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ABSTRACT

Data on employee exposures, bioassay results, effluent releases, in-plant airborne radioactivities, and environmental monitoring for Rocketdyne operations during 1987 are reviewed. This review is prepared, as required by Special Nuclear Materials License No. SNM-21, to determine (1) if there are any upward trends developing in personnel exposures for identifiable categories of workers or types of operations or effluent releases, (2) if exposures and effluents might be lowered under the concept of as low as reasonably achievable, and (3) if equipment for effluent and exposure control is being properly used, maintained, and inspected.

Personnel exposures have been further reduced.

Effluent releases are at insignificant levels compared to regulatory standards, do not show any upward trends, and do not appear to be reducible by reasonable means.

To the extent covered by this review, equipment for effluent and exposure control was properly used, maintained, and inspected.

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INTRODUCTION

The Rocketdyne special nuclear materials license[1] requires that an annual report be made to the Radiation Safety Committee of the Nuclear Safeguards Review Panel reviewing personnel exposure and effluent release data. The format and content of this report have been well established in prior issues.[2-13] While this report is prepared primarily to satisfy a requirement of the NRC license, all operations with radioactive material and radiation-producing devices have been included.

These reports for the years 1975 through 1986[2-13] provide a historical basis for the identification of trends. It should be noted that, in some instances, both NRC-licensed and non-NRC-licensed activities take place in the same building. In these cases, certain measurements (e.g., ventilation air exhaust radioactivity) have not been made separately for each type of activity.

Additionally, it is not possible to separate the integrated personnel radiological doses to that attributable to either nonlicensed activities for the DOE or the activities licensed by NRC or the State of California.

The following Rocketdyne facilities and operations are specifically covered in this report:

1) Rockwell International Hot Laboratory (RIHL) - Building 020, Santa Susana Field Laboratories

2) Nuclear Material Development Facility (NMDF) - Building 055, Santa Susana Field Laboratories

3) Radioactive Material Disposal Facility (RMDF) - Buildings 021, 022, and related facilities at Santa Susana Field Laboratories (DOE jurisdiction)

4) Applied Nuclear Research (ANR) - The Gamma Irradiation Facility and Laboratories in Building 104 at De Soto.

Work at various facilities during 1987 is briefly described below:

- RIHL--The Fermi fuel disassembly project was completed in May. Waste cans were welded, and cell cleanup was begun. Some preliminary D&D work was started. The SEFOR glove box was disassembled, size-reduced, and packaged for disposal. An improved breathing air supply system was installed.

- RMDF--Declad EBR-II fuel was shipped to SRP. Fermi fuel was transferred to/from RIHL. Fermi waste was shipped for disposal. Radioactive water was evaporated and slude-packaged for disposal. The neutron modulator, ethylene glycol, was drained from some NLI casks, and the casks were installed in ISO shipping containers. The ethylene glycol was decontaminated of small amounts of radioactivity to permit disposal of this material as a hazardous waste. Some ethylene glycol was reserved for recharging two casks.

- NMDF--A confirmatory survey was performed by ORAU for NRC in February, and the license was terminated in October.

- GIF--Research continued on food irradiation, with work being done on pork shelf-life improvements for Iowa State University. Radiation hardness testing of infrared sensors was performed for the Science Center.

- Applied Nuclear Research--The mass-spectrometer lab performed measurements on fusion materials, on tritium "tricked" samples for tritium storage, irradiated reactor pressure vessel materials. Some research work was also done on fusion neutron dosimetry.

- Industrial Radiography--Continued production radiography for rocket engine fabrication. A special bare film inspection of a cracked SSME flow channel was performed that allowed repair and acceptance of the engine. Two X-ray tubes were dropped due to failure of the support systems. One radiographer was recorded as having an exposure in excess of the regulatory limits since adequate information did not exist to refute the film badge report. A lead glass viewing window was installed in Cell 6 at C001.

- Miscellaneous--ISI operations were performed at Atucha, River Bend, Chin Shan, and Fort Calhoun nuclear power plants. Consultant services were also provided to TMI-1 regarding ISI by one of our competitors. Generally, routine work was performed in other operations.

I. PERSONNEL DOSIMETRY

Personnel dosimetry techniques generally consist of two types: those which measure radiation incident on the body from external sources (film badges) and those which measure internal deposition of radioactivity via inhalation, ingestion, skin absorption, or through wounds (bioassays). These measurement methods provide a natural separation of the exposure modes to (1) permit an evaluation of the more significant exposure routes and (2) to allow a differentiation between those exposure sources which are external and controllable in the future and those which may continue to irradiate the body for some time period (i.e., internal deposits).

A. FILM/TLD DATA

1. Whole Body Monitoring

Personnel external radiation exposures for the pertinent activities for the year are shown in Figure 1 as a cumulative log-normal distribution. It should be noted (see Summary, Section VI) that, with one notable exception, all whole-body exposures were less than 2 rem and were well below the allowable annual occupational total of 12 rem for NRC and State-licensed operations and 5 rem for DOE operations. The highest exposure shown, 7.36 rem, resulted from an X-ray industrial radiographer, whose film badge showed this during the first calendar of the year. While the exposure seemed unlikely, there was no data available to refute the film badge, and so the exposure had to be accepted. Otherwise, the data show good implementation of the goal of 1 rem per year maximum.

For comparison, the distributions of exposures reported for NRC licensees[13] and DOE contractors[14] for 1983 are shown as solid curves.

The Rocketdyne dose distribution is well below the NRC distribution and generally below the DOE distribution. A more significant comparison can be made in terms of the group dose. The group dose received by Rocketdyne

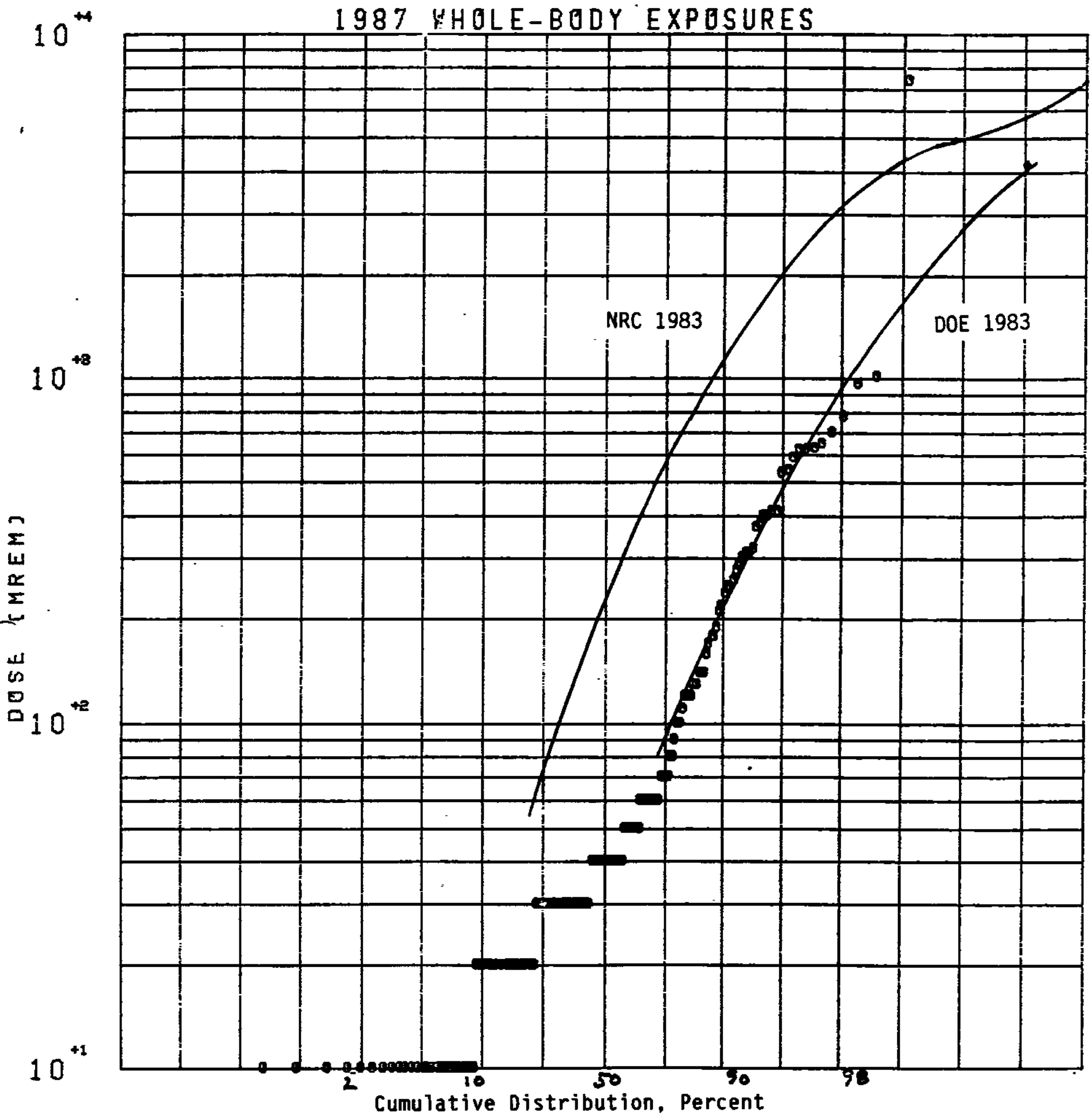

Figure 1. Cumulative Log-Normal Distribution for Whole-Body Radiation Exposures of Occupationally Exposed Individuals in 1987

