OFFICE FOR

NUREG-1272
VOL. 6, NO. 2

ANALYSIS AND EVALUATION OF OPERATIONAL DATA

1991 ANNUAL REPORT

NONREACTORS

U.S. NUCLEAR REGULATORY COMMISSION

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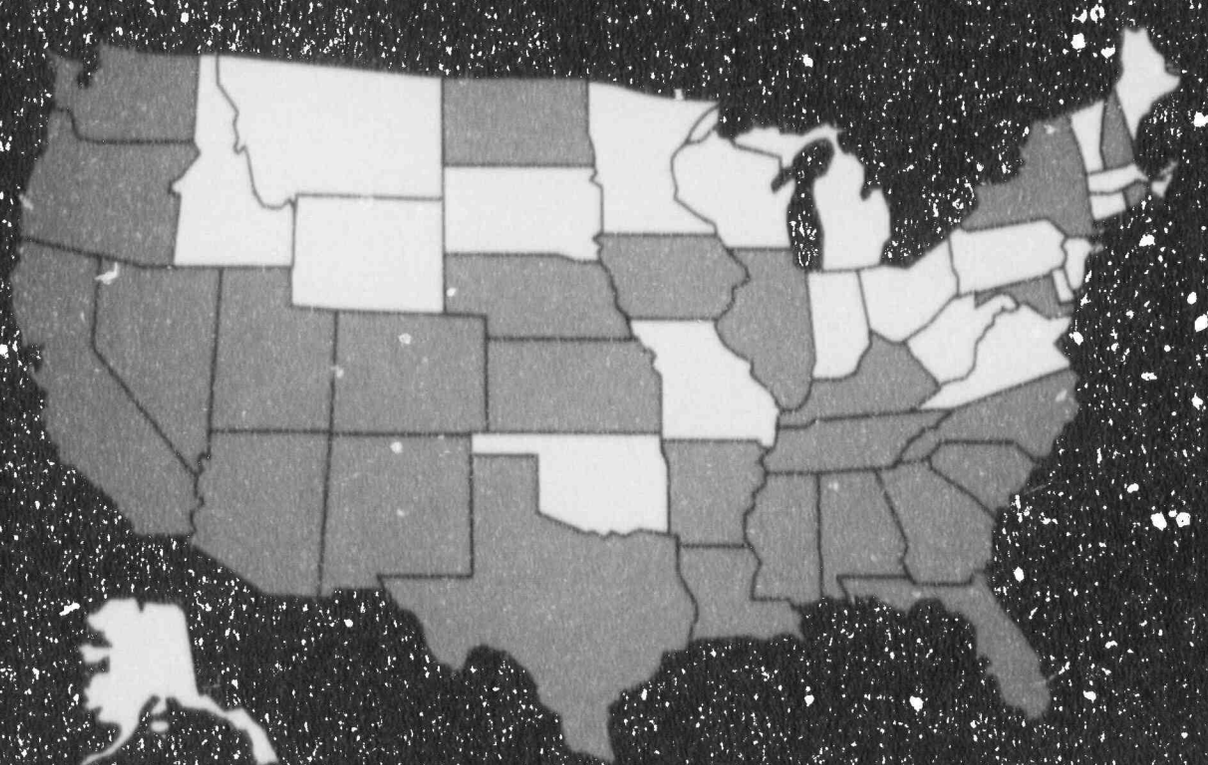

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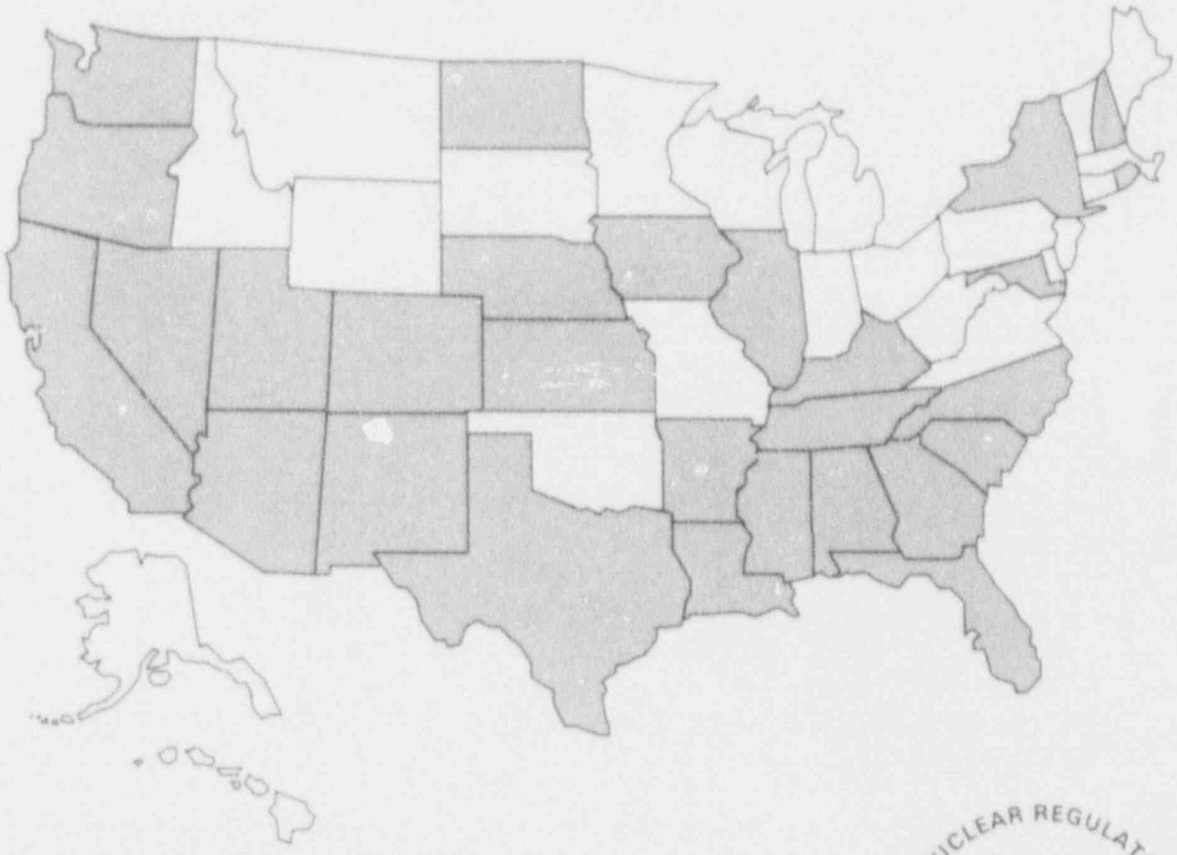

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U.S. NUCLEAR REGULATORY COMMISSION

AUGUST 1992

The map on the cover highlights in white those States for which NRC continues to regulate the use of radioactive material in nonreactor applications. The other States have signed agreements with NRC allowing them to perform this role.

Previous Reports in Series

The following semiannual or annual reports have been prepared by the Office for Analysis and Evaluation of Operational Data (AEOD):

- Semiannual Report, January–June 1984, AEOD/S405, September 1984
- Semiannual Report, July–December 1984, AEOD/S502, April 1985
- Annual Report 1985, AEOD/S601, April 1986
- *Report to the U.S. Nuclear Regulatory Commission on Analysis and Evaluation of Operational Data 1986*, NUREG-1272, AEOD/S701, May 1987
- *Report to the U.S. Nuclear Regulatory Commission on Analysis and Evaluation of Operational Data–1987*, Power Reactors, NUREG-1272, AEOD/S804, Vol. 2, No. 1, October 1988
- *Report to the U.S. Nuclear Regulatory Commission on Analysis and Evaluation of Operational Data–1987*, Nonreactors, NUREG-1272, AEOD/S804, Vol. 2, No. 2, October 1988
- *Office for Analysis and Evaluation of Operational Data 1988 Annual Report, Power Reactors*, NUREG-1272, Vol. 3, No. 1, June 1989
- *Office for Analysis and Evaluation of Operational Data 1988 Annual Report, Nonreactors*, NUREG-1272, Vol. 3, No. 2, June 1989
- *Office for Analysis and Evaluation of Operational Data 1989 Annual Report, Power Reactors*, NUREG-1272, Vol. 4, No. 1, July 1990
- *Office for Analysis and Evaluation of Operational Data 1989 Annual Report, Nonreactors*, NUREG-1272, Vol. 4, No. 2, July 1990
- *Office for Analysis and Evaluation of Operational Data 1990 Annual Report, Power Reactors*, NUREG-1272, Vol. 5, No. 1, July 1991
- *Office for Analysis and Evaluation of Operational Data 1990 Annual Report, Nonreactors*, NUREG-1272, Vol. 5, No. 2, 1991

Abstract

The annual report of the U.S. Nuclear Regulatory Commission's Office for Analysis and Evaluation of Operational Data (AEOD) describes activities this office performed during 1991. The report is published in two separate parts. NUREG-1272, Vol. 6, No. 1, covers power reactors and presents an overview of the operating experience of the nuclear power industry from the NRC perspective, including comments about the trends of some key performance measures. The report also includes the principal findings and issues identified in AEOD studies over the past year and summarizes information from such sources as licensee event reports, diagnostic evaluations, and reports to the NRC's Operations Center. NUREG-1272, Vol. 6, No. 2, covers nonreactors and presents a review of the events and concerns during 1991 associated with the use of licensed material in nonreactor applications, such as personnel overexposures and medical misadministrations. The reports discuss the Incident Investigation Team program and summarize both the Incident Investigation Team and Augmented Inspection Team reports issued during 1991. Each volume contains a list of the AEOD reports issued for 1981 through 1991.

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Abbreviations

ACRS	Advisory Committee for Reactor Safeguards
AEOD	NRC's Office for Analysis and Evaluation of Operational Data
AIT	Augmented Inspection Team
AO	Abnormal Occurrence
CFR	*Code of Federal Regulations*
Ci	curie
DOT	Department of Transportation
DUF_4	depleted uranium tetrafluoride
EDO	NRC's Executive Director for Operations
FMEA	Failure Modes and Effects Analysis
HAZOP	Hazard and Operability Analysis
HEPA	high-efficiency particulate air
HF	hydrofluorination
HOO	Headquarters Operations Officer
IIP	Incident Investigation Program
IIT	Incident Investigation Team
µCi	microcurie
mCi	millicurie
mg	milligram
MORT	Management Oversight and Risk Tree
MPC	maximum permissible concentration
mrem	millirem
NCS	nuclear criticality safety
NDA	nondestructive assay
NMSS	NRC's Office of Nuclear Material Safety and Safeguards
NRC	U.S. Nuclear Regulatory Commission
NRER	Nonreactor Event Report
PIP	performance improvement program
ppm	parts per million
RCEP	Radiological Contingency and Emergency Plan
REAC/TS	Radiation Assistance Center/Training Site
RSO	radiation safety officer
SNM	special nuclear material
SSD	source-to-skin distance
TLD	thermoluminescent dosimeter
UF_6	uranium hexafloride
UNH	uranyl nitrate hexahydrate
UPS	uninterruptible power supply
URU	uranium recycle unit
WWTF	Waste Water Treatment Facility

Executive Summary

One of the activities of the Office for Analysis and Evaluation of Operational Data (AEOD) is the review and evaluation of operating experience of nonreactor programs involving the use of materials licensed by the U.S. Nuclear Regulatory Commission, such as source material, natural and enriched uranium, and byproduct materials. Our review and evaluation identifies safety-significant events and concerns, their causes, and the trends indicated by the events. When we identify a safety concern, the AEOD staff recommends agency actions to resolve the problems underlying the safety concern.

Many of the States have entered into agreements with NRC to manage the use of byproduct materials, natural uranium, and small amounts of enriched uranium or other special nuclear materials. These States, known as Agreement States, oversee the programs run by their licensees. NRC licensees comprise about 30 to 40 percent of the total number of licensees.

Approximately 8000 licensees are authorized by the NRC to possess and use licensed materials outside of reactors. The majority of licensees (about 5500) are authorized to use byproduct materials for such applications as radiography, gauges, and well-logging. Approximately 2200 licensees are authorized to administer byproduct materials or radiation from byproduct materials to individuals for medical diagnosis or therapy. The comparable numbers for the 28 Agreement States are about twice the numbers for NRC-regulated States. Sixteen Agreement States provided data to the NRC in 1991. These States have a population of licensees that is about equal to that of the NRC-regulated States.

The dominant health concern associated with the use of licensed materials is the possible damage that can occur from overexposure to radiation. In 1991, NRC licensees reported 21 nonreactor events in which 26 individuals received exposures that were greater than those permitted by NRC regulations. All of the individuals were employed by a licensee. Most of these overexposures represent exposures that exceed NRC's quarterly regulatory limits by a small amount.

The 16 Agreement States reported 67 overexposures. Of these, 13 individuals were reported to have received exposures of less than 1.85 rem in a single event. Most of the 54 remaining exposures exceeded the quarterly regulatory limits by a small amount. Some of the exposures may be attributable to materials not licensed by the NRC.

The staff estimates that about 7 million diagnostic procedures, 30,000 radiopharmaceutical therapy procedures, and 50,000 brachytherapy procedures are performed annually in the United States. In addition, about 100,000 patients receive cobalt-60 teletherapy treatments each year.* The staff estimates that Agreement State licensees perform about 60 percent of these treatments and that NRC licensees perform the remaining 40 percent.

The NRC received 463 misadministration reports during 1991 from NRC-regulated States, which involved 520 patients. Of these reports, 444 concerned diagnostic misadministrations and 19 concerned therapy misadministrations. In addition to the 19 therapy misadministrations, 2 diagnostic misadministrations of iodine-131 in 1991 involved patients who received thyroid doses of more than 1000 rads each, a dose far in excess of the dose for the diagnostic procedures for which they were scheduled.

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*U.S. Nuclear Regulatory Commission, "10 CFR Part 35, Basic Quality Assurance Program, Records and Reports of Misadministrations or Events Relating to the Medical Use of Byproduct Material," *Federal Register*, Vol. 55, No. 10, January 16, 1990, pp. 1439-1449.

The number of therapy misadministrations reported by the NRC licensees during 1991 was about the same as that in 1990 and about two times the average number reported in 1981 through 1989. The number of diagnostic reports was about the same as that in 1990 and 10 percent higher than the average rate of the 9 previous years. However, despite these increases in the numbers of reportable events, the error rate for all types of misadministrations remained very low.

During 1991, 16 Agreement States submitted reports from 103 licensees to the NRC of 8 therapy and 112 diagnostic misadministrations involving 148 patients. AEOD evaluated misadministration data from Agreement States in 1991 for the first time.

The NRC's Operations Center in Bethesda, Maryland, provides a focal point for NRC communications with Commission licensees, State agencies, and other Federal agencies. Of the 2365 notifications that were reported to the NRC Operations Center in 1991, 138 involved nonpower reactor events. A "Site Area Emergency" was declared as a result of a transportation event, and an "Alert" was declared at a fuel fabrication facility. The remainder of the notifications involved events that did not meet the threshold to be classified as one of four classes of an emergency.

During 1991, an Incident Investigation Team investigated an event at the General Electric Company Nuclear Fuel and Component Manufacturing facility, in Wilmington, North Carolina. An estimated 150 kilograms (320 pounds) of uranium were inadvertently transferred to an unfavorable geometry waste treatment tank. Because of the tank configuration and type and quantity of fissile material available, the potential for a nuclear criticality accident was created. In investigating this event, the team noted shortcomings with respect to the NRC's regulations and regulatory guidance, license and licensing process, and inspection program.

AEOD is in the process of producing a videotape on good practices in cobalt-60 teletherapy. This videotape will use data from reported medical misadministrations to identify those practices that result in the most frequent types of errors. The video will illustrate good practices that are designed to avoid errors while performing teletherapy procedures. The staff will prepare the video with support from Argonne National Laboratories.

1 Introduction

The NRC licenses the use of reactor-produced isotopes, the milling of uranium, and the subsequent processing of either natural or enriched uranium and special nuclear materials (SNM). Several States, known as Agreement States, have entered into agreements with the NRC to manage the use of byproduct materials, natural uranium, and small amounts of enriched uranium or other special nuclear materials. In 1991, 28 States participated in the NRC Agreement States program. Appendix A to this report gives information on the location and population of AS and NRC-regulated States by NRC region.

The dominant number of these materials licensees are authorized to use byproduct materials for such applications as radiography, gauges, and well logging and to administer byproduct materials or radiation from these materials to individuals for medical diagnosis or therapy. A relatively small number of licensees use uranium or SNM in other operations. Generally, these latter licensed operations have little negative impact on public health and safety.

The Office for Analysis and Evaluation of Operational Data (AEOD) was created in 1979 to provide, as one of its primary roles, a strong, independent capability to analyze operational data. This role was strengthened and expanded in 1987 in accordance with the Commission's emphasis on operational safety matters.

AEOD implements this role in the nonreactor area through the analysis and evaluation of operational safety data associated with the use of radioactive materials in nonreactor applications. AEOD publishes studies of specific operational events and, as appropriate, recommends agency actions to reduce the probability that these events will recur with the same frequency or will lead to more serious events.

In May 1987, AEOD also became responsible for the U.S. Nuclear Regulatory Commission's Incident Response, Diagnostic Evaluation, Technical Training, and Incident Investigation Programs. Incidents of potentially major safety significance are investigated by Incident Investigation Teams (IIT) directed by headquarters offices. Incidents of less significance are investigated by Augmented Inspection Teams directed by the NRC regional offices.

AEOD tracks the recommendations and staff actions contained in its studies and IIT reports until they are resolved. The appropriate NRC program office or regional office acts on these recommendations and actions. The office to which the recommendation or action is addressed is responsible for resolving it.

AEOD keeps informed of studies undertaken by other organizations within the NRC and normally will not duplicate a study unless a particular need or special circumstance exists. Thus, the nonreactor staff of AEOD does not review in depth all nonreactor events or operating problems.

AEOD also coordinates the overall NRC operational data program and serves as the central point for interaction with domestic and foreign organizations performing similar work.

The 1991 AEOD Annual Report is published in two separate parts: *Power Reactors* and *Nonreactors*. The report on *Nonreactors*, Vol. 6, No. 2, is an overview of events reported by nonreactor licensees during 1991, together with a report on the activities of an IIT in the nonreactor area.

More detail on the events reported by nonreactor licensees will be found in the following appendices:

- Appendix A, Report on 1991 Nonreactor Events
- Appendix B, Report on 1991 Licensee Misadministrations
- Appendix C, Report on 1991 Agreement State Licensee Nonreactor Events and Misadministrations
- Appendix D, Summary of 1991 Abnormal Occurrences
- Appendix E, Reports Issued From 1981 Through 1991
- Appendix F, Status of AEOD Recommendations
- Appendix G, Status of NRC Staff Actions for Events Investigated by Incident Investigation Teams

2 Feedback From Nonreactor Licensee Operational Experience

During 1991, the NRC received reports on a large number of events that involved NRC and Agreement State licensees. This section provides an overview and summary of these reported events involving nonreactor facilities and medical misadministrations.

2.1 Overview of Operating Experience

The dominant health concern associated with the use of licensed materials for nonmedical uses is the possible damage that can occur from overexposure to radiation. Lost or stolen radioactive materials are sometimes a source of exposures. Data on leaking sources can provide information on design deficiencies or end-of-life problems with specific sources, both of which might lead to personnel exposures. Events that involve release of radioactive materials or result in the introduction of radioactive material into consumer products can also result in unplanned exposure to radiation. The overexposures that NRC licensees reported are discussed in Appendix A to this report.

The dominant problem with the use of radioactive material in medicine arises when a staff member who delivers the radioactive material or radiation dose to a patient does not follow physician's directives. The misadministrations that NRC licensees reported are discussed in Appendix B to this report.

In addition to events NRC licensees reported by April 30, 1992, the NRC was provided information on all nonreactor events and misadministrations received by 15 Agreement States. In addition, NRC received reports from Maryland for part of the year. These data are discussed in Appendix C to this report.

The NRC has approximately 8000 licensees authorized to possess and use natural uranium and special nuclear material (SNM) (predominantly in support of the reactor fuel cycle) and byproduct materials of SNM. Of these licensees, about 5500 are authorized to use byproduct materials for such applications as radiography, gauges, and well logging. About 2200 medical licensees are authorized to administer byproduct materials or radiation from these materials to individuals for medical diagnosis or therapy. A relatively small number of licensees use uranium or SNM in fuel cycle operations.

Because the 16 Agreement States for which 1991 data has been reviewed have about the same population as NRC-regulated states, the number of licensees in the two groups is estimated to be about the same. Although the number of licensees may be about the same, the number of licensees in certain categories in Agreement States may differ from that in NRC-regulated States.

2.1.1 Radiation Exposures

2.1.1.1 Radiation Exposures From Reactors and Nonreactors

Sources of Radiation Exposure

The six main sources of radiation exposure to people are natural radiation (82 percent) and radiation from the following five man-made sources (18 percent): medical uses, occupational activities, nuclear production of electricity, miscellaneous environmental sources, and consumer products.* According to the National Council on Radiation Protection and Measurements, the total average effective dose equivalent to a person in the United States is approximately 360 mrem per year. About 100 mrem per year.

* Ionizing Radiation Exposure of the Population of the United States, NCRP Report No. 93, National Council on Radiation Protection and Measurements, September 1987.

per year comes from natural background excluding radon. The importance of environmental radon as the largest source of human exposure (about 200 mrem per year) has only recently received public attention. The average person in the United States receives an effective dose equivalent of about 50 mrem per year from medical applications. The whole fuel cycle, including operation of reactors, contributes less than 1 mrem per year. All the other manmade sources of radiation combined add up to approximately 6 mrem per year effective dose equivalent.

Almost all of the radiation dose from nuclear power plants is occupational dose, that is, the dose to the nuclear power plant employees and their contractors who work at the plant. Because the economics of operating a plant create a strong impetus to lower exposures and achieve ALARA objectives (As Low As Reasonably Achievable), utility violations of NRC limits on personnel exposure are rare, and the vast majority of nuclear power plant personnel have annual exposures far below NRC regulatory limits specified in Part 20 of Title 10 of *The Code of Federal Regulations* (10 CFR Part 20). The rule-of-thumb for occupational exposure is 1 person-rem/MW-yr. The actual mean value has been reduced from 1.9 in 1973 to 1 in 1985, and to 0.55 in 1990. The reduction is believed to be primarily the result of the licensees' extensive dose reduction efforts and improved fuel performance. Some measures that reduce collective exposure are the licensees' efforts to have an effective maintenance program, experienced and well trained personnel, a good water chemistry control program, effective decontamination and cleanup practices, good fuel cladding integrity, effective radiation exposure control programs, and an alert health physics staff. The performance of reactors is discussed in NUREG-1272, Vol. 6, No. 1.

NRC regulates both reactors and nonreactor applications of nuclear materials. All NRC licensees are required to supply appropriate personnel monitoring equipment to, and require the use of such equipment by, each individual who receives or is likely to receive a dose in any calendar quarter in excess of 25 percent of the allowable limits specified in 10 CFR Part 20. Certain licensees, namely those involved with industrial radiography, manufacturing and distribution of materials, low-level radioactive waste disposal, independent spent fuel storage installations, fuel fabrication and processing, and reactor operators are required to provide annual summaries of exposure data for individuals for whom personnel monitoring had been required.

The most recent data readily available for this group of licensees are for 1990. Data for the licensees for a 5-year period from 1986 through 1990 are given in Table 2.1. Reactors monitor about 10 times as many individuals, have about 10 times as many individuals with measurable doses, and are responsible for about 10 times as much collective dose as the other categories of licensees. Operations that directly support the operation of reactors, (i.e., independent spent fuel storage and fuel fabrication and processing have collective doses that are about one percent of that of reactors).

Of the six categories of licensees that are required to report collective exposures for monitored individuals, industrial radiography has the highest average measurable dose per worker. In each year except 1986, the average dose to workers in industrial radiography exceeded that to workers at reactors. For each category of licensee, the average measurable dose per worker is far below the allowable limits established in 10 CFR Part 20. Reactor licensees, by virtue of the large number of employees, had the highest collective exposure (36,947 rem to 203,434 people) for 1990, followed by radiographers (2120 rem to 6523 people), manufacturers and distributors (693 rem to 4195 people), and fuel fabrication and processing (287 rem to 13,756 people). Low-level waste disposal (26 rem to 784 people) and independent spent fuel storage (6 rem to 56 people) licensees have relatively low collective doses.

Over this 5-year period, the average measurable dose has declined for independent spent fuel storage, fuel fabrication and processing, and commercial light-water reactors. The average measurable dose has remained constant for low-level

waste disposal and has increased slightly for industrial radiography and manufacturing and distribution.

A second measure of the control of exposure of personnel is the number and extent of overexposures. A summary of the data on the number of reports from and the number of individuals overexposed in NRC-licensed facilities for reactors and nonreactors for the years 1986 through 1990 is given in Table 2.2. Data for Agreement State licensees are not included in this table because they are not readily available. Every year the number of events and the number of individuals overexposed in nonreactor applications exceeded those exposed at reactor sites.

Data on the number of individuals with measurable exposures are not readily available for all groups of NRC and Agreement State nonreactors; but they are available for NRC-licensed radiographers, the licensee category having the largest number of overexposures of employees. The number of overexposures and the number of workers with measurable doses for personnel working at reactors and NRC-licensed radiographers are shown in Table 2.3. As can be seen, the rate of overexposures of radiographers is greater by more than a factor of 10 than that for personnel working at a reactor site. The special radiological problems of industrial radiography have been recognized for a long time. The NRC has provided a special guidance/training document, NUREG/BR-0024, "Working Safely in Gamma Radiography," for radiographers for the purpose of reducing over-exposures.

Data are also available for fuel fabrication and processing licensees. These categories of licensees report relatively few overexposures (from 0 to 3 annually between 1986 and 1990) but had an exposure rate that, in general, exceeded that of reactors.

The number of overexposures reported annually by industrial radiography, fuel fabrication and processing, and reactor licensees over the 5-year period 1986 through 1990 represents a rate that is small; in no case was the overexposure rate more than 0.3 percent of the number of workers with measurable doses.

2.1.1.2 Radiation Overexposures at Nonreactors

In 1991, the NRC received reports of events in which 26 individuals received exposures in excess of one of the regulatory limits specified in 10 CFR Part 20. Licensees of the 16 Agreement States that provided data to the NRC reported overexposures to 67 individuals. Most of the overexposures were whole body overexposures of employees received in the course of their employment.

Table 2.4 shows the type and number of overexposures reported in 1991.

Whole body overexposures. The majority of whole body overexposures reported by both NRC-regulated licensees and Agreement States licensees are quarterly overexposures between 1.25 rem/calendar quarter and 3 rem/calendar quarter. Both NRC licensees and Agreement States reported several overexposures in excess of the 3 rem/quarter limit. NRC licensees reported 4 overexposures above 3 rem/quarter and the Agreement State licensees that provided data to the NRC reported 26. The highest overexposure an NRC licensee reported was 10 rem; the highest overexposure an Agreement State reported was 19.2 rem. However, in two events reported by a Louisiana licensee, the radiographers received both a whole body and an extremity dose that exceeded regulatory limits. These overexposures have been counted only as whole body overexposures.

Nonradiation Workers. Two members of the public received extremity exposures in the course of the recovery of a source lost on a public road. A New York licensee reported that a worker of the hospital housekeeping staff was in the therapy room while two portal films were taken. A Texas licensee

Table 2.1 Annual exposure data for certain categories of NRC licensees, 1986–1990

Industrial Radiography

Year	No. of Licensees	No. of Monitored Individuals	No. of Workers With Measurable Doses	Collective Dose (person–rems)	Average Individual Dose–rem	Average Measurable Dose per Worker–rem
1986	335	7,952	5,130	2,108	0.26	0.41
1987	312	7,236	4,454	1,835	0.25	0.41
1988	286	6,878	4,223	1,981	0.29	0.47
1989	276	6,745	4,352	2,067	0.31	0.47
1990	258	6,523	4,458	2,120	0.33	0.48

Manufacturing & Distribution

Year	No. of Licensees	No. of Monitored Individuals	No. of Workers Wth Measurable Doses	Collective Dose (person–rems)	Average Individual Dose–rem	Average Measurable Dose per Worker–rem
1986	33	4,042	2,065	745	0.18	0.36
1987	24	3,589	2,317	716	0.20	0.31
1988	16	2,177	868	343	0.16	0.40
1989	48	4,554	2,345	770	0.17	0.33
1990	55	4,195	2,272	693	0.17	0.31

Low-Level Waste Disposal

Year	No. of Licensees	No. of Monitored Individuals	No. of Workers With Measurable Doses	Collective Dose (person–rems)	Average Individual Dose-rem	Average Measurable Dose per Worker-rem
1986	2	996	175	31	0.03	0.18
1987	2	778	173	24	0.03	0.14
1988	2	864	171	27	0.03	0.40
1989	2	925	119	35	0.04	0.29
1990	2	784	115	26	0.03	0.23

Table 2.1 (cont.)

