skin of W. Body	Extremity	W. Body & Extremity	Whole Body	Skin of W. Body	Extremity	W. Body & Extremity
INDUSTRIAL RADIOGRAPHY																
No. of Individuals	18	0	5	2	15	0	3	3	23	0	1	0	28	0	0	3
Total of Doses (rems)	77.3	0	4,644	21.9 W.B. 102 Extr.	79.3	0	516	293.0 W.B. 40,046 Extr.	101.8	0	87	0	383.9	0	0	14.0 W.B. 256 Extr.
Highest Dose (rems)	17.0		2,000	20 W.B. 72 Extr.	16.0		400	250 W.B. 30,000 Extr.	27.5		Same as Above		284 (Eyes)			5.9 W.B. 175 Extr.
Lowest Dose (rems)	1.3		49	1.9 W.B. 30 Extr.	2.1		36	21.0 W.B. 46 Extr.	1.3				1.3			3.1 W.B. 30 Extr.
POWER REACTORS																
No. of Individuals	2	0	0	0	16	0	0	0	19	0	0	0	43	0	0	0
Total of Doses (rems)	4.5	0	0	0	49.7	0	0	0	61.2	0	0	0	156.9	0	0	0
Highest Dose (rems)	3.1				5.1				4.0				5.4			
Lowest Dose (rems)	1.4				1.7				2.2				1.3			
MANUF. & DISTRIBUTION																
No. of Individuals	4	0	5	1	3	0	6	0	2	0	2	1	5	0	6	3
Total of Doses (rems)	16.6	0	135	4.75 W.B. 25 Extr.	6.3	0	134	0	3.6	0	44	1.3 W.B. 28 Extr.	11.8	0	186	14.1 W.B. 164 Extr.
Highest Dose (rems)	5.2		46	Same as Above	3.2		27		2.1		21	Same as Above	4.3		44	5.5 W.B. 86 Extr.
Lowest Dose (rems)	4.0		19		1.5		19		1.5		23		1.4		21	3.8 W.B. 19 Extr.
MEDICAL																
No. of Individuals	13	0	0	0	0	0	1	0	9	0	0	0	8	0	1	0
Total of Doses (rems)	58.4	0	0	0	0	0	19	0	28.1	0	0	0	34.2	0	22	0
Highest Dose (rems)	16.0						Same as Above		5.6				14.2		Same as Above	
Lowest Dose (rems)	1.3								1.3				1.4			
ALL OTHERS																
No. of Individuals	3	2	3	0	10	1	1	2	3	2	2	1	11	1	0	0
Total of Doses (rems)	6.2	22	102	0	29.7	40.0	80	24.7 W.B. 101 Extr.	8.3	23.5	42	6.0 W.B. 240 Extr.	424.6	8.9	0	0
Highest Dose (rems)	3.1	13	45		14.2	Same as Above	Same as Above	16.6 W.B. 55 Extr.	5.7	13.6	23	Same as Above	400	Same as Above		
Lowest Dose (rems)	1.3	9	25		1.3			8.1 W.B. 46 Extr.	1.3	9.9	19		1.7			
TOTALS																
Total No. of Individuals	40	2	13	3	44	1	11	5	58	2	5	2	95	1	7	6
Total of Doses (rems)	163.0	22	4,881	26.7 W.B. 127 Extr.	165.0	40.0	759	317.7 W.B. 40,147 Extr.	203.0	23.5	173	7.3 W.B. 265 Extr.	990.4	8.9	208	28.1 W.B. 420 Extr.

TABLE 12 (Continued)

SUMMARY OF OVEREXPOSURES TO EXTERNAL SOURCES OF RADIATION

TYPE OF LICENSEE	1975 PART(S) OF BODY OVEREXPOSED				1976 PART(S) OF BODY OVEREXPOSED				1977 PART(S) OF BODY OVEREXPOSED			
	Whole Body	Skin of W. Body	Extremity	W. Body & Extremity	Whole Body	Skin of W. Body	Extremity	W. Body & Extremity	Whole Body	Skin of W. Body	Extremity	W. Body & Extremity
INDUSTRIAL RADIOGRAPHY												
No. of Individuals	12	0	2	0	20	0	2	4	8	0	1	1
Total of Doses (rems)	61.5	0	74	0	115.1	0	860	54.1 W.B. 6,943 Extr.	41.7	0	630	5.2 W.B. 18 Extr.
Highest Dose (rems)	28.0		38		22.8		20	24.0 W.B. 3,750 Extr.	18.0		Same as Above	Same as Above
Lowest Dose (rems)	1.5		36		1.3		840	5.6 W.B. 43 Extr.	2.5			
POWER REACTORS												
No. of Individuals	14	0	3	0	20	0	0	0	27	0	0	0
Total of Dosis (rems)	44.2	0	83	0	74.3	0	0	0	52.9	0	0	0
Highest Dose (rems)	3.8		40		10.1				3.6			
Lowest Dose (rems)	2.4		22		0.9				1.3			
MANUF. & DISTRIBUTION												
No. of Individuals	3	0	2	0	1	0	3	0	2	3	6	0
Total of Doses (rems)	8.5	0	41	0	1.5	0	71	0	3.6	40.0	123	0
Highest Dose (rems)	3.6		21		Same as Above		25		1.9	20.1	24	
Lowest Dose (rems)	1.7		20				23		1.7	8.4	19	
MEDICAL												
No. of Individuals	3	0	0	0	9	0	0	0	3	0	3	0
Total of Doses (rems)	4.7	0	0	0	15.7	0	0	0	5.4	0	71	0
Highest Dose (rems)	1.8				2.5				2.3		28	
Lowest Dose (rems)	1.4				1.3				1.4		21	
ALL OTHERS												
No of Individuals	6	1	0	0	7	0	0	0	3	0	1	0
Total of Doses (rems)	14.6	8.1	0	0	15.7	0	0	0	226.0	0	30	0
Highest Dose (rems)	5.4	Same as Above			4.2				220.0		Same as Above	
Lowest Dose (rems)	1.3				1.4				2.6			
TOTALS												
Total No. of Individuals	38	1	7	0	57	0	5	4	43	3	11	1
Total of Doses (rems)	133.5	8.1	198	0	222.3	0	931	54.1 W.B. 6,943 Extr.	329.6	40.0	854	5.2 W.B. 18 Extr.

