Los Alamos National Laboratory
Radiological Protection Program

First Quarter CY 2000

Performance Indicators for Radiation Protection

June 1, 2000

ESH-12
Radiation Protection Services
(505) 665-7921

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MANAGEMENT SUMMARY

INTRODUCTION

This report covers all radiological operations conducted at Los Alamos National Laboratory (LANL). It includes University of California (UC) operations as well as contractors and subcontractors. The majority of the information (data) in this report comes from two sources. The first source, dosimetry information, is obtained from the Radiation Information Management Team of ESH-12. The remainder of the information is obtained from the DOE Occurrence Reporting and Processing System (ORPS) [DOE Order 232.1]. The data contained in this report are current as of the date that the report was prepared, and are accurate to the best of the team's knowledge.

1.0 GENERAL SITE INFORMATION

A. Major radionuclides at the site:

Plutonium, Uranium, Tritium and mixed activation products

2.0 EXTERNAL RADIATION EXPOSURE

A. Dosimetry Notification Levels (LANL specific):

Whole Body Dose (EDE) ……..1 rem
Lens-of-the-Eye …… 3 rem
Extremities/Organ/Tissue ……..10 rem

Radiation Worker Dose Limits: (10CFR835)

Whole Body …….. 5 rem
Lens-of-the-Eye …… 15 rem
Extremity …… 50 rem

B. Collective Radiation Dose: (person-rem)

Year	External Dose (EDE)	Total Effective Dose (TEDE)
1992	132	136
1993	142	169
1994	178	183
1995	235	236
1996	189	197
1997	182	203
1998	158	168
1999	128	131
2000(ytd)	31	31

C. Individual Data:

(1) Maximum Individual Dose Received: (rem)

Year	Whole Body (EDE)	Neutron	Extremity
1994	1.743	1.515	na
1995	1.949	1.705	na
1996	1.954	1.465	na
1997	1.794	1.374	35.230
1998	1.846	1.370	28.100
1999	1.910	1.451	6.888
2000(ytd)	0.643	0.423	3.326

(2) Average Individual Non-Zero Dose Received (whole body external):

Year	Average Individual non-zero dose (rem)
1994	0.075
1995	0.088
1996	0.091
1997	0.074
1998	0.085
1999	0.091
2000(ytd)	0.051

D. Number of Personnel in Dose Categories: External (EDE)

Dose Category (rem)	1996	1997	1998	1999	2000(ytd)
Zero	9106	11171	9158	9632	7527
0.001-0.010	616	863	485	478	165
0.011-0.025	518	698	602	326	156
0.026-0.050	239	327	220	173	115
0.051-0.075	108	123	103	96	52
0.076-0.100	72	79	71	62	38
0.101-0.250	248	201	194	159	59
0.251-0.500	93	102	95	76	16
0.501-0.750	52	43	31	26	2
0.751-1.000	14	26	19	16	0
1.001-2.000	21	18	19	15	0
2.001-3.000	0	0	0	0	0
3.001-4.000	0	0	0	0	0
4.001-5.000	0	0	0	0	0
> 5.000	0	0	0	0	0
Number Monitored	11087	13651	10997	11059	8130

3.0 PERSONNEL CONTAMINATIONS (DOE Order 232.1A criteria)

A. Number of skin contaminations:

1993 = 32
1994 = 42
1995 = 40
1996 = 43
1997 = 25
1998 = 25
1999 = 31
2000 = 10 (ytd)

B. Number of personal clothing contaminations:

1993 = 22
1994 = 28
1995 = 16
1996 = 21
1997 = 15
1998 = 10
1999 = 9
2000 = 2 (ytd)

4.0 OCCURRENCES/INCIDENTS

A. Number of DOE Order 232.1A reports filed relating to radiation protection and their classifications:

Year (CY)	Number of Reports (DOE Order 232.1 All	Number of Reports Related to Radiation Protection	Personnel Contamination Reports
1994	265	88	45
1995	253	87	46
1996	243	102	61
1997	178	70	44
1998	233	97	38
1999	197	74	41
2000(ytd)	32	15	15

B. Number of radiological incidents reported through the internal LANL RIR system:

Year (CY)	Number of Radiation Incident Reports (RIR)
1993	451
1994	496
1995	549
1996	447
1997	452
1998	530
1999	551
2000(ytd)	143

5.0 SUMMARY

No significant trends or problems have been noted through the first quarter of calendar year 2000.

6.0 UC PERFORMANCE MEASURES (Appendix F)

Radiation Protection of Workers

A. Groups with “apriori” ALARA goals > 5 person-rem YTD

1. Number of groups > 5 person-rem = 2
2. Number of groups within +/-20% of goal = 0

B. Groups with “apriori” ALARA goals < 5 person-rem YTD

1. Number of groups < 5 person-rem = 14
2. Number of groups within +/-1 person-rem = 13

C. Current performance criteria gradient = na

TABLE OF CONTENTS

FIGURES

I. Introduction and Purpose

Part of the process of maintaining radiation exposures as low as reasonably achievable (ALARA) includes monitoring ALARA program objectives. The 10CFR835 Implementation Guide stipulates a quarterly and yearly review of the radiological protection program, and it is for assistance in that purpose that this report is generated. In addition, the University of California (UC) contract, under which the UC operates LANL, requires that "Occupational external and tritium radiation exposures are managed to assure that individual doses do not exceed specified limits. An effective ALARA program is in place to manage dose." This report is a tool used in the tracking and review stages of the performance measures.

II. Scope

This report includes information from all radiological operations at the Laboratory involving radioactive sources, radioactive materials and machine-generated *ionizing* radiation. This report does not consider nonionizing radiation, environmental radiation, or consumer product radiation. It also does not apply to Laboratory radiological operations at the Nevada Test Site or to other Laboratory radiological operations remote to the Los Alamos area.

III. Definitions

The following terms have special meaning for this report.

Facility—a building, an area within a building, or a group of buildings that constitutes a logical unit for performance goal determination.

Organization—the entire Los Alamos National Laboratory or any management subunit (team/section, group, division).

Performance goal—a value chosen for a performance indicator (see definition below) to provide a target for improving the radiation protection program. The value, challenging but achievable, is based on historical experience, activities expected to be performed during the goal period, and professional judgment.

Performance indicator—a measurable parameter that may be used to suggest the condition of, or trend in, the radiation protection program. Performance indicators are divided into two groups: organizational and facility indicators. *Organizational* indicators are concerned with personnel exposures, while *facility* indicators are concerned with radiological conditions within buildings.

Radiation worker - an individual receiving an effective dose equivalent (EDE) of greater than 100 mrem during the calendar year.

IV. Performance Indicators

The ALARA performance goals and performance indicators shown below are taken from the *Radiological Performance Goals Program*, Laboratory Standard LS107-05.0, which was developed to address Article 133 – Radiological Performance Reports of the DOE Radiological Control manual. Since then LS107-05.0 has been replaced by LIR407-702 ALARA, which only addresses ALARA goals, but not performance reports. These indicators were selected because they were in keeping with using the fewest number of indicators to provide useful information to management and to trigger improvement. The *10CFR835* Implementation Guide cautions facilities to "select meaningful and measurable performance indicators."

Organizational ALARA Goals (Exposure Control)

1. effective dose equivalent (whole-body dose)
2. average worker effective dose equivalent (whole body)
3. maximum worker effective dose equivalent
4. maximum neutron dose to a worker
5. maximum extremity dose to a worker

Facility Radiological Performance Indicators

6. number of DOE order 232.1, radiological occurrences
7. number of skin contaminations
8. number of personal clothing contaminations
9. number of nasal contaminations
10. number of airborne monitor alarms (CAM)
11. number of area contaminations

V. Radiological Control Performance Indicators Presentations

EXPOSURE CONTROL

Number	Performance Indicator
1	Effective Dose Equivalent (EDE) - Whole Body
2	Average Worker Non-Zero Dose - Whole Body
3	Maximum Dose to a Worker - Whole Body
4	Maximum Neutron Dose to a Worker
5	Maximum Extremity Dose to a Worker

PI Number 1 Exposure Control - Effective Dose Equivalent

Performance Indicator Definition

The collective effective dose equivalent (whole body) for monitored individuals in each organization. The deep and neutron dose is measured by the primary dosimeter, i.e., thermoluminescent dosimeter (TLD). The tritium whole body dose is assessed through urinalysis and calculation. The collective effective dose equivalent is reported in units of person-rem.