Independent Spent Fuel Storage

Year	No. of Licensees	No. of Monitored Individuals	No. of Workers With Measurable Doses	Collective Dose (person–rems)	Average Individual Dose–rem	Average Measurable Dose per Worker–rem
1986	1	32	32	34	1.06	1.06
1987	2	129	64	41	0.32	0.64
1988	2	217	57	25	0.12	0.44
1989	2	190	102	33	0.17	0.33
1990	2	56	22	6	0.11	0.27

Fuel Fabrication and Processing

Year	No. of Licensees	No. of Monitored Individuals	No. of Workers With Measurable doses	Collective Dose (person–rems)	Average Individual Dose–rem	Average Measurable Dose per Worker–rem
1986	10	8,017	3,790	466	0.06	0.12
1987	10	10,370	3,994	514	0.05	0.13
1988	10	11,994	3,869	455	0.04	0.12
1989	8	11,583	2,992	243	0.02	0.08
1990	10	13,756	3,233	287	0.02	0.09

Commercial LWRs

Year	No. of Licensees	No. of Monitored Individuals	No. of Workers With Measurable Doses	Collective Dose (person–rems)	Average Individual Dose–rem	Average Measurable Dose per Worker–rem
1986	90	174,519	100,922	42,653	0.24	0.42
1987	96	197,666	104,330	40,590	0.21	0.39
1988	102	199,985	103,227	40,722	0.21	0.39
1989	107	202,697	108,253	36,152	0.18	0.33
1990	109	203,434	109,702	36,947	0.18	0.34

Table 2.2 Overexposure events reported by reactor licensees and NRC nonreactor licensees, 1986-1990

Type of Licensee	1986		1987		1988		1989		1990	
	No. of Reports	No. of People	No. of Reports	No. of People	No. of Reports	No. of People	No. of Reports	No. of People	No. of Reports	No. of People
Reactors	4	4	4	4	10	14	2	4	2	2
Medical & academic	2	2	4	4	6	6	10	17	7	8
Radiography	7	9	2	2	3	3	11	14	9	12
Commercial & industrial	3	3	2	2	3	3	0	0	4	4
Fuel cycle	1	1	1	2	1	1	0	0	1	3
Other	3	3	2	2	3	4	4	4	0	0

Table 2.3 Overexposure rates reported by reactor licensees and NRC radiography licensees, 1986-1990

	Reactors			Radiography Licensees		
Year	No. of Employees Overexposed	No. of Workers w/Measured Doses	Rate	No. of Employees Overexposed	No. of Workers w/Measured Doses	Rate
1986	4	100,922	0.00004	9	5,130	0.002
1987	4	104,330	0.00004	2	4,454	0.0005
1988	14	103,227	0.00014	3	4,223	0.0007
1989	4	108,253	0.00004	14	4,352	0.003
1990	2	109,702	0.00002	12	4,458	0.003

Table 2.4 Personnel exposures reported in 1991

Type of Exposure	No. Reported by NRC Licensees	No. Reported by Agreement States
Whole body		
1.25 – 3 rems/quarter	14	30
3 – 5 rems/quarter	3	25
5 – 7 rems/quarter	0	5
7 – < 12 rems/quarter	1	3
> = 12 rems/quarter	0	4
Unspecified dose	0	3
Nonradiation workers	2	2
Skin	1	0
Internal	1	2
Extremity	4	2
Eye	0	1

reported that a nonradiation worker entered a barricaded and posted work area during radiography.

Skin. An NRC licensee reported a single overexposure of the skin of an individual. The actual overexposure was received in 1981, but was discovered in 1991 during recalculation of doses in prior years.

Internal. An NRC licensee reported an internal exposure that was about twice the regulatory limit, and an Agreement State licensee reported two individuals with elevated uranium concentrations in their urine.

Extremity. NRC licensees reported six extremity exposures. Three of these were occupational exposures that exceeded the quarterly limits, and two were exposures to members of the public during recovery of a lost source. None of these exposures resulted in apparent damage. The sixth overexposure was cited by the NRC although the extremity exposure had resulted from X-ray equipment. The sixth individual has worked with materials regulated by the NRC during the period when he received the extremity overexposure from X-rays.

The 16 Agreement States that provided data to the NRC reported two extremity exposures that exceeded the quarterly limits.

2.1.1.3 Comparison of NRC Licensee and Agreement State Data

The 16 Agreement States that submitted data to the NRC reported the overexposure of 67 people in 1991. None of the whole body exposures exceeded 20 rem. In one event reported, as many as 13 people received overexposures with the maximum exposure being 1.84 rem. NRC licensees reported 25 overexposures, with the maximum overexposure being 10 rem. Although the population for NRC and Agreement State licensees are relatively equal, the Agreement States reported more overexposures than NRC licensees. Because most of the overexposures reported by Agreement States were to radiographers, and two Agreement States, Louisiana and Texas,

have large radiography programs that are included in this review, possibly the number of radiographers employed in the Agreement States is larger than the number employed in the NRC-regulated States. In the years 1967 through 1990, NRC licensees reported from 12 to 35 overexposures annually. Although the number of overexposures reported by the 16 Agreement States is relatively higher, enough data are not available over time to draw any conclusions at this time.

None of the overexposures reported in 1991, either by NRC licensees or by Agreement States resulted in any near-term effects on personnel.

2.1.2 Other Types of Events

AEOD reviewed other classes of events. These events included lost or stolen sources, abandoned sources, leaking or contaminated sources, consumer products, and fuel cycle facility events. Of the various types of fuel cycle facilities, only mills are located in Agreement States. Generally, none of the events had any reported adverse impact on public heath and safety.

The State of Washington reported that contaminated steel fencing parts were discovered when a truck was leaving Hanford Reservation. The fencing, contaminated with cobalt-60 (Co-60), had been imported from India. All Agreement States and NRC licensees cooperated to identify items of fencing that were contaminated so that the material would be isolated and would not be sold.

An event that occurred at an NRC-licensed fuel cycle facility, the subject of enhanced investigation, is discussed in Section 3, "Incident Investigation Program."

2.2 Medical Misadministrations

The NRC and Agreement States regulate certain aspects of the uses of reactor-produced radioisotopes in nuclear medicine and therapeutic radiology. Medical misadministrations are reported to NRC to comply with 10 CFR Part 35, "Medical Use of Byproduct Material," which became effective on November 10, 1980. The definition of a misadministration that was in effect in 1991 is in Appendix B to this report.

Although the misadministration reporting requirements originally became effective on November 10, 1980, and were revised in 1987, all Agreement States were not required to report misadministrations until March 1990. Medical facilities licensed by the NRC to use radioisotopes in nuclear medicine and radiotherapy for humans have been required to report misadministrations to the NRC since 1981.

A revision to 10 CFR Part 35 that includes reporting of misadministrations became effective on January 27, 1992. As part of this revision, the definition of misadministration has changed. As a result, very few diagnostic misadministrations will be reported in the future. However, procedures involving the misadministration of either iodine-125 (I-125) or iodine-131 (I-131) as sodium iodide in amounts exceeding 30 microcuries (μCi) will still have to be reported. Also, fewer therapy misadministrations will have to be reported under the revised regulation.

Agreement States regulate both reactor- and accelerator-produced radioisotopes whereas the NRC regulates only reactor-produced radioisotopes. Thus, misadministrations reported by Agreement States that involved the use of accelerator-produced isotopes are not included in this report.

An estimated 7-million diagnostic nuclear medicine procedures, 30,000 radiopharmaceutical therapy procedures (the ingestion or injection of radioactive compounds for patient therapy treatment), and 50,000 brachytherapy procedures (the insertion or implantation of sealed sources containing radioactive material for patient therapy treatment) are performed annually in the United States. In addition, about 100,000 patients receive Co-60 teletherapy treatments (external use of radiation for patient treatment) each year.* The NRC estimates that about 40 percent of all these procedures are performed by NRC licensees and 60 percent by all Agreement State licensees. The 16 Agreement States that provided data to the NRC together with the NRC-regulated licensees account for approximately 75 to 80 percent of all medical procedures involving NRC-regulated materials.

Therapy misadministrations are associated with procedures in which large doses of radiation are administered to patients to achieve a therapeutic effect. Diagnostic misadministrations are associated with procedures designed to permit a diagnosis with little exposure to the patient. An exception to the usual diagnostic procedure is the use of I-131, which may deliver to the thyroid or other organ a dose of several hundred to several thousand rads.

2.2.1 Misadministrations Reported During 1991

For 1991, approximately 348 NRC licensees, authorized to perform nuclear medicine studies or radiation therapy, reported one or more misadministrations, a total of 460 reports involving 520 patients. Of these reports, 444 concerned diagnostic misadministrations and 19 concerned therapy misadministrations. As shown in Table 2.5, approximately 103 Agreement State licensees reported one or more misadministrations, a total of 118 reports involving 148 patients. Of the 118 reports, 112 involved diagnostic misadministrations and 6 involved therapy misadministrations.

2.2.1.1 Therapy Misadministrations

NRC licensees reported 19 therapy misadministrations in 1991. Of these misadministrations involved teletherapy, 11 involved brachytherapy, 5 involved radiopharmaceutical therapy. The number of therapy misadministrations reported by NRC licensees was about twice the average number of therapy misadministrations reported from 1981 through 1990.

Of the three teletherapy misadministrations, two involved an inadequate review of the patient's chart and one involved an erroneous computer programming entry.

NRC licensees reported 11 brachytherapy misadministrations in 1991 that were caused by (1) error in the dose calculation, (2) error in identifying the treatment, (3) lack of training of involved personnel, (4) error in identifying the strength of implanted brachytherapy sources, (6) error in verifying the placement of the brachytherapy sources in relation to the treatment site, and (7) inadequate patient restraint.

The five radiopharmaceutical misadministrations were caused by (1) error in verifying patient identification, (2) defective equipment, (3) wrong dosage, (4) lack of verifying prescribed dosage, and (5) misreading of the dose calibrator.

* U.S. Nuclear Regulatory Commission, "10 CFR Part 35, Basic Quality Assurance Program, Records and Reports of Misadministrations or Events Relating to the Medical Use of Byproduct Material," *Federal Register*, Volume 55, No. 10, January 16, 1990, pp. 1439–1449.

Table 2.5 Medical misadministrations reported in 1991 by NRC and Agreement States*

Misadministrations						
	Diagnostic		Therapy		Total	
	NRC	AS	NRC	AS	NRC	AS
No. of reports	444	112	19	6	463	118
No. of licensees reporting	329	97	19	6	348	103
No. of patients involved	489	132	31	16	520	148

* Data from only 16 Agreement States are included in this table.

The Agreement State licensees reported six therapy misadministrations for 1991. Of these misadministrations, one involved teletherapy, three involved brachytherapy, and two involved radiopharmaceutical therapy. The reports on these misadministrations contained insufficient information to independently determine the primary cause and contributing factors that lead to the misadministrations.

The therapy misadministrations reported by NRC licensees could have been avoided if licensees had followed departmental procedures or had improved their existing procedures.

2.2.1.2 Diagnostic Misadministrations

For both NRC and Agreement State licensees, essentially all of the diagnostic misadministrations for 1991 involved either the administration of the wrong radiopharmaceutical or the administration of a radiopharmaceutical to the wrong patient. The number of the NRC diagnostic misadministrations in 1991 is about the same as in 1990 and about 10 percent higher than the average number received over the previous 9 years, 1981 through 1989. The causes reported by NRC and Agreement State licensees are generally the same as those reported in the past by NRC licensees, that is, simple errors associated with procedures for (1) ordering nuclear medicine scans, (2) preparing radiopharmaceuticals, and (3) administering radiopharmaceuticals.

Of the reports of diagnostic misadministrations received in 1991 from both NRC licensees and Agreement State licensees, about 65 to 70 percent involved the administration of the wrong radiopharmaceutical to a patient and 17 to 20 percent involved the administration of a radiopharmaceutical to the wrong patient. For NRC licensees, these fractions have remained relatively constant over time.

Included in the remaining NRC and Agreement State licensee diagnostic misadministrations were misadministrations involving (1) a diagnostic dosage of a radiopharmaceutical that differed from the prescribed dosage by greater than 50 percent and (2) the wrong route of administration (i.e., a route of administration other than that intended by the prescribing physician).

Of the 444 NRC and 112 Agreement State licensee reports of diagnostic misadministrations, 14 were NRC licensee reports and 8 were Agreement State licensee reports that involved the misadministration of I-131, further discussed in the next paragraph.

2.2.1.3 Diagnostic Misadministrations of Iodine

Of the 14 NRC licensee and 8 Agreement State licensee diagnostic iodine misadministrations reported in 1991, 2 NRC and 3 Agreement State cases resulted in thyroid doses of more than 1000 rads. In the first NRC licensee case, the nuclear medicine technologist misunderstood the referring physician's request; and in the second case, the nuclear medicine technologist misread the dose calibrator and did not verify the dosage label before administration. One Agreement State event was due to patient chart mix-up with a patient who could not speak English. The Agreement State did not provide the cause of error for the other two cases. The highest dose delivered to the thyroid was about 6500 rad for the NRC cases and about 20,000 rad for the Agreement State events.

Causes of the I-131 misadministrations for both NRC and Agreement State licensees were similar: (1) misunderstanding the referring physicians's request, (2) not checking the directive requesting a thyroid procedure, (3) not checking the dosage label, (4) misreading the dose calibrator, (5) selecting the wrong syringe containing the dosage, and (6) failure to identify a patient.

2.2.1.4 Diagnostic Misadministrations That Involve Commercial Radiopharmacies

Mislabeled doses received from radiopharmacies were responsible for 36 diagnostic misadministrations by NRC licensees and 36 diagnostic misadministrations in the Agreement States. The number of NRC licensee diagnostic misadministration reports involving the wrong radiopharmaceutical ordered from radiopharmacies is the same as that for Agreement State reports. The primary causes of these misadministrations were about the same as the diagnostic misadministrations reported by hospitals: (1) mislabeling syringes containing radiopharmaceuticals, (2) selecting the wrong vial when drawing a dosage, (3) misunderstanding the radiopharmaceutical or dosage order, and (4) mislabeling a vial or a vial shield.

2.2.2 Trends in Misadministration Reports from 1981-1991

For 1981 through 1991, NRC licensees reported 117 therapy misadministrations or an average of 11 therapy misadministrations per year. Over this period, 53 involved teletherapy, 41 involved brachytherapy, and 23 involved radiopharmaceutical therapy. In general, the causes of all of the therapy misadministrations were human errors involving dose calculations, review of patient's chart, patient setup or treatment, and patient identification.

In each of the 11 years from 1981 through 1991, a small number of diagnostic misadministrations involved the misadministration of I-131. An average of 6 such events has been reported annually; the range is from 2 to 13 reports per year. A few of these misadministrations involved the administration of large amounts of I-131.

The number of therapy events reported during 1991 was about two times the average number reported in the previous 10 years; and the number of diagnostic reports was about the same as for 1990 and about 10 percent higher than the previous 9 years. Nonetheless, the error rate for all types of misadministrations remained low. The estimated error rate ranged from 0.0002 per procedure for brachytherapy and radiopharmaceutical therapy to 0.0003 per patient for teletherapy.

AEOD evaluated misadministration data from Agreement States in 1991 for the first time.

2.3 Reporting of Abnormal Occurrences

AEOD prepares the quarterly Report to Congress on Abnormal Occurrences (NUREG-0090 series) and the associated *Federal Register* notices. After staff coordination of each quarterly abnormal occurrence (AO) report, it is sent to the Executive Director for Operations and, subsequently, to the Commission for review and approval. An AO may be an individual incident, a recurring event, a generic concern, or a series of incidents that the Commission determines is significant from the standpoint of public health or safety.

The quarterly AO reports issued in 1991 included 14 events from NRC licensees and 6 events from Agreement State licensees.

A summary of 1991 nonreactor and medical misadministration AOs (reported by both NRC and Agreement State licensees) is provided in Appendix D to this report. A summary of 1991 AOs at nuclear power plants and research reactors is provided in Appendix B to the companion volume of this report (NUREG-1272, Vol. 6, No. 1, *Power Reactors*).

2.4 Videotape on "Good Practices in Cobalt-60 Teletherapy"

AEOD is in the process of producing a videotape on good practices in cobalt teletherapy. This videotape will use data from reported medical misadministrations to identify those procedures that result in the most frequent types of misadministrations. The video will illustrate good practices that are designed to avoid errors while performing cobalt teletherapy procedures. The staff will prepare the video with support from Argonne National Laboratories.

3 Incident Investigation Program

The Incident Investigation Program (IIP) ensures that NRC investigations of significant events are timely, thorough, well coordinated, and formally administered. The scope of the IIP includes investigations of significant operational events involving reactor and nonreactor activities licensed by the NRC. Under the IIP, the NRC responds to an operational event according to its safety significance. For an event of potentially major safety significance, the Executive Director for Operations (EDO) establishes an Incident Investigation Team (IIT) to investigate the event, and, for an event of less safety significance, the cognizant NRC Regional Administrator may establish an Augmented Inspection Team (AIT) to investigate the event. Both IITs and AITs are assigned to determine the circumstances and causes of an operational event and to assess the safety significance of the event so that appropriate followup actions can be taken. Of the approximately 300 reported nonreactor events during 1991, one event, involving the General Electric Company in Wilmington, North Carolina, was judged to have a sufficiently high level of safety significance to warrant an IIT investigation.

The findings and conclusions of the IIT report are discussed in this section. The status of staff actions that the EDO assigned to various NRC offices associated with the General Electric investigation is given in Appendix F.

Incident Investigation of the Potential Criticality Accident at the General Electric Nuclear Fuel and Component Manufacturing Facility, Wilmington, North Carolina.

On May 29, 1991, at the General Electric (GE) Company Nuclear Fuel and Component Manufacturing Facility, approximately 6 miles north of Wilmington, North Carolina, an estimated 150 kilograms (320 pounds) of uranium were inadvertently transferred to an unfavorable geometry waste treatment tank. ("Unfavorable geometry" refers to a container or vessel that can hold enough uranium to produce a criticality.) Because of the tank configuration and type and quantity of fissile material available, the potential for a nuclear criticality accident was created. Such an accident would yield a burst of neutron and gamma radiation that would probably be fatal to anyone within 10 feet of the burst and cause radiation exposures of approximately 5 rads at 45 feet from the burst. However, no offsite radiological impact would be expected.

The licensee advised the NRC of the incident on May 29, 1991. Because of the nuclear criticality safety significance of the incident, the NRC upgraded the agency's response mode from "Normal" to "Standby" and activated both headquarter's and regional incident response centers and the licensee's site. NRC formed and dispatched a response team to the site. After extensive communications with NRC, the licensee declared an "Alert," implemented provisions of the emergency plan, and notified Federal, State, and local offsite authorities about 6:40 a.m., on May 30, 1991.

On May 31, 1991, the NRC's EDO established an eight-member IIT, directing them to (1) fact find as to what happened, (2) identify probable causes, and (3) make appropriate findings and conclusions.

The IIT arrived in Wilmington, North Carolina, on June 2, 1991. The team was selected based on its broad knowledge of facility event analysis, with individual members having specific knowledge of fuel fabrication operations, chemical operations, instrument and controls, maintenance, human factors, radiological emergency preparedness, and nuclear criticality safety.

The IIT concluded that there were three interrelated root-causes which contributed to the incident.

- There was a pervasive licensee attitude that a nuclear criticality was not a credible accident scenario. While the licensee

understood and recognized that a nuclear criticality with low-enriched uranium was technically possible, and that there were regulatory requirements to establish measures to guard against such an accident, the licensee's perception was that the risk was so low that a criticality inherently would not happen.

- Licensee management did not provide effective guidance and oversight of licensed activities to assure that facility operations were conducted in a safe manner.

- There was a deep-seated production-minded orientation within the licensee organization that was not sufficiently tempered by a "safety first" attitude, particularly regarding nuclear criticality safety.

The team also concluded that NRC regulatory oversight of the fuel facility was deficient in some respects. The team noted shortcomings with respect to the NRC's regulations and regulatory guidance, license and licensing process, and inspection program. This lack of sufficient oversight had the effect of contributing to a situation where safety margins eroded to the extent that the licensee had little or no latitude to accommodate operator errors or equipment failures.

NUREG-1450, "Potential Criticality Accident at the General Electric Fuel and Component Manufacturing Facility, May 29, 1991," dated August 1991, documents the results of the team's investigation.

4 Data From the Nuclear Regulatory Commission's Operations Center for 1991

The NRC's Operations Center in Bethesda, Maryland, provides a focal point for NRC communications with Commission licensees, State agencies, and other Federal agencies about operating events in the commercial nuclear sector. The Operations Center is staffed 24 hours a day by an NRC Headquarters Operations Officer (HOO), who is trained to receive, evaluate, and respond to events reported to the Operations Center.

Of the 2365 notifications that were reported to the NRC Operations Center in 1991 under NRC's prompt notification requirements, 138 events involved nonpower reactor events. Of the 138 nonpower reactor events, 43 involved fuel facilities, 9 involved research reactors, 14 involved hospitals, 27 were radioactive material events, 22 were transportation events, and 23 involved events not fitting into one of these categories. A small subset of these notifications involved events that licensees classified as one of the four classes of emergencies: "Unusual Event," "Alert," "Site Area Emergency," and "General Emergency." The remainder of the notifications involved events that did not meet the threshold to be classified as an emergency.

Table 4.1 provides information on the "Site Area Emergency" declared as a result of a transportation event and an "Alert" declared at the General Electric Fuel Fabrication Facility in Wilmington, North Carolina. An "Unusual Event" represents a condition that is of no immediate threat to the public health, and an "Alert" indicates actual or potential substantial degradation of plant safety. An event classified as a "Site Area Emergency" or a "General Emergency" indicates a major failure of one or more systems required for public safety or an event with the potential for a major offsite radiological release. Exercises are held periodically to ensure that NRC's and the licensee's response organizations are proficient in dealing with each type of emergency. In 1991, NRC headquarters and regional offices participated in emergency planning exercises with Nuclear Fuel Services, Erwin, Tennessee (June 19, 1991).

Actions taken by the NRC HOO in response to these notifications of events ranged from a computer or log entry, followed by appropriate notifications, to establishing emergency conference calls among the HOO, the licensee, and the senior NRC regional and headquarters staff members. For very significant events, these conference calls would result in activation of the agency's Incident Response Plan. In 1991, the NRC was placed in "Standby" during the General Electric Fuel Fabrication Facility "Alert" event in accordance with the NRC Incident Response Plan (NUREG-0728, Revision 1).

Table 4.1 "Site Area Emergency" and "Alert" events reported in 1991 at nonreactor facilities

Name of Facility	Event No.	Date	Description	Duration
Site area emergency				
General Electric Fuel Fabrication, Wilmington, NC	22468	12/16/91	Truck carrying new fuel involved in a traffic accident	65 hours 11 minutes
Alerts				
General Electric Fuel Fabrication, Wilmington, NC	21103	05/29/91	Loss of process control in the solvent extraction portion of the nitrate waste treatment system	44 hours 42 minutes

* The licensee is currently revising its procedures concerning criteria for declaring a "Site Area Emergency." Under the proposed criteria, this incident would be classified as an "Unusual Event."

5 Summary

Our review of the data on nonreactor events and misadministrations that were reported to the NRC and a group of 16 Agreement States in 1991 did not show any significant events. The number of diagnostic misadministrations reported by the NRC licensees was about the same as in 1990 and about 10 percent higher than the average rate for the previous 9 years. The number of therapy misadministrations reported in 1991 by NRC licensees was about 2 times higher than the average number reported in the prior 10 years. AEOD evaluated misadministration data from Agreement States in 1991 for the first time.

The NRC's Operations Center in Bethesda, Maryland, provides a focal point for NRC communications with Commission licensees, State agencies, and other Federal agencies. Of the 2365 notifications that were reported to the NRC Operations Center in 1991, 138 involved nonpower reactor events. A "Site Area Emergency" was declared as a result of a transportation event, and an "Alert" was declared at a fuel fabrication facility. The remainder of the notifications involved events that did not meet the threshold to be classified as an emergency.

During 1991, an Incident Investigation Team investigated an event at the General Electric Company Nuclear Fuel and Components Manufacturing Facility, in Wilmington, North Carolina. An estimated 150 kilograms (320 pounds) of uranium were inadvertently transferred to an unfavorable geometry waste treatment tank. Because of the tank configuration and type and quantity of fissile material available, the potential for a nuclear criticality accident was created. In investigating this event, the team noted shortcomings with respect to the NRC's regulations and regulatory guidance, license and licensing process, and inspection program for this event.

The most recent readily available collective exposures for NRC licensees in the categories of industrial radiographers, manufacturing and distribution of materials , low-level waste disposal, independent spent fuel storage, and fuel fabrication and processing showed that, in 1990, all of these operations maintained the average exposure of their personnel well below the annual limits specified in 10 CFR Part 20.

Although the number of overexposures reported by Agreement State licensees was proportionally larger than that reported by NRC licensees, no significant overexposures from operations were reported in 1991, and the numbers of reports of lost material and leaking sources was comparable for both groups of licensees.

Appendix A

Report on 1991 Nonreactor Events

Appendix A

AEOD/N91-02

Report on 1991 Nonreactor Events

by the
Nonreactor Assessment Staff
Office for Analysis and Evaluation of Operational Data

Prepared by
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Contents

Tables

1 Nonreactor Event Report Database

The Nonreactor Event Report (NRER) database for the Office for Analysis and Evaluation of Operational Data (AEOD) contains information on events involving licensed nuclear materials, fuel cycle operations, and personnel radiation exposures. The NRER database management system provides for input, storage, retrieval, and computer-assisted analyses of operational event data. AEOD sometimes uses the system to identify trends in operational safety events that may signal a need for remedial actions by the NRC, licensees, or both. AEOD generally does not incorporate information on transportation events into the NRER database because the Department of Energy funds a transportation incident file, which is maintained by Sandia National Laboratories. The Sandia report, *Transportation Accidents/Incidents Involving Radioactive Materials 1971–1989* (SAND-90-7025C)* summarizes data from 1971 through 1989.

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* Cheryl E. Cashwell, Transportation Accidents/Incidents Involving Radioactive Materials 1971-1989, (SAND-90-7025C) (TTC-0972), April 1990.

2 Review of 1991 Nonreactor Events

2.1 Events That Occurred During 1991

The NRER database includes 386 records of events NRC licensees reported that were entered into the database during 1991. This number is equivalent to approximately 8 reports per 100 licensees. Information on these events was included in reports nonreactor licensees submitted to the regional offices or in other documents, primarily in reports of inspections the NRC conducted. The NRER database does not include information from certain fuel cycle licensee reports, such as those related to routine effluent releases, and does not include information from reports from NRC licensees of medical misadministrations, which are included in Appendix B to this volume of the AEOD Annual Report. Table A-1 provides information on the types of licensees for which information was entered into the database. More reports were received in 1991 from radiography licensees than in previous years because of revised reporting requirements in Part 34, Section 30, of Title 10 of the *Code of Federal Regulations* (10 CFR 34.30) which became effective on January 10, 1991. In addition, more reports were entered from uranium hexafloride (UF_6) and special nuclear materials licensees. The increase in the number of reports from UF_6 and special nuclear materials licensees may be attributable to Incident Investigation Team (IIT) or Augmented Inspection Team (AIT) inspections at these categories of facilities in 1990 and 1991.

An NRER database record may be associated with more than one category of event. For example, a report from a radiography licensee concerning a personnel radiation exposure would be entered as a radiation exposure event as well as an event involving radiography. The nonreactor licensee reports were cataloged as entries in the following areas: personnel radiation exposures; lost, abandoned, and stolen material; leaking sources; release of material; fuel cycle (e.g., mills, source material, UF_6 facilities, special nuclear material); industrial radiography; manufacturing and distribution (including medical); commercial and industrial measuring systems (excluding well-logging); and other.

2.1.1 Radiation Exposure

The criteria that define the exposure limits are in 10 CFR 20.101(a) and (b), 20.103(a), and 20.105. The limits that were in effect during 1991 are as follows*:

Restricted areas:

whole body	1.25 rem/calendar quarter, or 3 rem/calendar quarter, if the individual's prior occupational exposure is obtained in writing, and the accumulated exposure does not exceed 5 (N-18), where N is the individual's age.
extremity	18.75 rem/calendar quarter
skin	7.5 rem/calendar quarter
inhalation	40 maximum permissible concentration (MPC) hours/week for 13 weeks; MPC is given in 10 CFR Part 20, Appendix B, Table 1, Col. 1
minors	10 percent of above limits

Unrestricted areas:

individuals	0.5 rem/year, subject to rate limitations

* The last revision of 10 CFR Part 20 will not become effective until 1993 or later.

Table A–1 Types of licensees that submitted nonreactor reports, 1991

Type of Licensees	No. of Reports Received*
Academic	11
Medical	74
Commercial and industrial measuring systems	86
Well-logging	18
Other measuring systems	68
Manufacturing and distribution (excluding medical)	20
Industrial radiography	37
Fixed site	0
Multiple locations (field)	37
Irradiator	2
Research and development	36
Source materials**	33
Mills	0
UF_6 facilities	28
Other	5
Special nuclear material** (including plutonium)	49
Other	38
Total	386

* Medical misadministration reports are not included.

** Routine environmental effluent release reports (e.g., reports required by 10 CFR 40.65 and 10 CFR 70.59) were not included in the totals for source materials and special nuclear material licensees.

Five categories of nonreactor licensees are required to report collective exposures of their personnel: industrial radiography, manufacturing and distribution, low-level waste disposal, independent spent fuel storage, and fuel fabrication and processing. Table A–2 shows the number of individuals badged during 1990 (the most recent data readily available when this report was prepared) and their collective dose. The average individual dose ranged from 0.02 rem per person at fuel fabrication and processing licensees to 0.33 rem per person at industrial radiography licensee facilities. All of these average doses were far below the Part 20 annual exposure limits. Data from badges is one measure of the control of exposure of personnel. A second measure is the number and extent of overexposures.

The NRC received 21 reports of events during 1991 in which an overexposure occurred. Twenty-six individuals received exposures in excess of one of the regulatory limits given in this section. Information on the exposure reports is provided in Tables A–3 and A–4.

Medical and Academic

Six events were reported in which a single individual was overexposed, and one report was received that reported the overexposure of two nurses while restraining a patient. All of the overexposures reported by medical and academic licensees represented exposures in excess of quarterly limits to

Table A–2 Collective exposures at nonreactor facilities, 1990

Category	No. of Licensees	No. of Monitored Individuals	No. of Workers With Measurable Doses	Collective Dose (person–rem)	Average Individual Dose–rem	Average Measurable Dose per Worker–rem
Industrial radiography	258	6,523	4,458	2,120	0.33	0.48
Manufacturing & distribution	55	4,195	2,272	693	0.17	0.31
Low-level waste disposal	2	784	115	36	0.03	0.23
Independent spent fuel storage	2	56	22	6	0.11	0.27
Fuel fabrication & processing	10	13,776	3,233	287	0.02	0.09

Table A–3 Categories of licensees associated with overexposures, 1991

Type of Licensee	No. of Reports	No. of Individuals Overexposed
Medical & academic	7	8
Radiography	6	9
Commercial & industrial	7	8
Fuel cycle	1	1

personnel while performing their duties. Four of the overexposures represented whole body exposures of 3.1 rem or less; two were extremity exposures of 56 rem or less; and one was the accidental ingestion of iodine-131 (I-131) in an amount that was 2.2 times the limit.

Radiography

NRC received six reports in which nine radiographers or radiographer assistants were overexposed in excess of quarterly limits. In one case, one radiographer received an exposure of 10 rem, an exposure in excess of the annual limit. The extremity exposure to an employee of Diamond H Testing, cited by NRC as a violation, involved an exposure of 1000-4000 rem to the fingers from an X-ray device. For this employee, less than 1 rem whole body exposure was attributable to NRC-regulated materials.