sum of the whole body doses incurred by these individuals has ranged from 133.5 man-rems to 1018.5 man-rems during these years. In 1977 the number of individuals overexposed during industrial radiography operations, as well as the number of man-rems, decreased sharply from previous years. The incidents involving the largest doses, however, are consistently reported by industrial radiographers and large irradiator facilities.

The number of reported personnel exposures to airborne concentrations of radioactive materials in excess of limits was considerably less in 1977 than in previous years. This was partly due to a change in the reporting requirements. There were only four cases 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). None of these cases exceeded the annual intake limit, equivalent to 2000 MPC-hours.

APPENDIX A

ANNUAL WHOLE BODY EXPOSURES AT LICENSED NUCLEAR POWER FACILITIES

1973 – 1977

PLANT NAME AND LICENSE NUMBER	YEAR	Number of Individuals with Whole Body Exposures in the Following Ranges (Rems)															Total Number Monitored	Number with Measurable Exposure	Total Man-Rems Per Site Per Year	Average Individual Exposure Rems (Measurable Exposures Only)	Megawatt Years Generated (MW Yr)
		No Measurable Exposure	Measurable – 0.10	0.10 – 0.25	0.25 – 0.50	0.50 – 0.75	0.75 – 1.0	1.0 – 2.0	2.0 – 3.0	3.0 – 4.0	4.0 – 5.0	5.0 – 6.0	6.0 – 7.0	7.0 – 8.0	8.0 – 9.0	9.0 – 10.0					
ARKANSAS 1 DPR 51	1975	488	87	44	8	5	3										635	147	21	0.14	588
Commercial in 12/74	1976	197	174	94	72	29	24	49	14	7	8	4	1				673	476	289	0.61	463
PWR; 850 MWe	1977	247	251	116	78	43	33	63	16	1							848	601	256	0.43	610
BEAVER VALLEY DPR 66	1977	676	193	73	39	9	1	6	2	7	1						1,007	331	87	0.26	328
Commercial in 10/76																					
PWR; 852 MWe																					
BIG ROCK POINT	1973	0	52	38	26	26	15	41	18	4	7	7	6	1			241	241	285	1.18	51
DPR 6	1974	20	93	52	22	17	11	43	17	8	6	6	6				301	281	276	0.98	41
Commercial in 3/63	1975	34	137	60	26	12	7	23	24	6	4	1					334	300	180	0.60	35
BWR; 72 MWe	1976	15	205	90	50	33	23	41	27	12	6	1					503	488	289	0.59	29
	1977	28	213	58	33	23	16	61	46	4	9	2					493	465	334	0.72	44
BROWNS FERRY 1 & 2	1975	2,085	1,638	457	180	57	20	28									4,465	2,380	325	0.14	162
DPR 33, 52	1976	2,039	1,741	285	115	37	20	9									4,246	2,207	234	0.11	337
Commercial in 8/74,	1977	2,558	631	410	288	155	113	197	64								4,416	1,858	863	0.46	1,328
3/75																					
BWR; All 1065 MWe																					
BRUNSWICK 2 DPR 62	1976	1,816	714	203	187	65	31	49	13	3							3,081	1,265	326	0.26	296
Commercial in 11/75	1977	2,020	517	244	189	114	83	173	120	49	21	2					3,532	1,512	1,120	0.74	291
BWR; 821 MWe																					
CALVERT CLIFFS 1	1976	1,822	360	66	45	22	11	3									2,329	507	74	0.15	751
DPR 62	1977	654	1,323	397	235	123	64	117	6								2,919	2,265	547	0.24	557
Commercial in 5/75																					
PWR; 845 MWe																					
D.C. COOK 1 DPR 58	1976	977	164	93	67	35	17	18	1								1,372	395	116	0.29	805
Commercial in 8/75	1977	1,190	386	130	82	56	59	82	7								1,992	802	300	0.37	546
PWR; 1054 MWe																					
COOPER STATION	1975	407	404	73	40	23	12	23	4								986	579	117	0.20	456
DPR 46	1976	757	352	100	76	61	55	101	16	1	0	1					1,520	763	350	0.46	432
Commercial in 7/74	1977	783	117	39	35	34	18	52	13	7							1,098	315	198	0.63	538
BWR; 778 MWe																					
DRESDEN 1, 2, 3	1973	2,919	575	209	154	60	48	129	77	63	16	7	3				4,260	1,341	939	0.70	1,112
DPR 2, 19, 25	1974	1,793	505	237	178	101	75	182	124	94	65	23	6	4			3,387	1,594	1,662	1.04	838
Commercial in 7/60,	1975	1,687	403	210	156	125	153	629	306	166	109	29	24				3,997	2,310	3,423	1.48	709
6/72, 11/71	1976	1,370	461	293	231	137	81	213	181	94	45	7	2	1			3,116	1,746	1,690	0.96	1,024
BWR; 200, 794, 794 MWe	1977	1,059	493	296	210	165	110	277	188	102	19	2					2,921	1,862	1,694	0.91	1,132