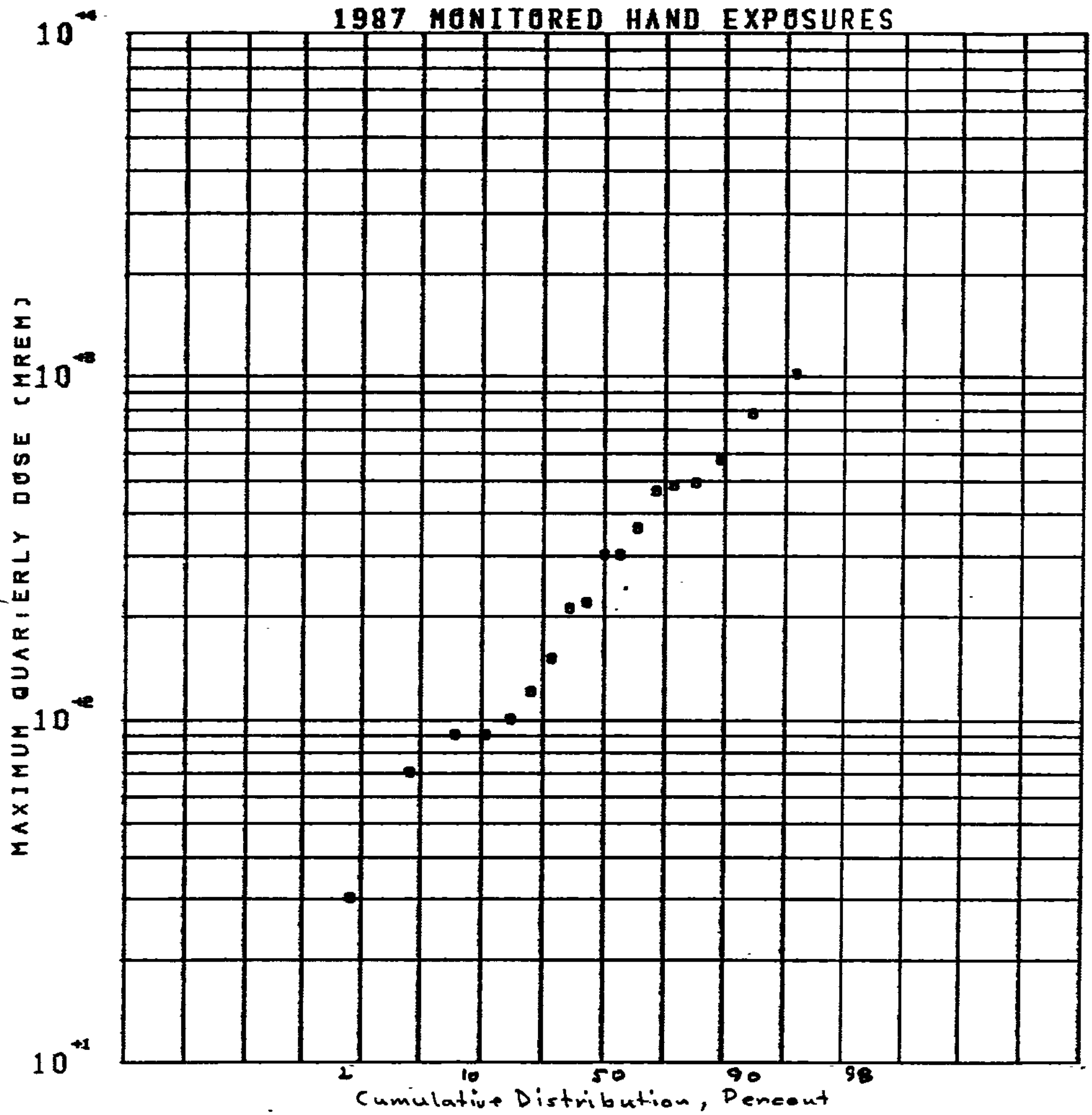

Figure 2. Cumulative Log-Normal Distribution for Quarterly Hand Exposures in 1987

employees in 1987 amounted to 27.4 person-rem. Of this total, 7.4 person-rem resulted from the industrial radiographer exposure. Off-site ISI operations accounted for 5.6 person-rem. Thus, routine operations resulted in approximately 14.4 person-rem. This is the lowest group exposure yet experienced. If the distribution of doses had been that shown for NRC licensees in 1983, the group dose would have been 107.6 person-rem. If the doses had been those shown for DOE for 1983, the group dose would have been 34.0 person-rem, for DOE exposures in 1985, the group dose would have been 32.6. Comparisons such as these should be viewed with caution because of differences in the type of work between the Rocketdyne workforce and both the NRC licensees and the DOE contractors, but generally show a much better level of control in our operations. Adjusted for the suspect industrial radiographer exposure, and without further qualification, the comparisons show that our external exposures are controlled by a factor of 5 better than the average NRC licensee and a factor of 1.7 better than the average DOE operation.

2. Extremity Monitoring

Operations with radioactive material that may involve locally high exposures are conducted with additional "extremity" monitoring, usually for the hands. "Whole-body" doses received when explicit extremity monitoring is not performed are assumed to represent the extremity doses and should be added to the recorded extremity doses. This is difficult to do, so for the purpose of monitoring extremity exposures, it is noted that neither extremity nor whole-body doses are high, and that even the sum of the maximum quarterly hand dose (1,010 mrem) and the maximum routine whole-body dose (1,010 mrem) is approximately 11% of the NRC and State of California limits of 18.75 rem per quarter.

B. BIOASSAYS

Bioassays normally consist of analysis of urine and occasionally fecal samples. Personnel whose work assignments potentially expose them to radioactive aerosols are routinely evaluated in this manner. Normally, urinalyses are performed quarterly and fecal analysis only when gross internal contamination is suspected. A statistical summary of the results for 1987 appears in Table 1, while a detailed listing of the positive results are shown in Table 2. Only three types of analyses showed positive results this year: FP3A, UR, and UF. The UF analysis is chemically selective for uranium. The FP3A analysis is assumed to be indicative of Sr-90, although other radionuclides, such as Co-60, may also be detected. Further analysis could specifically quantify Sr-90, and identify interfering radionuclides, if significant activities were found. The UR analysis is radiometrically selective for uranium, and is effective for enriched uranium (EU).

Followup results are shown, where available (even into 1988), to indicate the decrease of detected activity to negligible levels. Many of the positive results appear to be the result of laboratory contamination.

The excretion rates assumed to be indicative of 1 MPBB for various radionuclides and the minimum detectable activities (MDA) are:

Radionuclides	Standard Excretion Rate	MDA
Sr-90	480 dpm/day	30 dpm/day
U	100 ug/day	0.30 ug/day
EU	220 dpm/day	3.75 dpm/day

These excretion rates are based on an assumption of equilibrium between intake and elimination. Transient elimination following an acute exposure will generally indicate a much higher body burden than actually exists.

The highest result shown for Sr-90, 14.0%, was essentially gone 49 days later, and may have resulted from an anomaly at the laboratory, or may have represented some other beta-emitting radionuclide, such as Co-60, which has a relatively short biological half-life (9.5 days).

Table 1. Summary of Bioassays - 1987

Measurement Type*	Total Tests	Total Positive Results	Total Individuals With Positive Results
UF	189	7	6
UR	190	2	1
PUA	36	0	0
FP3A	227	5	4
FP3B	227	0	0
Total	869	14	11

*UF = Uranium - Fluorometric
UR = Uranium - Radiometric
PUA = Gross Plutonium-alpha
FP = Fission Products

(For a discussion of specific analytical techniques employed, as identified by "TYPE," see Appendix B in Reference 9)

Table 2. Positive Bioassay Result Summary - 1987

H&S Number	Sample Date	Analysis Type*	Results: Per Vol. Anal.	Results: Per 1500 ml-day	Assumed Specific Radionuclide	Assumed Critical Nuclide Equivalent MPBB (%)
1495	102787	UF	0.0003	0.45	U	0.45
1495	102759	UR	2.42	18.17	EU	8.25
1495	Repeat	UF	0.0003	0.45	U	0.45
1495	Repeat	UR	0.22	-	EU	0
1495	120287	UR	0.87	6.50	EU	2.95
1495	Repeat	UR	0	0.00	EU	0
1495	011288	UR	0.1198	-	EU	0
2312	070887	FP3A	8.97	67.27	Sr-90	14.0
2312	082687	FP3A	1.53	-	Sr-90	0
3078	100587	FP3A	4.04	30.32	Sr-90	6.3
3078	111387	FP3A	3.02	-	Sr-90	0
3506	100587	UF	0.0015	2.25	U	2.25
3506	111887	UF	0.0000	0.00	U	0
3914	110187	UF	0.0005	0.75	U	0.75
3914	122287	UF	0.0000	0.00	U	0
4162	040987	FP3A	6.25	46.85	Sr-90	9.8
4162	072087	FP3A	0.65	-	Sr-90	0
4162	100587	FP3A	4.04	34.81	Sr-90	7.3
4162	111687	FP3A	2.86	-	Sr-90	0
4303	072087	UF	0.0014	2.10	U	0
4303	100587	UF	0.000	0.00	U	0
4404	070687	UF	0.0019	2.85	U	2.85
4404	032488	UF	0.0002	-	U	0
4912	100787	UF	0.0010	1.50	U	1.50
4912	112087	UF	0.0001	-	U	0
4948	040687	FP3A	4.66	34.94	Sr-90	7.3
4948	051987	FP3A	0.0000	0.00	Sr-90	0

UF: Fluorimetric Uranium
FP: Fission Products
UR: Radiometric Uranium
(FP3A is presumptively Sr-90; FP3B is specifically Cs-137)

(For a brief description of the specific analytical techniques, see Appendix B of Reference 9)

II. RADIATION/RADIOACTIVITY MEASUREMENTS

The measurements and surveillance performed to determine local radiation levels in the working areas where radioactive materials are used are described below.

A. AREA RADIATION LEVELS

Film badges ("location badges") are placed throughout the facilities, and are kept in place during the entire calendar quarter. Some of these are in nominally low-exposure areas while some are in relatively high-exposure (but low-occupancy) areas. The average and maximum exposure rates determined for each quarter are shown in Table 3.

The maximum values for the RMDF are associated with the evaporator and are in an unoccupied area. The reduction during this year reflects a generally more effective control of facility exposure rates. The high-exposure rate for the fourth quarter in the Applied Nuclear Research Laboratories is associated with the sandblaster. This source should be controlled more carefully.

B. INTERIOR AIR SAMPLES - WORKING AREAS

In those working areas where the nature of the tasks being performed and the materials in use might lead to the potential for generation of respirable airborne radioactivity, periodic local air sampling is performed. A summary of these results for 1987 is given in Table 4.