Performance Indicator Purpose

The purpose of this indicator is to measure the effectiveness of organizational radiological control programs in maintaining collective site personnel external effective dose equivalents below a pre-selected annual goal and as low as reasonably achievable (ALARA).

Comments

The monthly collective external effective dose equivalent will be plotted in order to discern trends. Totals for previous years will be compared to the current year's cumulative dose to evaluate performance.

Summary

NMT-2 is the group with the highest dose through the first quarter of CY2000. This group's radiation exposure is at TA-55, the Plutonium Processing and Handling Facility. Appendix F of the UC contract requires groups to be within plus or minus 20%, or plus or minus 1 person-rem of their projected goal by the end of calendar year 2000 (see section 6 of Management Summary).

The chart below details the dose history at LANL from 1989. Figure 3 illustrates the monthly breakdown for cumulative external dose since 1994. Figure 4 provides more group details, but includes only the top twenty groups that account for over 90% of the Laboratory's total dose.

Year	Cumulative EDE Dose (person-rem)	TEDE (person-rem)
1989	327	352
1990	229	245
1991	163	229
1992	132	136
1993	142	169
1994	178	183
1995	235	236
1996	189	197
1997	182	203
1998	158	168
1999	128	131
2000	31	31

FIGURE 1
Effective Dose Equivalent – Yearly (person-rem)

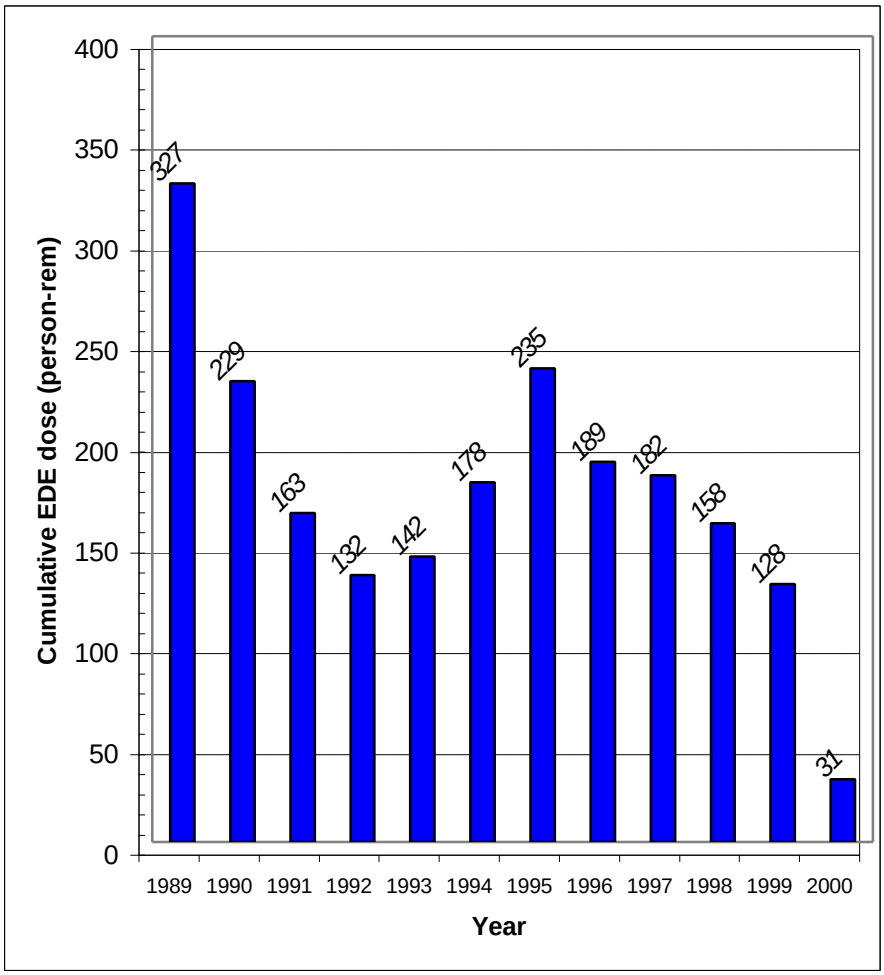


FIGURE 2
Total Effective Dose Equivalent (person-rem)

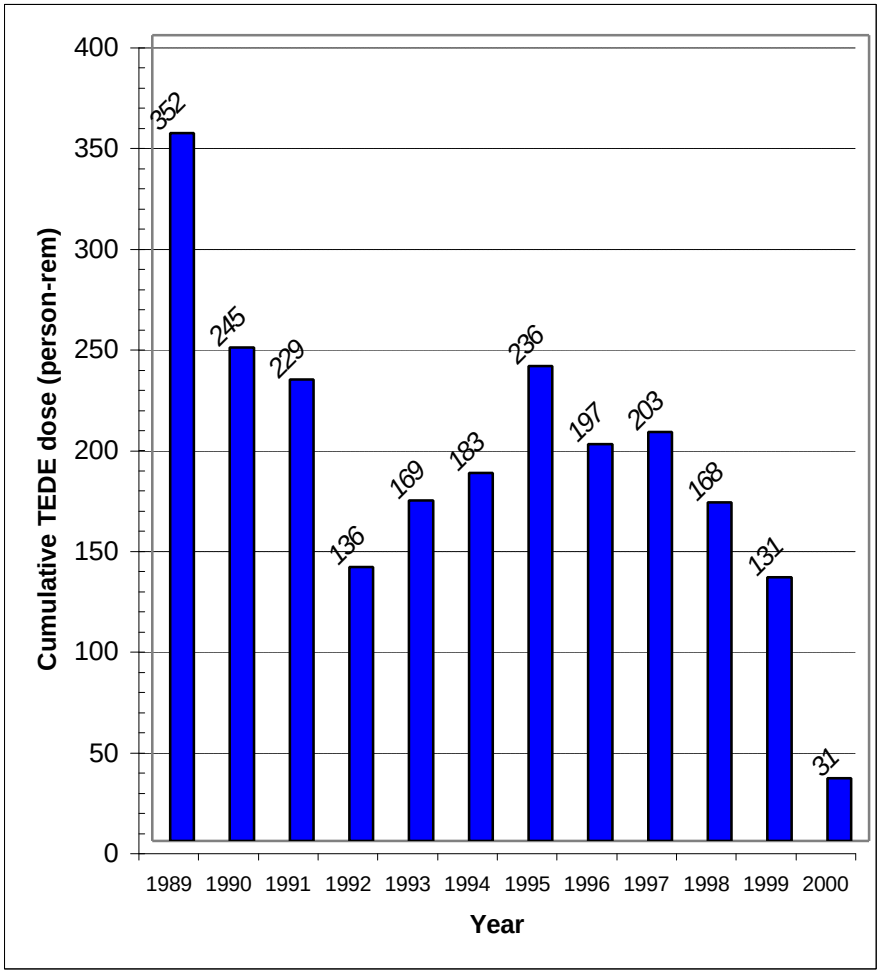


FIGURE 3
Effective Dose Equivalent
Cumulative Exposures
(person-rem)