APPENDIX A (Continued)

PLANT NAME AND LICENSE NUMBER	YEAR	Number of Individuals with Whole Body Exposures in the Following Ranges (Rems)															Total Number Monitored	Number with Measurable Exposure	Total Man-Rems Per Site Per Year	Average Individual Exposure Rems (Measurable Exposures Only)	Megawatt Years Generated (MW-Yr)
		No Measurable Exposure	Measurable <0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.0	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.0	6.0-7.0	7.0-8.0	8.0-9.0	9.0-10.0					
DUANE ARNOLD DPR-49	1976	725	148	77	55	35	17	18									1,075	350	105	0.30	304
Commercial in 2/75	1977	636	180	78	73	63	39	87	18								1,174	538	299	0.56	354
BWR; 538 MWe																					
FITZPATRICK DPR-59	1976	705	262	152	84	32	18	42	5	3	2						1,305	600	202	0.34	488
Commercial in 7/75	1977	650	260	232	241	146	114	257	104	18	7	1					2,030	1,380	1,080	0.78	461
BWR; 821 MWe																					
FORT CALHOUN DPR-40	1974	232	184	68	39	15	10	10	1								559	327	71	0.22	294
Commercial in 9/73	1975	153	192	63	54	26	20	73	34	7							622	469	294	0.63	252
PWR; 457 MWe	1976	130	261	40	47	44	21	59	20	17	7						646	516	313	0.61	265
	1977	58	248	44	58	45	36	75	20	7	2						593	535	297	0.56	334
GINNA DPR-18	1973	62	122	49	32	22	23	35	22	8	5	1					381	319	224	0.70	410
Commercial in 7/70	1974	98	123	85	73	57	56	262	186	48	9	4	1				982	884	1,225	1.39	254
PWR; 490 MWe	1975	151	127	93	93	68	74	206	20	4							836	685	538	0.78	365
	1976	111	139	113	92	72	56	240	41	4	1						869	758	636	0.84	248
	1977	147	112	70	79	52	48	145	22	2							677	530	401	0.76	346
HADDAM NECK DPR-61	1973	361	445	118	61	31	32	146	74	24	15	4	1				1,312	951	697	0.73	293
Commercial in 1/68	1974	215	303	85	61	28	21	30	14	5	2	1					765	550	201	0.37	521
PWR; 575 MWe	1975	370	181	91	90	87	54	193	93	6							1,165	795	703	0.88	494
	1976	356	280	58	47	35	34	122	65	3							1,000	644	449	0.70	482
	1977	230	279	124	98	93	72	149	64	7	5	2	1				1,124	894	642	0.72	458
E.I. HATCH DPR-57	1976	482	386	114	62	33	10	22	2	0	1						1,112	630	134	0.21	495
Commercial in 12/75	1977	320	515	327	180	100	61	103	15	2							1,623	1,303	465	0.36	447
BWR; 786 MWe																					
*HUMBOLDT BAY DPR-7	1973	25	66	26	11	4	4	38	29	25	7						235	210	266	1.26	50
Commercial in 8/63	1974	41	110	37	20	13	11	35	35	17	18						337	296	318	1.07	43
BWR; 63 MWe	1975	38	100	28	10	15	9	25	29	22	27						303	265	339	1.28	45
	1976	78	139	44	48	38	30	66	89	32	37						601	523	683	1.31	-3
	1977	85	157	72	72	56	43	212	204	155	92						1,148	1,063	1,905	1.79	0
**INDIAN POINT 1,	1973	443	429	222	168	111	110	804	772	132	108	69	44	23	6		3,441	2,998	5,262	1.75	0
2, 3 DPR-5,	1974	617	336	125	90	75	56	162	124	41	9	1					1,636	1,019	911	0.89	556
26, 64	1975	744	330	141	88	57	53	110	49	29	27	7					1,635	891	705	0.79	584
Commercial in 10/62,	1976	656	368	217	177	112	111	272	135	68	63	49	14	3	0	(10-11) 1	2,246	1,590	1,950	1.23	273
8/73, 8/76	1977	607	333	255	235	143	92	173	88	54	16	2					1,998	1,391	1,071	0.77	1,225
PWR; 265, 873, 873 MWe																					
KEWAUNEE DPR-43	1975	143	56	18	16	6	2	5	1								247	104	28	0.27	402
Commercial in 6/74	1976	84	87	56	57	49	30	79	21	2							465	381	270	0.71	405
PWR; 535 MWe	1977	80	112	58	49	25	21	46	1								392	312	140	0.45	405

*Humboldt Bay was shutdown all of 1977 for seismic modifications.