Table 3. Location Badge Radiation Exposure - 1987

Facility	Q1	Q2	Q3	Q4
	Calendar Quarter			
	Average Exposure Rate (mR/h) / Maximum Exposure Rate (mR/h)			
RIHL	0.06 / 0.58	0.06 / 0.54	0.06* / 0.55	0.11** / 1.43
Fenceline	0.002 / 0.01	0.01 / 0.023	0.016 / 0.027	0.007 / 0.023
RMDF	1.11 / 3.77	1.14 / 3.63	1.60 / 5.65	1.24 / 3.83
Fenceline	0.060 / 0.20	0.036 / 0.16	0.028 / 0.11	0.059 / 0.32
GIF	0.024 / 0.096	0.032 / 0.11	0.021 / 0.073	0.016 / 0.064
ANRL	0.26 / 1.47	0.14 / 0.39	0.17 / 0.49	0.17 / 0.79

*Two badges were damaged by heat, estimated values

**Additional badges were installed in high-exposure areas.

Table 4. Interior Air Sample Summary - 1987

		Average Airborne Activity Concentration (μCi/ml)				
		Calendar Quarter				
Area	Sample	Q1	Q2	Q3	Q4	MPC
RIHL	Unposted alpha	8×10^{-15}	*	*	*	2×10^{-12}
	beta	3×10^{-14}	*	*	*	1×10^{-9}
	Posted alpha	8×10^{-15}	*	*	*	2×10^{-12}
	beta	3×10^{-14}	*	*	*	1×10^{-9}
	Maximum alpha	4×10^{-14}	1×10^{-14}	1×10^{-14}	6×10^{-14}	2×10^{-12}
	beta	1×10^{-12}	6×10^{-14}	6×10^{-13}	3×10^{-12}	1×10^{-9}
RMDF	Facility Average	0.35 MPC	0.23 MPC	0.007 MPC	0.041 MPC	
	Facility Maximum	0.61 MPC	0.46 MPC	0.011 MPC	0.079 MPC	

*Because of generally low airborne activity, averages were not calculated.

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III. EFFLUENT MONITORING

Effluents which may contain radioactive material are generated at certain Rocketdyne facilities as a result of operations performed either under contract to DOE, or under the NRC Special Nuclear Materials License SNM-21, or under the State of California Radioactive Material License 0015-70. The specific facility identified with the NRC license is Building 020 at the SSFL at Santa Susana.

An annual report of effluent releases, prepared by Radiation & Nuclear Safety in the Health, Safety, and Environment Department, describes in detail the monitoring program at Rocketdyne for gaseous effluents from the Rocketdyne facilities. The data reported in the 1987 edition of that report[16] for atmospherically discharged effluents for the facilities identified above is presented in Table 5. (No releases of radioactively contaminated liquids were made, either to the sewer or to the environment.)

Effluent releases are extremely low as a result of a combination of factors. Much of the radioactive material processed is in relatively undispersible form, many of the operations are conducted in glove boxes and sealed hot cells, and the effluent is filtered by pre-filters and HEPA filters. The HEPA-filter systems are tested annually by use of a polydisperse DOS aerosol. The test dates and filtration efficiencies for several exhaust systems, and the required efficiencies, are shown below:

		Measured	Required
RMDF (Vault 14884)	4/15/87	99.98%	99%
RMDF (Vault 14885)	4/15/87	99.95%	99%
RMDF (Decon 14886)	4/15/87	99.95%	99%
RMDF (Decon 14887)	4/15/87	99.98%	99%
RIHL	11/17/87	99.99%	99.95%
ANR (EF-405)	6/1/87	99.90%	99%
GIF	5/15/87	99.98%	99%

All filter systems satisfied their requirements.

Table 5. Atmospheric Emissions to Unrestricted Areas - 1987

Location	Approximate Emissions Volume (m^3)	Activity Monitored	Approximate Lower Limit of Detection (10^{-15} µCi/ml)	Annual Average Concentration (10^{-15} µCi/ml)	Sampling Period Maximum Observed Concentration (10^{-15} µCi/ml)	Total Radioactivity Released (Ci)	Percent of Guide[a]	Percent of Samples with Activity <LLD
104 De Soto	1.7×10^8	Alpha	0.30	1.72	11.4	2.9×10^{-7}	0.05	28
		Beta	0.31	4.03	11.3	6.7×10^{-7}	0.001	0
020 SSFL	5.4×10^8	Alpha	0.30	0.34	1.25	1.8×10^{-7}	0.57	56
		Beta	0.31	6.96	19.31	3.7×10^{-6}	0.02	0
021-022 SSFL	2.4×10^8	Alpha	0.30	0.10	9.91	2.5×10^{-7}	0.17	31
		Beta	0.31	50.91	486.70	1.2×10^{-5}	0.17	0
Total	9.5×10^8				Total	1.7×10^{-5}	-	-
Annual average ambient air radioactivity concentration[b]		Alpha		1.5	Ambient			
		Beta		28.9	equivalent[c]	2.8×10^{-5}	-	-

[a]Assuming all radioactivity detected is from Rocketdyne nuclear operations.
Guide: De Soto site: 3×10^{-12} µCi/ml alpha, 3×10^{-10} µCi/ml beta; CAC-17.
SSFL site: 6×10^{-14} µCi/ml alpha, 3×10^{-11} µCi/ml beta, 10 CFR 20 Appendix B, CAC-17, and DOE Order 5480.1 Chapter XI.
[b]Averaged result for 7-day (200 m^3) SSFL continuous air sampler.
[c]Natural radioactivity contained in equivalent volume of air discharged through exhaust systems after filtration.
Note: All release points are at the stack exit.

IV. ENVIRONMENTAL MONITORING PROGRAM

The basic policy for control of radiological and toxicological hazards at Rocketdyne requires that adequate containment of such materials be provided through engineering controls and, through rigid operational controls, that facility effluent releases and external radiation levels are reduced to a minimum. The environmental monitoring program provides a measure of the effectiveness of the Rocketdyne safety procedures and of the engineering safeguards incorporated into facility designs. Specific radionuclides in facility effluent or environmental samples are not routinely identified due to the extremely low radioactivity levels normally detected, but may be identified by analytical or radiochemistry techniques if significantly increased radioactivity levels are observed.

The annual report of environmental monitoring, prepared by Radiation & Nuclear Safety in the HS&E Department, describes in detail the Rocketdyne environmental monitoring program.

Some of the data reported in the 1987 edition of that report(16) are presented here. It is important to remember that the radiological activity levels reported can be attributed not only to operations at NRC licensed, DOE-sponsored, and State of California-licensed facilities, but also to external influences such as naturally occurring radioactive materials, the Chernobyl reactor accident, and fallout from nuclear weapon testing.

These data are:

- Soil gross radioactivity data presented in Table 6
- Soil plutonium radioactivity data presented in Table 7
- De Soto and SSFL Sites - Domestic water radioactivity data presented in Table 8
- Bell Creek and Rocketdyne site retention pond radioactivity data presented in Table 9
- Ambient air radioactivity data presented in Table 10 (and shown graphically in Figure 3)
- Ambient radiation data presented in Table 11.

Table 6. Soil Radioactivity Data - 1987

Area	Activity	Number of Samples	Gross Radioactivity (pCi/g) Annual Average Value and Dispersion	Maximum Observed Value[a] and Month Observed
On-site (quarterly)	Alpha	48	27.1 ± 7.7	40.1 (December)
	Beta	48	25.4 ± 2.1	30.7 (April)
Off-site (quarterly)	Alpha	48	25.7 ± 7.7	55.1 (April)
	Beta	48	23.9 ± 3.5	29.1 (April)
Pond R-2A mud No. 55	Alpha	4	24.1 ± 6.4	33.1 (April)
	Beta	4	23.6 ± 1.2	25.0 (April)
Bell Creek upper stream bed soil No. 62	Alpha	4	24.9 ± 7.7	34.0 (January)
	Beta	4	24.0 ± 0.8	25.2 (April)

[a]Maximum value observed for single sample.

Table 7. Soil Plutonium Radioactivity Data - 1987

Sample Location	22 June 1987 Survey Results		7 December 1987 Survey Results	
	^{238}Pu (pCi/g)	^{239}Pu + ^{240}Pu (pCi/g)	^{238}Pu (pCi/g)	^{239}Pu + ^{240}Pu (pCi/g)
S-56	0 ± 0.0001	0.0006 ± 0.0002	0.0006 ± 0.0002	0.0018 ± 0.0003
S-57	0.0001 ± 0.0001	0.0012 ± 0.0003	0.0006 ± 0.0002	0.0031 ± 0.0004
S-58	0.0002 ± 0.0001	0.0022 ± 0.0003	0.0032 ± 0.0007	0.0071 ± 0.0010
S-59	0.0001 ± 0.0001	0.0033 ± 0.0005	0.0012 ± 0.0003	0.0032 ± 0.0006
S-60	0 ± 0.0001	0.0017 ± 0.0004	0.0046 ± 0.0007	0.0024 ± 0.0005
S-61[a]	0.0002 ± 0.0002	0 ± 0.0002	0.0017 ± 0.0004	0.0001 ± 0.0001

[a]Off-site location

Table 8. Supply Water Radioactivity Data - 1987

Area	Activity	Number of Samples	Gross Radioactivity (10^{-9} μCi/ml) Average Value and Dispersion	Gross Radioactivity (10^{-9} μCi/ml) Maximum Value[a] and Month Observed
De Soto (monthly)	Alpha	12	5.14 ± 6.62	25.12 (November)
	Beta	12	3.40 ± 0.72	4.52 (November)
SSFL (monthly)	Alpha	24	5.10 ± 3.81	14.98 (April)
	Beta	24	3.59 ± 1.03	6.04 (November)

[a]Maximum value observed for single sample.

Table 9. SSFL Site Retention Pond, Site Runoff, and Well Water Radioactivity Data - 1987
(Sheet 1 of 4)

Area	Activity	Number of Samples	Gross Radioactivity Concentration ($\times 10^{-9}$ µCi/ml)		
			Annual Average Value and Dispersion	Maximum Value[a] and Month Observed	Percent of Samples With Activity <LLD[b]
Pond No. 6 (Monthly)	Alpha	12	1.75 ± 1.65	3.87 (October)	100
	Beta	12	4.66 ± 0.98	5.76 (October)	0
Pond No. 12 (R-2A) (Monthly)	Alpha	12	2.78 ± 1.98	5.35 (October)	100
	Beta	12	4.38 ± 0.61	5.67 (October)	0
Upper Bell Creek No. 17 (Seasonal)	Alpha	3	2.03 ± 0.69	2.76 (March)	100
	Beta	3	3.28 ± 0.93	3.85 (November)	0
Well WS-4A (Seasonal)	Alpha	c			
	Beta				
Well WS-5 (Seasonal)	Alpha	12	4.06 ± 3.50	10.52 (December)	75
	Beta	12	3.96 ± 0.63	4.91 (December)	0
Well WS-6 (Seasonal)	Alpha	c			
	Beta				
Well WS-7 (Seasonal)	Alpha	c			
	Beta				

Table 9. SSFL Site Retention Pond, Site Runoff, and Well Water Radioactivity Data - 1987
(Sheet 2 of 4)