Commercial and Industrial

NRC received seven reports from commercial and industrial licensees. Each of five reports represented the overexposure of an individual in excess of the quarterly limits. A sixth report involved an extremity overexposure exceeding the annual limit of 75 rem; the seventh report involved two extremity exposures that were incurred by members of the public in the course of recovering a lost source.

Fuel Cycle

The exposure to the employee of a fuel cycle licensee exceeded the quarterly limit to skin. The overexposure, which actually occurred in 1981, was discovered during recalculation of doses for prior years using a new dose correction factor.

Table A–4 Personnel radiation overexposures, 1991

Licensee	License Number	Location	Event Date	Number of Individuals Overexposed	Type of Overexposure
Allegheny Gen. Hosp.	370131701	Pittsburgh, PA	07/28/89	2	Whole body
Alt & Witzig Eng., Inc.	131868501	Indianapolis, IN	11/01/88	1	Whole body
Aultmann Hospital	340131205	Canton, OH	07/15/91	1	Whole body
Blazosky Assoc., Inc.	372850701	State College, PA	02/27/91	1	Whole body
Cleveland Cl. Found.	340046601	Cleveland, OH	04/12/91	1	Extremity
Coaldale St. Gen. Hosp.	371752201	Coaldale, PA		1	Extremity
Combustion Eng., Inc.	70-1100	Windsor, CT	03/31/81	1	Skin
Cotton Houston Ser., Inc.	422682301	Huffman, TX	11/04/91	1	Whole body
Diagnostic Photon Corp.	521634502	Carolina, PR	12/20/90	1	Whole body
East Fed. Lands Hwy. Div.	452309001	Sterling, VA	10/07/91	1	Whole body
Diamond H Testing Co.	ID-191	Chubbuck, ID	01/29/91	1	Extremity
Indiana University	130275203	Indianapolis, IN	01/22/91	1	Internal
Inspection Serv. and Test.	502325701	Fairbanks, AK	05/21/91	1	Whole body
Intermountain Testing Co.	050787201	Englewood, CO	10/24/91	1	Whole body
Materials Insp. & Testing	131696102	Fort Wayne, IN	10/01/86	1	Whole body
Muskogee Reg. Med. Ctr.	351315701	Muskogee, OK	02/01/91	1	Whole body
Plant Inspection Co.	042103201	Diablo Canyon, CA	09/19/91	2	Whole body
Space Science Services, Inc.	090755001	Jacksonville, FL	12/02/91	3	Whole body
Syncor	221917401	St. Paul, MN	04/15/91	1	Extremity
University of Oklahoma	350317601	Oklahoma City, OK	08/09/91	1	Whole body
West. Atlas Int'l., Inc.	420296401	Houston, TX	09/05/91	2	Extremity

2.1.2 Lost, Abandoned, and Stolen Sources

Licensees are required to report the loss or theft of licensed sources that have occurred in such quantities and under such circumstances that it appears to the licensee that a substantial hazard may result to persons in unrestricted areas (10 CFR 20.402(a)(1)). During 1991, licensees reported 75 events that involved lost or stolen licensed material that was not recovered and 16 events in which well-logging sources were abandoned. Tables A–5 and A–6 present a list of these events. Only one event indicates that a lost source resulted in any overexposure. A source was lost by Western Atlas on a public road, and two members of the public received extremity exposures in the course of its recovery.

Table A–5 Lost or stolen sources, 1991

Isotope*	Location	Licensee	Licensee Number**	Event Date	Probable Ultimate Disposal
Am-241	Lombard, IL	Prof. Serv. Ind., Inc.	242615401	07/17/91	unknown
Am-241	Indianapolis, IN	Atec Associates, Inc.	131773201	01/20/91	unknown
Am-241	W. Lafayette,IN	Indiana Dept. of Trans.	130968902	12/02/92	unknown
Am-241	Farmington, MI	NTH Consultants, Ltd.	211489401	06/12/91	unknown
Am-241	Fort Bragg, NC	Dept. of the Army	120072213	10/01/89	unknown
Am-241	New York, NY	Kupper & Company	292843901	08/22/91	unknown
Am-241	Columbus, OH	BBC&M Engineering, Inc.	341889401	08/22/91	unknown
Am-241	Enon, OH	Westinghouse Env.	322118301	11/20/90	unknown
Am-241	West Point, PA	Merck, Sharp & Dohme Res.	370153108	10/30/91	unknown
Am-241	Pierre, SD	So. Dakota Dept. of Trans.	400866904	07/23/91	unknown
Am-241	Manassas, VA	VA Dept. of Trans.	451338001	06/12/91	unknown
Am-241	Oshkosh, WI	GL Curwood, Inc.	482580401	03/01/90	unknown
Am-241	Milwaukee, WI	W.H. Brady Co.	482011501		comm. waste
C-14	Fort Carson, CO	Dept. of the Army	052685401	02/27/91	comm. waste
C-14	Horsham, PA	Rhone-Poulenc	291014402	02/11/91	unknown
Co-60	Perth Amboy, NJ	Raritan Bay Medical Ctr.	291193501		unknown
Cs-137	Hartford, CT	Millstone Nuclear Power St.	50-245	01/17/91	other
Cs-137	Coshocton, OH	Stone Container Corp.	340955202	06/12/91	unknown
Fe-55	Paulsboro, NJ	Mobil Res. & Devel. Corp.	290050502	09/17/91	unknown
H-3	San Diego, CA	GL City of San Diego	GL	07/27/91	unknown
H-3	Iowa City, IA	Dept. of Veterans Affairs	140082201	12/14/90	unknown
H-3	Worcester, MA	Cambridge Bioscience Corp.	202065101	06/19/91	unknown
H-3	Ann Arbor, MI	KMS Fusion, Inc.	211544601	08/04/91	comm. waste
H-3	Offutt, NE	Dept. of the Air Force	422353901	06/14/91	unknown
H-3	Brooks AFB, TX	Dept. of the Air Force	422535901	07/23/91	comm. waste
H-3	Brooks AFB, TX	Dept. of the Air Force	422535901	09/12/91	other
I-125	Washington, DC	Dept. of the Navy	452364501	09/26/91	unknown
I-125	Methuen, MA	Holy Fam. Hosp. & Med. Ctr.	201391602	04/02/91	unknown
I-125	St. Louis, MO	Washington University	240157003		unknown

Footnotes at end of table

Table A–5 (cont.)

Isotope*	Location	Licensee	Licensee Number**	Event Date	Probable Ultimate Disposal
I-125	Monroeville, PA	Forbes Regional Health Ctr.	371810401	12/17/90	unknown
I-131	Washington, DC	District of Columbia General	080428906	06/18/91	comm. waste
I-131	Minneapolis, MN	Riverside Medical Ctr.	220325101	02/25/91	comm. waste
I-131	Billings, MT	Deaconess Med. Ctr.	250105101		incineration
I-131	Long Branch, NJ	Monmouth Med. Ctr.	290811303		incineration
I-131	Youngstown, OH	St. Elizabeth Hospital	340113101	06/06/91	comm. waste
I-131	Lancaster, PA	Lancaster General Hospital	371186601	09/25/91	incineration
Ir-192	Fort Bragg, NC	Dept. of the Air Force	422353901	05/29/91	unknown
Kr-85		Dept. of the Army	290102214	08/05/91	other
Ni-63	Milford, MA	Millipore Corporation	201835802	11/11/90	unknown
Ni-63	Rahway, NJ	Merck, Sharp & Dohme Res.	290011706	07/31/91	comm. waste
Ni-63	Denville, NJ	First Env. Labs/CWM	292840201	06/07/91	unknown
Ni-63	Avondale, PA	Hewlett-Packard Co.	370700202	04/04/91	unknown
Ni-63	Avondale, PA	Hewlett-Packard Co.	370700202		unknown
P-32	Ann Arbor, MI	University of Michigan	210021504	04/10/91	unknown
P-32	Ann Arbor, MI	University of Michigan	210021504	11/05/91	comm. waste
Pm-147	Hutchinson, MN	GL Hutchinson Tech., Inc.	GL	06/11/91	comm. waste
Po-210	Shelton, CT	GL ITT Corporation	GL		unknown
Po-210	Needham, MA	GTE Gov. Systems Corp.	200685202		unknown
Po-210	Andover, MA	Hewlett-Packard Co.	GL	07/03/91	unknown
Po-210	Evart, MI	GL Evart Products Co.	GL	08/01/89	unknown
Po-210	Bronson, MI	GL Solvay Automotive Inc.	GL	08/06/91	comm. waste
Po-210	St. Clair, MI	GL Plastech Eng. Prod.	GL		unknown
Po-210	Hopkins, MN	GL Honeywell, Inc.	GL	01/09/91	comm. waste
Po-210	Clifton, NJ	GL Permanent Label	GL	07/25/91	unknown
Po-210	Columbus, OH	GL Menasha Corp.	211492201	02/27/91	unknown
Po-210	Fremont, OH	GL Automotive Ind., Inc.	GL	06/13/91	unknown
Pu-238	Pittsburg, PA	Allegheny General Hospital	70-1395	07/11/91	other
S-35	Waltham, MA	Brandeis University	200195805	01/15/91	unknown

Footnotes at end of table

Table A–5 (cont.)

Isotope*	Location	Licensee	Licensee Number**	Event Date	Probable Ultimate Disposal
Th	Bethel, CT	Ambel Precision Manf.	40-8972	02/27/91	unknown
U-235	Cambridge, MA	Harvard University	70-83	06/12/91	unknown
U(depleted)	Geneva, OH	Advanced Medical Sys., Inc.	341908901	08/06/91	unknown
Y		Dept. of Agriculture	190091506	10/31/91	comm. waste
Y	New Haven, CT	Yale University	060018303	10/16/91	comm. waste
Y	Dover AFB, DE	Dept. of the Air Force	422353901	10/22/90	comm. waste
Y	Minneapolis, MN	University of Minnesota	220018746	02/08/91	incineration
Y	Kansas City, MO	Kansas City, MO	241138801	11/13/90	unknown
Y	St. Louis, MO	V.A. Medical Ctr.	240014405	08/16/91	comm. waste
Y	Marlin, PA	Roanoke Electric Co.	NL	03/26/91	scrap metal
Y	MacDill AFB, TX	Dept. of the Air Force	422353901	08/02/91	comm. waste
Y	Houston, TX	V.A. Medical Ctr.	420008406	05/31/91	incineration
Y	Suffolk, VA	Peanut City Scrap Metal	NL	03/06/91	scrap metal
Z	Terre Haute, IN	GL Accurate Glass, Inc.	GL		unknown
Z	Ravenna, OH	GL The Oak Rubber Co.	GL	10/09/89	unknown
Z	Elizabeth, PA	Charles Bluestone Co., Inc.	371848301		scrap metal
Z	Richmond, VA	County of Henrico, VA	451729302	08/01/90	unknown

* Y more than one isotope
Z unspecified
** GL general license
NL no license

Table A–6 Abandoned well-logging sources, 1991

Isotope*	Location	Licensee	License Number	Event Date
Am-241	Offshore, LA	Schlumberger Technical Corp.	420009003	11/14/90
Am-241	Offshore, LA	Haliburton Logging Service	420106807	12/23/91
Am-241	Taneytown, MD	Appalachian Geophysical Survey	371979801	10/02/91
Am-241	Billings, MT	Reich Geo-Physical, Inc.	251830401	07/30/91
Am-241	Offshore, TX	Schlumberger Well Services	420009003	05/28/91
Am-241	Houston, TX	Schlumberger Well Services	420009003	08/29/91
Am-241	Houston, TX	Western Atlas International, Inc.	420296401	07/09/91
Am-241	Arlington, TX	Sperry-Sun Drilling Services	422684401	10/26/91
Am-241	Oakwood, VA	Marshall Miller and Associates	451719501	12/24/90
Co-60	Offshore, LA	Western Atlas International, Inc.	420296401	03/26/91
Cs-137	Anchorage, AK	Cameo Wireline, Inc.	502138801	11/01/91
Cs-137	New Orleans, LA	Haliburton Logging Service	420106807	01/09/91
Cs-137	Oklahoma City, OK	BPB Instruments, Inc.	352689501	05/29/91
Cs-137	Houston, TX	Haliburton Logging Service	420106807	09/05/91
H-3	Houston, TX	Western Atlas International, Inc.	420296401	05/20/91
Z	Offshore, TX	Sperry-Sun Drilling Services	422684401	06/11/91

* In most cases, when an americium source is abandoned, a Cs-137 source is also abandoned.
Z unspecified

Lost or Stolen Sources

Of the 80 reports of lost or stolen sources that were not recovered, 17 sources were sent to commercial waste disposal, 3 were sent to scrap processors, 5 were incinerated, and the location of 47 is unknown. In addition, another four have been disposed of in other ways: one source was lost from an aircraft over rugged terrain, one source was probably disposed of with radioactive waste, one source was disposed of with normal trash outside of the United States, and one pacemaker source was interred with a body. Generally the lost sources consisted of sealed sources, isotopes used in research or medical treatment, or tritium exit signs.

Americium-241 (Am-241) – Of the 15 reports of lost sources containing Am-241, 11 involved lost or stolen gauges; 2 involved lost general-licensed devices; 1 report was about lost chemical agent monitors; and 1 was about the loss of a liquid scintillation counter.

Carbon-14 (C-14) – One licensee reported a package containing 250 microcurie (μCi) of C-14 missing, and in a second report, the Army reported having disposed of C-14 to commercial waste.

Cobalt-60 (Co-60) – A Co-60 source, 0.03 millicurie (mCi), in storage awaiting disposal, was lost.

Cesium-137 (Cs-137) – Four cesium sources of various strengths were lost: one 8 mCi source was contained in a lost moisture density gauge; one 1 mCi source was lost by a licensee of a nuclear power plant; a 1.5 mCi source was reported lost on board a ship following damage to a shipping container; and a gauge containing 13 mCi was reported lost. In addition to these lost sources that have not been recovered, a lost Cs-137 calibration source was recovered, and two members of the public received extremity exposures in the process.

Iron-55 (Fe-55) – A loss of a sealed source of 50 mCi of Fe-55 was discovered when the instrument in which it was contained was dismantled revealing an empty instrument.

Tritium (H-3) – Seven losses of tritium were reported. Three of the reports concerned lost or stolen tritium exit signs and one concerned lost or stolen compasses. The Air Force lost a tritium light over rugged terrain. Two events concerned the loss of 3.5 and 5 mCi of tritium, respectively.

Iodine (I) – There were two events reported in which iodine-125 (I-125) seeds were lost and two events in which vials of I-125 were lost. In one of the events involving lost vials of I-125, one vial was found at a Federal Express facility.

The NRC received six reports of missing I-131 material. All reports were received from medical licensees and represent the inadvertent incineration of contaminated items or the disposal of contaminated items before a decay period of ten half-lives.

Iridium-192 (Ir-192) – Iridium seeds containing 14.7 mCi Ir-192 were lost at a military medical facility.

Krypton-85 (Kr-85) – The Army reported disposing of some test samples containing Kr-85 outside of the United States.

Nickel-63 (Ni-63) – The NRC received five reports of lost Ni-63 sources from electron capture devices or gas chromatographs.

Phosphorus-32 (P-32) – The NRC received two reports of lost P-32. In one event, vials containing P – 32 were stolen; in the second, material was either not received or was disposed of with the packaging.

Promethium-237 (Pm-237) – A small Pm-237 source was reported lost.

Polonium-210 (Po-210) – Ten reports were received involving the loss of general-licensed devices containing Po-210.

Plutonium-238 (Pu-238) – A plutonium-powered pacemaker was interred with the body of a deceased individual who had a pacemaker implanted.

Sulfur-35 (S-35) – One report was received of lost S – 35 that was part of a labeled chemical.

Thorium (Th) – Fourteen drums containing about 4 mCi of Th were reported stolen.

Uranium-235 (U-235) – An ionization chamber containing a small amount of U-235 was reported lost.

Uranium U (depleted) – A rotor containing depleted uranium was reported lost.

Other materials – The NRC received ten reports of the loss of material containing more than one isotope. Generally the reports involving the loss of more than one isotope involved the disposal of trash from laboratories or medial licensees. Two reports involved radioactivity found in trash.

The four reports that did not identify the isotope involved the loss of two general-licensed devices, the loss of a gas chromatograph containing a radioactive source, and the rejection of a load of scrap steel that was contaminated.

Abandoned Well-Logging Sources

NRC licensees are required to report the location of abandoned well-logging sources to the NRC. The 17 events reported during 1991 did not result in any known releases of radioactive materials. (See Table A–6.)

2.1.3 Leaking or Contaminated Sources

Some licensees are required to leak-test sources and to report leaking ones under 10 CFR 34.25; others are required to leak-test sources and to report leaking ones as a condition of their license. In both cases, a removable contamination exceeding the most common test limit for removable contamination (0.005 μCi) is considered evidence of leakage. Licensees are required to report to the NRC removable contamination exceeding the amount specified in 10 CFR 34.25 or in a license condition.

Twenty-one occurrences of leaking or contaminated sources were reported during 1991. Table A–7 includes information from reports of these events. None of the events resulted in a radiation overexposure. The isotopic sources found to be leaking or contaminated contained americium, barium, cobalt, cesium, tritium, iodine, nickel, and strontium.

2.1.4 Release of Materials

During 1991, the NRC received reports of 29 events in which radioactive materials were released. Generally, the events had little effect on any area beyond the immediate area of the release.

2.1.5 Consumer Products

An additional category of events, "consumer products," was defined and included in the database in 1985. Reports of this category of event describe those events in which radioactive material was found in, or had a reasonable probability of being introduced into, nonlicensed consumer products. NRC received information from several sources stemming from one event of this type during 1991. All of the reports involved the detection of contaminated fencing materials imported from India.

2.1.6 Fuel Cycle Facilities

The NRC entered information on 49 fuel cycle events into the nonreactor database in 1991. Of these events, 16 involved the manufacture of uranium hexafluoride, and 33 involved fuel fabrication.

Manufacturing Events

Sequoyah Fuels, Gore, Oklahoma, reported 16 events. They declared the first an "Unusual Event" when a mechanical coupling on a fire water pipeline that serves a cable tray sprinkler system failed. This failure caused several hundred gallons of water to be sprayed into the main process building in the vicinity of the denitration area and washed some built-up uranium contamination from behind some equipment. No breach of uranium containment systems occurred.

In the second event, the licensee declared an "Unusual Event" when visible accumulations of dried raffinate sludge were found outside of the restricted area surrounding a raffinate pond. The licensee believed that high winds dried some of the raffinate,

Table A–7 Leaking sources, 1991

Isotope *	Location	Licensee	License Number	Event Date	Manufacturer
Am-241	Waltham, MA	Panametrics, Inc.	200718101	06/03/91	Monsanto
Am-241	Twinsburg, OH	Reuter-Stokes Inst., Inc.	34182330[1]	11/05/91	New England Nuc./NER479C
Co-60	Marion, PA	Berthold Systems, Inc.	372122e01	10/14/91	Berthold Lab 300 IRI
Cs-137	Boston, Ma	Boston University	200080511	09/27/91	
H-3	E. Lansing, MI	Michigan State University	210002129		Varian GC
I-125	New Haven, CT	Yale University	060018303	07/23/91	
Ni-63	Augusta, ME	State of Maine	180225401	12/29/91	Hewlett-Packard
Ni-63	Ipsilanti, MI	Canton Analytical Lab.	211929502	05/08/91	Shimadzu
Ni-63	St. Louis, MO	Anheuser-Busch Co., Inc.	240384704	05/07/91	Perkin-Elmer/Sigma 2000
Ni-63	Kansas City, MO	Midwest Research Institute	240256402	12/31/91	
Ni-63	Saratoga, NY	State of New York (Perkin Elmer)	060213508	09/14/90	Perkin-Elmer/ECD
Ni-63	Avondale, PA	Hewlett-Packard Co.	370700202	03/15/91	
Ni-63	Avondale, PA	Hewlett-Packard Co.	370700202	04/04/91	
Ni-63	Avondale, PA	Hewlett-Packard Co.	370700202	01/01/91	
Ni-63	Avondale, PA	Hewlett-Packard Co.	370700202	03/06/91	
Sr-90	Redondo Beach, CA	TRW, Inc.	092304301	01/18/91	Isotope Products Lab
Sr-90	Buchanan, NY	New York Power Authority	50-286	08/09/91	Eberline/DA1-8
Z	Tulsa, OK	QUEST	352681501	04/16/91	Amersham/A424-9
Z	Avondale, PA	Hewlett-Packard Co.	370700202	06/25/91	
Z	Avondale, PA	Hewlett-Packard Co.	370700202	09/09/91	
Z	Avondale, PA	Hewlett-Packard Co.	370700202	10/09/91	

Z unspecified

allowing it to become windblown and dispersed from the pond. No overexposures occurred.

In a third event, liquid having a high uranium concentration was discovered inside the facility's restricted area. Rainwater apparently washed some process material from a leaking tank flange onto an adjacent concrete pad.

The licensee discovered a light dusting of UO_2/UF_4 powder on the fourth floor and roof of the hydrofluorination (HF) building in the fourth event.

The powder was leaking around the seams of an air cooling duct off an HF reactor. The leak indicated a leak in the vessel wall from a crack around the upper half of the circumference of a weld.

In the fifth event, a lightning strike caused a temporary power failure to all plant operations. No licensed material was involved, and the power was restored.

The licensee observed uranium in the area around the feed to an HF reactor in the sixth event. The uranium had been discharged from the reactor cooling exhaust line to the roof of the main process building. The leak was attributed to a crack in the reactor shell that extended down the shell about one and one-half inches.

In the seventh event, two workers in the depleted uranium tetrafluoride (DUF_4) plant were contaminated. The contamination measured on one worker was 15,00 cpm on the skin of the neck and 20,000 cpm on the hands. The contamination of the other worker's hands averaged 8000 cpm with a maximum measurement of 25,000 cpm.

An "Unusual Event" was declared when a small "puff" of DUF_4 powder was discharged from an enclosure during packaging. The licensee determined that the powder level in the dust collector was too high for this eighth event.

In the ninth event, the licensee reported that the UF_6 reduction plant, including the dust collector blower, was shut down to allow the dust collector hopper to be emptied and the rotary valve below the hopper to be repaired. An "Unusual Event" was declared and the plant was placed on a full-face respiratory protection.

In the tenth event, the licensee reported that during work on the rupture disk downstream of a relief valve on a cold trap, workers unexpectedly encountered a very small amount of solidified UF_6 when they opened up the line. The UF_6 began vaporizing as it reacted with the air, and a small cloud began forming in the area. The licensee classified this event as an "Unusual Event."

In the eleventh event, the licensee reported that a facility-owned pickup truck was accidentally pulled into a sludge settling pond. The pickup was removed and cleaned. The licensee stated that additional decontamination would be performed in conjunction with the repair of the truck.

In the twelfth event, fixed surface contamination was discovered on the asphalt surface of the warehouse yard east of the facility. The licensee believes that the probable source of the surface contamination was due to the major UF_6 release that occurred in 1986. The asphalt was scraped off and the contamination was reduced to a level well under NRC's release limits.

In the thirteenth event, surveys identified removable alpha radioactivity that exceeded a license action level on some surfaces. The licensee implemented radiological controls to prevent spread of the contamination. No overexposures occurred.

In the fourteenth event, elevated uranium concentration levels were being released from the hydrogen fluoride offgas scrubber system that discharges its treated gas stream through the main plant effluent stack. The licensee initiated numerous measures to determine the source of elevated uranium levels.

In the fifteenth event, the licensee failed to ensure that a sealing gasket was in place on the front mainway hatch of a tanker trailer being used to transport raffinate sludge. As a result, slurry leaked during the shipment of the material from the licensee's facility to a disposal site in New Mexico.

In the sixteenth event, a tank experienced a boilover during routine boildown operations and released

approximately 70 gallons of molten uranyl nitrate hexahydrate (UNH). The molten UNH quickly solidified on floors, walkways, stairs, and various equipment surfaces. No personnel contamination was noted as a result of the incident. The most significant contributing factor to the boilover involved a decision by control room personnel to provide steam to the tank to boil off what was falsely assumed to be excess water to increase the uranium concentration.

Uranium [illegible] Cycle Events

Babcock and Wilcox (B&W), Naval Reactor Fuels, Lynchburg, Virginia, reported five events. The first event was related to a potential problem with their criticality alarm system. The potential problem was related to the possible saturation and resulting inoperability of detectors at high-energy fission release levels. The licensee declared an "Unusual Event" and discontinued transfers of fissile material within the facility until the problem was corrected.

In the second event, the licensee declared an "Unusual Event" when approximately 30 percent of the audible alarms did not actuate during a routine test. They did not actuate because an electrical wire had been severed during the installation of other wiring.

In the third event, a worker was exposed to and inhaled radioactive contaminated acid fumes in the uranium recovery dissolver area when an enclosure door was opened and the ventilation system failed to provide adequate air flow to prevent the fumes escape from the enclosure into the workers breathing zone. No overexposure resulted from this event.

In the fourth event, the licensee declared an "Unusual Event" when an inline monitor in a waste stream line, which carries waste solution from the scrap recovery facility to the waste treatment facility, went into continuous alarm and shut a valve, terminating the flow.

In the fifth event, while testing a new evacuation alarm system, the licensee discovered that the system alarms could not be heard inside three buildings. The licensee evacuated the three buildings and roped them off until the evacuation alarm system was operational.

Babcock and Wilcox (B&W), Commercial Nuclear Fuel Plant, Lynchburg, Virginia, declared an "Unusual Event" related to a potential problem with their criticality alarm system. The potential problem was related to the possible saturation and resulting inoperability of detectors at high-energy fission release levels. B&W stopped all handling and processing of fissile material until the problem was corrected.

Babcock and Wilcox (B&W), Apollo, Pennsylvania, reported that a fire occurred in a paint storage area. No radioactive material was involved and the B&W facility was not affected.

Combustion Engineering (CE), Windsor, Connecticut, identified a small ammonia leak from a tank in the fuel fabrication yard. No odor was detectable offsite.

Combustion Engineering (CE), Hematite, Missouri, experienced an unplanned release of UF_6. A steam valve failed, resulting in the incomplete hydrolysis of UF_6 and its concomitant release. Most of the unreacted UF_6 reacted with limestone in the offgas scrubber, but a small amount was released from the stack. No release limits were exceeded in this event.

General Electric (GE) Company, Wilmington, North Carolina, reported 15 events. In the first event, a tanker truck pumped sulfuric acid into a tank containing hydrochloric acid necessitating the evacuation of the fabrication building because of fumes.

A process control problem occurred with the consequent release of enriched uranium into an unsafe geometry tank. GE declared an "Alert" during this event. This second event was the subject of an NRC IIT inspection. Additional information on the event and the NRC findings can be found in Appendix G and Section 3, Incident Investigation Program, of this report.

In a third event, about 400 gallons of liquid containing small amounts of uranium were transferred to an unsafe geometry tank. The transfer was made before obtaining all required analytical results.

A timer for a pellet press was reset so that three times the allowable volume of pellets could have collected before the press would have been shut off automatically in a fourth event.

In a fifth event, a waste tank was discharged without the operator being aware of the correct concentration of material in the waste. An operator stated that he observed that a waste tank dumped its contents without intervention, but GE determined that the operator responded to the wrong item on the computer screen.

A portion of the contents of a rad waste tank was improperly discharged to a lagoon in a sixth event. An operator transposed sample results of two tanks, and the independent verification process failed to ensure that the proper value had been used.

In a seventh event, a process pump that supplies cooling water to a recovery unit tripped, but an automatic backflow feature prevented backflow of uranium to the nonfavorable geometry cooling tower.

A device used to measure the uranium concentration in waste streams malfunctioned in an eighth event. The malfunction was believed to have begun 3 hours before its discovery. The cause was the blockage in the atomizer of a plasma spectrometer. A second spectrometer, normally used in conjunction with the first, was out of service.

In a ninth event, the licensee reported that incorrect information was entered on a form for a non-like-kind valve replacement, a quality assurance breakdown.

Uranium contamination was reported below the floor in a slab tank area at an expansion joint; the contamination could have resulted from a spill of 200 gallons of nitric acid. The licensee was concerned that damage to the floor could affect the stability of the slab tanks, compromising criticality control. A large volume of earth was removed from beneath the spill area to remove contamination from this and previous spills in this tenth event.

Fifty-eight kilograms of uranium dioxide were detected within the enclosure of a slugger press in an eleventh event. A die broke and allowed the powder to fall to the bottom of the enclosure. The accumulation of powder represented a failure of the nuclear criticality safety geometry control, but the second nuclear criticality safety control involving control of the mass in the enclosure was maintained.

A component in the criticality warning system failed, rendering the system inoperable in a thirteenth event. Temporary detectors were deployed and wired into the system.

In the course of a licensing review of the uranium recycle unit (URU), GE determined that two work stations and one piece of equipment in a section of the URU had been approved only for enrichments of 4.025 percent or less although enrichments of 4.4 and 4.8 percent had been processed in that section. In this fourteenth event, GE revoked the approval for enrichments greater than 4.035 percent in that part of the URU and evaluated the criticality of the subject stations and equipment. On the basis of the reevaluation, GE approved the URU for use with enrichments up to 4.8 percent.

A hose clamp failed, resulting in the release of 82 kilograms of uranium powder to the confinement around the press. The nuclear criticality safety geometry control failed, but the nuclear criticality moderation safety control was maintained in this fifteenth event.

In addition to these 15 events that occurred at their facility, GE reported that a car struck a truck carrying a shipment of fresh fuel from the Wilmington, North Carolina, facility to Vermont Yankee Nuclear Power facility in Vernon, Vermont. The outer wooden packaging burned, and the inner metal packaging was damaged. GE declared a "Site Area Emergency" for this event. No releases of radioactive material occurred.

Nuclear Fuels Services, Inc., Erwin, Tennessee, experienced six events. In the first event, an operator cut the tip of his finger with some resulting contamination with plutonium. The injury resulted from the use of an ultra-high pressure jetting system. Medical treatment was provided after consulting the Radiation Assistance Center/Training Site (REAC/TS) in Oak Ridge.

In a second event, four people were moving a glove box when it slipped and ruptured. Three movers were wearing positive pressure respirators and the fourth was wearing an incompletely sealed bubble suit. No one was overexposed as a result of the incident.

The criticality monitoring signal failed to transfer to the uninterruptible power supply (UPS) when power to the plant was lost in a third event. The monitors were connected to the emergency power generator until the UPS was available. The UPS was lost because of a loose connection.

In the fourth event, an improper discharge of liquid to an unsafe geometry tank occurred when sample numbers were mixed up.