**Indian Point 1 was defueled in 1975.

APPENDIX A (Continued)

PLANT NAME AND LICENSE NUMBER	YEAR	Number of Individuals with Whole Body Exposures in the Following Ranges (Rems)															Total Number Monitored	Number with Measurable Exposure	Total Man-Rems Per Site Per Year	Average Individual Exposure Rems (Measurable Exposures Only)	Megawatt Years Generated (MW-Yr)
		No Measurable Exposure	Measurable < 0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.0	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.0	6.0-7.0	7.0-8.0	8.0-9.0	9.0-10.0					
LACROSSE DPR-45	1973	71	51	13	13	4	3	17	25	21	10						228	157	221	1.40	24
Commercial in 9/69	1974	38	34	15	7	7	4	13	19	15	1						153	115	139	1.21	38
BWR; 50 MWe	1975	60	40	20	17	4	5	25	23	19	12						225	165	234	1.42	32
	1976	92	34	13	12	7	4	30	14	4							210	118	110	0.93	21
	1977	64	38	21	5	5	3	16	21	15	11	6					205	141	225	1.59	11
MAINE YANKEE DPR-36	1973	6,319	615	70	42	19	14	21	1								7,101	782	117	0.14	409
Commercial in 12/72	1974	4,374	362	32	35	28	22	63	44	17	10	3	2	1			4,993	619	420	0.68	433
PWR; 790 MWe	1975	233	168	44	32	38	30	84	39	5							673	440	319	0.73	543
	1976	265	115	44	25	22	14	24									509	244	85	0.35	710
	1977	532	254	47	37	47	31	76	16								1,040	508	245	0.48	587
*MILLSTONE POINT 1	1973	1,112	552	150	97	72	63	186	43	12	6	2	1				2,296	1,184	663	0.56	225
DPR-21	1974	1,000	887	664	245	105	94	268	154	35	18	6	1				3,477	2,477	1,430	0.58	430
Commercial in 3/71	*975	908	686	629	354	212	99	317	130	70	48	22	10	7	3		3,495	2,587	2,022	0.78	465
BWR; 660 MWe	1976	454	486	149	105	90	61	304	126	36	18	3					1,841	1,377	1,194	0.87	449
	1977	290	537	236	119	48	31	66	18	11	8	1					1,365	1,075	394	0.37	576
*MILLSTONE POINT 2	1976	315	382	87	69	27	17	24	10	3	1						935	620	168	0.27	517
DPR-65	1977	180	333	147	74	30	19	41	11	7	5						847	667	242	0.36	496
Commercial in 12/75																					
PWR; 830 MWe																					
MONTICELLO DPR-22	1973	903	162	69	74	29	20	31	11	4	1						1,304	401	176	0.43	340
Commercial in 6/71	1974	467	362	130	137	78	51	55	22	6	1						1,309	842	349	0.41	349
BWR; 545 MWe	1975	434	246	140	228	124	92	369	79	37	25	7	4	2			1,787	1,353	1,353	1.00	345
	1976	407	97	47	56	27	26	40	13	6	4	4	2	3			732	325	263	0.81	475
	1977	637	186	96	84	59	49	165	174	35	8	4					1,497	860	1,000	1.16	426
NINE MILE POINT	1973	516	191	56	40	38	37	97	39	15	23	13	1				1,066	550	567	1.03	411
DPR-63	1974	463	224	95	83	39	24	111	93	24	26	17	4				1,203	740	824	1.11	386
Commercial in 12/69	1975	641	193	99	59	27	33	119	50	37	23	9					1,290	649	681	1.05	359
BWR; 610 MWe	1976	544	132	51	38	25	18	38	40	21	23	6					936	392	428	1.09	483
	1977	915	218	98	68	54	76	347	163	29	20	20					2,008	1,093	1,383	1.27	347
OCONEE 1, 2, 3	1974	409	256	134	123	68	78	149	35	1							1,253	844	517	0.61	651
DPR-38, 47, 55	1975	255	275	163	117	61	47	102	47	15	2						1,084	829	497	0.60	1,839
Commercial in 7/73,	1976	266	288	181	156	120	92	225	108	44	1						1,481	1,215	1,026	0.84	1,557
9/74, 12/74	1977	282	466	205	169	143	125	262	174	50	1						1,877	1,595	1,329	0.83	1,485
PWR; all 887 MWe																					
OYSTER CREEK DPR-16	1973	129	141	104	72	38	41	183	86	49	11	12	14	14	10	7	911	782	1,236	1.58	425
Commercial in 12/69	1974	109	207	140	110	83	41	203	77	30	27	14	3				1,044	935	984	1.05	434
BWR; 650 MWe	1975	264	439	157	119	69	59	202	56	43	26	25	10	4	1		1,474	1,210	1,140	0.94	374
	1976	133	398	279	284	176	92	234	72	34	9	4					1,715	1,582	1,078	0.68	455
	1977	180	297	215	232	159	125	458	120	38	16	11	2				1,853	1,673	1,614	0.96	586
PALISADES DPR-20	1973	70	162	105	73	71	72	348	90	26	21	6	1				1,045	975	1,133	1.16	287
Commercial in 12/71	1974	330	249	77	97	53	58	148	68	19	5						1,104	774	627	0.81	9
PWR; 805 MWe	1975	149	204	70	51	36	29	57	38	9	1						644	495	306	0.62	302
	1976	144	227	67	94	40	47	138	99	18	12						886	742	696	0.93	346
	1977	328	149	62	52	36	15	18									660	332	100	0.30	580