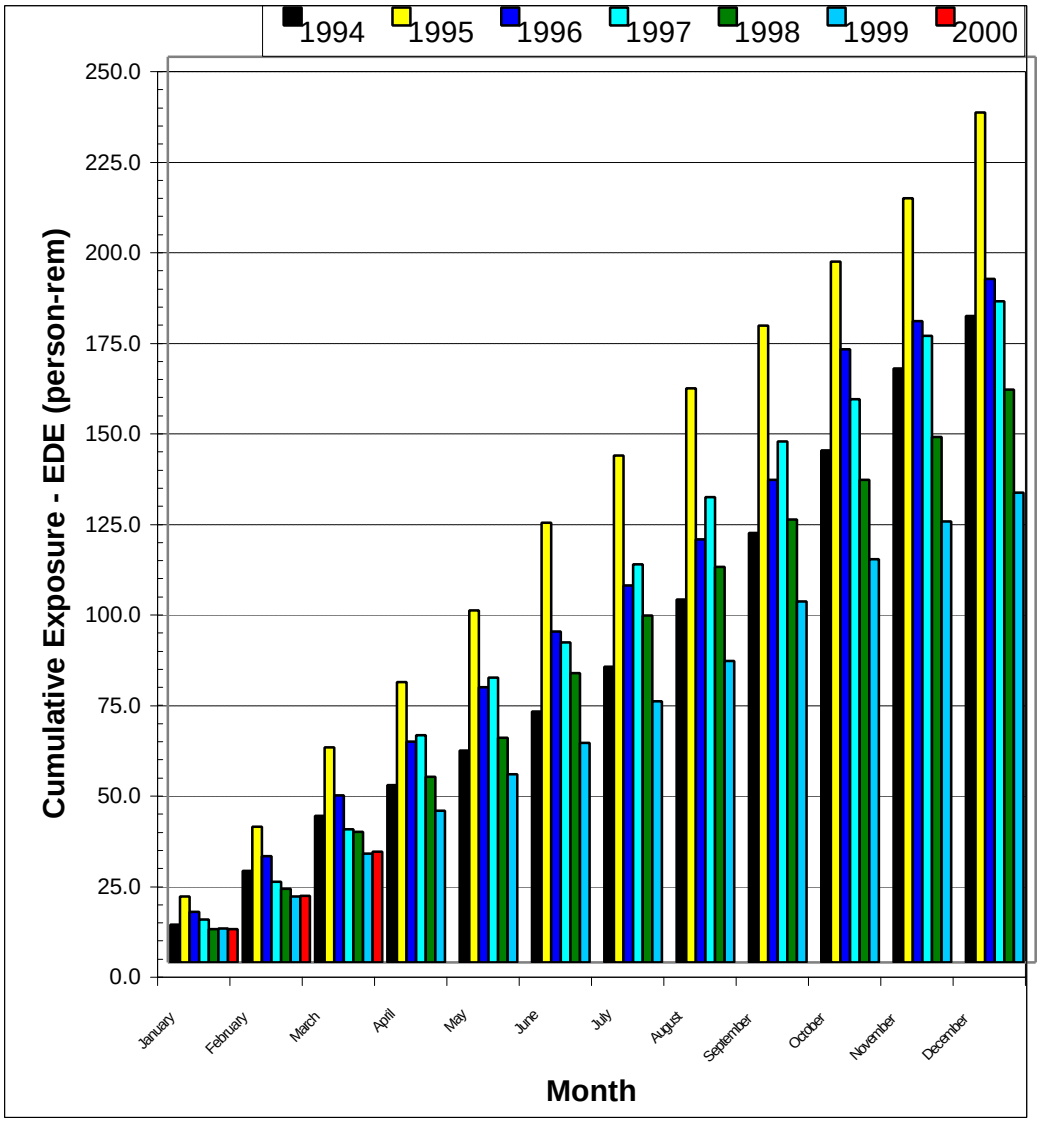


FIGURE 4
Top Twenty Groups (EDE) during CY 1999
Los Alamos National Laboratory
(person-rem)

NMT-2	5.859
NMT-9	5.381
JCNNM	4.313
ESH-1	2.983
NMT-4	2.265
NMT-5	2.205
NMT-15	1.428
NMT-7	1.191
NMT-11	0.497
NMT-1	0.474
ESA-MT	0.419
NMT-16	0.331
LANSCE-7	0.299
CST-11	0.225
NIS-6	0.224
FWO-SWO	0.185
NMT-8	0.183
ESA-WMM	0.174
ESH-4	0.152
MST-6	0.145

PI Number 2 Exposure Control - Average Worker Non-Zero Dose

Performance Indicator Definition

The average worker non-zero external (deep + neutron) effective dose equivalent (whole body) for each organization. This dose is measured by the primary dosimeter, i.e. thermoluminescent dosimeter (TLD) for deep and neutron. This dose is reported in units of mrem. The average is to be obtained by dividing the total exposure for each evaluation period by the number of individuals at LANL who have non-zero exposures.

Performance Indicator Purpose

The purpose of this indicator is to measure the effectiveness of organizational radiological control programs in maintaining average worker external effective dose equivalents below a pre-selected annual goal and as low as reasonably achievable (ALARA).

Comments

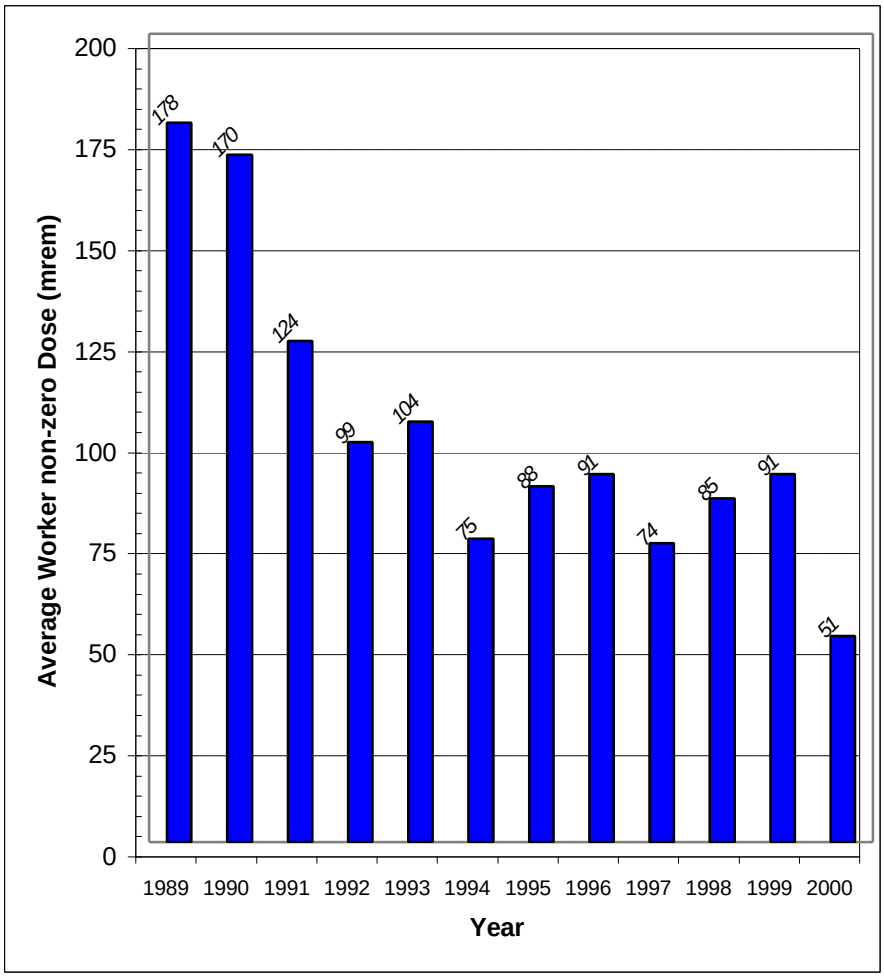
Each year the average worker non-zero dose - whole body will be plotted. The previous year's dose is also shown in an effort to determine trends.

Summary

This performance indicator can be used as a crudely simplistic method of normalizing dose. Normally an increase in cumulative dose would go hand-in-hand with an increase in the number of workers, thereby the average worker dose would remain constant. An increase in the average worker dose would indicate that the radiation worker is receiving more of the external dose. As can be seen in figure 5, the overall trend since 1994 has been a steady one and has seen a dramatic reduction from 1989.

Average Worker (mrem)		
Year	Non-zero Dose	# Non-Zero
1989	178	1837
1990	170	1382
1991	124	1314
1992	99	1333
1993	104	1365
1994	75	2397
1995	88	2507
1996	91	1981
1997	74	2480
1998	85	1839
1999	91	1427
2000	51	603

FIGURE 5
Average Worker non-zero Dose Effective Dose Equivalent (mrem)



PI Number 3 Exposure Control - Maximum Effective Dose Equivalent to a Worker

Performance Indicator Definition

The maximum effective dose equivalent (whole body) to a worker in each month. This dose is measured by the primary dosimeter, i.e., thermoluminescent dosimeter (TLD) for deep and neutron. This dose is reported in units of mrem.

Performance Indicator Purpose

The purpose of this indicator is to measure the effectiveness of organizational radiological control programs in maintaining the maximum effective dose equivalent (whole body dose) to a worker below a pre-selected annual administrative control level and as low as reasonably achievable (ALARA).