Area	Activity	Number of Samples	Gross Radioactivity Concentration ($\times 10^{-9}$ µCi/ml) Annual Average Value and Dispersion	Maximum Value[a] and Month Observed	Percent of Samples With Activity <LLD[b]
Well WS-8 (Seasonal)	Alpha	2	6.86 ± 0.28	7.06 (September)	0
	Beta	2	3.12 ± 0.36	3.37 (September)	0
Well WS-9 (Seasonal)	Alpha	c			
	Beta				
Well WS-9A (Seasonal)	Alpha	1	1.09 ± 0	1.09 (January)	100
	Beta	1	3.55 ± 0	3.55 (January)	0
Well WS-9B (Seasonal)	Alpha	c			
	Beta				
Well WS-11 (Seasonal)	Alpha	1	4.40 ± 0	4.40 (December)	100
	Beta	1	4.49 ± 0	4.49 (September)	0
Well WS-12 (Seasonal)	Alpha	2	12.97 ± 5.19	16.64 (September)	0
	Beta	2	3.70 ± 1.21	4.56 (June)	0
Well WS-13 (Seasonal)	Alpha	12	3.99 ± 2.08	8.63 (September)	92
	Beta	12	4.01 ± 0.32	4.62 (May)	0

Table 9. SSFL Site Retention Pond, Site Runoff, and Well Water Radioactivity Data - 1987
(Sheet 3 of 4)

Area	Activity	Number of Samples	Gross Radioactivity Concentration ($\times 10^{-9}$ μCi/ml) Annual Average Value and Dispersion	Maximum Value[a] and Month Observed	Percent of Samples With Activity <LLD[b]
Well WS-14 (Seasonal)	Alpha	2	4.82 ± 0.93	5.48 (September)	100
	Beta	2	4.07 ± 0.92	4.71 (September)	0
Well OS-1 (Seasonal)	Alpha	4	5.49 ± 3.20	9.46 (March)	75
	Beta	4	4.23 ± 0.57	4.88 (March)	0
Well OS-2 (Seasonal)	Alpha	4	7.50 ± 4.87	14.24 (March)	25
	Beta	4	2.88 ± 0.78	3.37 (March)	0
Well OS-3 (Seasonal)	Alpha	2	8.89 ± 1.75	10.13 (June)	0
	Beta	2	3.90 ± 0.12	3.99 (March)	0
Well OS-4 (Seasonal)	Alpha	2	4.50 ± 5.70	8.54 (March)	50
	Beta	2	4.50 ± 1.10	5.28 (March)	0
Well OS-5 (Seasonal)	Alpha	4	2.44 ± 1.97	3.76 (December)	100
	Beta	4	4.44 ± 0.27	4.85 (December)	0
Well OS-8 (Seasonal)	Alpha	4	3.88 ± 2.38	6.44 (December)	100
	Beta	4	3.18 ± 1.04	4.73 (September)	0

Table 9. SSFL Site Retention Pond, Site Runoff, and Well Water Radioactivity Data - 1987 (Sheet 4 of 4)

Area	Activity	Number of Samples	Gross Radioactivity Concentration ($\times 10^{-9}$ μCi/ml) Annual Average Value and Dispersion	Maximum Value[a] and Month Observed	Percent of Samples With Activity <LLD[b]
Well OS-10 (Seasonal)	Alpha	4	1.84 ± 1.65	3.78 (March)	100
	Beta	4	1.32 ± 0.10	1.48 (March)	0
Well OS-13 (Seasonal)	Alpha	3	3.32 ± 3.86	7.24 (March)	100
	Beta	3	3.18 ± 0.45	3.64 (September)	0
Well OS-15 (Seasonal)	Alpha	3	14.32 ± 2.89	16.12 (June)	33
	Beta	3	5.49 ± 1.13	6.64 (March)	0
Well OS-16 (Seasonal)	Alpha	3	10.32 ± 7.65	15.74 (March)	33
	Beta	3	4.71 ± 0.63	5.09 (June)	0
Well RS-20 (Seasonal)	Alpha	2	1.37 ± 1.16	2.19 (December)	100
	Beta	2	1.28 ± 0.50	1.63 (September)	50
Well RS-21 (Seasonal)	Alpha	2	7.73 ± 9.67	14.57 (June)	50
	Beta	2	2.06 ± 0.07	2.11 (June)	0
Well RS-22 (Seasonal)	Alpha	2	-0.88 ± 0.005	-0.88 (June)	100
	Beta	2	0.93 ± 0.35	1.18 (June)	50

[a]Maximum value observed for single sample.
[b]Lower limit of detection: Approximately 0.4 x 10^{-9} μCi/ml alpha; 1.10 x 10^{-9} μCi/ml beta for water: approximately 3.2 pCi/g alpha; 0.37 pCi/g beta for soil.
[c]Not sampled during year due to well being out of service.

Table 10. Ambient Air Radioactivity Data - 1987

Area (monthly)	Activity	Number of Samples	Gross Radioactivity Concentrations--Femtocuries per m^3 (10^{-15} μCi/ml)			
			Annual Average Value and Dispersion	Maximum Value[a] and Month Observed	Percent of Guide[b]	Percent of Samples With Activity <LLD[c]
De Soto on-site (2 locations)	Alpha Beta	690	1.9 ± 2.6 26.9 ± 20.4	15.3 (05/16) 111.9 (08/03)	0.06 <0.01	99 66
SSFL on-site (5 locations)	Alpha Beta	1770	1.9 ± 2.4 26.8 ± 18.3	36.1 (10/25) 106.7 (11/13)	3.2 0.09	99 64
SSFL sewage treatment plant	Alpha Beta	353	2.1 ± 2.4 27.6 ± 18.6	17.1 (10/02) 111.8 (11/13)	3.5 0.09	99 65
SSFL control center	Alpha Beta	338	1.9 ± 2.1 27.9 ± 20.1	9.0 (09/19) 104.1 (11/13)	3.2 0.09	99 64
All locations	Alpha Beta	3151	1.9 ± 2.4 27.0 ± 19.0	-	-	-

[a]Maximum value observed for single sample.
[b]Guide De Soto site: 3×10^{-12} μCi/ml alpha, 3×10^{-10} μCi/ml beta; 10 CFR 20 Appendix B, CAC 17.
SSFL site: 6×10^{-14} μCi/ml alpha, 3×10^{-11} μCi/ml beta; 10 CFR 20 Appendix B, CAC 17, DOE Order 5480.1A.
[c]LLD = 8.5×10^{-15} μCi/ml alpha; 3.1×10^{-14} μCi/ml beta.

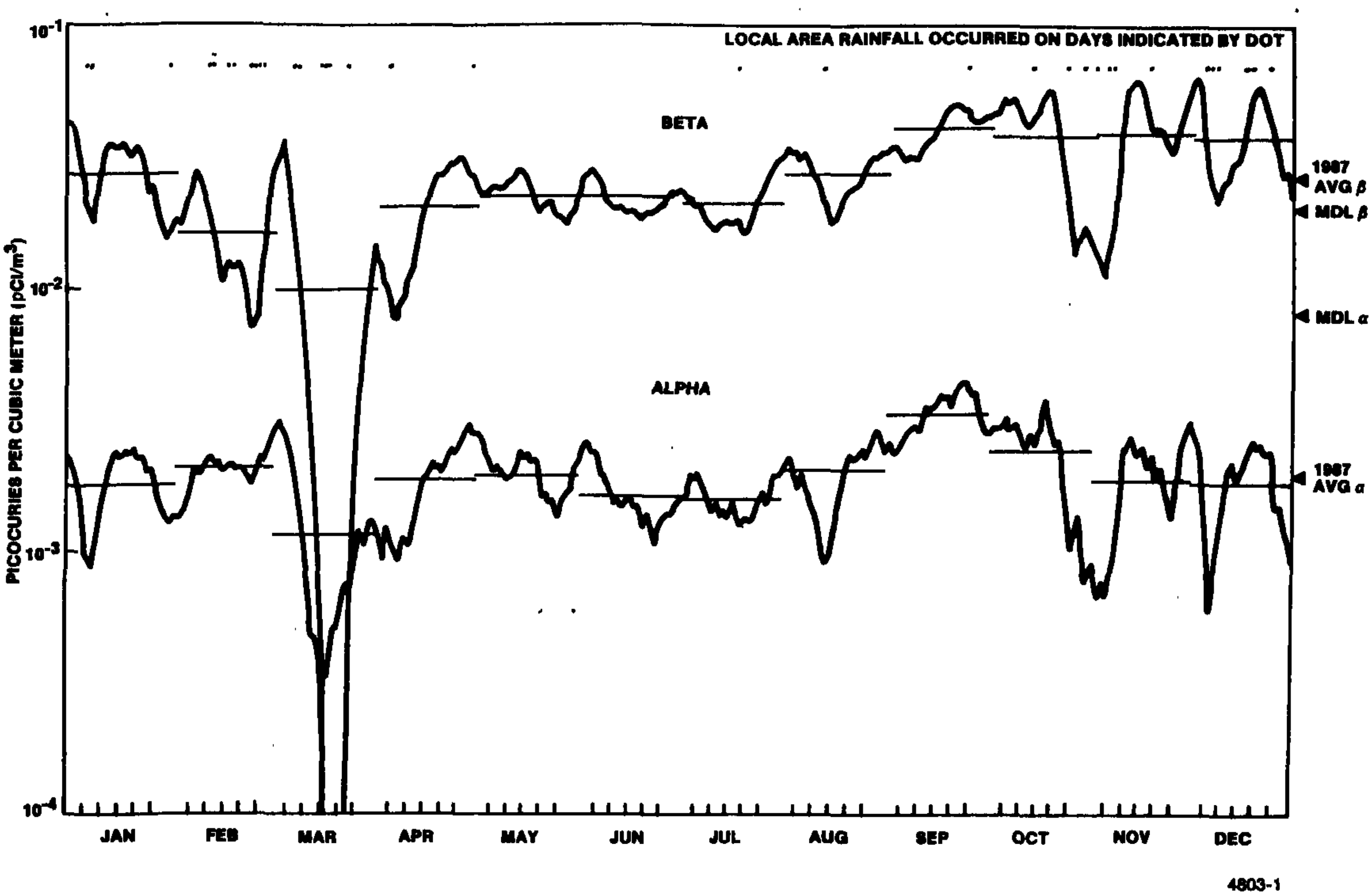

Figure 3. Average Long-Lived Airborne Radioactivity at the De Soto and Santa Susana Field Laboratories Sites - 1987

Table 11. De Soto and SSFL Sites - Ambient Radiation Dosimetry Data - 1987

TLD Location		Quarterly Exposure (mrem)				Annual Exposure (mrem)	Equivalent Exposure at 1000-ft ASL	
		Q-1	Q-2	Q-3	Q-4		(mrem)	(μrem/h)
De Soto	DS-1	27	30	36	28	121	122	14
	DS-2	27	29	47	26	129	131	15
	DS-3	26	30	49	27	132	133	15
	DS-4	28	31	39	31	129	130	15
	DS-5	26	29	38	28	121	122	14
	DS-6	28	32	55	30	145	147	17
	DS-7	23	37	31	31	122	124	14
	DS-8	25	28	28	27	108	109	12
Mean value		26	31	40	28	126	127	14
SSFL	SS-1	26	30	54	41	151	139	16
	SS-2	34	35	57	42	168	155	18
	SS-3	29	51	47	40	167	155	18
	SS-4	31	56	57	44	188	175	20
	SS-5	23	a	31	30	112	99	14
	SS-6	30	54	38	32	154	143	16
	SS-7	22	41	58	30	151	139	16
	SS-8	32	65	36	30	163	150	17
	SS-9	35	58	42	37	172	160	18
	SS-10	28	54	37	32	151	141	16
Mean value		29	49	46	36	158	146	17
Off-site	OS-1	23	24	34	24	105	108	12
	OS-2	24	46	48	25	143	140	16
	OS-3	24	48	39	30	141	143	16
	OS-4	25	49	51	27	152	150	17
	OS-5	29	42	44	33	148	149	17
Mean value		25	42	43	28	138	138	16

[a] Missing dosimeter; annual exposure estimated from data for three quarters.