*Millstone Point 1 & 2 reported together. However, since they are different types of reactors, the data was proportionately separated.

APPENDIX A (Continued)

PLANT NAME AND LICENSE NUMBER	YEAR	Number of Individuals with Whole Body Exposures in the Following Ranges (Rems)															Total Number Monitored	Number with Measurable Exposure	Total Man Rems Per Site Per Year	Average Individual Exposure Rems (Measurable Exposures Only)	Megawatt Years Generated (MW-Yr)
		No Measurable Exposure	Measurable - 0.10	0.10 0.25	0.25 0.50	0.50 0.75	0.75 1.0	1.0 2.0	2.0 3.0	3.0 4.0	4.0 5.0	5.0 6.0	6.0 7.0	7.0 8.0	8.0 9.0	9.0 10.0					
PEACH BOTTOM 2 & 3	1975	1,527	511	209	148	41	19	39	4								2,498	971	228	0.23	1,234
DPR 44, 56	1976	1,349	855	356	341	215	173	173	19	4							3,485	2,136	840	0.39	1,376
Commercial in 7/74,	1977	1,072	897	403	359	245	171	498	185	47	13	7	2				3,899	2,827	2,037	0.72	1,052
12/74																					
BWR: Both 1065 MWe																					
PILGRIM DPR 35	1973	292	88	42	24	23	13	28	6	4	2						522	230	126	0.54	484
Commercial in 12/72	1974	363	105	70	65	46	28	83	31	12	6	3	5				817	454	415	0.91	234
BWR: 655 MWe	1975	324	102	57	29	30	17	83	65	42	13	12	4	10	8	(10-11) 1	797	473	798	1.69	308
	1976	56	105	104	90	60	140	281	200	149	105	40	29	12	2		1,373	1,317	2,648	2.01	287
	1977	250	329	246	198	114	112	276	227	111	159	39	31	24	13	5	2,125	1,875	3,142	1.68	317
POINT BEACH 1 & 2	1973	237	110	47	42	44	23	81	150	4							738	501	588	1.17	694
DPR 24, 27	1974	353	138	39	36	34	33	90	23	6	1						753	400	295	0.74	760
Commercial in 12/70,	1975	274	65	32	32	27	17	79	46	19	16	5	1				613	339	459	1.35	801
10/72	1976	228	55	38	28	34	20	70	44	15	6	3					541	313	370	1.18	855
PWR: Both 497 MWe	1977	408	71	56	47	43	26	110	47	11	5	1					825	417	430	1.03	834
PRAIRIE ISLAND 1 & 2	1974	328	112	18	14	4	2										478	150	18	0.12	182
DPR 42, 60	1975	234	316	57	33	17	14	38	2								711	477	123	0.26	837
Commercial in 12/73,	1976	550	306	128	116	67	60	103	20	14	4						1,368	818	447	0.55	723
12/74	1977	231	297	140	98	62	37	63	15	6							949	718	300	0.42	867
PWR: Both 530 MWe																					
QUAD CITIES 1 & 2	1974	1,296	245	95	112	47	27	69	47	27	7	2					1,974	678	482	0.71	945
DPR 29, 30	1975	1,225	113	64	108	74	92	337	183	56	33	23					2,308	1,083	1,618	1.49	833
Commercial in 2/73,	1976	1,132	235	125	120	80	54	309	169	44	55	33	1				2,357	1,225	1,651	1.35	949
3/73	1977	984	251	113	100	66	47	124	76	87	40	1	2				1,891	907	1,031	1.14	970
BWR: Both 789 MWe																					
RANCHO SECO DPR 54	1976	151	179	62	26	15	6	9									448	297	58	0.19	267
Commercial in 4/75	1977	285	100	93	80	59	45	95	32	9	2						800	515	391	0.76	671
PWR: 918 MWe																					
H.B. ROBINSON 2	1973	1,092	348	86	64	41	37	121	94	19	18	3					1,923	831	695	0.83	455
DPR 23	1974	586	354	82	57	49	46	151	89	18	5	1	0	1			1,439	853	672	0.79	577
Commercial in 3/71	1975	599	230	50	55	52	67	138	172	33	30	21	1				1,448	849	1,142	1.34	502
PWR: 700 MWe	1976	600	151	39	42	37	47	109	152	13	7						1,197	597	715	1.20	584
	1977	696	264	87	50	46	35	86	28	23	14	1					1,330	634	465	0.72	493
SAN ONOFRE DPR 13	1973	108	218	80	69	45	34	81	30	11	1	1					678	570	353	0.62	274
Commercial in 1/68	1974	167	89	50	50	14	4	7	2	2	1						386	219	71	0.32	378
PWR: 436 MWe	1975	393	124	63	72	43	27	51	34	9	1						817	424	292	0.69	389
	1976	1,246	432	182	172	96	103	260	78	5	2						2,576	1,330	880	0.66	297
	1977	858	259	107	133	72	76	226	82	25	5						1,843	985	847	0.86	266
ST. LUCIE DPR 67	1977	851	197	116	50	25	16	31	8	2							1,296	445	152	0.34	610
Commercial in 12/76																					
PWR: 777 MWe																					