Comments

The maximum whole body dose to a worker (cumulative) will be plotted for the year. Data from previous years will be included for comparison.

Summary

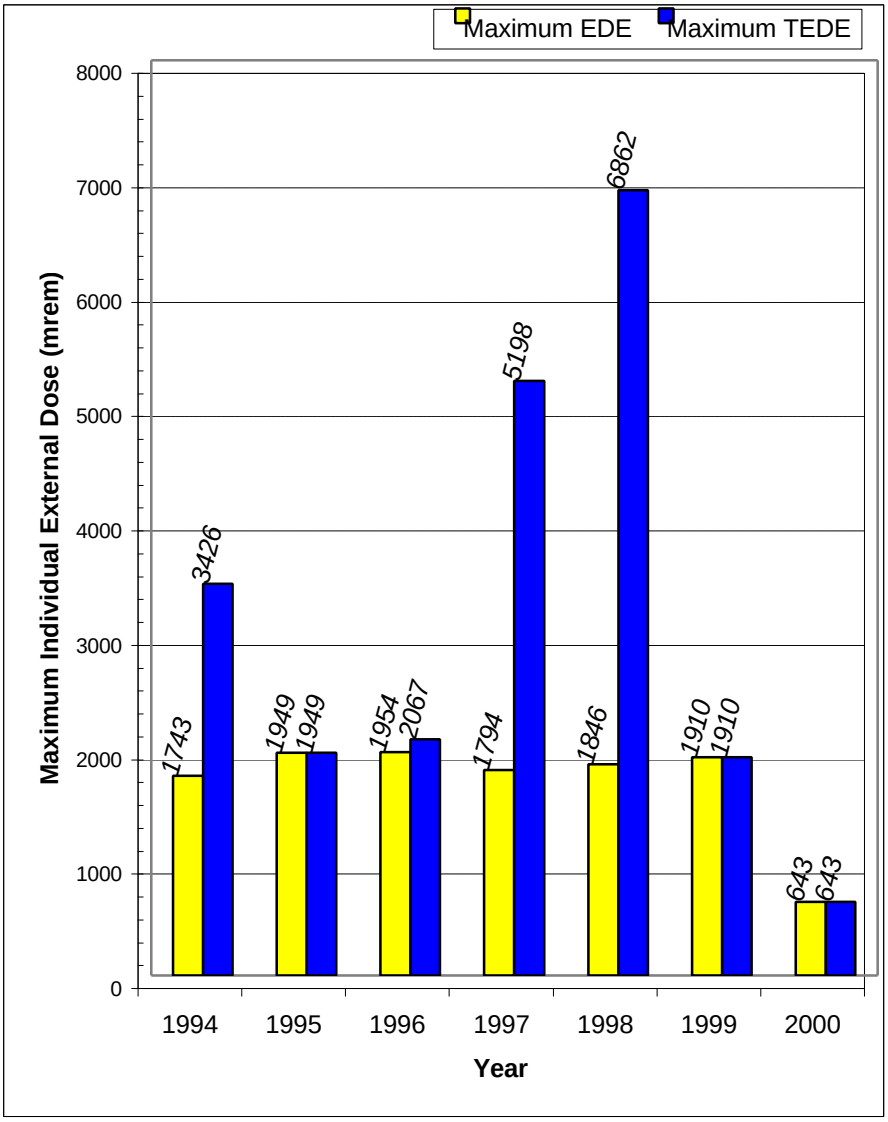
The maximum confirmed effective dose to a worker through the first quarter of CY2000 was 643 mrem. The highest external dose in the past five years was 1954 mrem, and it was recorded in 1996.

During the past six years no individual has exceeded 2000 mrem (EDE). The majority of external dose exposure is found at TA-55, the plutonium processing and handling facility.

The legal limit (10CFR835) for whole body dose (TEDE) is set at 5000 mrem. The maximum dose received at LANL in the past four years was 6862 mrem recorded in 1998.

Year	EDE Dose(mrem)	TEDE Dose(mrem)
1994	1743	3426
1995	1949	1949
1996	1954	2067
1997	1794	5198
1998	1846	6862
1999	1910	1910
2000	643	643

FIGURE 6
Maximum Effective Dose Equivalent to a Worker (mrem)



PI Number 4 Exposure Control - Maximum Neutron Dose to a Worker

Performance Indicator Definition

The maximum external effective dose equivalent from neutrons to a worker in each organization as measured by the primary dosimeter, i.e., thermoluminescent dosimeter (TLD). This dose equivalent is reported in units of mrem.

Performance Indicator Purpose

The purpose of this indicator is to measure the effectiveness of organizational radiological control programs in maintaining the maximum external effective dose equivalent from neutrons to a worker below a pre-selected annual goal and as low as reasonably achievable (ALARA).

Comments

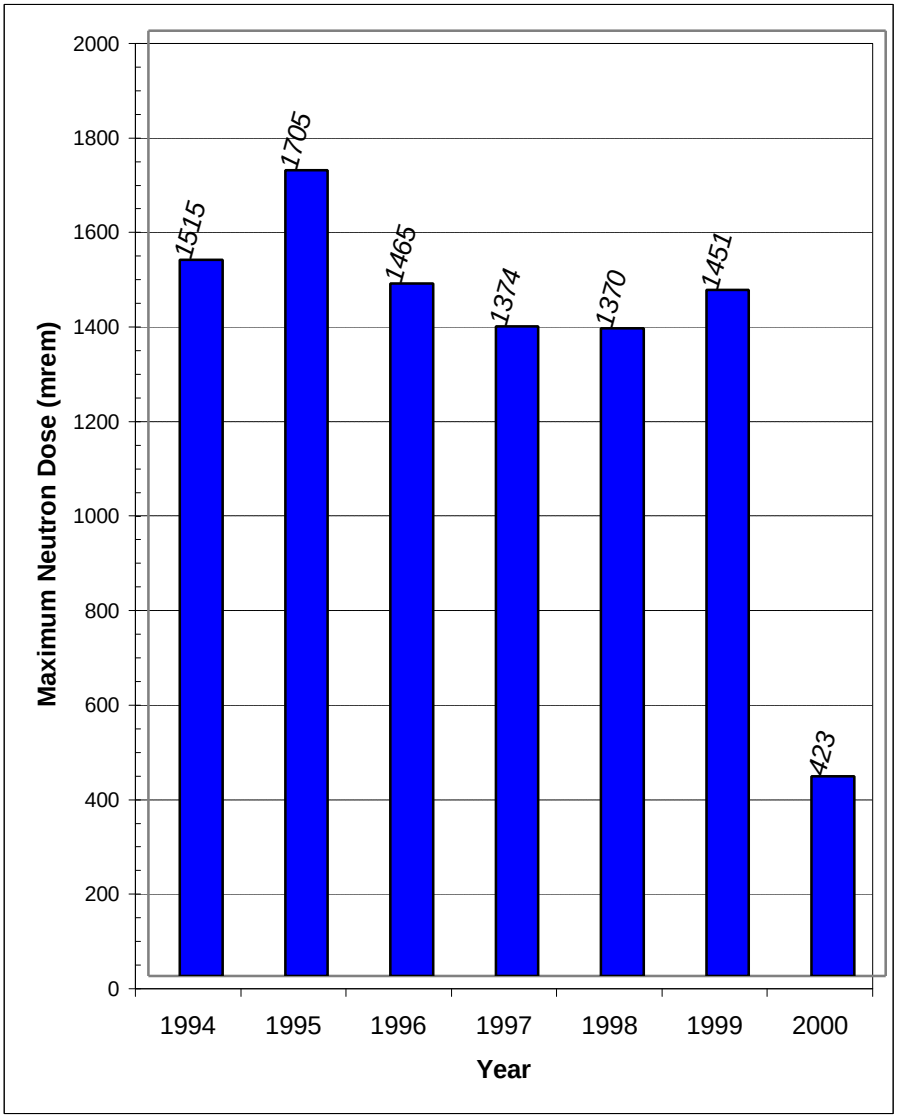
The maximum neutron dose to a worker will be plotted for the current calendar year and compared to previous years.

Summary

The maximum neutron dose to a worker through the first quarter of CY2000 was 423 mrem. The highest neutron dose in the past five years was 1705 mrem, and was recorded in 1995.