V. UNUSUAL EVENTS

There were several unusual events at facilities involving radiation or radioactive materials. These events are summarized below.

A. REPORTABLE INCIDENTS

The film badge processor, R. S. Landauer Jr. and Co., reported that a film badge assigned to a Rocketdyne employee had indicated an exposure of 7,360 mrem for the first calendar quarter of 1987. This exceeds the allowable limit of 1,250 mrem. The individual is an industrial radiographer and occasionally performed X-ray machine field radiography in the Peacekeeper assembly room at Canoga and sometimes at the Peacekeeper load facility (PLF) at SSFL. He had not made entries to the pocket dosimeter record sheets and so no refuting evidence could be provided. The radiographer was restricted from radiographic work for five quarters, until July 1988. Radiographer managers were advised of the need to properly control access to film badges when not in use and to assure that pocket dosimeter readings are properly recorded.

A concurrent overexposure of a film badge to 4,570 mrem to another industrial radiographer was refuted on the basis of sharp filter lines on the film, indicative of a single, stationary exposure, and proper recording of pocket dosimeter readings.

8. NONREPORTABLE INCIDENTS

The Radiation and Nuclear Safety group provides radiological monitoring and safety guidance for operations with radioactive material (including Special Nuclear Material) and radiation-producing devices. As part of this function, "Radiological Safety Incident Reports" are written and distributed. The purpose of these reports is to record incidents that were not significant enough to require formal reporting to any regulatory agency (AEC, NRC, ERDA, DOE, State of California), assure communication among the R&NS personnel, and enhance hazard awareness within the operations groups. Reporting of this sort has been done throughout the operations of Atomics International and Energy Systems Group (California) and is continuing as part of the Rocketdyne safety program.

To promote the purpose of these reports, the reporting criteria have been deliberately left vague and general. Generally, a report is written for any injury occurring in a radioactively contaminated area, abnormal release of contamination, fire involving radioactive material, or exposure of personnel to radiation or abnormal radioactive contamination. These criteria are well below the regulatory agency reporting requirements. Judgment is required in determining when to write a report, and the goal has been both to inform workers and management and to record those events that might be questioned in the future but because of lack of consequence would not be otherwise recorded.

The reports are distributed to all members of Radiation and Nuclear Safety and generally to the individuals personally involved, their managers, and any related management. Each incident is reviewed at the time of reporting, and case-by-case corrective actions are implemented as appropriate.

1. January 6, 1987 — When doing an exit survey when leaving the high-bay at RMDF, a worker found contamination on the soles of his shoes. Spotty contamination was found on the floor around the NAC cask being decontaminated, from spill reported in the "Nonreportable Incidents" section of the Annual Review for 1986.[13] More extensive floor surveys and cleanup were instituted.

2. January 7, 1987 — A health physicist became contaminated while surveying tools and equipment form the decontamination of the NAC cask (see above). Nasal contamination was detected and bioassay samples were submitted (results were less than detectable). Decontamination was successful. This was another case of contamination resulting from the extremely concentrated activity found in casks used for LWR fuel shipments.

3. January 16, 1987 — A worker at the RMDF, who had suffered a severe burn on one arm due to a grease fire at home, had been restricted from any work with potential for contamination. On three occasions, we was assigned to work on or near the NAC cask (see above). A management meeting resolved these improper assignments.

4. March 12, 1987 — A worker collapsed from heat exhaustion while existing Cell 4 at the RIHL. While no contamination or radiation exposure resulted from this incident, a major effort was made to improve working conditions by cooling the breathing air supply, obtaining "Blue Ice" vests, and also providing training on recognizing the early symptoms of heat stress.

5. July 10, 1987 — A personal survey done on a worker leaving Cell 2 at the RIHL showed beta contamination up to 20,000 rpm on his right wrist. This was removed by use of dry wipes. It appeared to have resulted from the taped coveralls-to-glove joint opening slightly. Workers were reminded to tape joints carefully.

6. July 14, 1987 — Contamination was found on a worker's neck while exiting Cell 2 at the RIHL. He was decontaminated by use of dry and wet wipes. This appears to have resulted from tape coming loose from the clothing due to excessive sweating. Workers were cautioned to watch for this.

7. July 19, 1987 — A water leak on the second floor of DS104 resulted in flooding of several of the Applied Nuclear Research laboratories on the first floor. Surveys of the area and cleanup equipment and analysis of the water showed no radioactive contamination.

8. July 20, 1987 — A worker found contamination on his neck when exiting Cell 2 at the RIHL. He was successfully decontaminated. This appears to be a repeat of Incident No. 6 (see above).

9. September 30, 1987 When a shielded shipping container lid was being reinstalled, the boom of the mobile crane swung to the side, independent of the operator's control. The crane tipped to the side, and the lid hit the ground. The lid was heat damaged. Investigation showed that the boom swing brake was not operative. Improvements in the inspection and operation practices of the crane were instituted.

10. November 9, 1987 A large piece of contaminated material was dropped into a waste box in the Decontamination Room at RMDF, releasing significant airborne radioactivity. The worker showed minor nasal contamination and submitted three bioassay samples. All showed less-than-detectable activity. A management conference was held regarding work instruction. Material is supposed to be wrapped and gently placed in the waste boxes.

11. November 18, 1987 A Maintenance employee entered a contaminated area before he could be stopped. His shoes were contaminated, but were cleaned satisfactorily. This incident apparently resulted from "English as a Second Language." The entry area was painted yellow with red lettering "Caution--Contaminated Floor" to help prevent recurrence.

12. December 1, 1987 While removing a shield plug from Cell 1 at the RIHL, a worker pinched his thumb, releasing blood inside his rubber surgeon's glove. The glove was not broken and no contamination was detected on his thumb.

The first two contamination incidents and the last three reported for 1986 had common causes involving a wet contaminated shipping cask. These were reviewed in detail by an ad hoc committee. The number of incidents, 12, is a considerable reduction from prior years. They are categorized as:

Personal contamination (6 incidents)

1, 2, 5, 6, 8, 11

Release of contamination (1 incident)

10

Potential exposure/contamination (4 incidents)

3, 4, 7, 12

Potential equipment damage (1 incident)

9

It is indicative of the low level of problems experienced during this year that the last two categories refer simply to "potential" problems. Two of the RMDF contamination incidents involved a common cause: the NAC cask, while three of the RIHL incidents involved apparent failure of taped seals on protective clothing.

VI. SUMMARY/TRENDS - EXPOSURE, EFFLUENTS

A. PERSONNEL EXPOSURES

Personnel exposures due to external radiation are summarized by year in the following table:

	Number of Persons in Exposure Range (rem)										Group		
Year	>0 0.1	0.1 0.25	0.25 0.5	0.5 0.75	0.75 1.0	1.0 2.0	2.0 3.0	3.0 4.0	4.0 5.0	>5.0	Total Exposed Persons	Dose (Person rems)	Average Dose (rems)
1987	130	22	15	8	2	1				1	179	27	0.153**
1986	134	20	11	7	5	3					180	23	0.126
1985	134	10	4	9	12	25					194	58	0.301
1984	178	16	14	5	8	14					235	45	0.192
1983	281	9	5	4	5	13	8	2	17		344	138	0.402
1982	349	29	8	3	6	15	4	7	8		429	116	0.271
1981	192	55	13	4	6	4					274	33	0.121
1980	357	39	10	3	5	9	3				426	56*	0.131*
1979	347	39	19	10	4	15	8	2			444	91*	0.204*
1978	432	60	18	16	4	18	9	1	1		559	110*	0.197*
1977	340	31	29	7	5	11	13				436	91*	0.209*
1976	295	38	17	14	5	9	2				380	59*	0.156*
1975	170	24	12	4	5	6	1	1			223	39*	0.175*

*Determined by use of mid-point of range

**Includes presumptive exposure of 7.36 rem to industrial radiographer. Omitting this exposure yields a group dose of 20 person-rem and an average dose of 0.112.

Data shown for 1980 and prior years include visitors. Visitor exposures rarely exceed 0.25 rem. Data for 1981 through 1985 represent occupationally exposed Rocketdyne employees excluding certain workers in Rocketdyne operations predating the merger, while 1986 and 1987 show all occupational exposures. The group dose was calculated exactly for the last seven years. This results in values that are approximately 10% lower than those calculated by use of the mid point of the exposure ranges.

Exposures during 1987 showed a slight reduction in group dose and average dose from prior years. When the presumptive industrial radiographer exposure is excluded, this reflects changes in the continuing effectiveness of the ALARA program.

Internal dosimetry for the estimation of organ doses or dose commitments that have been received from internally deposited radioactive material has not been generally done. It is complicated and time consuming, and the detected amounts of radioactive material have been so small as to not warrant it.

Internal depositions of radioactive material, as monitored by the bio-assay program, are shown in the table below.