The licensee found an inadequate procedure for a nondestructive assay (NDA) station that was not being used as designed after the NDA station alarm sounded. The alarm was unexpected because the amount of fissile material in the station was below the limit set for the station. The NDA station detector was inaccurate, causing the alarm to sound although the control limits of the station had not been reached.

A broken PVC pipe released 300 gallons of water. The water was collected in 55 gallon drums, all except one of which contained plutonium solution in concentrations that were below the limit for release to unrestricted areas. The contents of the one drum were retained for further cleanup.

Siemens Nuclear Power Corporation (formerly *Advanced Nuclear Fuels Corporation*), Richland, Washington, reported a fire inside a rubber transfer boot in the UNH dissolver glovebox. Uranium dioxide had ignited causing the rubber boot to burn, which in turn, ignited a Lexan hood. No exposures occurred, and the high-efficiency particulate air filters held. Contamination was limited to the dissolver hood.

UNC, Inc.'s Uncasville, Connecticut, facility experienced one event: zirconium fines in a filter housing ignited and caused a fire in the filter material. Air samples from the area showed no significantly elevated levels of radiation.

Westinghouse Electric Corporation's Commercial Nuclear Fuel Division, Columbia, South Carolina, experienced two events: In the first, a 6-inch city water line failed, resulting in the release of 3000 gallons of water to the contamination controlled area. No water was released outside of the building and no exposures resulted from the event. In the second event, circulation was lost in the concentration monitoring loop on an unfavorable geometry tank. One pump was discovered to be leaking and smoking. The pump was turned off and the redundant

pump was started. Because no flowmeter was in the line, downstream pressure was used to indicate flow in the loop. The flow in the loop was lost because a nut was lodged in the suction side of the monitoring loop line. The lack of flow caused overheating and concentration of the liquid, which triggered a high concentration alarm. The concentration monitoring loop is not a criticality safety contingency.

2.1.7 Radiography

During 1991, licensees reported 30 events that involved radiography. All of these occurred at remote sites. Table A-8 provides information on these reported events. All of the events involved overexposures or potential overexposures, transportation events, or lost or leaking sources. NRC requires in 10 CFR 34.30 that licensees report to the NRC events such as these and certain defects in radiography equipment.

NRC received the following 19 reports of defects as required by 10 CFR 34.30 in 1991. Reports of this type were not received in previous years unless the information was transmitted with the report of a personnel overexposure.

- AIX (Alaska Industrial X-ray, Inc.) reported a source disconnect with an Amersham Century S camera because the source tube was not connected to the exposure device.

- Amersham Corporation reported a defect in a component used in the manufacture of the Amersham Model 920 camera. A dimensional defect in the male fitting on the front end plate of the camera may prevent a secure connection of the guide tube. A guide tube that engages the bearings on the quick disconnect is not properly located on some of the defective parts so that the guide tube could become disconnected while the source is exposed. Amersham provided incomplete specifications to the machine shop that manufactures the fitting. All of the American customers that might be affected by the problem have been notified. The defective cameras will have to be returned for replacement of the f[illegible].

- Edwards Pipeline Testing, Inc., reported a disconnect with a SPEC 2T camera. The assistant radiographer failed to properly connect the source pigtail to the drive cable.

- Globe X-Ray reported that a source could not be fully retracted into an Amersham Model 660 camera. The locking slide bar had fallen back into the locked position and would not allow the source to be fully retracted. The Amersham operation and maintenance manual describes the possibility of this type of event with a fix to avoid it.

- H & G Inspection reported an event in which a "J" source assembly hung up inside the exposure device, an Amersham Model 89911 source assembly, and the cable connector broke loose. A pin in the pigtail connector caused the hangup.

  In a second event, H & G reported that a source could not be retracted into a Gulf Nuclear 20-V device. It became stuck in the guide tube, which had become crimped. When a new guide tube was connected to the device, the unit worked properly.

  MQS Inspection, Inc., reported a source disconnect with a Magnaflux Model MX-IC-100 exposure device. The exposure device had been disconnected from one guide tube and had not been connected to the other guide tube when the source was exposed. The source was able to be cranked out further than expected so that the radiographer retracted the source but was

Table A–8 Radiography events, 1991

Isotope*	Location	Licensee	License Number	Event Date	Type of Event**
Ir-192		Globe X-Ray Services, Inc.	351519401	08/07/91	
Ir-192		H&G Inspection Co., Inc.	422683801	07/29/91	
Ir-192	Anchorage, AK	Alaska Industrial X-Ray, Inc.	501608401	06/18/91	
Ir-192	Fairbanks, AK	Inspection Serv. & Test.	502325701	05/21/91	EXP
Ir-192	Diablo Canyon, CA	Plant Inspection Co.	042103201	09/19/91	EXP
Ir-192	Chubbock, ID	Diamond H Testing Co.	ID-191	01/29/91	EXP
Ir-192	Birch Run, MI	TEI, Inc.	372800401	10/24/91	
Ir-192	Gaylord, MI	TEI, Inc.	372800401	06/27/91	
Ir-192	Cloquet, MN	Twin Ports Testing, Inc.	482347601	05/18/91	
Ir-192	Grand Rapids, MN	Edwards Pipeline Testing, Inc.	352319301	02/16/91	
Ir-192	Trenton, NJ	MQS Inspection, Inc.	120062207	02/09/91	
Ir-192	Bordentown, NJ	Bran-Shon, Inc.	291415001	11/03/91	TRS
Ir-192	Minneapolis, MN	Edwards Pipeline Testing, Inc.	220137602	12/18/91	
Ir-192	Cincinnati, OH	MQS Inspection, Inc.	120062201	12/30/91	
Ir-192	Deerfield, OH	Bran-Shon, Inc.	342585001	08/24/91	LAS
Ir-192	Tulsa, OK	Edwards Pipeline Testing, Inc.	352319301	10/22/91	LKS
Ir-192	Tulsa, OK	QEST	352681501	05/17/91	LKS
Ir-192	Charleston, SC	Industrial NDT Co., Inc.	392488801	03/04/91	LAS
Ir-192	Chester, VA	Old Dominion Fabricators	451558101	08/23/91	
Ir-192	Newport News, VA	Newport News Shipbuilding	450942802	12/19/91	
Ir-192	Roberts, WI	Twin City Testing	220137602	10/09/91	
Ir-192	Kaukauna, WI	Professional Welding Assoc.	482580601	06/23/91	
Ir-192	Carter Creek, WY	H&G Inspection Co., Inc.	422683801	10/07/90	
Z	Englewood, CO	Intermountain Testing Co.	050787201	10/24/91	EXP
Z	Jacksonville, FL	Space Science Services, Inc.	090755001	12/02/91	EXP
Z	Burlington, MA	Amersham Corp.	201283601		
Z	St. Louis, MO	St. Louis Testing Labs., Inc.	240018802	08/05/91	
Z	Howell, NJ	Certified Testing Labs	291415001	11/04/91	TRS
Z	Huffman, TX	Cotton Houston Serv., Inc.	422682301	11/04/91	EXP
Z	Mills, WY	High Mountain Insp. Serv., Inc.	492680801	06/08/91	TRS

* Z means unspecified
** EXP Exposure
LAS Lost, Abandoned or Stolen Source
LKS Leaking Source
TRS Transportation

unable to return it to the shielded position. The source had become disconnected.

A second event was reported that occurred when a Gamma Century S device was being used. The source guide tube had become partially unscrewed from the quick disconnect fitting, forming a gap inside the guide tube that permitted the source assembly to "jackknife" and restricting the flexibility of the connection. The source jammed in the exposed position and could not be retracted into the fully shielded position.

- Newport News Shipbuilding reported that their personnel were unable to retract the Ir-192 source into the fully shielded position in an Amersham Model 660 camera. Examination of the equipment led to the conclusion that the pigtail had not been properly connected to the drive cable. The selector ring on the Model 660 could be moved to the "operate" position without the proper connection of the drive cable and source. Although Amersham knew of the possibility of such failures and had distributed details of a test to detect problem equipment in March 1991, Newport News had not been furnished with the information. Newport News performed the test on all equipment and found four other defective units. These were removed from service.

- Old Dominion Fabricators reported a source disconnect with a Gamma Industries Century SA camera; the disconnect was related to a defect in the drive cable.

- Professional Welding Associates reported an unintentional disconnect of the source assembly from the control cable with an SOEC Model 2T. The cause of the disconnect was operator error.

- St. Louis Testing Laboratories reported the failure of a lock box on a TECH/OPS 660 camera when an attempt was being made to unlock it. The camera had an automatic lock assembly and the source, therefore, was locked in place. The camera was returned to TECH/OPS for repair.

- TEI Analytical Services, Inc., reported two events in which a source could not be retracted to its fully shielded position in Automation Industries Model 520 Iriditrons. The licensee believes the cause of both events was the failure of the radiographer to properly connect the drive connector to the source assembly before making an exposure.

- Twin City Testing Corporation reported in one event that the lock cylinder on an Amertest Model 660 exposure device pulled out of the lock housing. The springs and tumblers of the lock mechanism were damaged and the key cylinder would not go back into the lock mechanism. The device was to be returned to Amersham for repair.

  In a second event, the licensee reported that a 20,000 pound vessel fell on the exposure device, Amertest Model 660, crushing the handle and bending the end plates. The lock mechanism ring on the damaged device could not be turned manually. The source was in the safe position when the accident occurred.

- Twin Ports Testing, Inc., reported a source disconnect with a Gamma Industries Century SA device. The quick disconnect coupling was not properly connected to the camera, causing the source assembly/guide cable connector to come apart when it passed through the tube/camera connector.

Six reports from radiography licensees involved overexposures, and two involved leaking sources. These reports have been discussed in Sections 2.1.1 and 2.1.3 respectively. NRC received two reports of lost sources that were recovered, and three reports of transportation events involving radiography devices that did not result in any damage to the device.

2.1.8 Manufacturing and Distribution

The NRC received 46 reports of events that involved manufacturing and distribution during 1991. Table A–9 provides information about these events. These licensees have no unique reporting requirements for events involving health and safety unless the requirements are incorporated into a license condition or an Order. None of the events was significant.

2.1.9 Gauges and Measuring Systems

Holders of specific licenses to possess gauges are required to report failures of, or damage to, shielding, on/off mechanisms, or indicators of the gauge, or detection of removable contamination on the gauge. In addition, 10 CFR Part 20 requires these licensees to report lost or stolen materials, releases of material, and so forth.

Reports of 33 events involving gauges or measuring systems were received during 1991. Table A–10 includes information from these reports. None of the events by itself was significant.

2.2 Abnormal Occurrences

In the 1991 *Report to Congress on Abnormal Occurrences* (AO) (NUREG-0090), three events at NRC licensees and four events at Agreement State licensees were determined to be AOs. The AOs at NRC licensees involved the following:

- significant degradation of plant safety at Nuclear Fuel Services in Erwin, Tennessee
- potential criticality accident at the General Electric Nuclear Fuel and Component Manufacturing Facility in Wilmington, North Carolina
- radiation exposures of members of the public from a lost radioactive source

The Agreement State AOs received in 1991 involved the following:

- radiation exposure of a nonradiation worker (1990 event)
- radiation overexposure of a radiation worker (1990 event)
- overexposure of a radiographer (1990 Event)
- exposures of nonradiation workers (1990 event)

Table A–9 Manufacturing and distribution, 1991

Isotope*	Location	Licensee	License Number	Event Date	Type of Event**
Am-241	Waltham, MA	Panametrics, Inc.	200718101	06/03/91	LKS
Cs-137	Sagola, MI	Louisiana-Pacific Corp.	481898602	06/25/91	GAU
Cs-137	Festus, MO	Union Electric Co.	240202004	08/02/91	MSC
Cs-137	Farrell, PA	Sharon Steel Corp.	371634601	07/16/91	EXP
Cs-137	Sistersville, WV	Union Carbide	470606703	12/09/90	EXP
H-3	Ann Arbor, MI	KMS Fusion, Inc.	211544601	08/04/91	RLM
I-125	Washington, DC	Dept. of the Navy	452364203	09/26/91	LAS, TRS
I-131	Chicago, IL	Syncor Corp.	131945101	02/25/91	TRS
I-131	Maryland Heights, MO	NL Federal Express		11/18/91	TRS
Ir-19.	Tulsa, OK	Amersham Corp.	201283601	04/16/91	RAD, LKS
Ir-192	Milne Point, AK	Alaska Ind. X-Ray, Inc.	501608401	06/18/91	RAD
Ir-192	Alden, KS	Cot. Houston Serv., Inc.	422682301	09/08/91	EXP, RAD
Ir-192	Burlington, MA	Amersham Corp.	201283601		RAD
Ir-192	Grand Rapids, MI	Edwards Pipe Testing, Inc.	352319301	02/16/91	RAD, EXP
Ir-192	Cloquet, MN	Twin Ports Testing, Inc.	482347601	05/18/91	RAD
Ir-192	Trenton, NJ	MQS Insp., Inc.	120062207	02/09/91	RAD
Ir-192	Tulsa, OK	Edwards Pipe Testing, Inc.	352319301	10/23/91	LKS,RAD
Ir-192	Tulsa, OK	QEST	352681501		TRS
Ir-192	Newport News, VA	Newport News Ship.	450942802	12/19/91	RAD
Ir-192	Chester, VA	Old Dominion Fabricators	451558101	08/23/91	RAD
Ir-192	Kaukauna, WI	Prof. Welding Assoc.	482580601	06/23/91	RAD
Ir-192	Roberts, WI	Twin City Testing	220137602	10/09/91	RAD
Ir-192	Superior, WI	Twin Ports Testing, Inc.	482347601	05/18/91	RAD
Ir-192	Carter Creek, WY	H&G Inspection Co., Inc.	422683801	10/07/90	RAD
Mo-99	St. Louis, MO	Mallinckrodt, Inc.	240420601	04/08/91	TRS
Mo-99	South Plains, NJ	Del-Med, Inc.	200032018	05/24/91	TRS

Footnotes at end of table

Table A–9 (cont.)

Isotope*	Location	Licensee	License Number	Event Date	Type of Event**
Tc-99M	Billerica, MA	Du Pont Merck Pharm.	202859801	09/10/91	
Tc-99M	Orange, NJ	Mallinckrodt, Inc.	292806401	03/07/91	TRS
Tc-99M	Orange, NJ	Mallinckrodt, Inc.	292806401	04/14/91	TRS
Tc-99M	Orange, NJ	Mallinckrodt, Inc.	292806401	06/04/91	TRS
Tc-99M	Toledo, OH	Syncor Corp.	341665401	02/18/91	TRS
Tc-99M	Cleveland, OH	Syncor Corp.	341640501	08/29/91	TRS
Tc-99M	Philadelphia, PA	MPI Phar. Serv., Inc.	372783002	01/09/91	TRS
Tc-99M	Tioga County, PA	NL Express Deliv.	NL	04/08/91	TRS
Tc-99M	Rice Lake, WI	Shared Med. Tech., Inc.	481754301	12/27/91	TRS
Tc-99M	Wauwatosa, WI	Syncor Corp.	481746601	09/17/91	TRS
Tc-99M	Bluefield, WV	Humana Hospital	472351701	09/10/91	TRS
U	[illegible]	Diagnostic Photon Corp.	521634502	03/21/91	EXP
Xe-133	[illegible]	Medi-Physics, Inc.	291536003	04/19/91	TRS
Xe-133	[illegible]	E.I. DuPont	200032019	07/19/91	TRS
Y	St. Paul, MN	Syncor Corp.	221917402	04/15/91	EXP
Z	Crawfordsvill[illegible], IN	Syncor Corp.	131922901	04/09/91	TRS
Z	Warren, MI	Mallinckrodt, Inc.	240420610	06/11/91	TRS
Z	St. Louis, MO	St. Louis Testing Lab.	240018802	08/05/91	RAD
Z	Cleveland, OH	Adv. Med. Systems, Inc.	341908901	07/16/91	
Z	Carolina, PR	Diagnostic Photon Corp.	521634502	12/20/90	EXP

* Y other
Z unspecified

** EXP exposure
GAU gauge
LAS lost or stolen source
LKS leaking source
MSC miscellaneous
RAD radiography
RLM release of material
TRS transportation

Table A–10 Gauges and measuring systems, 1991

Isotope*	Location	Licensee	License Number	Event Date	Type of Event**
Am-241	Danbury, CT	Testwell Craig Labs	061972001	06/24/91	TRS
Am-241	Dover, DE	State of Delaware	071 94701	05/21/91	
Am-241	Indianapolis, IN	Atec Assoc., Inc.	131773201	06/06/91	
Am-241	Novi, MI	CTI and Associates	211700701	04/26/91	TRS
Am-241	Plymouth, MI	Eng. and Testing Serv.	212631601	10/15/91	
Am-241	Columbus, OH	BBC&M Engineering, Inc.	341889401	10/25/91	
Am-241	Willoughby, OH	EDP/Triggs Cons., Inc.	342130101	10/29/91	
Am-241	Cincinnati, OH	H.C. Nutting Co.	341888201	01/15/91	
Am-241	State College, PA	Blazosky Associates, Inc.	372891507	02/27/91	EXP
Am-241	Philadelphia, PA	Philadephia, City of	370798307	05/08/91	
Am-241	Winchester, VA	Triad Engineering, Inc.	451820901	11/19/91	
Am-241	Charleston, WV	WV Dept of Highways	470783801	06/18/91	
Am-241	Casper, WY	Chen-Northern, Inc.	491700201	12/09/91	
Co-60	Newark, DE	Koch Eng. Co./Trutech	072838601	09/16/91	TRS
Cs-137	Indianapolis, IN	Alt & Witzig Eng.	131868501	11/01/91	EXP
Cs-137	Indianapolis, IN	GL Beveridge Paper Co.	GL**		EXP
Cs-137	Sagola, MI	Louisiana-Pacific Corp.	481898602	06/25/91	
Cs-137	Billings, MT	Dept. of Interior	251509101	09/16/91	MSC
Cs-137	Raleigh, NC	Berthold, Inc.	372122601	10/03/91	TRS
Cs-137	Farrell, PA	Sharon Steel Corp.	371634601	07/16/91	EXP
Cs-137	Richmond, VA	Geo-Systec		06/07/91	
Cs-137	Sistersville, WV	Union Carbide	470606703	12/09/90	EXP
Kr-85	Tamaqua, PA	ICI Americas, Inc.	372827101	06/03/91	RLM
Kr-85	Wi. Rapids, WI	Consolidated Papers, Inc.	480111701	06/19/91	EXP
Ni-63	St. Louis, MO	Anheuser-Busch Co., Inc.	240384704	05/07/91	LKS
Th	W. Mifflin, PA	Suisman and Blumenthal	061765301	07/05/91	WAS

Footnotes at end of table

Table A–10 (cont.)

Isotope	Location	Licensee	License Number	Event Date	Type of Event***
Z	Barrow, AK	North Slope Borough	S02325901	02/18/91	MSC
Z	East Hartford, CT	Ind. Material Testing	0620980l	10/19/90	
Z	Evansville, IN	GL Pro Form, Inc.	GL**	04/29/91	
Z	Fort Wayne, IN	Materials Insp. & Testing	131696102	10/01/86	EXP
Z	Rolla, MI	Missouri Eng. Corp.	242522700	06/28/91	TRS
Z	St. Paul, VA	W-L Cons. & Paving, Inc.	452500201	05/22/91	TRS
Z	S. Charleston, WV	Olin Corp.	472483701	12/13/91	

* Z unspecified
** GL general licensee
*** EXP exposure
LKS leaking source
MSC Miscellaneous
RLM release of material
TRS transportation

3 Findings

The number of events reported to the NRC in 1991 was about 30 percent greater than that in 1990. New reporting requirements for radiography licensees and increased numbers of reports entered for fuel cycle licensees were responsible for much of the increase. The most recent readily available collective exposures for industrial radiographers and licensees involved in, manufacturing and distribution, low-level waste disposal, independent spent fuel storage, and fuel fabrication and processing showed that all of these licensees maintained the average exposure of their personnel well below the annual limits specified in 10 CFR Part 20 in 1990. No significant overexposures resulted from operations by NRC licensees in 1991, and the numbers of reports of lost material and leaking sources was comparable to the numbers in previous years.

Appendix B

Report on 1991 NRC Licensee Misadministrations

Appendix B

AEOD/N91-03

Report on 1991 NRC Licensee Misadministrations

by the
Nonreactor Assessment Staff
Office for Analysis and Evaluation of Operational Data

Prepared by
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Contents

Tables

1 Introduction

The Office for Analysis and Evaluation of Operational Data (AEOD) reviews reports of medical misadministrations of radiopharmaceuticals or radiation from isotopes regulated by the NRC.* AEOD's review of these reports submitted to the NRC during 1991 is documented in this appendix.

The revised Part 35 of Title 10 of the *Code of Federal Regulations* (10 CFR Part 35), which became effective on April 1, 1987, defines a misadministration to mean the administration of –

- a radiopharmaceutical or radiation from a sealed source other than the one intended,
- a radiopharmaceutical or radiation to the wrong patient,
- a radiopharmaceutical or radiation by a route of administration other than that intended by the prescribing physician,
- a diagnostic dosage of a radiopharmaceutical differing from the prescribed dosage by more than 50 percent,
- a therapy dosage of a radiopharmaceutical differing from the prescribed dosage by more than 10 percent, or
- a therapy radiation dose from a sealed source involving errors in the source calibration, time of exposure, or treatment geometry that result in a calculated total treatment dose differing from the final prescribed total treatment dose by more than 10 percent.

Part 35 was revised again on January 27, 1992, to include the Quality Management Rule. As a part of this revision, the definition of the misadministrations that are reportable to the NRC so that the reporting requirements for almost all diagnostic misadministrations will be eliminated.

However, certain diagnostic and therapy procedures involving the misadministration of either iodine-125 (I-125) or iodine-131 (I-131) in amounts exceeding 30 microcuries (μCi) will still be reportable. In addition, an increased therapy threshold of more than 20 percent difference from the total prescribed dose instead of the existing threshold of more than 10 percent difference from the prescribed dose (except for gamma stereotactic radiosurgery where the threshold for the total misadministered dose differs by more than 10 percent from the total prescribed dose) will eliminate the reporting of some of the therapy misadministrations. For example, about 15 percent of the reported 1991 therapy misadministrations would be eliminated if the recently revised regulation had been in effect.

NRC licensees reported medical misadministrations to the NRC to comply with the 1991 requirements in 10 CFR 35.33. This section requires that licensees report all therapy misadministrations. The reporting criteria for diagnostic misadministrations in this section require that licensees report only those diagnostic misadministrations in which (1) radioactive material not intended for medical use was administered, (2) the administered dosage was five-fold different from the intended dosage, or (3) the patient was likely to receive an organ dose greater than 2 rem or a whole-body dose greater than 500 millirem (mrem).

* The Atomic Energy Act of 1954, as amended in 1974, limits the NRC's regulation of radioactive materials to reactor-produced isotopes.

Approximately 7 million diagnostic procedures, 30,000 radiopharmaceutical therapy procedures, and 50,000 brachytherapy procedures are performed annually in the United States. In addition, about 100,000 patients receive cobalt-60 (Co-60) teletherapy treatments each year.* The NRC estimates that Agreement States licensees perform about 60 percent of these procedures and NRC licensees perform 40 percent. Appendix C presents a detailed analysis of the Agreement State's misadministration data.

Diagnostic misadministration, as used in NRC regulations, refers to the misadministration of radioisotopes in nuclear medicine studies such as renal scans and bone scans. Therapy misadministration, as used in NRC regulations, refers to the misadministration of radiation in the treatment of patients from Co-60 teletherapy (external use of radiation for patient therapy treatment), gamma stereotactic radiosurgery (external use of radiation from about 200 small Co-60 sources for patient therapy treatment), brachytherapy (insertion or implantation of sealed sources containing radioactive material for patient therapy treatment), or radiopharmaceutical therapy. The significance of any event stems from the potential effect of the event on the public health and safety. Generally, the total risk ascribed to an event is a function of the frequency of the event and the magnitude of the potential effect of the event.

Licensees have reported about 119 therapy misadministrations to the NRC over the 11-year period from 1981 through 1991. The estimated error rate per patient is 0.0003 for teletherapy and 0.0002 per procedure for brachytherapy and radiopharmaceutical therapy.

Generally, the magnitude of the potential or actual effect of a therapy misadministration and a diagnostic misadministration differ. Therapy misadministrations are associated with procedures in which large doses of radiation are administered to patients to achieve a therapeutic effect, while diagnostic misadministrations are associated with procedures requiring small dosages of radiation, except for the diagnostic administration of I-131 or I-125.

Licensees have reported over 4400 diagnostic misadministrations to the NRC over the 11-year period from 1981 to 1991. NRC estimates that about 3 million procedures are performed annually by NRC licensees, making the estimated diagnostic patient error rate 0.0001 per procedure.

Diagnostic misadministrations that result in the erroneous administration of I-131 may result in thyroid or other organ doses that range from several hundred rads to several thousand rads. These doses may approximate therapy-equivalent misadministrations.

Because both therapy misadministrations and diagnostic misadministrations have about the same estimated error rate, therapy misadministrations and some I-131 misadministrations as a class, appear to be individually and collectively more significant than diagnostic misadministrations. AEOD, therefore, reviews in detail reports of therapy misadministrations and misadministrations that involve the administration of I-131. Most reports of diagnostic misadministrations are reviewed from a collective or statistical viewpoint.

This appendix is a compilation of data on misadministrations reported to the NRC from January through December 1991 and is divided into the following sections: "Therapy and Diagnostic Misadministrations Reported to NRC During 1991," "Licensee Proposed Corrective Actions," and "Findings and Conclusions."

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* U.S. Nuclear Regulatory Commission, "10 CFR Part 35, Basic Quality Assurance Program, Records and Reports of Misadministrations or Events Relating to the Medical Use of Byproduct Material," *Federal Register*, Volume 55, No. 10, January 16, 1990, pp. 1439-1449.

2 Therapy and Diagnostic Misadministrations Reported to NRC During 1991

2.1 General

From January through December 1991, NRC licensees involved in radiation therapy and nuclear medicine reported 19 therapy misadministrations and 444 diagnostic misadministrations, which is equivalent to approximately 21 events per 100 licensees. Table B–1 summarizes the statistics for the medical misadministrations reported to the NRC for 1991. Of approximately 2200 NRC licensees authorized to perform nuclear medicine studies or radiation therapy, 348 reported one misadministration or more for a total of 463 reports involving 520 patients. Of the 463 reports on misadministrations, 444 involved diagnostic misadministrations and 19 involved therapy misadministrations.

Table B–1 Medical misadministrations reported to NRC during 1991

	Misadministration		
	Diagnostic	Therapy	Total
No. of reports	444	19	463
No. of patients involved	489	31	520*
No. of licensees reporting	329	19	348

* The number of patients is much higher than the number of reports. This is due to multiple patients that may be involved in a single misadministration and are included in one report.

Table B–2 lists the number of misadministration reports received during 1991 and the previous 10 years. This table also provides the number of reports according to type of misadministration, the number of patients involved, and the number of licensees reporting misadministrations. The figure of 444 diagnostic reports for 1991 was about the same as the number for 1990 and about 10 percent higher than the average rate of the years 1981 through 1989. The 19 therapy misadministrations reported during 1991 was about two times higher than the average number reported annually in 1981 through 1990.

Table B–3 provides estimates of the error rate for the various types of therapy procedures and diagnostic procedures.

2.2 Therapy Misadministrations

Licensees reported 19 therapy misadministrations during 1991. Of these misadministrations, 3 involved teletherapy, 11 involved brachytherapy, and 5 involved radiopharmaceutical therapy. Table B–4 presents data on the type and probable cause of these misadministrations.

2.2.1 Teletherapy Misadministrations

Licensees reported three teletherapy misadministrations during 1991. Of these, two involved an inadequate review of the patient's chart, and one involved an erroneous computer programming entry.

- In the first of the three teletherapy misadministrations reported during 1991, a patient was prescribed a Co-60 teletherapy treatment of 250 rads to the brain; however, the patient received an unintended dose of 57 rads to the neck area. The two technologists involved in this treatment picked up the wrong patient's chart and failed (1) to check the identifying picture, which was in the chart, (2) to check the patient's identification on the daily schedule, and (3) to communicate with the patient. The licensee

Table B–2 Misadministration reports for 1981–1991

Type of misadministration	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	Total	Average
Therapy	10	4	4	14	4	7	9	12	10	24	19	117	11
Diagnostic													
Iodine-131	2	3	2	3	3	5	5	7	10	13	14	67	6
Other	428	414	332	395	377	433	409	386	397	430	430	4,431	403
No. of patients	517	451	437	442	410	495	459	470	486	573	520	5,260	478
No. of licensees reporting	351	355	293	318	293	369	348	344	326	350	348	3,695	336

Table B–3 Error rate for misadministrations
(Based on aggregated 11-year data)

Type of Procedure	Estimated Number of Procedures by NRC Licensees	Number of Misadministrtions	No. of Patients	Error Rate
Therapy				
Teletherapy	404,800*	53	137	0.0003
Brachytherapy	202,400	41	41	0.0002
Radiopharmaceutical	126,500	23	23	0.0002
Diagnostic	41,000,000	4,445	5,260	0.0001

* This figure represents the estimated number of patients that received teletherapy treatments.

Table B–4 Type and probable cause of therapy misadministrations reported in 1991

Teletherapy	
Inadequate review of the patient's chart	2
Error in the computer programming entry	1
Brachytherapy	
Error in the dose calculation	4
Error in identifying the treatment area	1
Inadequate training of the involved personnel	1
Inadequate review of the patient's chart	1
Inadequate review of the patient's chart	1
Error in identifying the strength of implanted brachytherapy sources	1
Error in verifying the placement of the brachytherapy sources in relation to the treatment site	1
Inadequate patient restraint	1
Radiopharmaceutical therapy	
Error in verifying patient identification	1
Defective equipment	1
Wrong dosage	1
No verification of prescribed dosage	1
Misreading the dose calibrator	1

stated that to prevent recurrence of this misadministration, the picture of the patient will be relocated to the section of the chart that contains the treatment setup parameters for identification purposes.

- In the second misadministration, a patient undergoing a teletherapy treatment received 287 rads to the thoracic vertebrae instead of 300 rads to the cervical vertebrae. The technologist involved in the treatment did not adequately review the patient's chart that indicated the correct treatment for the cervical vertebrae. To prevent recurrence of this misadministration, the licensee stated that, in the future, it will stress to the radiation technologists the need to carefully read a patient's chart and to recognize notations of changes in the fields to be treated. Also, when a field is completed, the administered dose is to be recorded in the patient's chart, using a different color ink.