Year	Dose(mrem)	Location
1994	1515	TA-55
1995	1705	TA-55
1996	1465	TA-55
1997	1374	TA-55
1998	1370	TA-55
1999	1451	TA-55
2000	423	TA-55

FIGURE 7
Maximum Neutron Dose to a Worker (mrem)



PI Number 5 Exposure Control – Maximum Extremity Dose to a Worker

Performance Indicator Definition

The maximum extremity dose to a worker as measured by secondary dosimetry; finger rings, wrist bands. This dose equivalent is reported in units of mrem.

Performance Indicator Purpose

The purpose of this indicator is to measure the effectiveness of organizational radiological control programs in maintaining extremity doses as low as reasonably achievable (ALARA).

Comments

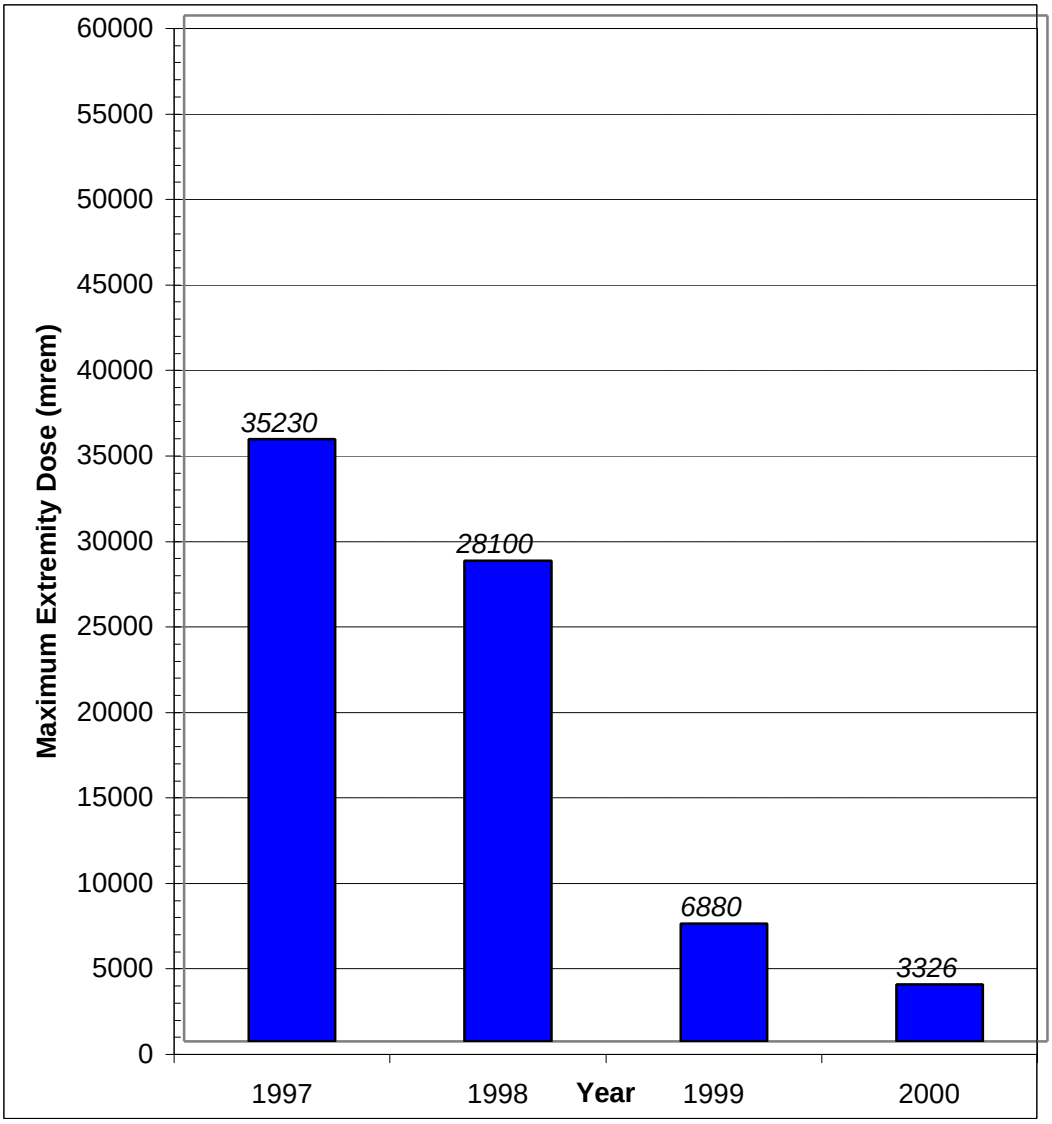
The maximum extremity dose to a worker will be plotted for the current calendar year and compared to previous years. This indicator has only been tracked since CY1997.

Summary

The maximum extremity dose to a worker through the first quarter of CY2000 was 3,326 mrem.

Year	Dose(mrem)	Location
1997	35230	TA-55
1998	28100	TA-55
1999	6880	TA-55
2000	3326	TA-55

FIGURE 8
Maximum Extremity Dose to a Worker (mrem)



RADIOLOGICAL PERFORMANCE INDICATORS

Number	Performance Indicator
6	Number of DOE Order 232.1, Radiological Occurrences (personnel)
7	Number of Skin Contaminations
8	Number of Personal Clothing Contaminations
9	Number of Nasal Contaminations
10	Number of Continuous Airborne Monitor Alarms (CAM)
11	Number of Area Contaminations

PI Number 6 Radiological Performance Indicators - Number of DOE Order 232.1, Radiological Occurrences (personnel)

Performance Indicator Definition

The number of DOE Order 232.1 radiological occurrences of a personal contamination nature. These occurrences are skin contaminations, nasal contaminations and personal clothing contaminations.

Performance Indicator Purpose

The purpose of this indicator is to monitor the performance of the radiological protection program, other than dosimetry. Such as personal protective equipment (PPE), engineered designs, ventilation, etc.

Comments

To display the values for this performance indicator (and all others), they are divided into four categories: the two main radiological facilities {the plutonium processing and handling facility (TA-55) and the chemistry and metallurgy research facility (CMR)}; the remaining occurrences at the other LANL facilities; and the total LANL occurrences. The values reported are the number of occurrence reports, and may not reflect the number of individuals contaminated. Performance Indicators 7, 8 and 9 will reflect numbers of individuals involved in personnel contaminations on the following pages.