APPENDIX A (Continued)

PLANT NAME AND LICENSE NUMBER	YEAR	Number of Individuals with Whole Body Exposures in the Following Ranges (Rems)															Total Number Monitored	Number with Measurable Exposure	Total Man-Rems Per Site Per Year	Average Individual Exposure Rems (Measurable Exposures Only)	Megawatt-Years Generated (MW-Yr)
		No Measurable Exposure	Measurable <0.10	0.10-0.25	0.25-0.50	0.50-0.75	0.75-1.0	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.0	6.0-7.0	7.0-8.0	8.0-9.0	9.0-10.0					
SURRY 1 & 2 DPR 32, 37	1973	419	748	55	57	19	28	25	4								1,355	936	152	0.16	714
Commercial in 12/72, 5/73	1974	1,004	870	218	171	95	67	176	81	22	8	5	2				2,719	1,715	884	0.52	718
PWR; Both 822 MWe	1975	580	813	145	158	108	98	314	247	80	18	7	6	1			2,528	1,948	1,649	0.85	1,079
	1976	581	802	264	251	158	126	574	382	77	51	31	21	7	8	5	3,334	2,753	3,165	1.15	928
	1977	97	517	222	149	102	111	338	194	48	28	19	8	8	1		1,957	1,860	2,307	1.24	1,082
THREE MILE ISLAND 1	1975	-	-	-	78	31	15	6	1								131+	131+	73+		676
DPR 50	1976	901	290	221	107	55	107	33	6								1,720	819	286	0.35	529
Commercial in 9/74	1977	118	504	249	148	66	66	86	3								1,240	1,122	360	0.32	624
PWR; 819 MWe																					
TROJAN NPF 1	1977	369	231	129	124	61	23	2	1								960	591	174	0.29	741
Commercial in 5/76																					
PWR; 1130 MWe																					
TURKEY POINT 3 & 4	1973	949	283	80	42	25	6	7	1								1,393	444	78	0.17	402
DPR 31, 41	1974	876	225	182	138	62	46	85	44	11	1						1,670	794	454	0.57	953
Commercial in 12/72,	1975	849	361	173	117	130	71	211	82	22	8	1					2,025	1,176	876	0.74	1,004
9/73	1976	1,013	457	317	232	156	92	230	96	48	17	2					2,660	1,647	1,184	0.72	972
PWR; Both 693 MWe	1977	1,014	407	214	175	95	78	186	99	39	21	5					2,333	1,319	1,036	0.79	928
VERMONT YANKEE	1973	516	112	58	28	8	11	23	4								760	244	85	0.34	222
DPR 28	1974	576	137	60	36	24	17	56	23	4							933	357	216	0.61	304
Commercial in 11/72	1975	773	60	87	42	24	27	27	13	2							1,055	282	153	0.54	429
BWR; 514 MWe	1976	988	313	129	120	56	65	101	24	7							1,803	815	411	0.50	389
	1977	535	292	80	86	64	50	59	10								1,176	641	258	0.40	423
YANKEE ROWE DPR 3	1973	2,500	24	21	25	10	18	26	8	1							2,633	133	99	0.74	127
Commercial in 7/61	1974	3,060	59	39	25	19	23	48	23	7							3,303	243	205	0.84	111
PWR; 175 MWe	1975	1,572	95	19	42	21	48	23	1								1,821	249	116	0.47	145
	1976	986	50	23	41	16	9	13									1,138	152	59	0.39	142
	1977	1,018	407	54	48	52	34	85	40	4	1						1,743	725	356	0.49	117
ZION 1 & 2 DPR 29, 48	1974	1,657	168	80	34	15	6	2	0	1							1,963	306	56	0.18	424
Commercial in 12/73,	1975	1,260	147	118	98	35	26	12									1,696	436	127	0.29	1,181
9/74	1976	1,073	192	129	98	72	68	155	52	5	2	0	0	0	1		1,847	774	571	0.74	1,132
PWR; Both 1040 MWe	1977	646	158	75	91	60	62	153	95	51	20	6	9	4			1,430	784	1,004	1.28	1,291
*CRYSTAL RIVER 3 DPR 72	1977	646	166	35	5												852	206	16	0.08	
Commercial in 3/77																					
PWR; 797 MWe																					
*DAVIS BESSE 1 NPF 3	1977	336	22	2	2												362	26	2	0.08	
Commercial in 11/77																					
PWR; 906 MWe																					
*FARLEY 1 NPF 2	1977	672	328	11	11	2	0	4									1,028	356	30	0.08	
Commercial in 12/77																					
PWR; 829 MWe																					
*FORT ST. VRAIN DPR 34	1977																				
Not Commercial																					
HTGR; 330 MWe																					
*SALEM 1 DPR 70	1977	203	982	167	111	40	14	8	1								1,526	1,323	172	0.13	
Commercial in 6/77																					
PWR; 1091 MWe																					