- In the third misadministration, a licensee reported that during a review of the hand calculations for Co-60 teletherapy treatments, the licensee discovered that 13 patients received radiation doses that varied more than 10 percent from the prescribed dose. Of the 13 patients, 3 received a dose

that exceeded 10 percent of the prescribed dose, and 10 received doses ranging from 10 percent to 27 percent below the prescribed dose. All misadministrations resulted from an erroneous computer programming entry into the treatment planning computer, using wedge factors. To prevent recurrence of these misadministrations, the licensee stated that, in the future, it will modify the quality assurance program to require the performance of hand calculation verifications on all computer-generated treatment plans.

2.2.2 Brachytherapy Misadministrations

Licensees reported a total of 11 cases of brachytherapy misadministrations during 1991 that were caused by (1) error in the dosage calculation, (2) error in identifying the treatment area, (3) inadequate training of involved personnel, (4) inadequate or no review of a patient chart, (5) error in identifying the activity of implanted brachytherapy sources, (6) error in verifying the placement of the brachytherapy sources in relation to the anatomical treatment site, and (7) inadequate patient restraint.

- In the first case, a patient was prescribed brachytherapy treatment for ocular melanoma. The prescription indicated a dose of 30,000 rads to be administered to the base of the tumor and 14,300 rads to the apex of the tumor. The treatment involved the use of I-125 seeds contained in an eye plaque. The physicist involved in the procedure changed the coordinates for each seed in the computer, but failed to change the associate points for calculation of dose to various depths within the eye. As a result, the patient received a dose of about 59,000 rads to the base of the tumor and 19,500 rads to the apex of the tumor. The licensee stated that to prevent recurrence of this misadministration, in the future, a second physicist will check each plaque and plaque treatment plant before to the implant procedure.

- In the second case, a patient was prescribed an endobronchial brachytherapy treatment using iridium-192 (Ir-192) seeds. A dose of 3000 rads was prescribed to be administered to the treatment area. However, the patient received a dose of 2045 rads, approximately 32 percent less than the prescribed dose. The misadministration occurred because the treatment dose calculations the licensee performed were based on a tumor distance of 1 cm instead of the prescribed distance of 1.5 cm. This miscalculation occurred because the licensee's physicist used a brachytherapy calculation form with an incorrect algorithm for this procedure. To prevent recurrence of this misadministration, the licensee stated that it had (1) destroyed all forms using the incorrect algorithm in the calculation, (2) corrected the computer program written by a former employee, and (3) required an isodose line treatment plan, as an independent check, for every procedure.

- In the third case, a brachytherapy misadministration that occurred in 1987 was reported to the NRC in 1991. A patient was prescribed a brachytherapy treatment of 4000 rads, using a cesium-137 (Cs-137) sealed source implant for a period of 50 hours. However, the source was not removed until an additional 22 hours of treatment time had elapsed because of an error in determining the removal time. The additional treatment time resulted in a calculated intracavitary treatment dose differing from the prescribed dose by approximately 44 percent. To prevent recurrence, the licensee is planning a new quality assurance procedure for checking and recording the prescribed dose, the planned and actual source loading and unloading date and time, and the source implant duration in hours.

- In the fourth case, a patient was prescribed a dose rate of 19 rads per second, using a high dose rate remote afterloading device. During dosimetry calculations for additional treatment, the licensee discovered that the patient had only received 13 rads per second. Owing to magnification distortions in the X-ray image of the target site, a correction factor of 1.35 should have been factored into the geometrical definitions of the target boundaries. Failure to use the correction factor caused a 31.6 percent underexposure.

- In the fifth case, a patient was prescribed a therapy treatment with a strontium-90 (Sr-90) eye applicator. The treatment plan provided for three treatments of 1000 rads each to the patient's left medial conjunctiva. However, the first treatment was made to the lateral aspect of the patient's left conjunctiva. The licensee stated the error was due to the difficulty in identifying the exact treatment area because of the patient's eye movement limitations following surgery for removal of a nonmalignant tumor. To prevent recurrence, the licensee stated that, in the future, patients not fully recovered from anesthesia or who have a limited range of motion of the eye would not be treated until the next working day following the day of the surgical procedure.

- In the sixth case, a patient was prescribed a brachytherapy treatment of 2400 rads using Ir-192 and Cs-137 sealed sources. However, because the oncology resident involved in the procedure was inadequately trained and a licensed therapist was not present during insertion of the sources, only the Ir-192 sources were used. As a result, the patient received a radiation dose to the treatment area of 1000 rads instead of the prescribed 2400 rads. To prevent recurrence of this misadministration, the licensee stated that (1) it will train the oncology residents on the use of brachytherapy tools (2) all residents will perform implants under the direct supervision of a licensed therapist for the first year of training, and (3) it will transport containers for evidence of any misplaced sources.

- In the seventh case, a patient was prescribed five brachytherapy treatments of the nasal septum, using a high dose rate Ir-192 afterloading unit. However, at the fifth treatment, the physicist picked up the wrong patient chart, failed to verify the patient's identity, and the treatment program information for the wrong patient was entered into the computer. As a result, the source was mispositioned by approximately 5 centimeters and the patient received 73 rads to the lips, an area not intended for treatment. To prevent recurrence of this type of misadministration, the licensee stated that in the future (1) the physicist will check each patient's identity, using the patient's photograph or other means of verification, (2) the chart for a patient receiving more than one treatment will be placed in a specified location, and (3) the training will include a general section on high dose rate afterloading devices.

- In the eighth case, a patient was scheduled to receive a teletherapy treatment to the head and neck area, using a linear accelerator. The patient spoke minimal English and the oncology physician did not speak the patient's language. The oncology physician asked the patient which area of the body was being treated, and the patient pointed toward his head. Without reviewing the patient's chart, the physician believed that the patient was scheduled for Sr-90 treatment, and administered a dose of 1000 rads to the surface of the right eye. To prevent recurrence of this type of misadministration, the licensee stated that (1) each physician will be handed a patient's chart directly by an aide, (2) a patient's chart will include a photograph of the patient, (3) access to Sr-90 beta applicator will be limited to the physics department and the

chief technologist, (4) a member of the physics staff will accompany a physician during all Sr-90 treatments, and (5) it will conduct additional staff training.

- In the ninth case, a patient was prescribed a brachytherapy treatment, using a Cs-137 source. After an applicator–a Delclos cylinder–was loaded with a 20-milligram (mg) and 15 - mg equivalent Cs-137 source, it was to be inserted into the patient to treat cancer. However, the wrong sources were loaded and inserted into the patient, which led to a 29-percent patient underdose. To prevent recurrence, the licensee stated that, in the future, it will modify the procedures to require that a technician verify that the sources are the ones to deliver the prescribed dose before loading them and will instruct technologists what actions to take should they discover a discrepancy.

- In the tenth case, a patient was prescribed a brachytherapy treatment of the brain, using I-125 seeds implanted in the inner catheter of a double catheter system. The prescribed dose was 3150 rads. However, upon completing the treatment and removing the catheter, the licensee noted that one of the seeds was not fully inserted into the catheter as specified in the treatment plan. As a result, the dose delivered to the patient was about 20 percent less than what was prescribed. To prevent recurrence of this misadministration, the licensee stated that (1) implant procedures will be changed to mark the inner catheter at the approximate level of the skull, (2) the catheter entrance and end coordinates will be written down, (3) a computerized tomography scan will be taken immediately post-operatively to verify the position of the seeds, and (4) the treatment planning computer will be used to evaluate the actual location of the seeds.

- In the eleventh case, a patient was prescribed a brachytherapy gynecological treatment, using a mold containing 109 millicuries (mCi) of Cs-137. Two days later, the radiation therapist in charge checked the placement of the mold and found that it was dislodged by about 8 centimeters. Additionally, the licensee found the strap used to hold the mold in place and the strap used to restrain the patient were loose. The mold was replaced. The licensee estimated that the normal tissues 8 cm away from the treatment area would have received 200 rads during the course of the treatment. It also estimated that, in the worst case, owing to the movement of the mold, the dose was approximately 350 to 400 rads. The licensee stated that to prevent recurrence of this misadministration, the strap normally used to hold the mold in place will henceforth be taped unless contraindicated by other conditions of the patient.

2.2.3 Radiopharmaceutical Therapy Misadministrations

Licensees reported a total of five radiopharmaceutical therapy misadministrations during 1991. These cases of misadministrations were caused by (1) error in verifying patient identification, (2) defective equipment, (3) wrong dosage, (4) no verification of the prescribed dosage, and (5) misreading of the dose calibrator.

- In the first case, a patient was prescribed 10 mCi of I-131 for the treatment of hyperthyroidism. The administering physician did not cross-check the patient's identification and administered the dosage to a patient who was scheduled for a lung treatment. Five minutes after administration, the error was discovered and the patient was adminis-

tered potassium iodide (KI), a thyroid blocking agent. The licensee stated that to prevent recurrence of this misadministration, it will prepare a check list so that each person administering the dosage will check, as a minimum, the name of the patient and the patient number. It will also require this person to notify the nursing staff if a patient is undergoing radiopharmaceutical therapy.

In the second case, a patient was prescribed a 10-mCi dosage of I-131 for a thyroid treatment. However, the patient received only 8.7 mCi of I-131. The licensee stated that this misadministration was in part due to the defect of the rubber stopper in the vial supplied by the radiopharmacy that caused the I-131 to be trapped in the vial. To prevent recurrence, the licensee stated that it (1) notified the commercial radiopharmacy not to supply them with I-131 in a vial with a rubber stopper, (2) provided inservice training to all the staff technologists, and (3) in the future, will require that the residual activity in the vial be measured before discharging the patient.

- In the third case, a patient was prescribed a dosage of 5.75 mCi of I-131 to be administered in the form of a capsule for the treatment of Grave's disease. The dosage was assayed in the dose calibrator at 5 mCi before it was administered to the patient. The licensee stated that because it receives unit dosages from a radiopharmacy, it doesn't always get the exact dosage prescribed. However, to prevent recurrence, in the future, the licensee will instruct all technologists to inform the nuclear medicine physician in attendance of any discrepancy between what is prescribed and what is administered.

- In the fourth case, a patient was prescribed a dosage of 15 mCi of I-131 for the treatment of Grave's disease. However, the patient was administered a dosage of 28.6 mCi of I-131. The radiopharmacist and supervising nuclear medicine physician involved in this procedure failed to note the prescribed dosage and administered the patient the dosage received from a commercial radiopharmacy. To prevent recurrence, the licensee stated that the radiopharmacist was reinstructed about proper dosage verification techniques and safeguards. Also the nuclear medicine physician must visually check the dosage of the prescribed and administered radiopharmaceutical before administration.

- In the last case, a patient was prescribed 10 mCi of I-131 for thyroid treatment. However, the patient was administered a 12-μCi dosage of I-131. The licensee reported that a 10-mCi capsule was ordered from the distributor, but the distributor shipped a 12-μCi capsule. The licensee personnel that received the dosage did not note the error. Before administration, the dosage was assayed in a dose calibrator. Expecting a 10-mCi dosage, the dose calibrator was misread as mCi rather than μCi, and the wrong dosage was administered to the patient. The licensee attributed the cause of this event to human error. To prevent recurrence, the licensee stated that the procedures relating to the use of I-131 will be reviewed and updated.

2.3 Diagnostic Misadministrations

Of the 444 reports of diagnostic misadministrations received in 1991, 66 percent involved the administration of the wrong radiopharmaceutical to a patient, and 20 percent involved the administration of a radiopharmaceutical to the wrong patient. Included in the remaining diagnostic misadministrations, 35 misadministrations involved a diagnostic dosage of a radiopharmaceutical that differed from the prescribed dosage by more than 50 percent, and 5 involved the wrong route of administration (that is, a route of administration other than the one intended by the prescribing physician). The number of

diagnostic reports for 1991 was about the same as the number in 1990–10 percent higher than the average rate of the previous 9 years. The annual number of diagnostic reports from 1981 through 1991 ranged from 334 in 1983 to 444 in 1991, an average of about 400 per year. The types and causes of the diagnostic misadministrations were about the same as those reported in previous years. In effect, all of the diagnostic misadministrations involving the wrong radiopharmaceutical or the wrong patient stem from human error. The primary errors associated with the administration of a radiopharmaceutical to a patient were errors during the preparation or administration of radiopharmaceutical dosages, such as –

- selection of the wrong vial when drawing a dosage,
- selection of the wrong syringe from the dosage cart,
- misinterpretation of the physician's order,
- reconstitution of the wrong reagent kit, and
- misunderstanding the radiopharmaceutical or the dosage order.

The primary errors associated with the administration of a radiopharmaceutical to the wrong patient were –

- the patient's identity was not correlated with the correct study,
- the study was requested for wrong patient,
- the wrong patient was delivered to the nuclear medicine department, and
- the patient answered to the wrong name.

Licensees stated that contributing factors for these primary errors were –

- a heavy workload,
- the patient's identification bracelet not checked,
- the patient's chart not checked,
- the patient's requisition not checked,
- a new employee involved, and
- a student technologist involved.

Relatively simple quality management procedures (checking the patient's identification against the study and the patient's medical history, asking the patient to state his or her name) might reduce the frequency of these events.

2.3.1 Diagnostic Misadministrations of Iodine

Of the 444 diagnostic misadministrations reported to the NRC in 1991, 14 involved the administration of I–131 in amounts that resulted in delivering of doses to the thyroid or other organs that range from 7 millirads to 6500 rads. Causes of the I-131 misadministrations included (1) misunderstanding the referring physician's request, (2) not checking the directive requesting a thyroid procedure, (3) not checking the dosage label, (4) misreading the dose calibrator, (5) selecting the wrong syringe containing a dosage, and (6) failing to identify a patient.

Two of these misadministrations resulted in thyroid doses of more than 1000 rads. In the first, a patient was prescribed a diagnostic thyroid procedure that required the administration of a 50-μCi dosage of I–131. Instead, the patient was administered a 5-mCi dosage of I-131. An NRC consultant estimated that the patient received a dose of approximately 6500 rads to the thyroid instead of the prescribed 50 to 70 rads. The licensee stated that the original prescription for the procedure prepared by a physician's assistant at the direction of the referring physician was modified as a result of a discussion between the

physician's assistant and the nuclear medicine technologist. The licensee, subsequently, established new procedures requiring an authorized physician to specifically approve a dosage of more than 50 μCi of I-131 before its oral administration.

In the second misadministration, a patient scheduled to receive a diagnostic dosage of I-131, was mistakenly administered a dosage of I-131 in the therapy range. The misadministration occurred when a nuclear medicine technologist misread the dose calibrator and administered 6.2 mCi rather than 6.2 μCi. The patient was administered KI solution to reduce the uptake of radioactive iodine. The licensee estimated, based on 24-hour uptake measurements, that the uptake of radioactive iodine in the thyroid was approximately 5 percent, resulting in an estimated dose to the thyroid of 1612 rads. The licensee attributed the cause of the misadministration to human error, and the technologist not verifying the dosage by reviewing the printed dosage label before administering it.

Additionally, in 1991, a diagnostic I-131 event occurred that involved the administration of 2 mCi of I-131 for a thyroid procedure instead of the prescribed 300 μCi of I-123. As a result, the patient received a dose of approximately 1554 rads to the thyroid. This event was caused by a misunderstanding of the referring physician's request and the inadequate review of the referring physician's order requesting the thyroid procedure. The NRC is currently reviewing this event to determine whether it meets the criteria for the definition of a misadministration under 10 CFR 35.2.

2.3.2 Diagnostic Misadministrations That Involve Commercial Radiopharmacies

Of the 444 reports of diagnostic misadministrations received in 1991, 66 percent involved the administration of the wrong radiopharmaceutical to a patient. About eight percent of these diagnostic misadministrations resulted from use of radiopharmaceuticals ordered from radiopharmacies.

The causal factors associated with these misadministrations included (1) mislabeling a syringe containing a radiopharmaceutical, (2) selecting the wrong vial when drawing a dosage, (3) misunderstanding the radiopharmaceutical or dosage order, and (4) mislabeling a vial or vial shield. However, because radiopharmacies can supply many hospitals, a single mislabeling event could result in the administration of the wrong radiopharmaceutical to many patients. Licensees reported that 28 patients received misadministrations as a result of errors that occurred at radiopharmacies. As previously indicated in this appendix, the calculated error rate for diagnostic misadministrations from reported data is very low, 0.01 percent; however, radiopharmacy practice appears to be an area in which efforts expended to reduce human errors could be productive.

2.4 Abnormal Occurrences

In the Report to Congress on Abnormal Occurrences (AOs) (NUREG-0090) for 1991, 13 medical misadministrations were AOs. Of these, 11 occurred in the NRC-regulated states and 2 in Agreements States. The AOs for NRC licensees included –

- two teletherapy misadministrations that involved inadequate review of the patient's chart,
- a teletherapy misadministration that involved an error in the computer programming entry,
- two brachytherapy misadministrations that involved inadequate review of the patient's chart,
- a brachytherapy misadministration that involved an error in the dose calculation,
- a radiopharmaceutical misadministration that involved a failure to follow departmental procedures for patient identification,

- a radiopharmaceutical misadministration that involved a technician not verifying the prescribed dosage,
- a diagnostic misadministration of I-131 that involved a technologist misreading the dose calibrator and not verifying the dosage,
- a diagnostic misadministration of technetium-99m MDP (Tc-99m MDP) that involved an error in the dosage calculation, and
- a diagnostic misadministration that involved misunderstanding of the referring physician's request for an I-131 procedure.

3 Licensee-Proposed Corrective Actions

To prevent recurrence of misadministrations that occurred in 1991, licensees took the following corrective actions most frequently:

- reinstructed personnel,
- reprimanded the technologist or other personnel,
- implemented new radiopharmaceutical labeling and handling procedures,
- implemented new procedures that require the technologist to check the patient's directive, and
- implemented new procedures for patient identification.

As the corrective actions and their effectiveness are licensee-specific, a meaningful determination of whether corrective actions were effective would have to focus on the trend in misadministration rates for each licensee that reported several misadministrations. Because the reported misadministration rate estimated for a sample of licensees was 0.1 percent – a very small number – NRC has not made a detailed evaluation of these rates and their associated corrective actions.

4 Findings and Conclusions

Licensees reported 19 therapy misadministrations during 1991, a number that is about two times higher than the average number reported in the prior 10 years. These teletherapy, brachytherapy, and radiopharmaceutical therapy misadministrations might have been prevented by quality management procedures that demanded patient chart review, verification of patient dose calculations, verification of the type of prescribed treatment, identification of the correct anatomical treatment area, and patient identification.

Most diagnostic misadministrations for 1991 involved either administering the wrong radiopharmaceutical or administering a radiopharmaceutical to the wrong patient. The number of diagnostic reports for 1991 was about the same as the number in 1990 and about 10 percent higher than the average rate for the previous 9 years. The causes reported by licensees for 1991 are, generally, simple errors associated with preparing and administering radiopharmaceuticals and selecting the correct patient, such as (1) processing nuclear medical requisitions, (2) reading dosage and vial labels, and (3) identifying patients. In addition, for misadministrations involving I-131, the primary causes included (1) misunderstanding the referring physician's directive, (2) not checking the directive requesting a thyroid procedure, (3) not checking the dosage label, (4) misreading the dose calibrator, (5) selecting a syringe containing the wrong dosage, and (6) failing to identify a patient.

Appendix C

Report on 1991 Agreement State Licensee Nonreactor Events and Misadministrations

Appendix C

Report on 1991 Agreement State Licensee Nonreactor Events and Misadministrations

by the
Nonreactor Assessment Staff
Office for Analysis and Evaluation of Operational Data

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Contents

Tables

1 Introduction

The NRC licenses the use of reactor-produced isotopes, the milling of uranium, and the subsequent processing of either natural or enriched uranium and special nuclear material (SNM). Several States, known as Agreement States, in Section 274 of the Atomic Energy Act, as amended, have entered into agreements with NRC to regulate the use of byproduct materials, natural uranium, and small amounts of enriched uranium or other SNM. Of these nonreactor licensees, the dominant number are authorized to use byproduct materials for such applications as radiography, gauges, and well-logging and to administer byproduct materials or radiation from these materials to individuals for medical diagnosis or therapy. A relatively small number of licensees use uranium or SNM in other operations. Generally, these licensed programs have little negative impact on public health and safety. In 1991, 28 States participated in the NRC Agreement States program. Table C–1 shows the location and population of Agreement States and NRC-regulated States by NRC region.

The regional population of licensees regulated by the NRC in each of NRC's five regions exceeds that of the Agreement States only in NRC regions I and III. NRC-regulated States are generally located in the northeastern and north central parts of the United States; virtually all of the southern and western States are Agreement States. From Table C–1, one can see that the population encompassed in Agreement States is about 65 percent of the population of the United States, and that the population encompassed in NRC-regulated States is about 35 percent. According to the "NRC Information Digest," 1991 Edition, NUREG-1350, Vol. 3, the Agreement States issue about 13,000 new, renewal, or license amendments each year while the NRC issues about 5400 such actions. On an aggregated basis, the Agreement States regulate about two-thirds of the activities involving byproduct and SNM licenses in the United States, each regulating approximately the number of licensees proportional to the population of its States.

On December 26, 1991, NRC's Office of State Programs and AEOD informed the Deputy Director for Operations of their intent to request the Agreement States to submit summaries of all incidents involving radioactive materials, including medical misadministrations, which the AEOD staff would review*. This appendix contains a review of a subset of all Agreement States data. The subset comprises the 16 States that submitted data by April 30, 1992.

* Memorandum for Hugh L. Thompson, Jr., Deputy Director for Nuclear Materials Safety, Safeguards and Operational Support, from Carleton Kammerer, Director, Office of State Programs, and Edward Jordan, Director, Office for Analysis and Evaluation of Operational Data, "Procedures for Receiving and Analyzing Misadministration Data From the Agreement States." (Reference M910612B)

Table C-1 Agreement and NRC-regulated States by NRC region

	Agreement States		NRC-Regulated States	
Region	State	Population in Millions	State	Population in Millions
I	* New York	18.0	Pennsylvania	12.0
	** Maryland	4.7	New Jersey	7.7
	New Hampshire	1.1	Massachusetts	5.9
	* Rhode Island	1.0	Connecticut	3.2
			Maine	1.2
			Delaware	0.7
			District of Columbia	0.6
			Vermont	0.6
TOTAL		24.8		31.9
II	* Florida	12.7	Virginia	6.1
	North Carolina	6.7	West Virginia	1.9
	Georgia	6.4		
	* Tennessee	4.9		
	Alabama	4.1		
	* Kentucky	3.7		
	* South Carolina	3.5		
	* Mississippi	2.6		
TOTAL		44.6		8.0
III	* Illinois	11.0	Ohio	10.9
	Iowa	2.8	Michigan	9.3
			Indiana	5.6
			Missouri	5.2
			Wisconsin	4.9
			Minnesota	4.4
TOTAL		13.8		40.3

Footnotes at end of table

Table C–1 (cont.)

	Agreement States		NRC-Regulated States	
Region	State	Population in Millions	State	Population in Millions
IV	*Texas	17.0	Oklahoma	3.2
	*Louisiana	4.4	Idaho	1.0
	*Colorado	3.3	Montana	0.7
	Kansas	2.5	South Dakota	0.7
	Arkansas	2.4	Wyoming	0.5
	*Utah	1.7		
	Nebraska	1.6		
	New Mexico	1.5		
	North Dakota	0.5		
TOTAL		34.9		6.1
V	California	29.0	Hawaii	1.1
	*Washington	4.8	Alaska	0.5
	*Arizona	3.6		
	*Oregon	2.8		
	Nevada	1.1		
TOTAL		41.3		1.6
TOTAL POPULATION		159.4		87.9

* Agreement States that submitted data to the NRC in 1991 by April 30, 1992.
** The State of Maryland submitted only partial data for 1991.

2 Nonreactor Licensee Operational Experience

This appendix contains a review of the data that Agreement States submitted before April 30, 1992. Section 2 provides an overview and summary of reported events involving nonreactor facilities that the following 16 States reported in 1991: Arizona, Colorado, Florida, Illinois, Kentucky, Louisiana, Maryland (partial data), Mississippi, New York (excluding New York City), Oregon, Rhode Island, South Carolina, Tennessee, Texas, Utah, and Washington.

These 16 Agreement States have a combined population of about 87 million, about the same as the NRC-regulated States. These States are located among all of the NRC regions and have populations ranging from large (Texas) to small (Rhode Island). The operating data from these States should provide a representative picture of the Agreement States as a whole, because by their very nature, the number and type of operating events that are reported, either in Agreement States or NRC-regulated States, vary statistically from year to year. This large sample, composed of a wide range of individual State populations and representing all areas of the United States, can be considered representative of the nature and type of events experienced by all Agreement States in general. The number of certain categories of licensees in Agreement States may be disproportionate to the categories in NRC-regulated States because of the differences in industry.

2.1 Nonreactor Events Reported in 1991

The dominant health concern associated with the use of licensed materials for non-medical uses is the possible damage that can occur from overexposure to radiation. Lost or stolen radioactive materials can also be a cause of exposures. Data on leaking sources can provide information on design deficiencies or end-of-life problems with specific sources that might lead to personnel exposures. Events that involve release of radioactive materials or result in the introduction of radioactive material into consumer products can also result in unplanned exposure to radiation.

2.1.1 Radiation Exposures

The regulations in all Agreement States must be compatible with NRC's Standards of Protection Against Radiation, Part 20 of Title 10 of the *Code of Federal Regulations* (10 CFR Part 20) and must track the requirements of 10 CFR Part 20 closely. In addition to regulating exposure from byproduct and SNM, Agreement States also regulate exposures from X-rays, accelerator-produced isotopes, and naturally occurring radioisotopes (e.g., radium) that NRC does not regulate. In 1991, the 16 Agreement States that submitted data to the NRC reported 67 over-exposures (Table C–2).

Thirteen individuals were reported to have been overexposed in a single event, as a result of the failure of the shutters in the open position on two of five gauges on a furnace burden bin at Occidental Chemical Company. The maximum exposure was 1.84 rem, and several of the 13 individuals may not have received an overexposure. Probably the backflow of hot gases from the furnace melted the shielding.

Of the remaining 54 exposures, licensees reported 2 extremity exposures that exceeded the quarterly limit; 1 exposure to an eye with no estimate of the exposure given; 2 internal exposures from uranium; 2 reports of exposure of nonradiation workers to whole body doses of 0.120 and 0.150 rem; and 47 whole body occupational exposures. Of the 47 whole body exposures, 17 were in excess of 1.25 rem/quarter, 23 were from 3 to 12 rem, and 4 were overexposures of 12 rem or more. Three over-exposure reports did not contain information on the amount of the overexposure. Some of the exposures

Table C–2 Personnel radiation overexposures, 1991

Licensee	Location	Event Date	Number of Exposures	Type of Exposure
H&H X-Ray Service	CO CO	09/16/91 12/16/91	1 1	Whole Body Eye
City of Cape Coral Engineering Department	Cape Coral, FL	09/01/91	1	Whole Body
C al X-Ray & Testing Corporation	Harvey, LA	06/20/91	1	Whole Body
X-Ray Inspection, Inc.	Sulphur, LA	05/13/91	1	Whole Body
Global X-Ray & Testing Corporation	Gulfport, MS	03/29/91	2	Whole Body
Good Samaritan Hospital	Suffern, NY	03/14/91	1	Whole Body
Occidental Chemical Corporation	Columbia, TN		13	Whole Body
BIX Testing Laboratory	Baytown, TX		3	Whole Body
D-Arrow Inspection, Inc.	Houston, TX		2	Whole Body
Eagle X-Ray	Mont Belvieu, TX		1	Whole Body
Four Seasons Industrial X-Ray	Beeville, TX	1990	1	Whole Body
French Well Surveys, Inc.	Houston, TX	1990	2	Whole Body
G&G X-Ray, Inc.	Corpus Christi, TX	1990	1	Whole Body
General Inspection Service	Houston, TX	1990	1	Whole Body
Global X-Ray & Testing Corporation	Houston, TX		1	Whole Body
H&G Inspection Co., Inc.	Sabine Pass, TX	06/14/90	1	Whole Body
H&G Inspection Co., Inc.	Houston, TX		1	Whole Body
H&G Inspection Co., Inc.	Houston, TX	09/28/91	1	Whole Body
Holmes Wireline Service	Odessa, TX	1990	1	Whole Body
Humana Hospital Medical City	Dallas, TX		1	Whole Body
Longview Inspection Co.	Longview, TX		2	Whole Body
Memorial Northwest Hospital	Houston, TX		1	Whole Body
Midland Inspection and Engineering	Midland, TX	1990	3	Whole Body
Non-Destructive Inspection	Clute, TX	1990	4	Whole Body
Professional Service Industries, Inc.	Houston, TX	07/27/91	1	Whole Body
Quality Industrial X-Ray, Inc.	Odessa, TX		1	Whole Body
R/A Services	Midland, TX	1990	1	Extremity
R/A Services	Midland, TX		1	Extremity
Racon	Tyler, TX	1990	1	Whole Body
Southwestern Laboratories	Houston, TX	1990	1	Whole Body
The Methodist Hospital	Houston, TX		1	Whole Body

Table C–2 (cont.)

Licensee	Location	Event Date	Number of Exposures	Type of Exposure
Tracer Service	Kilgore, TX		1	Whole Body
USX/Texas Uranium	George West, TX		2	Internal
Ultrasonic Specialties, Inc.	Houston, TX		1	Whole Body
Via NDT Engineering and Testing	Channelview, TX		1	Whole Body
X-Ray Systems	Arlington, TX	1987	1	Whole Body
X-Cel N.D.E.	Odessa, TX		2	Whole Body
Met-Chemical Testing Laboratories	Salt Lake City, UT	03/16/91	1	Whole Body
Quality Testing and Inspection	Lindon, UT	08/15/91	2	Whole Body

listed in Table C–1 may be attributable to X-rays and accelerator-produced products, materials not licensed by the NRC.

2.1.2 Lost, Stolen, or Abandoned Materials

Several of the Agreement States submitted reports on the loss or theft of licensed sources. In addition to losses of materials regulated by NRC, some Agreement State licensees reported the loss of naturally occurring materials, such as radium-226, or accelerator-produced materials. Data on materials not regulated by the NRC are not included in this report.