Summary

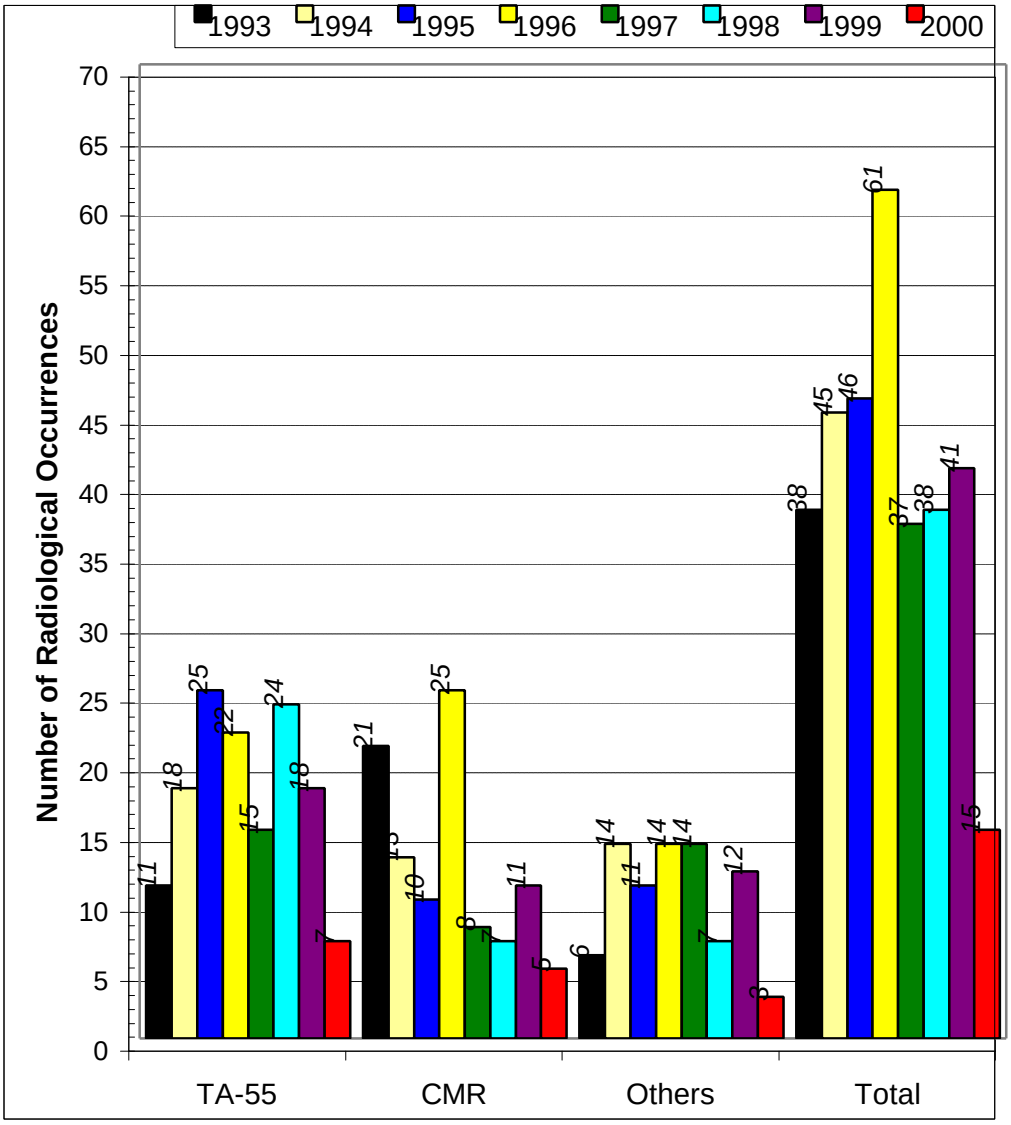
The number of radiological occurrences has remained steady with a peak year in 1996.

	Number of Occurrences			
Year	TA-55	CMR	Others	Total
1993	11	21	6	38
1994	18	13	14	45
1995	25	10	11	46
1996	22	25	14	61
1997	15	8	14	37
1998	24	7	7	38
1999	18	11	12	41
2000	7	5	3	15

Normalization

The ratio of radiation workers to occurrences (number of rad workers : number of occurrences) was 8.6 in 1994 (i.e., there was one occurrence for every 8.6 rad workers), 8.9 in 1995, 7.4 in 1996, 10.5 in 1997, 9.6 in 1998, 7.1 in 1999, and 5.1 through the first quarter of CY2000.

FIGURE 9
Number of DOE Order 232.1
Radiological Occurrences (personnel related)



PI Number 7 Radiological Performance Indicators - Number of Skin Contaminations

Performance Indicator Definition

The number of skin contaminations for all personnel (including visitors and contractors) in each organization for which the levels exceeded DOE Order 232.1 reporting levels.

Performance Indicator Purpose

The purpose of this indicator is to measure the effectiveness of engineered controls and worker performance to contain contamination at the source.

Comments

The number of skin contaminations will be plotted for the year. The totals for previous years will be displayed for trending and comparison.

Summary

The number of skin contaminations has remained steady in all areas at LANL, a trend that continued through 1999.

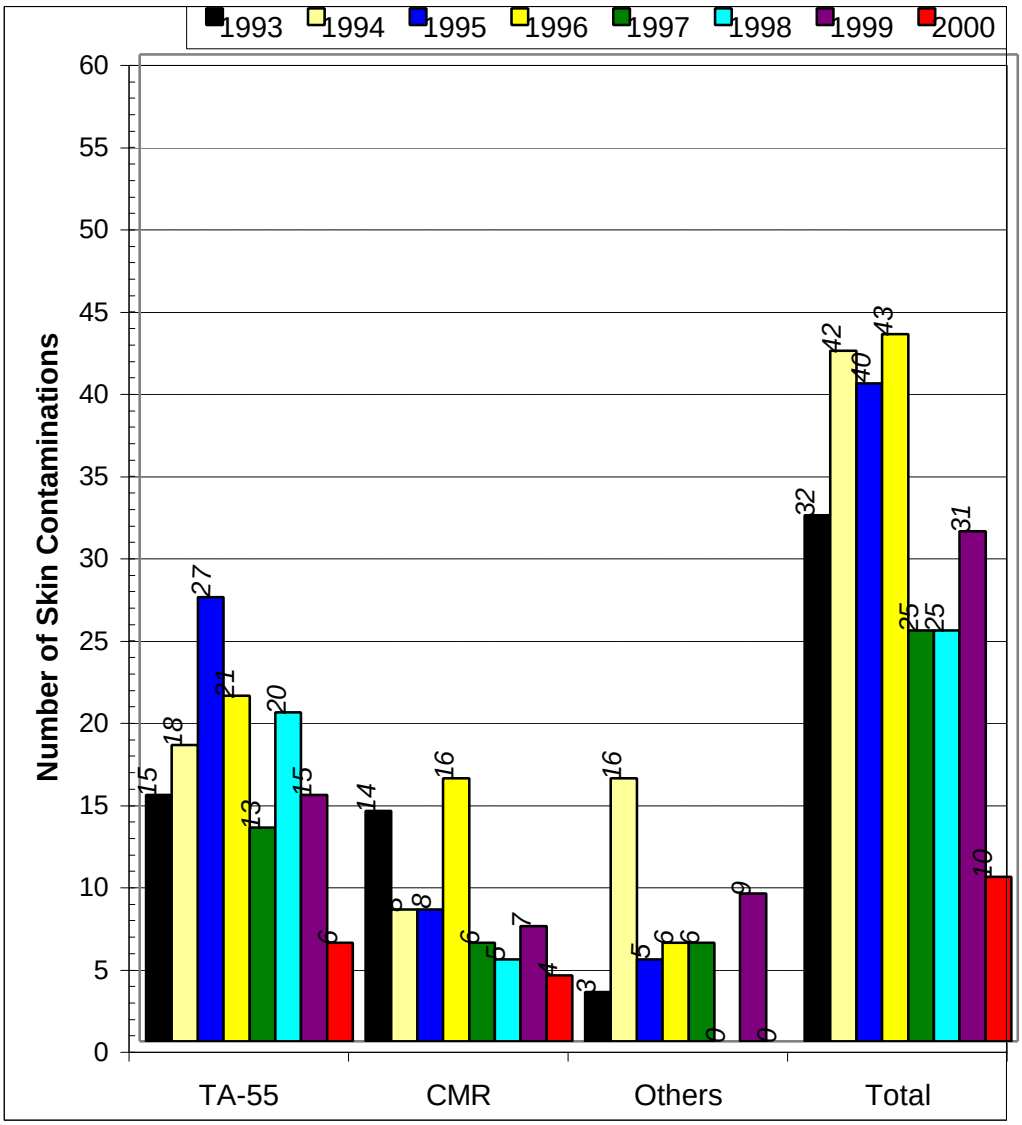
Number of Skin Contaminations Occurrences

Year	TA-55	CMR	Others	Total
1993	15	14	3	32
1994	18	8	16	42
1995	27	8	5	40
1996	21	16	6	43
1997	13	6	6	25
1998	20	5	0	25
1999	15	7	9	31
2000	6	4	0	10

Normalization

The ratio of radiation workers to skin contaminations (number of rad workers : number of skin contaminations) was 9.2 in 1994 (i.e., there was one skin contamination for every 9.2 rad workers), 10.2 in 1995, 10.5 in 1996, 15.6 in 1997, 14.6 in 1998, 9.4 in 1999, and 7.7 through the first quarter of CY2000.

FIGURE 10
Number of Skin Contamination Occurrences



PI Number 8 Radiological Performance Indicators - Number of Personal Clothing Contaminations

Performance Indicator Definition

The number of personal clothing contaminations for all personnel (including visitors and contractors) in each organization for which the levels exceeded DOE Order 232.1 reporting levels.

Performance Indicator Purpose

The purpose of this indicator is to measure the effectiveness of engineered controls and worker performance to contain contamination at the source.

Comments

The number of personal clothing contaminations will be plotted for the year. The totals for previous years will be displayed for comparison.