*Plants that had not been in commercial operation for one full year as of 12/31/77, but from whom an annual report was received.
+Did not report those not required to be monitored.

APPENDIX B

OVEREXPOSURE SUMMARIES

1977

Industrial Radiography - License Number 20-00302-02

On June 16, 1977, a radiographer and his assistant were conducting radiography operations utilizing 36 curies of cobalt-60 and 95 curies of iridium-192. After completion of the cobalt exposures, the source was properly retracted into the projector, but the source plug was not replaced and the guide tube was left attached. The iridium projector was then set up and, after the exposure time elapsed, the assistant radiographer mistakenly cranked out the cobalt source instead of cranking in the iridium source. Upon entering the vault, he claimed his survey meter did not indicate any radiation levels. Believing the area to be safe, he proceeded to remove the exposed film. The radiographer then entered the vault to set up the next shot, and he claimed his survey meter was reading zero. It was only after completion of this set up and leaving the vault to crank out the iridium source, that the mistake was discovered. The radiographers immediately cranked in both sources and called their supervisor who sent their badges for emergency processing. From film badges worn by the two individuals and re-enactments of the incident, it is estimated that the radiographer received a dose of 4 rems to the trunk of the body, up to 11 rems to the gonads, up to 18 rems to

the eyes, and from 100 to 400 rems to two small areas on the left side of the head where he bumped it on the iridium guide tube. It is estimated that the assistant radiographer received a whole body exposure of 4 rems. Corrective actions included a refresher course for all radiographic personnel in the operation of survey meters and proper methods of conducting radiographic surveys. See also NUREG-0090-08, "Report to Congress on Abnormal Occurrences, April - June 1977."

Industrial Radiography - License Number 06-01781-08

On September 7, 1977, while conducting industrial radiography on a submarine under construction in the Shipyard, a reel operator (a qualified radiographer) was exposed to radiation from 80 curies of iridium-192 for approximately 2-1/2 minutes. After completion of the radiograph, the reel operator cranked in the source and proceeded to set up for the next exposure while the head radiographer was gone. Evidently the operator failed to fully retract and lock the source. He also failed to follow proper procedures by not waiting for the responsible radiographer to return, and by neglecting to determine the radiation levels in his work area. The dose estimate for the reel operator was determined to be 5.2 rems to the whole body and 18 rems to the right foot. All radiographers have been re-instructed in the importance of compliance with written procedures, especially in the use of survey meters. The present training programs are being reviewed to determine if more stringent standards are necessary to prevent a recurrence of this type of

incident. The reel operator was disciplined for failure to comply with operating instructions.

Industrial Radiography - License Number 37-02607-02

On November 12, 1977, a radiographer was conducting radiography operations using a 75 curie iridium-192 source. After making several exposures, the radiographer attempted to return the source to its shielded position when he noticed that his survey meter was still reading 125 millirems per hour. This reading was the same as when the meter was sitting on top of the storage container. Realizing the source was still in the collimator, he proceeded to adjust the collimator with his hand in order to retract the source back into the container. He then called his supervisor to report the incident. After several re-enactments of the incident, using dosimeters in critical areas, it was determined that the radiographer received a whole body dose of approximately 1 rem and from 300 to 600 rems to the first two fingers of the left hand. The radiographer's hand was calculated to have been in close proximity to the source for approximately 3 to 5 seconds. As a result of this incident, the licensee has initiated a new formal management audit system to augment their present program of internal audits. The licensee also plans to retrain each radiographer and to confirm his level of comprehension with written tests and observation of on-the-job activities. See also NUREG-0090-10, "Report to Congress on Abnormal Occurrences, October - December 1977."