Of 70 events reported during 1991, 63 events involved lost, abandoned, or stolen licensed material that was not recovered, and 7 events involved abandoned well-logging sources. Tables C–3 and C–4 provide summaries of these events. None of the events resulted in a known radiation overexposure.

Lost or Stolen Sources

Of the 63 reports of lost or stolen sources that were not recovered, 13 sources were sent to commercial waste disposal, 9 were sent to scrap processors, and the location of the remaining 38 is unknown. In addition, another three have been lost or disposed of in other ways. In one event, radioactive material was included with biomedical waste; in another, material was lost at sea; and in the third, a human body containing iodine-125 seeds was released for burial. Generally the lost sources consisted of sealed sources, isotopes used in research or medical treatment, or tritium exit signs.

Americium-241 (Am-241) – The 10 lost Am-241 sources were sealed sources; 5 of them involved the loss or theft of moisture density gauges.

Carbon-14 (C-14) – Of three events reported, one event involved the inadvertent disposal of commercial waste contaminated with C-14; a second event involved material containing C-14 lost at sea; and a third event involved the disposal of biomedical waste contaminated with C-14.

Table C–3 Lost or stolen sources, 1991

Isotope	Location	Licensee	Licensee Number	Event Date	Disposition
Am-241	Lake Worth, FL	Ardamaan & Associates	9728	03/17/91	unknown
Am-241	Plainfield, IL	Testing Service Corporation	860117801	08/29/91	unknown
Am-241		Siemens Medical Systems	MD3310201	02/07/91	unknown
Am-241	Brooklyn, NY	Kupper & Company (NJ)/NYC Police		8/22/91	unknown
Am-241	Maspeth, NY	Independent Testing Labs		10/16/91	unknown
Am-241	El Paso, TX	Sergent, Hauskins & Beckwith		08/14/91	unknown
Am-241	Houston, TX	Western Atlas International			unknown
Am-241	Round Rock, TX	TN Technologies, Inc.		01/21/91	comm. waste
Am-241	Seattle, WA	Swedish Hospital		02/12/91	unknown
Am-241	Seattle, WA	Swedish Medical Center		04/29/91	unknown
C-14	IL	Searle Laboratory, Research & Development	860146901	04/01/91	comm. waste
C-14	OR		9139		sea
C-14	San Antonio, TX	Cancer Therapy & Research Center		03/25/91	bio-med waste
Co-57	IL	St. Elizabeth's Hospital	860118001	07/05/91	unknown
Cr-51	El Paso, TX	University of Texas–El Paso			comm. waste
Cs-137	IL	Dow Chemical U.S.A.		01/31/91	unknown
Cs-137	Louisville, KY	Alliant Health System		09/11/91	unknown
H-3	Orlando, FL	Walt Disney World	2731	02/01/91	unknown
H-3	Joliet, IL	GL Red Roof Inn–Joliet		11/05/91	unknown
H-3	Dallas, TX	Isolite Corporation		07/10/91	unknown
H-3	Houston, TX	Schlumberger Well Services			unknown
I-123	IL	Louis A. Weiss Memorial Hospital	120241801	06/18/91	unknown
I-125	Miami, FL	Baxter Healthcare Corporation	1362	09/30/91	comm. waste
I-125	IL	St. Joseph Hospital	860126801	05/24/91	unknown
I-125	Suffern, NY	Good Samaritan Hospital		02/07/91	interred
I-125	Memphis, TN	Regional Medical Center–Memphis	R79160	03/28/91	unknown
I-125	Houston, TX	Baylor College of Medicine		05/13/91	comm. waste
I-131	Temple, TX	Scott and White Clinic			comm. waste

Table C–3 (cont.)

Isotope	Location	Licensee	Licensee Number	Event Date	Disposition
Ir-192	El Paso, TX	Providence Memorial Hospital		05/23/91	comm. waste
Ir-192	Fort Worth, TX	Moncrief Radiation Center			unknown
Ir-192	Pasadena, TX	Technical Welding Laboratory		08/28/91	unknown
Na-22	IL	Amersham Corporation		01/25/91	unknown
P-32	IL	Amersham Corporation	12128360I	04/23/91	unknown
P-32	IL	Elmhurst Memorial Hospital	120628902	09/12/91	comm. waste
P-32	OR		9141		comm. waste
Po-210	St. Petersburg, FL	E-Systems, Inc.	GL	07/03/91	unknown
Po-210	IL	GL Arrem Plastics	999200574	07/29/91	unknown
Po-210	IL	GL Arrem Plastics	999200574	12/19/91	unknown
Po-210	IL	GL Jefferson Smurfit Corporation	999203662	05/08/91	unknown
Po-210	IL	GL Zenith Electronics	999100470	04/01/91	unknown
Po-210	Rockford, IL	GL Adapt Plastics	999211228	09/20/91	unknown
Po-210	Dallas, TX	GL E-Systems			unknown
Po-210	Dallas, TX	GL Texas Instruments, Inc.			unknown
Po-210	Garland, TX	GL Varo, Inc.			unknown
Po-210	Irving, TX	GL Boeing Electronics			unknown
Po-210	Lubbock, TX	Industrial Molding Corporation			unknown
S-35	Houston, TX	Baylor College of Medicine		10/24/90	comm. waste
S-35	Salt Lake City, UT	University of Utah	UT1800001	10/09/91	comm. waste
Sr-90	Austin, TX	Eye Center of Austin		05/18/91	unknown
Tl-204	Dallas, TX	GL Texas Instruments, Inc.			unknown
Y*	Brookhaven, NY	Brookhaven National Laboratory		08/09/91	scrap
Y	Chattanooga, TN	Erlangen County Hospital	R33080		unknown
Y	Galveston, TX	University of Texas Medical			comm. waste
Z**	Grand Junction, CO	NL Leweo Iron & Metal, Inc.	9100143	01/11/91	scrap
Z	Lewiston, NY	Mount St. Mary's Hospital			unknown
Z	Ogdensburg, NY	Champlain Valley Physicians Hospital		01/23/91	comm. waste

* Footnotes at end of table

Table C–3 (cont.)

Isotope	Location	Licensee	Licensee Number	Event Date	Disposition
Z**	Plymouth, UT	Nucor Steel	NL	01/23/91	scrap
Z	Plymouth, UT	Nucor Steel	NL	04/05/91	scrap
Z	Plymouth, UT	Nucor Steel	NL	04/08/91	scrap
Z	Plymouth, UT	Nucor Steel	NL	04/11/91	scrap
Z	Plymouth, UT	Nucor Steel	NL	05/03/91	scrap
Z	Plymouth, UT	Nucor Steel	NL	05/23/91	scrap
Z	Seattle, WA	Salmon Bay Steel		11/26/91	scrap

* Y other
** Z unknown

Cobalt-57 (Co-57) – A sealed source used in nuclear medicine was lost. A search through linens and trash for the Co-57 source was not successful.

Cesium-137 (Cs-137) – In each of the two events reported, a Cs-137 sealed source was lost.

Tritium (H-3) – Three reports discussed exit signs that were stolen, and one report discussed a lost sealed tritium source whose content was below the exempt limit.

Iodine – There were seven reports of lost iodine isotopes. The iodine-123 isotope was lost in a capsule; three of the events in which iodine-125 (I-125) was lost involved lost seeds, and two involved material contaminated with I-125. One of the events involving lost seeds resulted when a body was released for burial before the I-125 seeds were removed. The report of the event of loss of iodine-131 (I-131) involved the loss of material contaminated with I-131.

Iridium-192 (Ir-192) – Two reports were of events in which medical licensees lost Ir-192 seeds. The third report concerned a lost radiography camera containing an Ir-192 source of 86 Ci.

Sodium-22 (Na-22) – A package containing 1 μCi of Na-22 was lost in shipping from Illinois to Texas.

Phosphorus-32 (P-32) – Three events involving the loss of P-32 were reported. One involved the loss in shipping, and two involved the inadvertent disposal of ordinary waste contaminated with P-32. Polonium-210 (Po-210) – There were 11 reports of lost general-licensed devices containing Po-210.

Sulfur-35 (S-35) – Two events were reported in which ordinary trash contaminated with S-35 was disposed of.

Strontium-90 (Sr-90) – A medical licensee reported Sr-90 eye applicator stolen.

Thallium-204 (Tl-204) – A general licensed device containing 0.1 mCi of Tl-204 was reported lost.

Other (Y) – Three reports were received of events in which mixtures of isotopes were lost. In one event, copper contaminated with various isotopes was stolen from Brookhaven National Laboratory. In another event, three check sources used for quality control tests could not be located when a hospital changed ownership; and in the third event, waste contaminated with a mixture of isotopes was disposed of as regular trash.

Unknown (Z) – In reports of 10 events, the isotope was not identified. Eight of the events involved the detection of radioactive material at a scrap dealer. In

four of these, the radioactive material was scale on pipe and could have been naturally occurring radioactive material not licensed by the NRC. In three of the other events, a scrap dealer identified radioactive material in a shipment, and the material was returned to the vendor or to the State authorities.

Three other events involved loss of a sealed marker source and disposal of a radioactive pacemaker to normal trash, reportedly on the advice of the manufacturer.

Abandoned Well-Logging Sources

In the data that the 16 Agreement States gave to the NRC in 1991, licensees reported the abandonment of 7 well-logging sources. In addition, two other Am-241 sources, one in Maryland and one in Texas, became disconnected down-well; however, recovery operations have not been completed yet. The events reported did not result in any known releases of radioactive materials (See Table C–4).

2.1.3 Leaking or Contaminated Sources

Eighteen occurrences of leaking or contaminated sources were reported during 1991. Table C–5 includes information from reports of these events. None of the events resulted in a known radiation overexposure.

2.1.4 Release of Materials

In the data that the 16 Agreement States gave the NRC were reports of 26 events in which material was released. None of the events resulted in any known overexposures; generally, none of the events had any effect on any area beyond the immediate area of the release.

Table C–4 Abandoned well-logging sources, 1991

Isotope	Location	Licensee	License Number	Event Date
Am-241*	Houston, TX	Computalog		01/16/91
Am-241	Houston, TX	Halliburton Company		09/08/91
Am-241	Wilkerson, MS	Schlumberger Well Services	MS46301	10/01/91
Co-60	Rankin City, MS	Shell Development Company	MS28401	11/08/91
Co-60	Gulfport, MS	Shell Development Company	MS28401	12/11/91
Co-60	Houston, TX	French Well Surveys		12/11/90
U-238	Houston, TX	Western Atlas		

* In most cases, when an americium source is abandoned, a Cs-137 source is also abandoned.

Table C–5 Leaking sources reported, 1991

Isotope	Location	Licensee	License Number	Event Date	Manufacturer
	Houston, TX	Valco Instruments		06/17/91	
Am-241	Fort Worth, TX	Computalog Wireline Products		05/15/91	
Am-241	Graham, TX	Phoenix Surveys, Inc.		08/23/91	
Am-241	Houston, TX	Sperry-Sun Drilling Services			Gammatron
Cd-109	West Palm Beach, FL	United Technologies-Pratt & Whitney	901	02/25/91	Kevex/0102
Co-60	Houston, TX	Houston Northwest Radiotherapy			
Co-60	Longview, TX	Professional Service, Inc.			
Cs-137	Natchez, MS	International Paper Co.	02001	08/19/91	GRP/850233
Cs-137	Texas City, TX	Amoco Oil Company		09/17/91	
Fe-55	IL	Amersham Corporation		11/13/91	
Fe-55	IL	Amersham Corporation	121283601	04/01/91	
Fe-55	Austin, TX	Asoma Instruments, Inc.			
Fe-55	Austin, TX	Asoma Instruments, Inc.		07/24/91	
Fe-55	Austin, TX	Asoma Instruments, Inc.	L02788	05/30/91	Amersham/IEC.D1
Ir-192	St. Rose, LA	Source Products & Equipment Co.	LA2966L01	10/28/91	
Sr-90	Tallahassee, FL	Humana Hospital	12341	02/15/91	
Sr-90	Dallas, TX	Tamko Asphalt Products, Inc.			
Z*	Austin, TX	Asoma Instruments Inc.		06/17/91	

* Z means unspecified

2.1.5 Consumer Products

Several Agreement States reported contaminated fencing that arrived from India. The radioactive items, which were contaminated with Co-60, had been manufactured by a firm in India and had been imported into the United States through two firms in California and Texas.

2.2. Medical Misadministrations

Agreement States issue licenses and currently regulate about 4000* institutions (e.g., hospitals, clinics, or physicians in private practice). Of the 28 Agreement States, only 16, who issue about 2200 licenses, provided readily available data on 1991 misadministration events. One of these States, Maryland,

* U.S. Nuclear Regulatory Commission, "10 CFR Part 35, Quality Management Program and Misadministrations," *Federal Register*, Vol. 56, No. 143, 1991, p.34104.

submitted misadministration data for only a portion of the year.

Medical misadministrations are reported to the NRC as required in 10 CFR Part 35, "Medical Use of Byproduct Material." Although the requirements for reporting misadministrations became effective on November 10, 1980, and were revised in 1987, licensees in Agreement States were not required to report misadministrations until March 1990 (matter of compatibility).

The definition of a misadministration that was in effect in 1991, as stated in the revised 10 CFR Part 35, which became effective on April 1, 1987, is given in Appendix B to this report.

2.2.1 General

Approximately 7 million diagnostic procedures, 30,000 radiopharmaceutical therapy procedures, and 50,000 brachytherapy procedures are performed annually in the United States. In addition, about 100,000 patients receive Co-60 teletherapy treatments each year. The NRC estimates that Agreement State licensees perform about 60 percent of these procedures and NRC licensees* perform about 40 percent.

From January through December 1991, an estimated 2200 licensees involved in radiation therapy and nuclear medicine in the 16 Agreement States that provided data to the NRC reported 6 therapy misadministrations and 112 diagnostic misadministrations, which is equivalent to approximately 5 misadministrations per 100 licensees. Table C–6 summarizes the statistics for the medical misadministrations for 1991 reported by Agreement State licensees. In a total of 118 reports involving 148 patients, 103 licensees reported one or more misadministrations. Of the 118 reports on misadministrations for 1991, 112 involved diagnostic misadministrations, and 6 involved therapy misadministrations.

* U.S. Nuclear Regulatory Commission, "10 CFR Part 35, Basic Quality Assurance Program, Records and Reports of Misadministrations or Events Relating to the Medical Use of Byproduct Material," *Federal Register*, Vol. 55, No. 10, January 16, 1990, pp. 1439-1449.

2.2.2 Therapy Misadministrations

The 16 Agreement States reported 6 therapy misadministrations for 1991. Of these misadministrations, one involved teletherapy, three involved brachytherapy, and two involved radiopharmaceutical therapy. Most of the reports on these misadministrations did not contain sufficient information to independently determine the primary cause and contributing factors of the misadministrations.

2.2.2.1 Teletherapy Misadministrations

The one teletherapy misadministration involved an error in the treatment planning. The licensee involved possessed two accelerators and a Co-60 teletherapy unit. During one fraction of a treatment using the Co-60 unit, the technologist accidentally used the accelerator source-to-skin distance (SSD) in the treatment planning instead of the Co-60 SSD. This caused the patient to receive a dose of 396 rads instead of the prescribed 250 rads. The licensee developed new procedures to prevent recurrence.

2.2.2.2 Brachytherapy Misadministrations

Agreement State licensees reported a total of three brachytherapy misadministrations for 1991. The first misadministration involved the implantation of the wrong radioisotope. Two patients were scheduled for brachytherapy treatment of the prostrate. The first patient was implanted with I-125 seeds. Not all the seeds were used, so the unused seeds were returned to the magazine and secured in the carrying case tray.

Table C–6 Medical misadministrations reported by Agreement States, 1991

	Diagnostic	Therapy	Total
No. of reports	112	6	118
No. of patients involved	132	16	148
No. of licensees reporting	97	6	103

Later in the day, the second patient, who was to be implanted with palladium-103 (Pd-103) seeds, was implanted with the Pd-103 seeds plus the five additional I-125 seeds remaining from the earlier patient. The licensee did not provide any information as to the cause or effects of this misadministration.

The second case involved a computerized treatment planning error. The licensee stated that in two lung treatments and nine gynecological treatments the patients received doses which ranged from 13 to 69 percent more than the prescribed dose. The licensee stated that the cause of these misadministrations was physician error. Additional information was not provided in the report.

In the third case, the administered dose varied from the prescribed dose by more than 20 percent. The licensee did not provide any additional information.

2.2.2.3 Radiopharmaceutical Therapy Misadministrations

Agreement States submitted two events involving radiopharmaceutical misadministrations in 1991. One of the misadministrations involved phosphorus-32 (P – 32) while the other involved I-131.

In the first misadministration, a patient was to be administered 15 mCi of P-32 in a colloidal form. The patient was injected with 2 mCi of Tc-99m sulfur colloid, and the distribution across the abdomen was checked. Afterwards, the patient was administered 15 mCi of P-32, using an intraperitoneal catheter. However, the next day it appeared that radioactive material had been infused into the colon, an area not intended for treatment. The licensee estimated the dose rate delivered to the bowel between 1250 to 3000 rads. The licensee revised the existing protocols to avoid future errors. The licensee provided no additional information about the details of this misadministration.

The second case involved the administration of a 15-mCi dosage of I-131 to patient "A" instead of to patient "B." The licensee stated that both patients had the same first and last names and that the administration took place without the responsible physician present, a violation of the State's radiation control regulations. The patient was scheduled for and underwent surgery 3 days after the misadministration without any regard for the possible exposure of the surgical room staff. As a result of this misadministration, a consultant estimated that the patient received 3000 rads to the thyroid.

2.2.3 Diagnostic Misadministrations

Of the 112 reports of diagnostic misadministrations received in 1991 from Agreement State licensees, 66 percent involved the administration of the wrong radiopharmaceutical to a patient, and 17 percent involved the administration of a radiopharmaceutical to the wrong patient. Included in the remaining diagnostic misadministrations, 7 misadministrations involved a diagnostic dosage of a radiopharmaceutical that differed from the prescribed dosage by more than 50 percent. For the diagnostic misadministration reports that contained information regarding the cause of the misadministrations, Agreement States reported that the licensees gave the following causes:

- selecting the wrong syringe from dosage cart,
- selecting wrong vial when drawing dosage,

- selecting wrong patient,
- misunderstanding the referring physician's request, and
- misunderstanding the radiopharmaceutical or dosage order.

2.2.3.1 Diagnostic Misadministrations of Iodine

Of the diagnostic misadministrations that Agreement State licensees reported in 1991, 8 cases involved the administration of I-131. Reports of three of these cases provided sufficient information to ascertain that each of the three patients received a thyroid dose of more than 1000 rads.

In the first case, a patient prescribed to receive a 5-mCi diagnostic dosage of I-131 was administered a 20-mCi dosage of I-131. The licensee stated that this was caused by a chart mix up and miscommunication with a patient who could not speak English.

In the second case, a patient was prescribed 15 μCi of I-131. However, the patient was administered 15-mCi of I-131. No additional information was provided in the licensee's report.

In the third case, a patient prescribed to receive a thyroid procedure using Tc-99m was administered 2 mCi of I-131. The licensee did not report the cause of the error.

2.2.3.2 Diagnostic Misadministrations That Involve Commercial Radiopharmacies

Of the 112 reports of diagnostic misadministrations that were provided to the NRC by Agreement States in 1991, 70 percent involved the administration of the wrong radiopharmaceutical to a patient. About 32 percent of these diagnostic misadministrations resulted from radiopharmaceuticals ordered from radiopharmacies and involved 45 patients. The causal factors associated with these misadministrations included (1) mislabeling a syringe containing a radiopharmaceutical, (2) selecting the wrong vial when drawing a dosage, (3) placing a reconstituted vial in the wrong shield, and (4) setting the dose calibrator improperly.

3 Findings

The nonreactor events that 16 Agreement States reported in 1991 showed no significant overexposures from operations in 1991, and the types of lost material and leaking sources was similar to those NRC licensees reported.

The 16 Agreement States reported 118 misadministrations in 1991, including 6 therapy misadministrations. The six therapy misadministrations consisted of one teletherapy, three brachytherapy, and two radiopharmaceutical therapy. In addition, licensees reported eight diagnostic misadministrations involving iodine, three of which resulted in a thyroid dose in the therapy range. However, the prescribed dose for one of these misadministrations also would have produced a thyroid dose in the therapy range.

Although the therapy misadministrations submitted by Agreement States did not provide sufficient information about the circumstances that lead to the misadministrations, in general, the reports indicated that the errors that occurred while preparing, handling, and administering the radiopharmaceuticals were similar to the errors reported by NRC licensees.

Appendix D

Summary of 1991 Abnormal Occurrences (Nonreactors)

Abnormal Occurrences for 1991
(Nonreactors)

NRC Licensees

NUREG-0090, Volume 14, No. 1,
Report No. 91-1
Significant Degradation of Plant Safety at
Nuclear Fuel Services, Inc., in Erwin, Tennessee

Nuclear Fuel Services, Inc., is a fuel production facility that produces nuclear fuel for the U.S. Navy. On November 30, 1990, licensee personnel discovered that on November 28, 1990, 395 grams of uranium-235 (U-235), contained in liquid waste, had been processed through the waste water treatment system for collection and disposal of the uranium. This quantity was above the administrative criticality safety limit of 350 grams for the unfavorable geometry tanks used to hold the waste. (A favorable geometry tank is one having dimensions specifically designed to prevent criticality of its fissile material contents. An unfavorable geometry tank can be used, however, if the amount of fissile material is kept below that needed to achieve criticality.)

While the amount of U-235 was well below the amount needed for criticality, highly concentrated uranium solutions in an adjoining part of the process were available in quantities that were more than sufficient to have caused a criticality accident in the unfavorable geometry tank. The hydrostatic head associated with those highly concentrated solutions would have forced those solutions into the unfavorable geometry tank if the set of normally closed valves were faulty or were not fully closed.

Filling of storage tanks with liquid waste from the solvent extraction system in the high enriched uranium recovery process began on November 27, 1990. When the tanks were full, the contents were recirculated before sampling. An operator collected two samples of the liquid and submitted them for analysis. The analytical results, received on November 28, 1990, revealed that the uranium concentration in the liquid was well below the authorized discard limit; hence, the quantity of U-235 was below the safety limit of 350 grams. The liquid waste was then pumped to another tank where it was mixed again, sampled for material accountability purposes, and then pumped to the Waste Water Treatment Facility (WWTF).

On November 30, 1990, the laboratory reported that the results of the accountability sample were above the authorized discard limit. This higher concentration was confirmed by analysis of another sample, which had been obtained when the liquid was received at the WWTF. All discharges were halted as a special licensee investigation team initiated a review to determine the causes and corrective actions needed. At about 4:15 p.m., the licensee reported the incident to the NRC.

The NRC issued written confirmation on November 30, 1990, that the licensee would refrain from transferring liquid waste until certain actions had been completed (Letter from J. Philip Stohr, Director, Division of Radiation Safety and Safeguards, NRC Region II, to Charles R. Johnson, President, Nuclear Fuel Services, Inc., forwarding a Confirmation of Action Letter, Docket No. 70-143, License No. SNM-124, November 30, 1990). NRC dispatched an inspector to the site on December 1, 1990, and two other NRC personnel arrived on December 2, 1990, to perform a special NRC team inspection.

The licensee identified the probable causes of the November 28, 1990, event to be (1) less than adequate piping layout that allowed uranium solutions to flow into the unfavorable geometry tank and (2) personnel-related inadequacies in that operators had no knowledge of the potential for crossover of highly concentrated uranium solutions into unfavorable tanks as a result of open valves or other anomalies in the piping systems.

Following a review of the incident, the NRC concluded that other root-causes may exist in addition to those given by the licensee. These root causes include (1) a documented safety analysis was not available; (2) the design basis of the plant was less than adequate and the system drawings lacked adequate detail; and (3) absent a detailed safety analysis, equipment important to safety, such as valves, were not properly identified, protected, emphasized in plant control documents and training sessions, tested and maintained appropriate for their safety function, and did not possess positive closure indication.

The licensee missed an opportunity to preclude the problems several years earlier when modifying the piping system. The licensee's reviews of the modifications failed to identify the significant potential for uranium solutions to flow into unfavorable geometry vessels.

The special NRC team inspection identified two violations: (1) failure to adequately evaluate equipment joined by piping for the possibility of siphoning and (2) failure to adhere to the administrative criticality safety limit of 350 grams of U-235 in unfavorable geometry tanks.

Corrective actions included modification of the piping system to prevent highly concentrated uranium solutions from flowing into the unfavorable geometry tanks. GE initiated a review of the fuel recovery facility to identify the nuclear safety features and controls for each unfavorable geometry vessel. A nuclear criticality safety (NCS) performance improvement program (PIP), which had been instituted before the incident, was accelerated and expanded to address the root-causes. GE also trained the fuel recovery personnel to make them aware of the problem.

The NRC inspected the actions completed and, following the licensee's identification of the safety features and controls, issued a letter authorizing resumption of solution transfers on December 18, 1990, (Letter from Stewart D. Ebneter, Regional Administrator, NRC Region II, to Charles R. Johnson, President, Nuclear Fuel Services, Inc., forwarding a Letter of Authorization to resume operations in the Recovery Facility, Docket No. 70-143, License No. SNM-124, December 18, 1990). NRC held an Enforcement Conference with the licensee on January 18, 1991. On March 20, 1991, the NRC forwarded a Notice of Violation (for the violations identified during the special NRC team inspection) and proposed a civil penalty of $10,000 (Letter from Stewart D. Ebneter, Regional Administrator, NRC Region II, to Charles R. Johnson, President, Nuclear Fuel Services, Inc., forwarding Notice of Violation and Proposed Imposition of Civil Penalty – $10,000, Docket No. 70-143, License No. SNM-124, March 20, 1991.) The licensee has paid the civil penalty.

In early 1991, the NRC prepared an action plan for the licensee's facility. This plan is updated quarterly and tracks the completion of the licensee's PIP items, quarterly NRC and licensee management meetings on the PIP status, and NRC technical reviews of PIP. A full-time resident inspector was assigned to the facility on April 22, 1991.

NUREG-0090, Volume 14, No. 1,
Report No. 91-2
Medical Diagnostic Misadministration at Hutzel Hospital in Detroit, Michigan

On January 24, 1991, the licensee, Hutzel Hospital, Detroit, Michigan, notified NRC Region III that a medical diagnostic misadministration had occurred at its facility on January 17, 1991, when a patient was administered a dosage of iodine-131 (I-131) that was 100 times greater than that prescribed. Region III received a written report about this misadministration on February 1, 1991.

On January 16, 1991, a 37-year-old female patient (who had given birth to a baby 2 days earlier) was scheduled to have a thyroid scan to determine if she had a substernal goiter (beneath the breastbone). The licensee's normal procedure for such a thyroid scan usually involves administration of a 50-

microcuries (μCi) dosage of I-131, resulting in a thyroid dose in the range of 50 to 70 rads. The prescription was prepared by a physician's assistant at the direction of the referring physician. The nuclear medicine technologist subsequently discussed the procedure with the physician's assistant and asked whether the thyroid scan was the appropriate procedure. The technologist indicated a whole body scan to identify thyroid tissue throughout the body would be the appropriate test. The physician's assistant submitted a new order for the whole body scan. The I-131 was administered to the patient on January 17, 1991, and the whole body scan was performed on January 18, 1991.

The whole body scan involved a dosage of 5 millicuries (mCi) of I-131 instead of the 50 μCi used for the diagnostic procedure prescribed by the referring physician.

Because the patient's baby was not breast fed and was with the patient for only 30-minutes, the baby's exposure was only about 0.5 millirads. After the misadministration was discovered, contact between the mother and baby was restricted for two days to avoid further radiation exposure to the infant.

The NRC retained a medical consultant to evaluate the circumstances of this case. The consultant estimated that the patient received a dose of approximately 6500 rads to her thyroid. This exposure would carry a slightly increased risk of developing hypothyroidism or thyroid cancer. Because the patient was lactating, thus concentrating the radioactive iodine in the breasts, there would also be an increase in the patient's risk of breast cancer. The consultant recommended periodic monitoring of the patient for hypothyroidism and for breast and thyroid cancer.

This misadministration was caused by modifying the intended diagnostic procedure after a discussion between the physician's assistant and the nuclear medicine technologist. This modification was not reviewed by or approved by the patient's physician. The NRC staff conducted a special inspection on February 19, 1991, to review the circumstances of the misadministration and determined that the hospital had not provided training in the proper ordering and administration of radiopharmaceuticals to individuals working under the supervision of a physician designated on the NRC license.

The hospital adopted new procedures requiring specific approval by an authorized physician before the oral administration of more than 50 μCi of I-131. This authorization is to be obtained immediately before the planned administration. The hospital also reaffirmed that the technologist and physician's assistants are not permitted to change an order given by an attending physician.

The hospital recommended that the patient be placed on a thyroid hormone to inhibit the growth of thyroid nodules and that she be monitored for possible development of hypothyroidism or other complications.

The February 19, 1991, NRC inspection identified two apparent violations associated with the incident: (1) failure to instruct supervised individuals on the principles of radiation safety and (2) use of NRC-licensed material by unauthorized individuals. The NRC is still reviewing these inspection findings and enforcement action is pending.

NUREG-0090, Volume 14, No. 1, Report 91-3
Medical Therapy Misadministration at Washington Hospital Center in Washington, D.C.

On February 1, 1991, the licensee, Washington Hospital Center, Washington, D.C., notified NRC Region I that a therapeutic misadministration involving a teletherapy unit had occurred at its facility earlier that day.

A 74-year-old patient was to have received 250 rads to the brain for cancer treatment. The technologist correctly identified the patient; however, the tech-

nologist used another chart without verifying the name on the chart or the picture of the patient on the chart with the patient treated. No patient treatment area markers, such as tattoos, were used. Using the wrong chart, the technologist initiated treatment of the patient's larynx. The thyroid of the patient was not blocked from exposure to the teletherapy beam. While the patient was undergoing treatment, the technologist realized that the wrong organ was being treated and terminated the treatment. It was estimated that 57 rads were delivered to the larynx and about the same number to the patient's thyroid. After termination of the larynx treatment, the patient was given the proper treatment.

An NRC medical consultant reviewed the event, noted that no acute symptoms were present and that no long term medical implications were expected during the lifetime of the patient.

The technologist failed to follow proper identification procedures. The licensee provided additional training for the technologist in the proper identification procedures for treatment plan verification.