Summary

The total number of personal clothing contaminations has remained steady, although CMR values show a slight increase in contaminations for 1996 when compared to the previous two years. For 1997 and through 1999, the number of contaminations at CMR returned to a lower level.

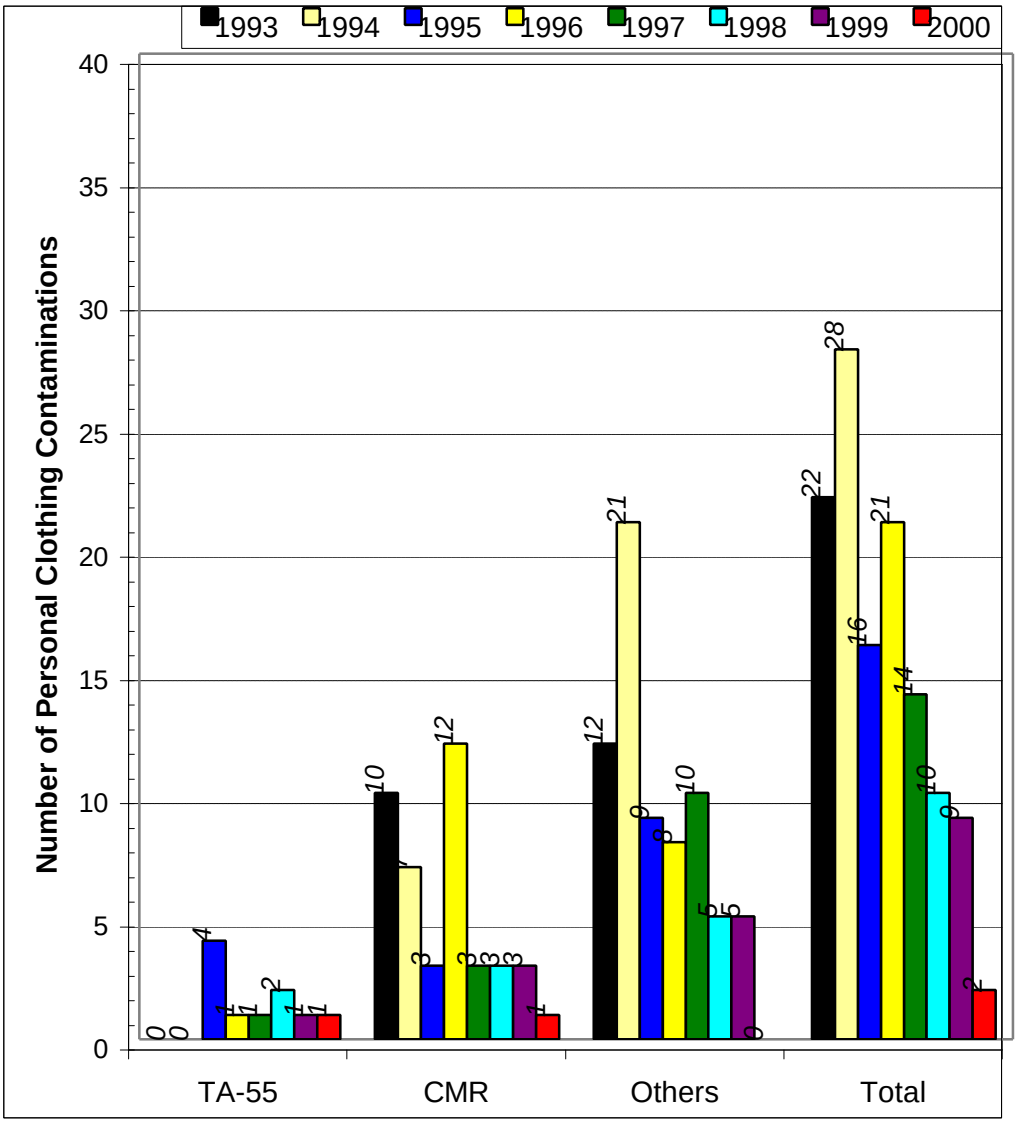
Number of Personal Clothing Contamination Occurrences

Year	TA-55	CMR	Others	Total
1993	0	10	12	22
1994	0	7	21	28
1995	4	3	9	16
1996	1	12	8	21
1997	1	3	10	14
1998	2	3	5	10
1999	1	3	5	9
2000	1	1	0	2

Normalization

The ratio of radiation workers to personal clothing contaminations (number of rad workers : number of contaminations) was 13.8 in 1994 (i.e., there was one personal clothing contamination for every 13.8 rad workers), 25.6 in 1995, 21.4 in 1996, 27.8 in 1997, 36.5 in 1998, 32.4 in 1999, and 38.5 through the first quarter of CY2000. This illustrates a decreasing “normalized” trend in personal clothing contaminations.

FIGURE 11
Number of Personal Clothing Contaminations



PI Number 9 Radiological Performance Indicators - Number of Nasal Contaminations

Performance Indicator Definition

The number of positive nasal contaminations for all personnel (including visitors and contractors) in each organization for which the contamination exceeded DOE Order 232.1 reporting levels.

Performance Indicator Purpose

The purpose of this indicator is to measure the effectiveness of engineered controls and worker performance to contain contamination at the source.

Comments

The number of nasal contaminations for all personnel will be plotted for the current year. Data from previous years (totals) will be included for comparison.

Summary

Any statistical evaluation would be extremely suspect due to the limited number of data points and the purely random nature of the data. No significant trends can be determined.

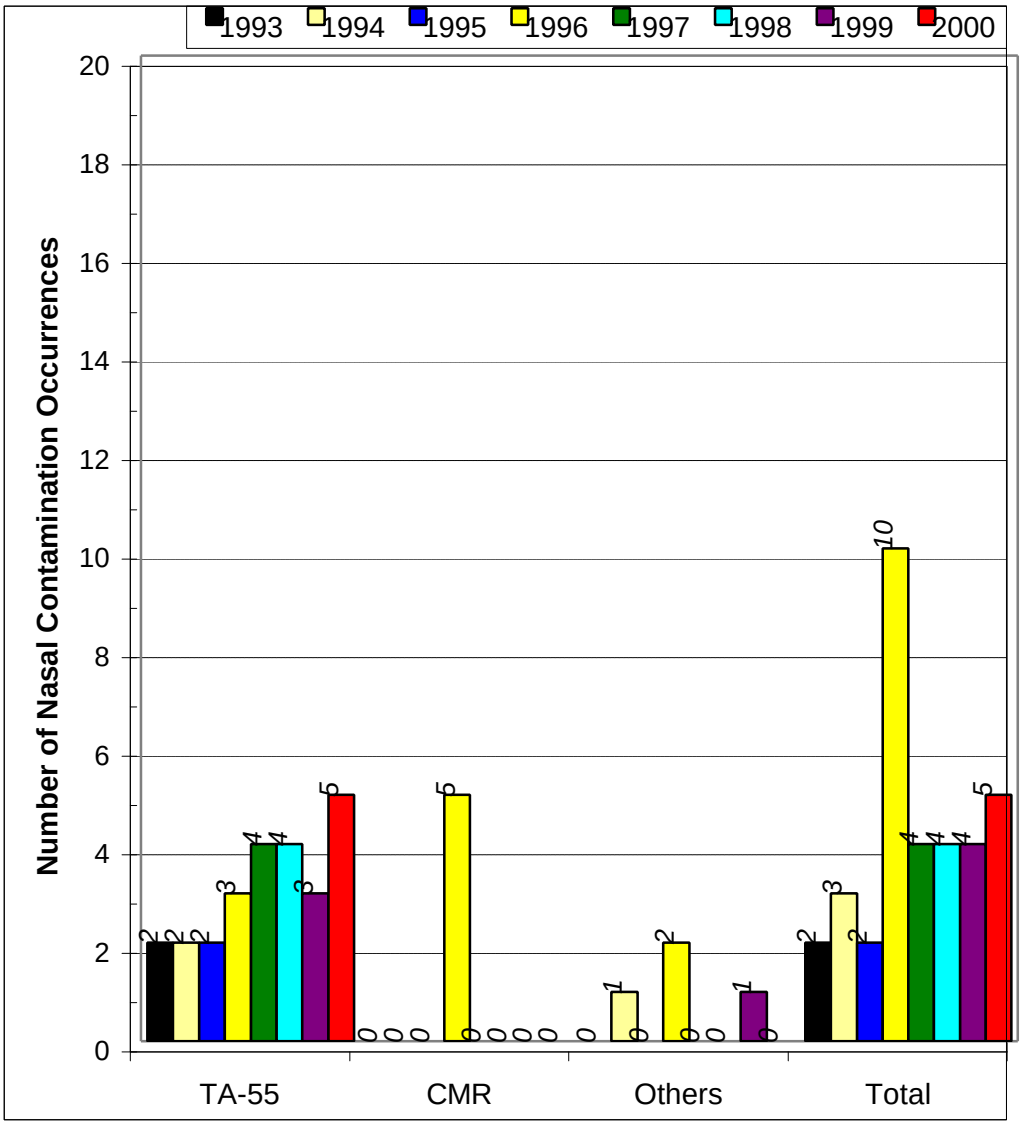
Number of Nasal Contamination Occurrences