Year	Number of Tests Performed	Number of Tests with Positive Results	Percent Positive
1987	869	14	1.6
1986	663	39	5.9
1985	644	69	10.7
1984	373	48	12.9
1983	527	30	5.7
1982	742	66	8.9
1981	768	66	8.6
1980	864	44	5.1
1979	1099	79	7.2
1978	1022	80	8.7
1977	1272	158	12.4
1976	1481	67	4.5
1975	1483	57	3.8

This table shows, for the past 12 years, all the tests performed and the number of tests that were considered to be "positive." A "positive" result is one that exceeds the minimum detectable activity (MDA) for the particular analysis. During the time covered by this series of reports, the number of bioassays has generally declined as the number of people working with unencapsulated radioactive material has decreased. Tests were increased in 1985 and 1986 to provide more detailed information for the purpose of future dose evaluations. The reduction in percentage of positive results for 1986 appears to be significant compared to 1985. Following tables show the distribution for the two major radionuclides tested during this time period: Cs-173 (FP3B) and Sr-90 (FP3A). While the FP3A analysis is not specifically selective for Sr-90, that is the most restrictive radionuclide likely to be present and detected.

Cs-137

Year	Number of FP3B Tests	Number with Positive Results	Fraction of Positive Results with less than 0.01% MPBB	Maximum % MPBB
1987	227	0	1.0	0
1986	255	8	0.250	0.02
1985	256	49	0.082	0.03
1984	136	30	0.656	0.72
1983	76	6	0.833	0.02
1982	171	4	0.667	0.03
1981	141	3	0	0.02
1980	116	4	0	0.04
1979	233	27	0	1.2
1978	271	22	Incomplete data	
1977	298	43	Incomplete data	
1976	171	6	0	0.02
1975	190	1	1.0	0.01

Sr-90

Year	Number of FP3A Tests	Number with Positive Results	Fraction of Positive Results with less than 10% MPBB	Maximum % MPBB
1987	222	5	0.80	14.0
1986	255	25	0.720	20.8
1985	256	19	0.842	14.5
1984	136	15	0.800	45.0
1983	74	0	1.000	
1982	174	32	0.407	59.8
1981	141	31	0.485	61.9
1980	116	7	0.286	58.8
1979	233	14	Incomplete data	
1978	271	45	Incomplete data	
1977	298	62	Incomplete data	
1976	169	10	0	21.7
1975	194	4	0.333	14.4

B. WORK PLACE RADIATION AND RADIOACTIVITY

The general radiation levels in the work place, as determined by readings from location badges averaged over the calendar year, are summarized in the table below:

	Facility Average Exposure Rate (mR/h) / Maximum Exposure Rate (mR/h)			
Year	GIF	RIHL	ANR	RMDF
1987	0.023 / 0.11	0.07 / 1.43	0.18 / 1.47	1.27 / 5.65
1986	0.08 / 0.22	0.06 / 0.57	0.23 / 1.06	2.92 / 11.3
1985	0.16 / 0.23	0.13 / 0.87	0.97 / 4.00	2.74 / 29.42
1984	0.49 / 0.80	0.13 / 1.15		1.72 / 7.06
1983	0.001 / 0.004	0.47 / 6.42		0.82 / 4.15
1982	0.02 / 0.06	0.10 / 0.21		4.24 / 42.4

Variations reflect changes in workload, with a significant problem at the RMDF in 1985 having been reduced in 1986, due to processing of radioactive water and the accumulation of the resultant sludge.

Airborne radioactivity, in terms of the average percentage of the maximum permissible (occupational) concentration (MPC) is shown for monitored areas below:

	Percent of MPC	
Year	RIHL	RMDF
1987	0.4	15.7
1986	0.2	6.3
1985	0.5	4.4
1984	0.5	-
1983	0.5	-
1982	0.06	-
1981	0.05	-
1980	0.20	-

C. ATMOSPHERIC EFFLUENT RELEASES

Atmospheric effluent releases are monitored by use of stack samplers at the major facilities. The results are shown below in terms of the total activity released. In some cases, the releases were at concentrations less than the ambient (natural) airborne radioactivity; in others, much of the activity is from natural sources, resulting from the use of unfiltered bypass air in the exhaust system.

A significant change has been made in the manner in which those releases are calculated from the effluent sampling measurements. Prior to 1982, all concentration values less than the minimum detection level (MDL) were set equal to the MDL in calculating the average concentration release. This was done on the basis of DOE requirements. It was recognized that this practice biased the reported results upwards by a considerable amount, and DOE changed its guidance. Now, all measured values, even zeroes and negative ("less than background") values, are used in the calculation.

The major fluctuation observed in the beta activity released from the RIHL is due primarily to changes in the work in the hot cells. The increase in beta activity released from the RIHL this year is mainly due to work being performed on the ventilation exhaust system. With these exceptions, a major fraction of the activity reported as discharged from the RIHL and the NMDF actually came from natural radioactivity in the unfiltered bypass air taken into the exhaust systems near the blowers to prevent excessive suction.

RADIOACTIVITY DISCHARGED TO ATMOSPHERE

(microcuries)
(Sheet 1 of 2)

	De Soto		Santa Susana		
	101	104	RIHL	RMDF	NMDF
1987					
Alpha	-	0.29	0.18	0.25	-
Beta	-	0.67	3.7	12.0	-
1986					
Alpha	-	0.08	0.13	0.05	0.04
Beta	-	0.78	22.0	13.0	4.0
1985					
Alpha	-	0.15	0.45	0.04	0.05
Beta	-	0.45	9.0	9.0	1.5
1984					
Alpha	-	0.44	0.10	0.074	0.04
Beta	-	0.59	4.5	3.7	0.98
1983					
Alpha	52.0	1.1	0.024	0.047	0.08
Beta	19.0	1.1	1.3	1.1	1.1
1982					
Alpha	1.2	0.24	0.03	0.024	0.023
Beta	0.94	1.1	14.0	0.61	1.0
1981					
Alpha	2.8	0.39	0.069	0.087	0.059
Beta	2.7	4.1	14.0	4.0	2.0
1980					
Alpha	5.3	1.0	0.17	0.061	0.082
Beta	4.3	4.9	17.0	1.7	1.1
1979					
Alpha	2.1	1.1	0.18	0.085	0.053
Beta	5.8	5.7	44.0	2.7	0.21
1978					
Alpha	16.0	0.65	0.13	0.1	0.081
Beta	5.0	4.3	59.0	11.0	-

RADIOACTIVITY DISCHARGED TO ATMOSPHERE

(microcuries)
(Sheet 2 of 2)

	De Soto		Santa Susana		
	101	104	RIHL	RMDF	NMDF
1977					
Alpha	10.0	0.88	0.1	0.11	0.15
Beta	4.1	7.5	13.0	3.0	-
1976					
Alpha	64.0	8.1	0.15	0.23	0.15
Beta	17.0	8.9	5.8	1.1	-
1975					
Alpha	3.7	5.4	0.15	0.45	0.19
Beta	2.6	12.0	6700.0*	10.0	-

*Released from burned fuel slug.

D. AMBIENT (ENVIRONMENTAL) RADIATION EXPOSURE

Ambient (environmental) radiation exposure rates as measured by CaF_2:Mn TLDs and averaged for all locations are shown below.

	Quarterly Dose (mrem)				Annual Dose (mrem)
	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	
1987	27.2	40.9	43.3	31.5	142.9
1986	21.8	28.7	30.9	28.7	110.1
1985	21.8	32.2	26.6	29.0	109.6
1984	29.9	30.1	25.6	19.6	105.2
1983	30.1	28.9	30.2	27.4	116.6
1982	29.1	30.8	31.8	31.9	123.8
1981	38.2	33.5	35.2	43.9	150.8
1980	35.0	34.4	37.7	49.1	157.3
1979	32.1	38.1	38.0	39.4	147.8
1978	27.3	35.5	33.4	36.6	133.1
1977	24.2	29.2	32.9	30.9	117.5
1976	21.6	24.8	22.5	25.0	93.9
1975	21.3	24.6	26.2	25.4	97.6

Considerable erratic behavior and responses with the TLD reader and the dosimeters were experienced this year and are believed responsible for the relatively higher values shown. Further review and possible editing of these data is planned.

The quarterly doses are plotted as a histogram in Figure 4. This graph, and the tabulated annual doses, show a clear increase from 1976 to 1980, followed by a decrease for 1981, 1982, 1983, and 1984. The data for 1985 and 1986 suggest a leveling off of this decline. All data prior to 1982 were obtained using an EG&G TL-3 reader. Data for 1982 and later were obtained