Irradiator Facility - License Number 29-13613-02

On September 23, 1977, a worker entered an irradiator facility while an array of sealed sources containing 500,000 curies of cobalt-60 was exposed. The normally electrically interlocked access door was disconnected, and the worker had not been told that the source array was in the exposed position. The individual stood about 10 feet from the source for a period of 10 seconds, which resulted in a dose to the whole body of approximately 220 rems. He was hospitalized for medical observation and treatment. The incident was directly caused by the decision of management to allow the source to be raised with the interlock and safety devices inoperative. Operation of the in-air irradiator when interlocks are inoperative is not only a violation of internal operating procedures, but also a violation of license requirements. Contributing factors included failure to conduct surveys and failure to follow procedures to control access to high radiation areas. See also NUREG-0090-10, "Report to Congress on Abnormal Occurrences, October - December 1977."

APPENDIX C

CAREER DOSES FOR RADIATION WORKERS TERMINATING DURING THE YEARS 1969-1977

NUCLEAR POWER REACTORS

Total Length of Employment	Number of Monitored Individuals	Number of Individuals with Measurable Doses	Total Number of Man-rems	Average Dose (rems) for the Period of Employment
0-90 Days	43,668	26,047	16,653	0.64
90 Days - 1 yr.	18,663	13,363	14,209	1.06
1-2 yrs.	4,217	3,270	5,388	1.65
2-3 yrs.	1,510	1,197	2,862	2.39
3-4 yrs.	692	600	1,678	2.80
4-5 yrs.	269	221	900	4.07
5-10 yrs.	431	386	1,898	4.92
10-15 yrs.	131	113	669	5.92
15-20 yrs.	36	33	265	8.03
> 20 yrs.	54	45	237	6.41

INDUSTRIAL RADIOGRAPHERS

0-90 Days	2,408	1,680	743	0.44
90 Days - 1 yr.	3,597	2,760	2,310	0.84
1-2 yrs.	2,546	1,935	2,802	1.45
2-3 yrs.	1,660	1,309	2,424	1.85
3-4 yrs.	1,158	927	2,039	2.20
4-5 yrs.	910	760	2,133	2.81
5-10 yrs.	2,968	2,587	9,285	3.59
10-15 yrs.	2,105	1,891	8,831	4.67
15-20 yrs.	787	720	3,442	4.78
> 20 yrs.	3,281	2,662	7,992	3.00

FUEL FABRICATORS AND PROCESSORS

0-90 Days	2,111	1,307	554	0.42
90 Days - 1 yr.	1,614	1,313	690	0.53
1-2 yrs.	1,020	944	974	1.03
2-3 yrs.	566	536	787	1.47
3-4 yrs.	408	390	535	1.37
4-5 yrs.	235	225	341	1.52
5-10 yrs.	710	677	1,891	2.79
10-15 yrs.	314	296	1,231	4.16
15-20 yrs.	135	126	496	3.94
> 20 yrs.	72	69	411	5.96

MANUFACTURERS AND DISTRIBUTORS

0-90 Days	103	77	21	0.27
90 Days - 1 yr.	161	132	86	0.65
1-2 yrs.	113	97	107	1.10
2-3 yrs.	70	59	74	1.25
3-4 yrs.	28	17	37	2.18
4-5 yrs.	13	12	42	3.50
5-10 yrs.	55	55	230	4.18
10-15 yrs.	19	19	73	3.84
15-20 yrs.	8	8	38	4.75
> 20 yrs.	0	0	0	0

NRC FORM 335 (7.77)

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

1. REPORT NUMBER (Assigned by DDC)
NUREG-0463

4. TITLE AND SUBTITLE (Add Volume No., if appropriate)
TENTH ANNUAL OCCUPATIONAL RADIATION EXPOSURE REPORT, 1977

2. (Leave blank)

3. RECIPIENT'S ACCESSION NO.

7. AUTHOR(S)
Barbara G. Brooks

5. DATE REPORT COMPLETED
MONTH: September YEAR: 1978

9. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
U.S. Nuclear Regulatory Commission
Office of Management and Program Analysis
Washington, D.C. 20555

DATE REPORT ISSUED
MONTH: October YEAR: 1978

6. (Leave blank)

8. (Leave blank)

12. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
U.S. Nuclear Regulatory Commission
Office of Management and Program Analysis
Washington, D.C. 20555

10. PROJECT/TASK/WORK UNIT NO.

11. CONTRACT NO.

13. TYPE OF REPORT
Annual

PERIOD COVERED (Inclusive dates)
Calendar Year 1977

15. SUPPLEMENTARY NOTES

14. (Leave blank)

16. ABSTRACT (200 words or less)

This is a report which summarizes the information reported by certain NRC licensees to the Commission's centralized repository of personnel occupational radiation exposure information. The bulk of the information in the report is derived from annual and termination reports submitted by commercial nuclear power reactors, industrial radiographers, fuel fabricators and processors and commercial distributors of byproduct materials in accordance with the requirements of 10 CFR 20.407 and 20.408.

17. KEY WORDS AND DOCUMENT ANALYSIS

17a. DESCRIPTORS

Not Applicable.

17b. IDENTIFIERS/OPEN-ENDED TERMS

18. AVAILABILITY STATEMENT
Unlimited.

19. SECURITY CLASS (This report)
Not Applicable.

21. NO. OF PAGES

20. SECURITY CLASS (This page)
Not Applicable.

22. PRICE
$