The Region I staff will examine the circumstances behind the incident during the next inspection of the program at the licensee's facility.

NUREG-0090, Volume 14, No. 1,
Report No. 91-4
Medical Therapy Misadministration at Hahnemann University Hospital in Philadelphia, Pennsylvania

On February 22, 1991, the licensee, Hahnemann University Hospital, Philadelphia, Pennsylvania, notified NRC Region I that a therapeutic misadministration had occurred at its facility during the period from February 14 to 18, 1991, while a patient was undergoing radiation therapy for a tumor in the eye.

A radiotherapy physician prescribed a therapeutic dose of 30,000 rads to the base of the tumor and 14,300 rads to the apex of the tumor from an iodine-125 (I-125) custom-designed eye plaque. While the physicist was designing the eye plaque, he decided to change to an eye plaque with a different radius of curvature. The physicist changed the coordinates for placement of each I-125 seed used in the plaque but failed to change the associated points for calculation of dose to various depths within the eye.

On February 18, 1991, the physicist suspected that an error had occurred while planning a treatment for another patient with a similar tumor. He retrieved patient data from the computer for the treatment started on February 14, 1991, reviewed the data, and confirmed that an error had been made. The patient's eye plaque was then removed. At that time, a treatment dose totaled about 59,000 rads to the base of the tumor and 19,500 rads to the apex of the tumor. The licensee stated that the dose received by the tumor was within acceptable medical treatment protocols for that type of tumor and that no acute effects were observed in the patient.

NRC Region I contacted an NRC medical consultant to review the event. The consultant stated that there was an increased risk of long-term adverse effects, (e.g., cataract, tissue damage).

The causes are attributed to human error on the part of the licensee's staff physicist, lack of written procedures, and lack of dual verification of dose calculations before administration.

The licensee's planned corrective actions include establishing written protocol for this procedure, including a second verification of the treatment calculations before administering dosages to patients.

An NRC Region I inspector conducted a special inspection of the circumstances surrounding this misadministration on February 25, 1991. The inspection report was forwarded to the licensee on March 11, 1991. One violation of NRC requirements was identified, (i.e., failure to notify the NRC of the therapy misadministration within 24 hours of discovery). The inspection report also noted that the inspector suggested that the licensee establish a written protocol for the procedure and the licensee agreed. NRC Region I and licensee managers met on March 21, 1991, to review the licensee's actions to prevent recurrence.

NUREG-0090, Volume 14, No. 1,
Report No. 91-5
Medical Therapy Misadministration at Clara Maass Medical Center in Belleville, New Jersey

On March 28, 1991, the licensee, Clara Maass Medical Center, Belleville, New Jersey, informed NRC Region I that a therapeutic misadministration, involving administration of I-131 to the wrong patient, had occurred earlier that day.

A radiotherapy physician prescribed a therapeutic dosage of 10 mCi of I-131 to a patient for the treatment of hyperthyroidism. The physician, who was familiar with the patient, was not able to administer the therapeutic dosage and asked another physician to administer it. In the meantime, a transporter noted that the patient was listed in a bed that she believed was occupied by another patient. The transporter asked the nuclear medicine secretary to check the discrepancy. The secretary referred to a patient list for the patient's name, noted the area of the hospital where the patient's room was, and changed the request form. The secretary did not know that there were two patients in the hospital with the same names. (The second patient was in the hospital for a lung condition.) Also, the secretary did not know the computer program that generated the patient list did not print duplicate entries. The patient's name who was to undergo treatment for hyperthyroidism was not printed on the list.

The physician who administered the dose picked up the request form and the I-131 dosage and went to the nursing station on the floor of the patient with the lung problem. The physician did not inform the nursing staff that he was about to administer a therapeutic dosage to one of their patients and went to the lung patient's room. There, he asked the patient's name and verified the name on the wrist band but did not cross-check the patient number on the wrist band with the patient number on the request form. The physician completed the request form and returned the patient folder to the nurses' station. Within 5 minutes of the administration of the radiopharmaceutical, the nurses discovered the error and informed the physician and the radiation safety officer (RSO). The licensee administered a thyroid blocking agent of 1000 milligrams of potassium iodide immediately, with 3 subsequent doses of 1000 milligrams each given at 4-hour intervals.

The licensee determined that the thyroid of the patient received an uptake of between 80 and 100 μCi of I-131, which would give a dose of between 112 and 140 rads. An NRC medical consultant, who reviewed the event, concurred with these figures. The licensee advised the NRC that no adverse effects were anticipated during the lifetime of the patient as a result of the misadministration.

The causes were attributed to failure to follow the hospital protocol of checking the patient identification number and failure to inform the head nurse of the floor of the therapeutic procedure before administration.

The licensee's planned corrective action includes establishing a check list that must be completed by individuals administering therapeutic dosages. Other actions include changing the computer program so that all of the information is printed out on the patient list and reinstruction of personnel regarding patient verification procedures.

On April 1, 1991, a Region I inspector conducted a special inspection of the misadministration. The

inspection report, which identified no violations of regulatory requirements, was sent to the licensee on April 17, 1991. The licensee's corrective actions are considered satisfactory.

NUREG-0090, Volume 14, No. 2, Report No. 91-6
Potential Criticality Accident at the General Electric Nuclear Fuel and Component Manufacturing Facility in Wilmington, North Carolina

On May 29, 1991, higher than expected amounts of uranium in a process tank of the waste treatment system posed a potential criticality safety problem at the General Electric Nuclear Fuel and Component Manufacturing facility, Wilmington, North Carolina. The amount was approximately 2300 parts per million (ppm) or 150 kilograms total uranium (about 4 percent enriched in U-235). The administrative criticality safety limit for transferring uranium into the process tank vessel (an unfavorable geometry tank) was 150 ppm. (Unfavorable geometry tank refers to a process vessel that can hold enough uranium to produce a criticality.)

During the morning of May 29, 1991, the licensee identified higher than expected amounts of uranium in a favorable geometry vessel in its solvent extraction system as a result of earlier problems with controls and equipment in that system. The licensee shut down the solvent extraction process and discovered higher than expected amounts of uranium had been improperly transferred into an unfavorable geometry waste tank. Licensee managers were notified, and a technical evaluation team was convened. Sparging (i.e., mixing) was initiated in this tank to minimize the criticality potential by preventing an accumulation of material in the bottom of the tank. During the afternoon of May 29, 1991, the licensee notified NRC Region II of the incident. Later, the licensee began uranium recovery operations from this tank via a centrifuge linked to the tank.

On the same day, the NRC dispatched a Region II site team and activated the headquarters and Region II incident response centers. The site team arrived early during the morning of May 30, 1991. At 6:38 a.m., e.d.t., on May 30, 1991, after discussions with the NRC response centers, the licensee declared an "Alert" in accordance with its Radiological Contingency and Emergency Plan.

On May 31, 1991, the NRC Executive Director for Operations (EDO) requested that the site team be upgraded to an eight-member NRC Incident Investigation Team (IIT). Also on May 31, 1991, the NRC issued a letter confirming the licensee's agreement to refrain from transferring material in certain portions of the waste streams, refrain from using the solvent extraction system, and cooperate with the IIT ("Confirmation of Action Letter" from Stewart D. Ebneter, Regional Administrator, NRC Region II, to William Ogden, Acting Manager, Nuclear Fuel & Components Manufacturing, General Electric Company, Docket No. 70-1113, License No. SNM-1047, May 31, 1991). The licensee continued to remove uranium by centrifuge from the tank through June 1, 1991. By this date, the licensee had transferred sufficient amounts of solution containing uranium from the tank via the centrifuge process to other nearby tanks to reduce the uranium in the tank to an amount less than the criticality safety limit. The licensee then terminated the "Alert" status and the NRC went to a normal response mode in both its headquarters and regional response centers.

The IIT, which arrived on site on June 2, 1991, was directed to determine the circumstances associated with the event, identify the probable causes of the event, and make appropriate findings and conclusions that would form the basis for any necessary follow-on actions. The IIT left the site on June 13, 1991. A Region II inspection team continued to monitor the licensee's followup actions at the site from May 30 through July 18, 1991.

On June 25, 1991, the licensee met with the NRC in the Region II office to discuss the status of the systems shutdown as a result of the event, the corrective actions needed before restart, and the longer term corrective actions at the facility. The licensee certified in letters dated July 4 and

July 7, 1991, that the corrective actions for restart of the waste systems, including a procedure for reporting all types of events to the NRC, were complete (Letters from William Ogden, Acting Manager, Nuclear Fuel & Components Manufacturing, General Electric Company, to Steward D. Ebneter, Regional Administrator, NRC Region II, Docket No. 70-1113, License No. SNM-1047, July 4 and July 7, 1991).

The NRC Region II onsite inspection team verified that these actions were complete. The NRC authorized the licensee to restart certain waste stream systems on July 7, 1991, and confirmed this in a July 11, 1991, letter ("Modification of Confirmation of Action Letter," from Steward D. Ebneter, Regional Administrator, NRC Region II, to William Ogden, Acting Manager, Nuclear Fuel and Components Manufacturing, General Electric Company, Docket No. 70-1113, License No. SNM-1047, July 11, 1991).

The IIT identified numerous problems at the plant, including inadequate management oversight, design deficiencies, procedural noncompliance, inadequate incident investigation, and a general deterioration of criticality controls. The IIT concluded that the problems can be summarized by three interrelated root causes that contributed to the incident: (1) a pervasive licensee attitude existed that a nuclear criticality was not a credible accident scenario, (2) licensee managers did not provide effective guidance and oversight of licensed activities to ensure that operations were conducted in a safe manner, and (3) a deep-seated, production-minded orientation existed within the licensee's organization that was not sufficiently tempered by a "safety first" attitude, particularly regarding nuclear criticality safety. In addition, the IIT identified various weaknesses in NRC regulatory guidance, and licensing and inspection programs that had the effect of contributing to the incident.

The licensee's corrective actions included the following: system walkdowns and verifying that documentation matched current plant configuration; revising procedures; retraining of operators; revamping sampling to ensure adequacy for measurement of uranium; sensitivity training of all plant personnel to follow procedures and report problems; documenting a scheme for reporting events; instituting additional management oversight of operators; establishing an audit system; and establishing a long-term plan to improve performance in staffing, emergency response, equipment reliability, and engineered systems to replace administrative criticality controls. The licensee reports the status of short- and long-term corrective actions to NRC Region II on a biweekly basis.

The licensee presented an outline of its corrective actions for restart of the solvent extraction system to the NRC in an August 9, 1991, letter (Letter from William Ogden, Acting Manager, Nuclear Fuel & Components Manufacturing, General Electric Company, to Steward D. Ebneter, Regional Administrator, NRC Region II, Docket No. 70-1113, License No. SNM-1047, August 9, 1991).

The NRC IIT formal report was published in August 1991 as NUREG-1450, "Potential Criticality Accident at the General Electric Nuclear Fuel and Component Manufacturing Facility," May 29, 1991. On the basis of the IIT's findings, the NRC EDO issued a memorandum on August 13, 1991, to identify and assign NRC staff responsibility for facility-specific actions, generic issues, and areas for regulatory improvement (Memorandum from James M. Taylor, NRC EDO, to Edward L. Jordan, Director, NRC Office for Analysis and Evaluation of Operational Data (AEOD), et al., "Staff Actions Resulting from the Investigation of the Potential Criticality Accident at the General Electric Nuclear Fuel and Component Manufacturing Facility, May 29, 1991," NUREG-1450, August 13, 1991). In response to the directive, the Office of Nuclear Material Safety and Safeguards (NMSS), AEOD, and Region II developed action plans and established milestones. Some of the short-term actions involving the plant were completed during the latter part of 1991. Some longer term actions that involve regulatory changes may take several years to complete. The resolution

status or disposition of each IIT staff action will be included in the annual reports issued by the NRC AEOD (NUREG-1272 series).

The IIT team briefed the Commission on the content of the IIT report on September 9, 1991, and briefed the Advisory Committee for Reactor Safeguards (ACRS) on October 10, 1991. The licensee and the NRC staff presented their views of the incident and actions in a formal Commission briefing on October 18, 1991.

Significant NRC inspector presence was maintained at the site during August through mid-October 1991. The inspectors reviewed operations in progress as the licensee restarted the solvent extraction process and reviewed actions taken by the licensee to improve its performance in criticality safety. The solvent extraction process has been operated safely since the NRC authorized operation on October 16, 1991. In an emergency exercise on December 18, 1991, the licensee demonstrated effective corrective actions for the problems in the licensee's emergency response program. These problems were identified by the IIT and NRC followup inspections.

The NRC issued NRC Bulletin 91-01, "Reporting Loss of Criticality Safety Controls," October 18, 1991, to all fuel cycle and uranium fuel research and development licensees. The bulletin requested the licensees to evaluate their criticality safety criteria and procedures, modify them as appropriate to ensure that events involving degradation of controls will be promptly evaluated and reported to licensee managers and the NRC as appropriate, and provide a description of their criteria and procedures to the NRC. On November 19, 1991, the NRC staff sponsored a workshop on Bulletin 91-01. Responses to the bulletin are due by the end of January 1992. These responses will be reviewed by NMSS; then the licensees' implementation of any needed improvements will be reviewed during NRC inspections.

In addition, NMSS established a Materials Regulatory Review Task Force. The purpose of the task force was to conduct a broad-based review of the Commission's current licensing and oversight programs for fuel cycle and large material plants. The task force was requested to define the components and subcomponents of an ideal regulatory evaluation system for these types of licensed plants and compare them to the components and subcomponents of the existing regulatory evaluation system. The task force prepared a report that discusses the findings from this comparison and proposes recommendations on the basis of the findings. This report was issued for public comment during February 1992 as Draft NUREG-1324, "Proposed Method for Regulatory Major Materials Licensees."

NUREG-0090, Volume 14, No. 2,
Report No. 91-7
Multiple Medical Teletherapy
Misadministrations at St. John's Regional
Medical Center in Joplin, Missouri

On April 12, 1991, the licensee, St. John's Regional Medical Center, Joplin, Missouri, notified NRC Region III that a number of cobalt-60 (Co-60) teletherapy misadministrations had occurred between September 1989 and March 1991. The misadministrations (defined as therapeutic doses varying more than 10 percent from prescribed doses) were discovered during a review of past treatment data in March and April 1991. On April 25, 1991, the licensee formally reported that 12 misadministrations had occurred.

Of the 12 patients, 3 received doses 10 percent to 18 percent higher than the prescribed doses, and 9 patients received doses from 10 percent to 27 percent below the prescribed doses. All misadministrations resulted from erroneous information in the treatment planning computer program. All treatments, with one exception, involved

the use of wedges, which consist of compensating material such as lead, placed in the radiation beam to more evenly distribute the prescribed dose of radiation to appropriate tissue.

The treatment discrepancies were first discovered in March 1991, when a therapy technologist pulled the files of previously treated patients to practice hand-calculated dosimetry for an upcoming board certification test. The technologist informed licensee managers that her results did not match the wedge-related treatment doses indicated in the patient files. On March 22, 1991, the RSO was asked to investigate the apparently conflicting results. On March 25, 1991, the radiation oncology staff began hand calculations of the doses to all patients who received wedge-related treatments since the inception of that type of treatment in August 1989. The licensee also initiated reruns of the original computer calculations. By March 29, 1991, the reruns showed that actual administered doses had deviated significantly from prescribed doses. All of the patients' referring physicians were subsequently notified of the dose differentials, except for one physician who had left the area. In the latter case, the patient was notified directly. Subsequently, the patients have been seen by their physicians for followup care. The licensee stated that no adverse effects have been observed to date.

In 11 of the 12 misadministrations, the licensee failed to calculate a computer program's "wedge normalization factor" in making initial dose calculations. The wedge normalization factor is described in the manufacturer's computer program instruction manual. Instead of using this factor, the licensee used different measured wedge factors that were not compatible with the computer program. A twelfth misadministration resulted from the licensee's failure to correct the computer program as directed by the manufacturer's release notes.

On April 12, 1991, the licensee requested an amendment to its NRC license to require independent verification of Co-60 teletherapy treatment plans. In addition, the licensee has implemented an internal procedure, which also requires independent verification of treatment p[illegible] before treatment. On April 15, 1991, Region III approved the amendment. The licensee must maintain records of the dual verification.

On April 18, 1991, NRC Region III conducted a special safety inspection at the medical center in response to the Co-60 misadministrations. On May 10, 1991, Region III issued a violation that cited the licensee for failing to notify the NRC within 24 hours of discovery of the initial misadministration. The NRC was not notified of the misadministrations until April 12, 1991, even though the first misadministration was identified on March 29, 1991.

NUREG-0090, Volume 14, No. 3,
Report No. 91-8
Radiation Exposures of Members of the Public From a Lost Radioactive Source

On September 5, 1991, Western Atlas International (the licensee) notified the State of Texas that a 2-curie (Ci) cesium-137 (Cs-137) sealed well-logging source had been lost that morning from the licensee's vehicle en route from the licensee's Yukon, Oklahoma, facility to its Houston, Texas, facility. The licensee initiated a search for the source, using radiation detectors, and retraced the route of the vehicle. Meanwhile, at approximately 5:30 p.m. on the same day, a citizen spotted the shipping container lying on the gravel shoulder about 30 feet from the southeast corner of the intersection of the Interstate 45 Exit 118 road and underpass road near Huntsville, Texas, and notified the Huntsville Police Department. A police officer was dispatched to the scene.

The radioactive source was found approximately 7 feet from its shipping container. The police officer picked up the source and is believed to have held it for about 5 seconds before dropping it approximately 6 to 12 inches from the container. The area was closed to the public until a member of the city's emergency management services retrieved the source at approximately 6:15 p.m. The source was replaced in the shipping container, which was

missing its shield plug. Licensee personnel placed the source in a complete shipping container at approximately 7:30 p.m.

A large pin that is supposed to be attached to the safety bar securing the shipping container shield plug was determined to be missing. Without this pin, the safety bar could slide out of position, and the plug and source could come out of the shipping container.

In addition, the bed of the truck from which the shipping container fell was a flat steel deck with no obstructions at the rear of the truck except for a canvas cover held in place with four elastic straps. During transportation, several shipping containers were fastened on the truck bed by locks attached to the containers and to the links of a slack steel chain attached to structural members of the truck. The shipping containers could move on the truck bed. Apparently, the slack allowed the shipping containers to accelerate when the vehicle turned corners, breaking a lock and allowing the subject shipping container to fall off the back of the truck.

The police officer who held the source received an estimated exposure of approximately 5 rem to his fingers. The individual who retrieved the source received an estimated exposure of approximately 150 millirem (mrem) to his fingers.

The event was attributed to human error. Licensee personnel did not follow the licensee's procedures or managerial instructions in correcting shipping container deficiencies and in properly securing the shipping containers to the transporting vehicle.

On September 6, 1991, the day after the incident, the licensee issued a memorandum to all their North American facilities concerning corrective measures that were effective immediately. Subsequently, the licensee took additional corrective actions to prevent such losses.

On September 6, 7, and 11, 1991, NRC Region IV inspectors conducted a special, announced radiation safety inspection of the licensee's byproduct material program. The inspection included the review of organization, management, training, radiation protection, independent measurements, notification, and transportation activities. The inspectors identified seven apparent violations of NRC regulations.

On December 20, 1991, the NRC issued a Notice of Violation and Proposed Imposition of Civil Penalty in the amount of $10,000. The proposed civil penalty was based on two of the apparent violations: (1) failure to block and brace the source container adequately and (2) failure to ensure the container's closure device was adequate.

NUREG-0090, Volume 14, No.3,
Report No. 91-9
Medical Diagnostic Misadministration at St. John's Mercy Medical Center in St. Louis, Missouri

A bone scan diagnostic study was scheduled by the licensee, St. John's Mercy Medical Center, St. Louis, Missouri, for September 9, 1991, for a 15-month-old male child with possible osteomyelitis (bone inflammation) of the ankle. The child was given an adult dose of technetium-99m MDP (Tc-99m MDP), the radioactive pharmaceutical used for a bone scan. The normal dose for a child of his weight would be 1.91 mCi. The standard adult dosage used for the diagnostic study was about 21.96 mCi, more than 10 times the intended dosage to the child.

The licensee uses a computer system as an aid to determine the appropriate amounts of the radiopharmaceutical to use in the bone scan. Pediatric patients are identified on the licensee's treatment list with an asterisk, accompanied by a handwritten notation of the patient's body weight.

The radiopharmacist who prepared the Tc-99m MDP for the bone scan failed to note the asterisk and handwritten body weight on the computer printout of scheduled diagnostic studies and prepared the standard adult dosage.

The nuclear medicine technician checked the patient's name on the dose ticket accompanying the syringe, but did not verify the radiopharmaceutical and dosage, as required by hospital policy. After the administration, the technician noted the volume of the Tc-99m MDP was greater than expected, rechecked the dose ticket, and discovered the error.

The error did not negate the results of the diagnostic study and the bone scan was completed. Although the amount of radiation the child received was greater than intended, the licensee determined the increased risk of biologic effects was not significant. The calculated radiation dose for the study was about 4.4 rads to the bone and 1.3 rads to the total body. Had the correct dosage been administered, the child would have received about 0.38 rads to the bone and 0.11 rads to the whole body.

The cause is attributed to human error on the part of the radiopharmacist and the nuclear medicine technician. The hospital has counseled the two employees involved in the error. Hospital managers met with the nuclear medicine department staff on September 17, 1991, to review the impact of the errors in this incident, to stress the importance of checking one's own work as well as the work of others, and to point out the need to follow department policies.

The NRC staff has reviewed the circumstance of the misadministration and will evaluate the licensee's corrective actions in a routine inspection to be conducted in the next several months.

NUREG-0090, Volume 14, No. 4,
Report No. 91-10
Medical Diagnostic Misadministration at I. Gonzalez Martinez Onnologic Hospital in Hato Rey, Puerto Rico

On June 17, 1991, a patient scheduled to receive a diagnostic dose of I-131 was mistakenly administered a dose of I-131 in the therapeutic range. The misadministration occurred when a nuclear medicine technologist misread the dose calibrator and administered 6.2 mCi rather than 6.2 μCi. The technologist realized the error 9 minutes after the dose was administered when the printed dose label from the dose calibrator was checked. The physician in charge promptly administered potassium iodide solution to the patient to reduce the uptake of the radioactive iodine. The licensee estimated, based on 24-hour uptake measurements, that the dose to the thyroid was 1612 rem.

The licensee continues to follow the patient's condition and has advised the NRC that the patient has not experienced any adverse effects because of the misadministration.

The cause is attributed to human error by the nuclear medicine technologist. The technologist did not verify the dose by reviewing the printed dose label before administering the dose.

The licensee's corrective actions included taking disciplinary action against the technologist and requiring that the nuclear medicine supervisor check each dose before the dose is administered to a patient.

NRC Region II conducted an inspection to review the circumstances associated with the event and identified no violations of NRC requirements.

NUREG-0090, Volume 14, No. 4,
Report No. 91-11
Medical Therapy Misadministration at William Beaumont Army Medical Center in El Paso, Texas

On August 30, 1991, a patient referred to the Medical Center for therapeutic radioiodine treatment of Graves' disease mistakenly received a 28.6 mCi oral dosage of I-131 instead of the prescribed oral dosage of 15 mCi of I-131. As a result, the patient's thyroid received about 31,900 rads instead of the 16,700 rads intended.

Before administering the dosage, the radiopharmacist involved was informed that a radioiodine treatment for Graves' disease had been requested. He assumed that it was a 29-mCi treatment rather than a 15-mCi treatment. (At the Medical Center, a 15-mCi dose is routinely used for Graves' disease while a 29-mCi dosage is used for thyroid disorders such as multinodular toxic goiters.) He then requested a 29-mCi dose from a commercial radiopharmacy. The actual dose received was 28.6 mCi and was labeled as such. When the radiopharmacist logged the dosage into the computer, after it had been measured by the dose calibrator, he failed to note the intended therapy dose in the referring physician's prescription. In addition, the counselling nuclear medicine physician did not verify the dosage to be administered with the intended dosage. The 28.6-mCi incorrect dosage was then administered to the patient.

The referring physician was notified on the day of the misadministration. The licensee stated that no adverse effects on the patient were noted. The patient's condition will be appropriately followed in the licensee's Endocrine Clinic.

The event was attributed to human error as a result of the radiopharmacist's and consulting nuclear medicine physician's inattentiveness and brief experience at the facility.

The radiopharmacist and consulting nuclear medicine physician were counselled and reinstructed about the proper drawing techniques and safeguards. For future therapies using radiopharmaceuticals, the counselling nuclear medicine physician must visually check the amount of drawn radiopharmaceutical, as measured by the radiopharmacist or technologist, with the physician's written prescription. The licensee also intends that the consulting nuclear medicine physician be familiar with the patient's case history before administering a therapeutic radiopharmaceutical dose.

Also, the licensee's RSO will conduct a training session in which all nuclear medicine personnel will be required to review the videotape entitled, "Good Practices in Preparing and Administering Radiopharmaceuticals," prepared by the NRC's AEOD.

NRC Region IV conducted an inspection to review the event and identified no violations of NRC requirements.

NUREG-0090, Volume 14, No. 4,
Report No. 91-12
Medical Therapy Misadministration at St. Joseph's Hospital and Medical Center in Paterson, New Jersey

On November 13, 1991, the licensee's acting RSO notified NRC Region I by a letter dated October 30, 1991, that a therapeutic misadministration involving a strontium-90 (Sr-90) beta applicator, with a nominal activity of 95.5 mCi, had occurred on October 25, 1991. The therapeutic treatment had been administered to the wrong patient.

The misadministration involved a 52-year-old male who was scheduled for a simulation for external beam therapy from a linear accelerator to the head and neck. This misadministration occurred when the radiation oncology department secretary directed the patient to wait in the wrong treatment room without

his chart. The patient spoke minimal English, and the radiation oncologist did not speak the patient's language. The physician asked the patient more than once which area of his body was being treated. The patient pointed toward his head as the area to be treated. On the basis of this poor exchange of information and without benefit of a review of the patient's chart, the oncology physician then administered a Sr-90 dose to the patient's eye. The licensee estimates that about 1000 rads were delivered in 11 seconds to the surface of the right eye. The licensee estimates that no harmful effects occurred to the patient as a result of this event.

An NRC medical consultant was retained to review the event. The consultant agreed with the licensee's estimate of dose to the patient's eye and concluded that the possibility of cataracts is low.

The cause was attributed to failure to follow the hospital protocol, which requires reviewing the patient's chart before administering treatment.

The licensee's planned corrective actions included the following:

1. Patients will only be directed to the treatment area by an aide who will hand the treatment charts directly to the physician.

2. Each patient's chart will include a polaroid photograph of the patient.

3. Access to the Sr-90 beta applicator storage area will be limited to the Physics Department and the Chief Technologist.

4. Physics staff will accompany the physicians during all Sr-90 beta applicator treatments and assist in determining the treatment times.

5. Staff training and reenforcement of appropriate patient processing procedures and NRC requirements will be conducted.

NRC Region I conducted a special inspection on November 15, 1991, of the circumstances surrounding this misadministration. On December 26, 1991, the NRC transmitted to the licensee a Notice of Violation and Proposed Imposition of Civil Penalties in the amount of $6,250. Two violations were identified: (1) the failure to review the patient's prescription, which resulted in the misadministration ($3,750); and (2) the failure to report the misadministration to the NRC within 24 hours of its discovery ($2,500). Both violations were classified as Severity Level III on a scale in which Severity Levels I through V range from the most significant to least significant, respectively. The licensee admitted the violation and paid the civil penalties.

NUREG-0090, Volume 14, No. 4,
Report No. 91-13
Medical Therapy Misadministration at University of Pittsburgh Presbyterian-University Hospital in Pittsburgh, Pennsylvania

On November 22, 1991, the licensee's RSO notified NRC Region I that a therapeutic misadministration involving a Co-60 teletherapy unit had occurred at their Presbyterian University Hospital facility on November 21, 1991. The therapeutic treatment had been administered to the wrong part of a patient's body.

The technologist had looked at the patient's chart but set up the wrong treatment field. The patient received 287 rads to the thoracic vertebrae (upper back) instead of the prescribed 300 rads to the cervical vertebrae (lower neck). Because the patient had previously undergone thoracic vertebrae treatment, the technologist erroneously assumed that the thoracic treatment was continuing and administered the treatment without adequately reviewing the patient's chart, which indicated the correct treatment area.

The licensee has determined that the treatment will not have any adverse effects on the patient. The

patient is suffering from metastatic cancer of the breast and was receiving palliative radiation treatments to the spine.

The cause was attributed to failure to follow the written prescription in the patient's chart.

Corrective actions included stressing to the radiation technologists the need to carefully read patients' charts and to recognize notations of changes in the fields to be treated. When a field is completed on a patient, the administered dose is to be recorded in the patient's chart, using a different color ink.

NRC Region I will examine the licensee's prevention and corrective actions at the next scheduled inspection.

NUREG-0090, Volume 14, No. 4,
Report No. 91-14
Medical Therapy Misadministration at University of Wisconsin Hospital in Madison, Wisconsin

A patient was undergoing a series of five treatments for a cancer of the nasal septum, using a high-dose-rate iridium-192 (Ir-192) afterloading unit. The initial four treatments were completed without incident. However, before the fifth treatment on November 27, 1991, the operating physicist picked up the wrong patient's chart located next to the device's control panel and entered the program information into the computerized device. While the treatment was underway, a student technologist inquired about the length of time to complete the treatment. The prescribing physician and the operating physicist indicated different lengths of time. The physician, realizing there was an error, directed that the treatment be stopped immediately. Subsequently, it was discovered that the physicist had used the chart for the wrong patient and, therefore, entered incorrect treatment program information into the computer. The correct treatment information was then entered into the computer and the treatment series completed.

The erroneous treatment information positioned the Ir-192 source so that the patient's lips received an exposure for about 1 minute. The dose calculation by the licensee indicated the patient received approximately 73 rads to the lips. According to the licensee, the radiation exposure received by the lips, for a correctly administered treatment to the nasal septum, would be about 25 rads. The licensee does not expect any consequences resulting from the additional exposure to the patient's lips from this misadministration.

The causes of the event were the physicist's failure to verify the identity of the patient and the physicist's assuming incorrectly that the chart at the control panel was for the patient undergoing treatment.

The licensee has directed that the operating physicist check the identity of each patient before treatment, using patient photographs or other means of verification. Patient charts for treatment series will be placed in a specified location. No exceptions will be made to the training required of a user. In the future, training will include a general section on high dose rate afterloading devices.