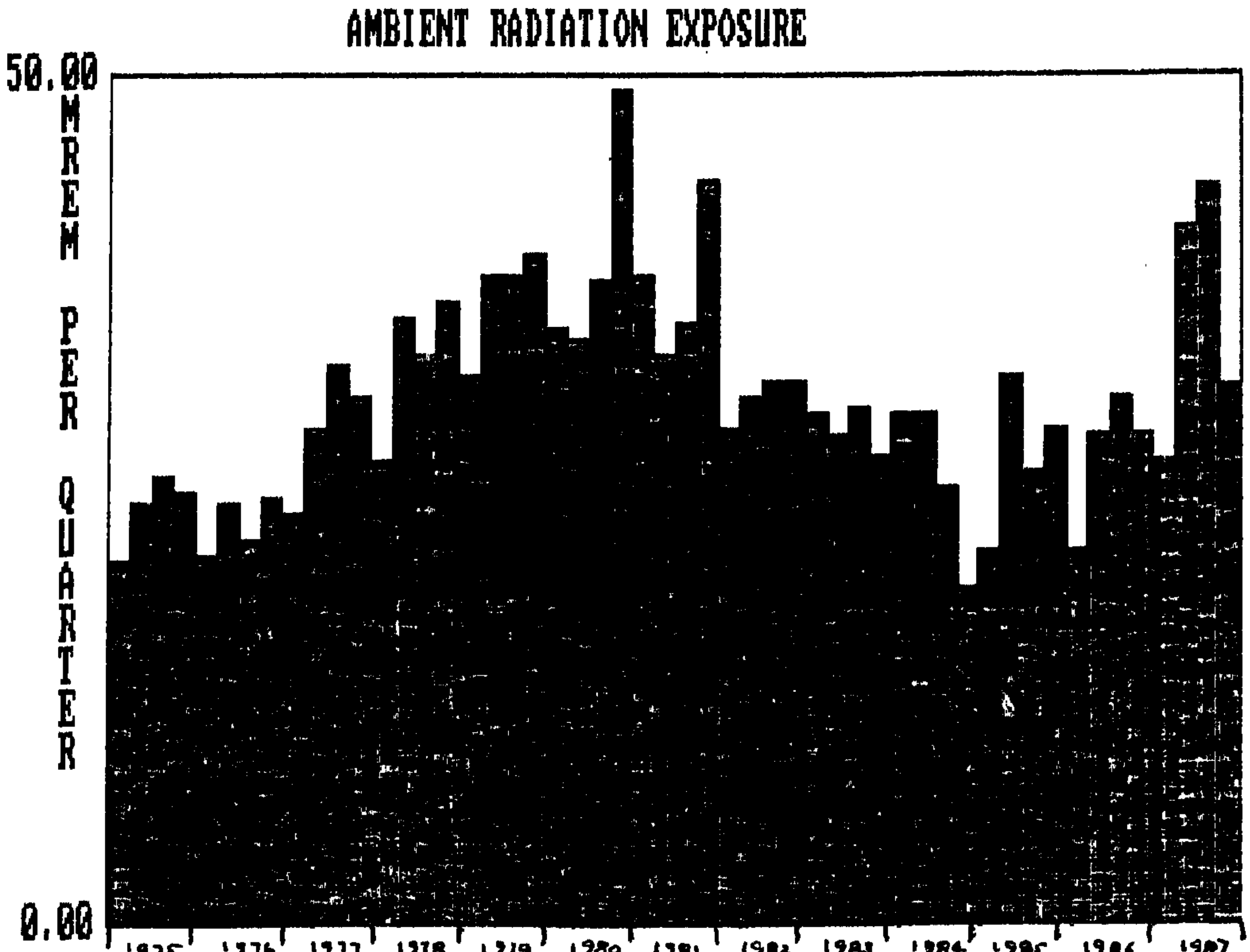

Figure 4. Averaged Quarterly Dose Recorded by Environmental TLDs

using a Victoreen Model 2810. This is a new reader, built on the basic design of the TL-3 reader, but with modern electronics and digital adjustments and readout.

The increasing trend (from 1976 to 1980) was also observed in data for the Rocky Flats Plant, the only other DOE facility where the same type dosimeters are used, but not at any other facility. The cause has not been identified, but since the trend exists equally for the De Soto, Santa Susana, and off-site TLDs, at this time it is assumed to be either a true environmental effect, or an artifact of the TLD reading or calibration.

The annual ambient exposure rates (mrem/year) measured at De Soto, SSFL, and the several offsite locations are shown below:

	De Soto		SSFL		Offsite	
Year	Average	Maximum	Average	Maximum	Average	Maximum
1987	126	145	158	172	138	152
1986	99	113	120	143	105	116
1985	100	107	124	152	105	112
1984	98	106	117	126	100	108
1983	110	123	126	136	115	123
1982	118	135	132	144	124	128
1981	144	159	162	188	148	162
1980	164	193	166	184	163	166
1979	138	149	161	193	131	140
1978	128	140	143	149	126	131
1977	116	125	121	138	106	108
1976	89	99	101	124	91	101
1975	96	105	104	123	94	105

Comparison of the average values and the maximum location values for the three types of sites shows the same increase from 1976 to 1980 and then a decrease to 1984. The cause of this behavior is under continuing study with no definite conclusions produced as yet. The values at SSFL are all somewhat greater than De Soto and the offsite locations due to the significantly greater elevation of the SSFL site, and possibly also due to the greater outcropping of uranium-mineral-bearing sandstone. There is no indication of significant exposure resulting from operations with radioactive material.

Average and maximum values for soil readioactivity are shown in Table 12. This table shows the change in reported alpha activity resulting from adoption of a calibration factor for thick soil samples. Prior to 1984, only relative

Table 12. Soil Radioactivity Summary
1975-1987

		Onsite				Offsite			
		Alpha		Beta		Alpha		Beta	
	Year	Average ± Dispersion	Maximum Value	Average ± Dispersion	Maximum Value	Average ± Dispersion	Maximum Value	Average ± Dispersion	Maximum Value
	1987	27.1 ± 7.7	40.1	25.4 ± 2.1	30.9	25.7 ± 7.7	55.1	23.9 ± 3.5	29.1
	1986	26.7 ± 6.6	40.1	26.1 ± 2.2	32.2	28.1 ± 5.9	39.0	24.2 ± 1.3	30.4
	1985	25.2 ± 7.3	48.4	24.2 ± 1.9	32.7	26.3 ± 7.8	46.0	23.9 ± 3.3	30.2
	1984	25.8 ± 6.0	43.4	24.2 ± 2.0	30.1	26.2 ± 7.2	51.3	23.3 ± 2.9	28.2
a	1983	0.6 ± 0.2	1.1	24.2 ± 2.0	29.7	0.6 ± 0.2	1.1	23.0 ± 2.8	27.8
	1982	0.7 ± 0.2	1.2	24.6 ± 2.3	30.1	0.7 ± 0.2	1.2	23.3 ± 3.7	32.9
	1981	0.7 ± 0.2	1.3	25.4 ± 3.5	38.2	0.6 ± 0.2	1.3	22.8 ± 4.5	33.2
b	1980	0.6 ± 0.2	1.1	24.0 ± 1.0	110.0	0.6 ± 0.2	1.0	23.0 ± 1.0	30.0
	1979	0.6 ± 0.2	1.1	25.0 ± 1.0	97.0	0.5 ± 0.1	0.8	23.0 ± 1.0	29.0
	1978	0.6 ± 0.2	1.0	24.0 ± 0.9	48.0	0.5 ± 0.1	1.0	24.0 ± 0.9	34.0
	1977	0.6 ± 0.2	1.1	24.0 ± 0.9	31.0	0.5 ± 0.2	0.8	23.0 ± 0.8	27.0
	1976	0.6 ± 0.2	0.8	25.0 ± 1.0	32.0	0.6 ± 0.2	1.0	24.0 ± 1.0	30.0
	1975	0.6 ± 0.1	1.0	25.0 ± 1.0	35.0	0.6 ± 0.2	1.0	24.0 ± 1.0	27.0

[a] Values reported for alpha activity in soil before 1984 are relative values only. The 1984 values reflect correction for self absorption of alpha particles by the thick soil samples.

[b] Prior to 1981, data less than the MDL were treated as equal to the MDL. For 1981 and later, actual measured values were used.

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values were reported, which served the function of monitoring for changes quite well but produced values that did not reflect the correlation of alpha and beta activity from naturally present radioactive elements (potassium, 0 alphas, 1 beta per decay; uranium chain, 8 alphas, 6 betas; thorium chain, 6 alphas, 4 betas).

Four high values of soil beta activity have been detected onsite (out of 1680 samples): those are shown as maximum values for the years 1978-1981. The maximum values for 1979 and 1980 were along the southwest side of the RMDF and may have resulted from a cleanup of the so-called "West Bank" near the RMDF just prior to these years. The 1978 and 1981 values were from samples taken near the SS Vault (T064). Follow-up surveys failed to locate additional, significant contamination. (It should be noted that only the 1980 value exceeds the working limit of 100 pCi/g gross detectable beta activity adopted for our decontamination work.)

Results for the semiannual plutonium soil analyses are shown in Tables 13 and 14. The onsite averages are generally higher than offsite but not greatly so. This may represent differences between the set of five onsite locations and the single offsite location. While plutonium is found in low concentrations everywhere as a result of atmospheric nuclear weapons tests at several different locations around the world, the concentration at a given location is affected by meteorological conditions following the test explosion and after deposition. Comparison of the onsite values shows no systematic variation with location relative to the NMDF.

After review of the results of vegetation sampling conducted over the prior 28 years, it was determined that this sample class did not provide significantly useful data. Fallout is more accurately assessed by measurement of airborne radioactivity and soil radioactivity. Therefore, the vegetation sampling was discontinued.

Table 13. Plutonium in Soil Summary
1978-1987
(Pu-239 + Pu-240, fCi/g)

	Onsite		Offsite
Year	Average ± Dispersion	Maximum Value	Average ± Dispersion
1987	2.7 ± 1.8	7.1	0.1 ± 0.1
1986	1.8 ± 1.3	3.8	1.2 ± 1.0
1985	2.6 ± 1.5	5.1	0.4 ± 0.2
1984	3.1 ± 1.3	5.2	0.4 ± 0.2
1983	5.2 ± 4.4	14.4	7.0 ± 0.2
1982	4.0 ± 2.4	7.3	2.7 ± 3.3
1982	4.2 ± 4.5	15.9	1.2 ± 1.0
1980	8.4 ± 8.5	29.5	1.3 ± 0.9
1979	7.0 ± 6.7	18.9	2.6 ± 1.3
1978	4.5 ± 2.9	9.0	4.4 ± 1.6
Grand Average	4.3 ± 4.5	7.1	2.0 ± 2.7

Table 14. Summary of Plutonium in Soil
(Pu-239 + Pu-240, fCi/g)

	Location	Average ± Dispersion	Maximum Value	Date
S-56	1100 ft NW NMDF	3.8 ± 4.4	14.4	December 1983
S-57	900 ft SE NMDF	3.5 ± 2.3	9.5	June 1980
S-58	500 ft SE NMDF	5.1 ± 4.3	18.9	December 1979
S-59	900 ft ESE NMDF	4.4 ± 3.9	18.6	December 1979
S-60	2000 ft SE NMDF	4.9 ± 6.7	29.5	December 1980
S-61	2.7 mi. NE NMDF		7.1	June 1983

Alpha and beta radioactivity in the supply water at the De Soto and SSFL sites are shown in Table 15. Water for the De Soto site is supplied by the Los Angeles Department of Water and Power from the Metropolitan Water District. Water for the SSFL site is supplied by Ventura County Water District No. 17, with varying amounts of supplemental water (up to 100%) from onsite wells operated by Rocketdyne. The water at De Soto is consistently, but not significantly, more radioactive than that at SSFL.

A change in the method of correcting for alpha attenuation in the mineral deposit from the water samples permits more accurate reporting of the alpha activity since 1983.

Alpha and beta radioactivity in environmental waters is shown in Tables 16A and 16B. The radioactivity concentrations in all three water sources sampled are quite similar. (Pond R-2A receives runoff and effluent from the Santa Susana nuclear facilities, while Pond 6 receives runoff and effluent from the other facilities. The Bell Creek sample, from the location sampled prior to 1986, appears to be mostly seepage from the Bell Canyon community. After 1985, water was automatically sampled at the head of Bell Creek.) The results for the pond water are very nearly the same as the supply water for 1986. No radionuclides present at the nuclear facilities have been found.

Tables 17A and 17B show the results of alpha and beta radioactivity measurements on ambient air samples. An apparent extreme decrease in alpha radioactivity after 1981 is due simply to a change in the method of treating the very low-level values. Until the end of 1981, each value that was less than the MDL for a single measurement was set equal to the MDL before inclusion in the average. This artificially elevated the average value. This effect was not nearly so great for the beta activity measurements. The beta values for De Soto, SSFL, and offsite samples are essentially identical. (The "offsite" samples are located at SSFL but at a considerable distance from the nuclear facilities.)