Year	TA-55	CMR	Others	Total
1993	2	0	0	2
1994	2	0	1	3
1995	2	0	0	2
1996	3	5	2	10
1997	4	0	0	4
1998	4	0	0	4
1999	3	0	1	4
2000	5	0	0	5

Normalization

Due to the statistically small numbers involved with this performance indicator, no normalization has been attempted.

FIGURE 12
Number of Positive Nasal Contaminations



PI Number 10 Radiological Performance Indicators - Number of Continuous Airborne Monitor Alarms

Performance Indicator Definition

The number of true continuous airborne monitor (CAM) alarms for the Laboratory that were reported in accordance with DOE Order 232.1 criteria. True alarms are defined as those alarms that are initiated by the presence of radioactivity on the monitor filter as confirmed by analysis.

Performance Indicator Purpose

The purpose of this indicator is to measure the effectiveness of facility airborne radioactivity monitoring programs as well as the effectiveness of facility airborne contamination control programs.

Comments

The cumulative number of CAM alarms will be plotted for the current year. Data from previous years will be included for comparison.

Summary

Due to the small numbers involved with this performance indicator no significant trends can be determined.

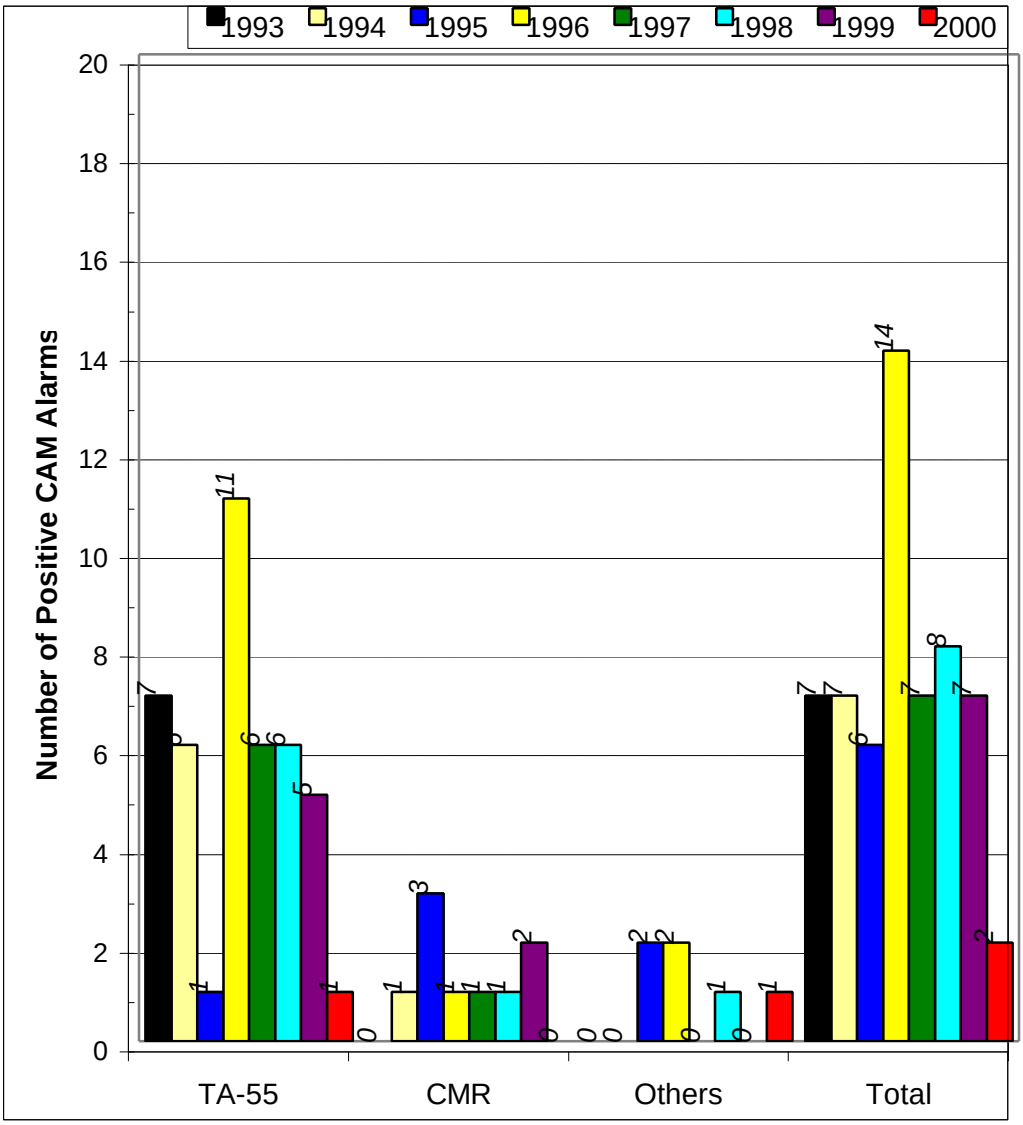
Number of CAM Alarm Occurrences

Year	TA-55	CMR	Others	Total
1993	7	0	0	7
1994	6	1	0	7
1995	1	3	2	6
1996	11	1	2	14
1997	6	1	0	7
1998	6	1	1	8
1999	5	2	0	7
2000	1	0	1	2

Normalization

Any normalization should be viewed with caution due to the insignificant number of occurrences. The ratio of radiation workers to true CAM's (number of rad workers : number of CAM's) was 55.0 in 1994 (i.e., there was one CAM alarm for every 55 rad workers), 68.3 in 1995, 32.1 in 1996, 55.7 in 1997, 45.6 in 1998, 41.7 in 1999, and 38.5 through the first quarter of CY2000.

FIGURE 13
Number of Continuous Airborne Monitor Alarms (CAM)



PI Number 11 Radiological Performance Indicators - Number of Area Contaminations

Performance Indicator Definition

The number of area contaminations within the Laboratory boundaries that were reported in accordance with DOE Order 232.1 criteria.

Performance Indicator Purpose

The purpose of this indicator is to measure the effectiveness of engineered controls and worker performance to contain contamination at the source.

Comments

The number of area contaminations will be plotted in comparison to previous years. The specific locations of these contaminations are listed on the reports. The majority of area contaminations are low level, and can be immediately decontaminated and placed back into operation. No determination has been made as to whether these occurrences were inside or outside of a radiologically controlled area, only that the contamination qualified for the DOE O232.1 criteria. This normally means contaminations outside a radiologically controlled area or unanticipated contamination within a radiologically controlled area.

Summary

The number of area contaminations has decreased during the past seven years .

Number of Area Contamination Occurrences

Year	TA-55	CMR	Others	Total
1993	20	23	39	82
1994	10	7	42	59
1995	9	9	30	48
1996	4	13	14	31
1997	4	6	17	27
1998	5	8	16	29
1999	6	4	12	22
2000	0	1	0	1

Normalization

The ratio of radiation workers to area contaminations (number of rad workers : number of area contaminations) was 6.5 in 1994 (i.e., there was one area contamination for every 6.5 rad workers), 8.5 in 1995, 14.5 in 1996, 14.4 in 1997, 12.6 in 1998, 13.3 in 1999, and 77.0 through the first quarter of CY2000. This illustrates a definite decreasing trend in the normalized rate of area contaminations.

FIGURE 14
Number of Area Contaminations