Table 15. Supply Water Radioactivity Summary, 1975-1987

		De Soto				SSFL			
		Alpha		Beta		Alpha		Beta	
	Year	Average ± Dispersion	Maximum Value	Average ± Dispersion	Maximum Value	Average ± Dispersion	Maximum Value	Average ± Dispersion	Maximum Value
	1987	5.14 ± 6.62	25.12	3.40 ± 0.72	4.52	5.10 ± 3.81	14.98	3.59 ± 1.03	6.04
	1986	4.41 ± 2.53	8.70	3.75 ± 0.62	4.69	6.55 ± 9.09	45.77	3.58 ± 0.95	6.75
	1985	2.76 ± 1.82	5.73	3.17 ± 0.78	4.6	2.45 ± 2.61	8.6	2.80 ± 0.52	3.95
	1984	3.82 ± 0.93	5.87	3.40 ± 0.45	4.3	3.53 ± 3.94	13.3	2.93 ± 0.60	4.01
a	1983	0.34 ± 0.23	0.88	3.53 ± 0.97	5.1	0.12 ± 0.13	0.41	3.00 ± 0.60	4.45
	1982	0.36 ± 0.23	0.79	3.97 ± 1.19	6.6	0.14 ± 0.12	0.38	3.01 ± 0.67	4.91
	1981	0.36 ± 0.20	0.77	3.78 ± 0.68	4.7	0.11 ± 0.12	0.44	2.79 ± 0.55	3.65
b	1980	not analyzed				0.22 ± 0.27	0.22	2.4 ± 0.7	3.4
	1979	not analyzed				0.23 ± 0.27	0.23	1.8 ± 0.7	3.9
	1978	not analyzed				0.26 ± 0.28	0.44	3.0 ± 0.8	3.6
	1977	not analyzed				0.25 ± 0.29	0.30	2.5 ± 0.7	3.6
	1976	not analyzed				0.25 ± 0.29	0.42	2.0 ± 0.7	2.5
	1975	not analyzed				0.24 ± 0.27	0.55	2.3 ± 0.7	3.2

[a]Values reported for alpha activity in water before 1984 are relative values only. Subsequent values reflect correction for self absorption of alpha particles by the thick mineral deposit of the counting sample.

[b]Prior to 1981, data less than the MDL were treated equal to the MDL. For 1981 and later, actual measured values were used.

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Table 16A. Environmental Water Radioactivity Summary
1975-1987
(Alpha, pCi/L)

		Pond R-2A		Pond 6		Bell Creek	
	Year	Average ± Dispersion	Maximum Value	Average ± Dispersion	Maximum Value	Average ± Dispersion	Maximum Value
	1987	2.78 ± 1.98	5.35	1.75 ± 1.65	3.87	2.03 ± 0.69	2.76
c	1986	4.18 ± 2.70	8.70	2.51 ± 2.88	9.51	2.02 ± 2.08	5.90
	1985	3.07 ± 1.94	6.61	1.06 ± 4.44	13.6	1.38 ± 7.09	19.7
	1984	0.15 ± 1.70	2.70	4.90 ± 9.11	25.9	4.15 ± 8.30	28.7
a	1983	0.13 ± 0.12	0.35	0.12 ± 0.11	0.27	0.08 ± 0.12	0.39
	1982	0.11 ± 0.13	0.28	0.17 ± 0.08	0.35	0.03 ± 0.06	0.14
	1981	0.07 ± 0.15	0.37	0.05 ± 0.08	0.17	0.05 ± 0.06	0.20
b	1980	0.23 ± 0.27	0.23	0.23 ± 0.27	0.23	0.23 ± 0.27	0.23
	1979	0.23 ± 0.27	0.25	0.25 ± 0.28	0.55	0.23 ± 0.27	0.24
	1978	0.25 ± 0.28	0.27	0.25 ± 0.28	0.35	0.24 ± 0.28	0.24
	1977	0.25 ± 0.29	0.28	0.24 ± 0.29	0.25	0.24 ± 0.29	0.24
	1976	0.28 ± 0.30	0.53	0.24 ± 0.29	0.24	0.25 ± 0.29	0.28
	1975	0.31 ± 0.29	1.2	0.24 ± 0.27	0.55	0.22 ± 0.27	0.28

[a]Values reported for alpha activity in water before 1984 are relative values only. Subsequent values reflect correction for self absorption of alpha activity by the thick mineral deposit of the counting sample.
[b]Prior to 1981, data less than the MDL were treated as equal to the MDL. For 1981 and later, actual measured values are used.
[c]Prior to 1986, Bell Creek was sampled at the eastern boundary of the residential community of Bell Canyon. In 1986, an automatic water sampler was installed that collects water only when water is present in the upper part of Bell Creek, immediately downstream from the discharge of Pond R-2A.

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Table 16B. Environmental Water Radioactivity Summary
1975-1987
(Beta, pCi/L)

	Year	Pond R-2A		Pond 6		Bell Creek	
		Average ± Dispersion	Maximum Value	Average ± Dispersion	Maximum Value	Average ± Dispersion	Maximum Value
	1987	4.38 ± 0.61	5.67	4.66 ± 0.98	5.76	3.28 ± 0.93	3.85
b	1986	3.58 ± 1.14	8.93	2.92 ± 0.94	4.57	2.60 ± 0.52	3.66
	1985	3.49 ± 0.79	5.56	3.58 ± 0.96	4.92	2.49 ± 0.75	3.79
	1984	4.25 ± 0.85	5.87	4.58 ± 0.75	5.66	2.88 ± 0.58	4.60
	1983	4.44 ± 1.84	9.15	3.57 ± 0.92	4.80	3.30 ± 0.60	4.20
	1982	3.93 ± 0.83	5.81	3.91 ± 1.08	5.34	3.29 ± 0.70	4.40
	1981	5.16 ± 1.22	8.30	4.25 ± 0.63	5.26	3.78 ± 0.65	5.00
a	1980	3.9 ± 0.8	5.70	2.9 ± 0.7	4.7	2.9 ± 0.8	5.2
	1979	4.5 ± 0.8	10.0	3.1 ± 0.8	4.7	3.2 ± 0.9	8.2
	1978	4.6 ± 0.8	6.3	4.3 ± 0.8	7.0	2.5 ± 0.8	3.5
	1977	5.2 ± 0.9	13.0	4.3 ± 0.8	6.4	1.8 ± 0.8	2.6
	1976	4.4 ± 0.8	7.0	4.3 ± 0.8	5.5	2.2 ± 0.8	2.9
	1975	4.5 ± 0.8	5.4	4.2 ± 0.8	5.5	2.4 ± 0.8	3.4

[a]Prior to 1981, data less than the MDL were treated as equal to the MDL. For 1981 and later, actual measured values are used.

[b]Prior to 1986, Bell Creek was sampled at the eastern boundary of the residential community of Bell Canyon. In 1986, an automatic water sampler was installed that collects water only when water is present in the upper part of Bell Creek, immediately downstream from the discharge of Pond R-2A.

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Table 17A. Ambient Air Radioactivity Summary
1975-1987
(Alpha, fCi/m^3)

	De Soto		SSFL		Offsite	
Year	Average ± Dispersion	Maximum Value	Average ± Dispersion	Maximum Value	Average ± Dispersion	Maximum Value
1987	1.9 ± 2.6	15	1.9 ± 2.4	36	1.9 ± 2.1	9
1986	2.9 ± 3.4	22	2.8 ± 3.3	37	2.9 ± 3.3	33
1985	2.7 ± 2.2	38	2.0 ± 1.6	44	2.0 ± 1.9	25
1984	1.9 ± 9.3	32	1.4 ± 3.4	29	1.4 ± 3.0	16
1983	2.4 ± 3.8	60	0.9 ± 5.4	24	1.2 ± 2.9	11
1982	1.7 ± 3.1	39	1.1 ± 2.6	30	1.7 ± 2.9	16
a 1981	6.9 ± 7.7	25	6.8 ± 7.9	35	6.8 ± 7.2	22
1980	6.5 ± 7.7	45	6.4 ± 7.8	25	6.3 ± 7.8	20
1979	6.6 ± 7.8	45	6.5 ± 7.6	40	6.2 ± 7.9	34
1978	8.4 ± 8.1	95	7.2 ± 7.9	21	7.2 ± 7.3	44
1977	6.6 ± 7.7	39	6.6 ± 7.5	35		
1976	6.7 ± 8.4	140	6.5 ± 7.2	53		
1975	6.3 ± 6.8	60	6.0 ± 6.3	88		

[a]Prior to 1982, data less than the MDL were treated as equal to the MDL. For 1982 and later, actual measured values are used.

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Table 17B. Ambient Air Radioactivity Summary
1975-1987
(Beta, fCi/m^3)

	De Soto		SSFL		Offsite	
Year	Average ± Dispersion	Maximum Value	Average ± Dispersion	Maximum Value	Average ± Dispersion	Maximum Value
1987	27 ± 20	112	27 ± 18	107	28 ± 20	104
1986	58 ± 103	1236	60 ± 94	1579	60 ± 90	1233
1985	44 ± 14	180	40 ± 13	170	40 ± 14	240
1984	27 ± 27	250	23 ± 14	200	24 ± 20	200
1983	26 ± 21	130	23 ± 17	180	25 ± 12	280
1982	26 ± 14	260	21 ± 16	180	22 ± 12	88
[a] 1981	120 ± 20	1100	120 ± 20	1100	120 ± 20	1600
1980	39 ± 14	380	36 ± 14	450	34 ± 15	360
1979	21 ± 13	100	21 ± 13	110	19 ± 15	100
1978	91 ± 17	1400	88 ± 17	1500	86 ± 16	1300
1977	170 ± 20	3000	170 ± 20	2800		
1976	96 ± 18	3700	110 ± 20	3400		
1975	76 ± 16	460	73 ± 15	730		

[a] Prior to 1982, data less than the MDL were treated as equal to the MDL. For 1982 and later, actual measured values are used.

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VII. ANTICIPATED ACTIVITIES DURING NEXT REPORTING PERIOD (1988)

Building 104 (GIF and ANR)

Continuation of low-level research with activated materials and operation of the Gamma Irradiation Facility.

Building 020 (RIHL)

Continue cleanup of cells in preparation for next project. Perform demonstration of D&D techniques.

Buildings 021/022 (RMDF)

Shipment of disassembled Fermi fuel and scrap.

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