NRC Region III conducted an inspection on December 17, 1991, to review the event and identified no violations of NRC requirements.

Agreement State Licensees

NUREG-0090, Volume 14, No. 1,
Report No. AS91-1
Medical Therapy Misadministration at Good Samaritan Medical Center in Phoenix, Arizona

The following account is based on information the Agreement State of Arizona provided the NRC during late 1990.

On July 26, 1989, the licensee, Good Samaritan Medical Center, Phoenix, Arizona, reported to the Arizona Radiation Regulatory Agency (State Agency) a series of three misadministrations involving the use of a Co-60 teletherapy unit in the licensee's Radiation Oncology Department. The misadministrations occurred from February to June 1989.

The three patients received exposures of approximately 14 percent, 11 percent, and 12 percent greater than the prescribed doses of 6200 rads, 6480 rads, and 5000 rads, respectively, from an AECL Theratron-80 unit containing 5529 Ci of Co-60 assayed on September 16, 1988. A beam correcting wedge had been used along with a treatment planning computer. Although the computer already contained a wedge correction factor, the technologist and dosimetrist added a second wedge correction factor after checking with the consulting physicist and being told that a wedge factor would be required.

While preparing to treat an additional patient assigned the same treatment protocol, a hand calculation of the treatment time indicated a wide discrepancy with the computer generated treatment time. This discrepancy led to a comprehensive search of past cases to reveal the subject three overexposures.

All three patients showed signs of skin erythema (reddening), and the first two patients (who had received radiation to the larynx region) reported hoarseness and pain on swallowing. The licensee stated that these symptoms are not unusual for patients undergoing radiotherapy, and, in fact, these same symptoms were mentioned to the patients as possible side effects of the treatment.

A consulting physicist was retained to review patient records and the hospital's handling of this case. Among the findings were (1) the number of hospital staff was inadequate for the patient load, (2) the departure of one physicist and the hiring of another physicist caused a loss of continuity in physics service, and (3) poor communication (documentation) occurred about the use of the computer-generated treatment plans.

The licensee has hired a full-time qualified therapy physicist and a technical administrator. These individuals will not have responsibilities outside of the therapy department. All computer-generated treatment plans will use hand calculations to verify the computer readings. Procedures for use of this computer to generate patient treatment plans have been revised.

A civil penalty of $3,000 was proposed by the State agency on January 19, 1990, after it conducted a thorough review of the licensee's Radiation Safety Committee's activities on December 22, 1989. The basis of the violation centered on the Radiation Safety Committee's failure to adequately conduct its activities and supervise the use of therapy sources.

Litigation continues on this event, and the State Agency has not received all records at this time.

NUREG-0090, Volume 14, No. 2,
Report No. AS91-2
Overexposure of a Nonradiation Worker

The following account is based on information the Agreement State of Texas provided the NRC during late May 1991.

During radiography operations, an unmonitored, nonradiation worker employed by the Exxon Corporation received a whole body exposure estimated to be between 1.8 and 3.9 rem from a radicactive source that was not properly shielded. This exceeds the abnormal occurrence reporting threshold of 0.5 rem in one calendar year for a member of the general public. In addition, a radiographer received a whole body exposure of about 7.7 rem. (This exceeds the license limit for whole body exposure to a radiation worker in one calendar quarter; however, it is below the abnormal occurrence reporting threshold of 25 rem whole body.)

On July 14, 1990, two employees of the licensee, H & G Inspection Company, Incorporated, Houston, Texas, were performing routine radiography of welds at Exxon's Texas Well #1, located in Sabine Lake. They were located on a barge near Port Arthur, Texas. They were using a Gulf Nuclear Model 20-V camera containing 60 Ci of Ir-192. After completion of a radiograph, Radiographer A cranked in the source, approached and surveyed the camera and guide tube, and locked the camera. He removed the exposed film and took it to the darkroom for Radiographer B to develop. Radiographer A returned to the weld to set up for the next exposure. During this procedure an Exxon employee approached the radiography camera inside the restricted area to discuss the next shot. Radiographer A had problems setting up the next shot and obtained Radiographer B's assistance. The Exxon employee left the area at this time.

The two radiographers completed the set-up and were leaving to make the radiograph when Radiographer B noticed that the lead radiographer's survey meter was off-scale on the high side. This indicated that the source was not in the shielded position. They moved away from the camera, unlocked the camera, and retracted the crank-out handle one-half turn. The camera was relocked and pocket dosimeters were checked. The pocket dosimeters were off-scale and the RSO was notified of the incident. The employees were ordered to return to the shop and their thermoluminescent dosimeters (TLDs) were mailed in for immediate processing.

The TLDs indicated that Radiographers A and B received about 7.7 rem and 1.3 rem, respectively. Because the nonradiation worker was not wearing any radiation dosimetry, his exposure was estimated by a reenactment of the event and calculations; these indicated he received a whole body exposure between 1.8 and 3.9 rem.

There were three root-causes for the event. The first cause was the camera locking with the source in the unshielded position. (The licensee stated that this is a design flaw in the lock box and is not an unusual occurrence with the Gulf Nuclear Model 20-V camera. The manufacturer of this camera is no longer in business.) The second cause was the failure of the radiographer to perform an adequate survey to determine whether the source was in the shielded position. Apparently, the radiographer went through the motions of performing the survey, became complacent while reading the meter, and failed to perceive what his meter was indicating. The third cause was use of inadequate procedures regarding unmonitored personnel entering a restricted area.

The radiographers and the Exxon employee were notified of their exposures. All licensee employees were notified of the incident by memorandum. The incident was discussed during the next safety meeting. New procedures were developed pertaining to unmonitored personnel entering restricted areas. The requirements for performing a proper survey were reemphasized to ensure that a source has been properly retracted into its shielded position. When the camera is moved to a different job site, the guide tube will be disconnected and the safety plug inserted. Anyone not following the new procedures will be fined $100.

The licensee was cited by the State agency for allowing an unmonitored individual to receive an exposure greater than 2 mrem in an hour, for the

exposures of the two radiographers, and for the failure to perform adequate surveys to determine whether the radiation source was secured. Additionally, because of overexposures that occurred more recently, the State agency is conducting a review to determine whether escalated enforcement is necessary.

NUREG-0090, Volume 14, No. 2,
Report No. AS91-3
Extremity Overexposure of a Radiation Worker

The following account is based on information the Agreement State of Illinois provided to the NRC during June 1991.

While extracting a 10-Ci Cs-137 source from its housing, a radiation worker employed by the licensee, Kay-Ray/Sensall Division, Mt. Prospect, Illinois, received an overexposure to his left hand. The actual exposure is not precisely known but was probably between 200 and 714 rem. Because the higher value, which was indicated by the worker's dosimetry, could not be disproved, 714 rem to the left hand was entered into the worker's radiation records. The event was investigated by the Illinois Department of Nuclear Safety, referred to below as the State agency.

On July 10, 1990, the worker was removing the source from a source housing so that the source could be transferred to a different housing for resale. Operating on this particular source holder (constructed of stainless steel and holding a larger than usual activity of Cs-137) required direct observation and timing of operations by the worker's supervisor.

The removal of the source/source holder assembly from the source housing was routine in every aspect. Using tongs, the source/source holder assembly was then moved to an area behind a lead-shielded work station and clamped into place. Extraction of the source from the source holder then began by peeling back the crimp on top of the source holder, using hand tools. After about 25 percent of the crimp was peeled back, the cylinder containing the source separated from the base of the source holder. The worker retrieved the cylinder containing the source and continued the extraction process. Following the uncrimping of the broken source holder, the worker tried to extract the source twice, being successful on his second attempt. The source was then placed in a lead pig for eventual loading into the new device. The total time reported by the worker's supervisor for the entire procedure was 4 minutes and 45 seconds.

Previous recorded extremity doses to employees involved with source changes on 10-Ci Cs-137 sources from stainless steel source holders were approximately 3 to 4 rem. However, because the source manipulation was unusual in this case, the supervisor suggested that the worker's ring TLD be processed. On July 12, 1990, the results indicated an exposure of 714 rem to the left hand.

A physician examined the worker on the evening of July 12, 1991. This included a physical examination of his hand as well as a blood test. No unusual results were reported by the physician. The worker showed no visible signs of acute radiation overexposure to his left hand. He stated that there was no discomfort, reddening, swelling, or other ill effects suffered as a result of this event. On July 20, after further blood tests and physical examination, an oncologist/hematologist informed the worker that all tests were normal and that he could find no sign of damage to the worker's hands or forearms. On the basis of these findings, the doctor believed that the worker had not been exposed to the high level of radiation reported.

The State agency inspectors witnessed a reenactment of the source extraction procedure, in which a blank stainless steel source holder was used. On the basis of these observations and measurements and data provided by the licensee, the State agency concluded that, while possible, it is unlikely that the worker received an exposure to his left hand of 714 rem. However, the agency concluded that an extremity overexposure did occur, estimated to be approximately 200 to 300 rem.

After completing the investigation, the following findings were discussed in an exit interview: (1) insufficient evidence existed to discount or to prove whether the worker received a dose of 714 rem to his left hand and (2) the licensee should continue medical followup observation and treatment if necessary and notify the State agency of any physical changes that occur.

The following recommendations were offered during the interview: (1) the licensee should contact the processor and have them check the TLD chip and reading system for proper response (quality assurance) and (2) the licensee should consider engineering or procedure changes to the procedures to increase the distance between the source and the source remover's hand. In the absence of this change, the licensee should consider discontinuing the reuse of high activity sources because of the potential for a radiation overexposure of this kind.

The causes are attributed to inadequate procedures and supervision during operations involving a high activity source. Greater use of remote handling equipment could considerably reduce the potential for overexposure.

The licensee proposed the following corrective actions: (1) no source capsule larger than 2 Ci will be uncrimped from its holder, (2) no source capsule larger than 0.5 Ci will be uncrimped from its holder without direct supervision of the operation, and (3) all source loaders' dosimeters (body badges, TLD rings, etc.) will be kept under lock and key when not in use.

On July 31, 1990, the State agency issued a notice of violation for the overexposure. The license was amended to include the licensee's proposed corrective actions and the letter transmitting the amendment included a strong suggestion that remote handling equipment be considered more often in the interest of keeping exposures as low as reasonably attainable.

NUREG-0090, Volume 14, No. 2,
Report No. AS91-4
Overexposure of a Radiographer

The following account is based on information the Agreement State of Texas provided the NRC during May 1991.

During radiography operations, a radiographer employed by the licensee, Big State X-Ray, Eastland, Texas, at Pride Refinery in Abilene, Texas, received an estimated exposure of 35 rem to his right thigh from a radioactive source that was not locked in its shielded position.

On November 7, 1990, two licensee radiographers were performing radiography outside the Pride Refinery when it started to rain. They moved their operations inside a building so they could continue working. At the completion of the first series of radiographs, Radiographer A proceeded to move the camera to the next weld for the next series of exposures. He stated that he surveyed the camera, got "no reading," locked the camera (but did not remove the key from the lock), and carried the camera to the next weld. He stepped over some obstacles and believes the key turned in the lock and released the source, which moved outside the shield.

At the next weld, he surveyed the camera and set up the next exposure. [It was later determined that the survey meter was not operating correctly because of internal moisture from the rain.] After completing the set-up, he noticed that the camera was unlocked and checked his pocket dosimeter. It was off the scale. He went to the crank-out handle and retracted the source about one and one-half turns. He then notified Radiographer B of the incident; Radiographer B stopped operations and had Radiographer A's film badge sent in for immediate processing. However, the film was damaged during shipment and could not be processed. His exposure was estimated by a reenactment of the event and calculations indicated he received a 35-rem exposure to the right thigh.

The primary cause of this incident was the failure of the radiographer to lock the source in the camera and remove the key before moving the camera. The radiographer also failed to determine whether his survey meter was operating correctly after it became wet in the rain.

The incident was discussed with all radiographic personnel of the company and all were cautioned of the consequences of failing to follow proper procedures.

The licensee was cited by the State agency for the overexposure and failure to properly lock and remove the key from the radiography camera before relocating it.

NUREG-0090, Volume 14, No. 4,
Report No. AS91-5
Exposure of a N\. \diation Worker

The following account is based on information in the Agreement State of California provided the NRC in December 1991.

On August 1, 1989, an intracavitary procedure was performed at San Gabriel Valley Medical Center, San Gabriel, California. Two Cs-137 sources, 42.2 mCi each, were loaded into colpostat devices and inserted into the patient for treatment. After the procedure was completed, the physician removed the devices and placed them in a lead container. The container was then transported to the room where the cesium storage safe was located; however, the sources were not removed from the inserts and placed in the safe as they should have been. On September 1, 1989, an employee of the medical center removed the inserts still containing the sources from the lead transport container and, thinking they were empty, placed them in an envelope to be transported to Methodist Hospital of Southern California in Arcadia, California, where they were intended to be used. The envelope was placed in the Radiology Department where it was picked up by an employee of a private medical group a few days later. This individual placed the envelope in his private car and drove to Methodist Hospital, which took approximately 25 minutes.

When the inserts were received by Methodist Hospital, the envelope was opened immediately and the sources were discovered inside. They were placed in a lead transport container and removed to the storage safe by staff of the hospital.

San Gabriel Valley Medical Center hired a medical physicist to evaluate and determine the extent of exposures that individuals had received as the result of this incident. Extensive time and motion studies were conducted, as well as the processing of personnel monitoring devices, to determine doses received. The individual who had transported the sources from one hospital to the other was a nonradiation worker and, therefore, did not wear a personnel monitoring device. Estimates are that he received about 106 rem to his right hand and 0.168 rem whole-body exposure. All others who came in contact with the sources wore personnel monitoring devices. Estimates of their exposures were within the occupational dose limits specified by the State's Radiation Control Regulations.

The medical center was cited for causing the delivery man to receive 106 rem to his right hand as a result of this event. He was notified in writing by the hospital of the nature and extent of his exposure and was provided a medical review. A medical examination of his hands on the day after the exposure, and three weeks later, did not reveal any evidence of skin changes or other symptoms. Also, his blood count showed no significant abnormalities.

The apparent cause of this exposure was the failure of hospital employees to follow proper procedures for storing of brachytherapy sources following their use. The individual who transported the sources from the patient's room to the cesium storage location at the medical center did not remove them from the colpostat source holders and place them in the storage safe. By leaving the sources in the holders, other personnel were easily exposed because the

sources were invisible and could only be detected by careful examination or use of a survey meter.

The medical center purchased a bench top Geiger-Mueller detector equipped with an audible alarm and installed it at their cesium storage location. The detector will alarm if sources are not secured inside the storage safe. Also, a refresher training was held for all staff covering the proper handling of brachytherapy sources held under the license. This training included removal and replacement of sources from the storage safe as well as quarterly inventories. Methods for surveying devices that contained cesium sources before taking them out of service was emphasized.

The inspection agency cited the medical center licensee for six items of noncompliance.

NUREG-0090, Volume 14, No.4,
Report No. AS91-6
Exposures of Nonradiation Workers

The following account is based on information the Agreement State of California provided the NRC in December 1991.

On November 2, 1990, Anaheim Memorial Hospital, Anaheim, California, shipped seven Cs-137 sources that had been used for a brachytherapy implant back to the supplier, Therapeutic Nuclides, Inc., Valencia, California. The sources consisted of two 50-mCi, three 25-mCi, and two 12-mCi sizes.

The Type 7A package used for shipment consisted of a plastic source retainer, fitted into a lead pig that was then placed inside a metal can. This metal can was placed inside a 5-gallon metal container and was surrounded on all sides by a high-density polyurethane foam. The inside container was secured with a lid and a snap ring. The outside container was secured with a lid and level lock ring.

Federal Express picked up the package on November 2, 1990, and first took it to the Fullerton, California, sort facility and then to the Los Angeles Airport (LAX) Hub sort facility. At LAX, the package came open while descending 8 feet on a 45-degree angle conveyor belt. At the bottom of the descent, all contents of the package became separated and scattered on the conveyor belt and around the work area.

A Federal Express employee noticed that the package had a radioactive label and immediately repacked the 5-gallon container; however, he did not realize that the sources had fallen out. The employee reported the incident to his supervisor who called in a hazardous materials specialist to examine the container. The specialist used a survey meter and determined no radiation level at the surface of the drum. Rather than question why he did not register any reading, he assumed that all items inside the package had been properly secured, and he allowed it to continue on to its destination.

The package arrived at Therapeutic Nuclides on Monday, November 5, 1990, but it was not opened until the following day. When the package was opened and discovered empty, the RSO for Therapeutic Nuclides immediately notified the Los Angeles County Radiation Control office (agency) and an investigation was begun. An agency inspector contacted Federal Express in an attempt to backtrack the route the package took from the time it was picked up at the hospital. She was able to focus her search on the Hub facility at LAX and discovered the sources there as soon as she entered the facility.

The inspector located all seven sources in various places throughout the facility. This inspector interviewed Federal Express personnel who came in contact or worked near where the sources were found. Those individuals who came in close contact with the sources were sent for medical evaluation and followup. Dose estimates were established for all workers, and all were notified of their estimated

doses. Individual dose estimates for the 24 employees involved ranged from 10 mrem to 1810 mrem, whole body. Also, three individuals who said they touched the sources had estimated extremity doses that ranged from 90 to 260 rem.

The U.S. Department of Transportation (DOT) investigated whether the package of sources was properly secured before pick-up by Federal Express. Strong evidence exists that the package was not properly sealed; therefore, when it fell down the conveyor belt it easily spilled open. The hospital staff supplied sworn statements to the Radiation Control Program staff that they had followed all procedures when they packaged the sources; however, DOT has run extensive tests on the container and has concluded that if it had been sealed properly, it would not have spilled its contents.

The State agency cited the licensee for failure to report the incident and for the exposure to personnel in excess of permissible levels.

Therapeutic Nuclides has redesigned their container to prevent this type of spill in the future.

NUREG-0090, Volume 14, No. 4,
Report No. AS91-7
Medical Therapy Misadministration at Northridge Hospital Medical Center in Northridge, California

The following account is based on information the Agreement State of California provided the NRC in December 1991.

On May 3, 1991, 15 mCi of I-131 intended for Patient "A" was administered in error to Patient "B," who had the same first and last names as Patient "A." The administration was made by the hospital's Certified Nuclear Medicine Technologist without the responsible physician present, which is a violation of the California Radiation Control Regulations. Patient "B" had reported to the hospital's Outpatient Department for a preoperational chest X-ray instead of reporting to her doctor's private office as she was instructed. Patient "A" was scheduled to receive a hyperthyroidism treatment that same morning.

When her name was called, Patient "B" answered and signed the consent form. She asked questions of her technologist about thyroid disorders and was given answers. The dose of 15 mCi was administered.

Later that same day, Patient "A" presented herself for the treatment. It was then that the hospital discovered that they had administered the dose to the wrong patient. Patient "B's" doctor was contacted, and he consulted with the Chief Nuclear Medicine physician. They decided to give Patient "B" 15 drops of a potassium iodine solution three times daily for 3 days plus forced fluids to reduce the uptake of the radioactive iodine. She underwent the previously scheduled surgical procedure 3 days after the dose was administered without any regard for the possible exposure of surgical room staff from the patient.

This incident was reported to the wrong unit of California's Department of Health Services by the hospital 5 days after it occurred. Not realizing the significance of the error, Radiologic Health was not contacted until May 31, 1991, 28 days after the error occurred. The Radiologic Health Unit of the Los Angeles County Health Department, the inspection agency for this licensee, began an investigation. The inspector discovered that the hospital had originally estimated the patient's thyroid dose to be much lower than it actually was. The agency retained a consultant who performed a complete workup of the patient. The patient's dose was established at 3000 rem to the thyroid, and she was informed of this in writing by the hospital. She was placed into a treatment followup program.

An evaluation of exposures to the surgical room staff was also made by the consultant. Their exposures were determined to be minimal, and they were also notified by the hospital.

The cause of this misadministration was due to the administration being made by the hospital's Certified Nuclear Medicine Technologist without the responsible physician present.

An enforcement conference was held at the Los Angeles County Health Department between members of the hospital administrative staff and representatives of the County and State Radiation Control Program staff. The hospital presented an extensive corrective action plan and explained new controls that would be implemented.

Representatives of the Radiologic Health Branch accepted the plan, and the case was referred to the city attorney's office to determine whether to file charges.

Appendix E

Reports Issued From 1981 Through 1991 (Nonreactors)

Nonreactor Reports Issued From 1981 Through 1991

Nonreactor Reports Issued in 1991

Engineering Evaluations

Date	Title	No.	Author
01/91	Brachytherapy Incidents Involving a Hand-Loading, Endobronchial Technique	N91-01	H. Karagiannis
07/91	Report on 1990 Nonreactor Events	[1]	K. Black
07/91	Medical Misadministration Report–Medical Misadministrations Reported to NRC From January 1990 Through December 1990	[2]	H. Karagiannis

Nonreactor Reports Issued in 1990

Engineering Evaluations

Date	Title	No.	Author
06/90	Report on 1989 Nonreactor Events	[3]	K. Black
06/90	Medical Misadministration Report—Medical Misadministrations Reported to NRC From January 1989 Through December 1989	[4]	H. Karagiannis

Nonreactor Reports Issued in 1989

Engineering Evaluations

Date	Title	No.	Author
06/89	Use of Radioactive Iodine for Infrequent Medical Studies and Those Performed Under an FDA Investigational Exemption of a New Drug (IND)	N901	H. Karagiannis
06/89	Report on 1988 Nonreactor Events	[5]	K. Black
06/89	Medical Misadministration Report—Medical Misadministrations Reported to NRC From January 1988 Through December 1988	[6]	H. Karagiannis

[1] Published as Appendix A of NUREG–1272, Vol. 5, No. 2, "AEOD 1990 Annual Report."
[2] Published as Appendix B of NUREG–1272, Vol. 5, No. 2, "AEOD 1990 Annual Report."
[3] Published as Appendix A of NUREG–1272, Vol. 4, No. 2, "AEOD 1989 Annual Report."
[4] Published as Appendix B of NUREG–1272, Vol. 4, No. 2, "AEOD 1989 Annual Report."
[5] Published as Appendix A of NUREG–1272, Vol. 3, No. 2, "AEOD 1988 Annual Report."
[6] Published as Appendix B of NUREG–1272, Vol. 3, No. 2, "AEOD 1988 Annual Report."

Nonreactor Reports Issued in 1989 (cont.)

Engineering Evaluations

Date	Title	No.	Author
05/89	Review of Therapy Misadministrations That Involved Multiple Patients and the Use of Computer Programs	T908	K. Black

Nonreactor Reports Issued in 1988

Special Study Reports

Date	Title	No.	Author
09/88	Review of Events at Large Pool-Type Irradiators (NUREG–1345, March 1989)	S807	E. Trager
10/88	Report on 1987 Nonreactor Events	N801	K. Black
10/88	Medical Misadministrations Reported to NRC for the Period January Through December 1987	N802	S. Pettijohn

Nonreactor Reports Issued in 1987

Special Study Reports

Date	Title	No.	Author
10/87	Radiography Overexposure Events Involving Industrial Field Radiography	S703	S. Pettijohn

Engineering Evaluations

Date	Title	No.	Author
01/87	Diagnostic Misadministrations Involving the Administration of Millicurie Amounts of Iodine-131	N701	S. Pettijohn
03/87	Diagnostic Misadministrations Reported to NRC for the Period January 1986 Through December 1986	N702	S. Pettijohn
03/87	Report on 1986 Nonreactor Events	N703	K. Black

Nonreactor Reports Issued in 1987 (cont.)

Technical Review Reports

Date	Title	No.	Author
11/87	Review of Data on Teletherapy Misadministrations Reported to the State of New York That Were the Title of PNO-I-87-74A	T711	S. Pettijohn
12/87	Distribution of Information Notices and Other "Mass Mailing" Information to Licensees That Have Users at Locations Remote From the Headquarters Locations	T714	S. Pettijohn

Nonreactor Reports Issued in 1986

Case Studies

Date	Title	No.	Author
08/86	Rupture of an Iodine-125 Brachytherapy Source at the University of Cincinnati Medical Center	C601	S. Pettijohn

Engineering Evaluations

Date	Title	No.	Author
06/86	Report on 1985 Nonreactor Events and Five-Year Assessment for 1981-1985 Reports	N601	K. Black
06/86	Medical Misadministrations Reported for 1985 and Five-Year Assessment of 1981-1985 Reports	N602	S. Pettijohn

Nonreactor Reports Issued in 1985

Case Studies

Date	Title	No.	Author
12/85	Therapy Misadministrations Reported to NRC Pursuant to 10 CFR 35.42	C505	S. Pettijohn
05/85	Summary of the Nonreactor Event Report Data Base for the Period January-June 1984	N501	K. Black

Nonreactor Reports Issued in 1985 (cont.)

Engineering Evaluations

Date	Title	No.	Author
06/85	Summary of the Nonreactor Event Report Data Base for the Period July-December 1984	N502	K. Black
07/85	Report on Medical Misadministrations for January-December 1984	N503	S. Pettijohn

Nonreactor Reports Issued in 1984

Case Studies

Date	Title	No.	Author
09/84	Breaching of the Encapsulation of Sealed Well-Logging Sources	C405	S. Pettijohn
05/84	Report on Medical Misadministrations for January Through June 1983	N204D	S. Pettijohn
06/84	Nonreactor Event Report Database for the Period July-December 1983	N401	K. Black
06/84	Events Involving Undetected Unavailability of the Turbine-Driven Auxiliary Feedwater Train	N402	E. Trager
07/84	Report on Medical Misadministrations for July-December 1983	N403	S. Pettijohn

Nonreactor Reports Issued in 1983

Engineering Evaluations and Technical Reviews

Date	Title	No.	Author
01/83	Nonreactor Event Report Database for the Period January-June 1982	N209A	E. Trager
03/83	I-125/I-131 Effluent Releases by Material Licensees	N301	S. Pettijohn
06/83	Mound Laboratory Fabricated PuBe Sources	N302	K. Black

Nonreactor Reports Issued in 1983 (cont.)

Engineering Evaluations and Technical Reviews

Date	Title	No.	Author
06/83	Americium Contamination Resulting From Rupture of Well-Logging Sources	N303	K. Black
06/83	Nonreactor Event Report Database From July through December 1982	N209B	K. Black
07/83	Americium-241 Sources	N304	
07/83	Report on Medical Misadministrations for January 1981-December 1982	N204C	S. Pettijohn
12/83	Potentially Leaking Americium-241 Sources Manufactured by Amersham Corporation	N306	S. Pettijohn
12/83	Nonreactor Event Report Database for the Period January-June 1983	N307	K. Black
03/83	Internal Exposure to Am-241	NT301	K. Black
04/83	Kay-Ray, Inc., Reports of Suspected Leaking Sealed Sources Manufactured by General Radioisotope Products	NT302	S. Pettijohn
08/83	Possession of Unauthorized Sealed Source/Exposure Device Combinations by MidCon Inspection Services, Inc.	NT303	S. Pettijohn

Nonreactor Reports Issued in 1982

Engineering Evaluations

Date	Title	No.	Author
02/82	Report on Medical Misadministrations for the Period November 10, 1980-September 30, 1981	N201	S. Pettijohn
01/82	Buildup of Uranium-Bearing Sludge in Waste Tanks	N202	K. Black
02/82	Lost Plutonium-238 Source	N203	K. Black
03/82	Report on Medical Misadministrations for CY 1981	N204	S. Pettijohn

Nonreactor Reports Issued in 1982 (cont.)

Engineering Evaluations

Date	Title	No.	Author
04/82	Preliminary AEOD Review of Iodine-125 Sealed Source Leakage Incidents	N205	E. Trager
05/82	Eberline Instrument Corporation Part 21 Report	N206	K. Black
05/82	AEOD Review of Iodine-125 Sealed Source Leakage Incidents	N207	E. Trager
08/82	Potentially Leaking Plutonium-Beryllium Neutron Sources	N208	S. Pettijohn
08/82	A Summary of the Nonreactor Event Report Data Base for 1981	N209	K. Black
11/82	Leaking Hoses on Self-Contained Breathing Apparatus (SCBA) Manufactured by MSA	N210	K. Black

Nonreactor Reports Issued in 1981

Engineering Evaluations

Date	Title	No.	Author
03/81	Interim Report on Brown Boveri Betatron Calibration Check Source	N101	E. Trager
03/81	Irradiator Incident at an Agreement State Facility (Becton-Dickinson, Broken Bow, Nebraska)	N102	K. Black
04/81	Interim Report on the October 1980 Fire at the Licensee's Sweetwater Uranium Mill	N103	E. Trager
04/81	Interim Report on the January 2, 1981, Fire at the Atlas Uranium Mill	N104	E. Trager
05/81	Interim Report on Tailings Impoundment Liner Failure at the Sweetwater Uranium Mill	N105	E. Trager
08/81	Review of Reports of Leaking Radioactive Sources	N106	E. Trager

Nonreactor Reports Issued in 1981 (cont.)

Engineering Evaluations

Date	Title	No.	Author
12/81	Engineering Evaluation of Fire Protection at Nonreactor Facilities	N107	E. Trager
12/81	Notes on AEOD Review of Emissions From Tritium Manufacturing and Distribution Licensees	N108	E. Trager

Appendix F

Status of AEOD Recommendations (Nonreactors)

Status of AEOD Recommendations

The Office for Analysis and Evaluation of Operational Data (AEOD) tracking system ensures that all formal AEOD recommendations are tracked until resolution. At this time, no issues involving AEOD recommendations are unresolved that warrant the attention of the Executive Director for Operations.

Formal recommendations are tracked and listed in this section. Additionally, actions based on AEOD suggestions contained in engineering evaluations and special reports are routinely implemented by NRC program offices. These AEOD suggestions are not formally tracked or closed out by AEOD.

AEOD Recommendation Tracking System

Outstanding Recommendations*

Recommendation Source: Case Study AEOD/C505

Responsible AEOD Engineer: K. Black (Author: S. Pettijohn)

Title or Subject: "Therapy Misadministrations Reported to the NRC Pursuant to 10 CFR 35.42"

Recommendation 4: In addition, to the extent that the NRC implements Recommendation 3, the action should be made an item of compatibility for Agreement States.

Responsible Office/Div/Br	Contact	Priority
OSP/SAP	V. Miller	N/A

Status: The Implementation Plan and Agreement State Compatibility Section of the Quality Management Program and Misadministrations (*Federal Register*, Volume 56, pp. 34104-34122, 7/25/91), states that the requirement for a quality management program is a matter of compatibility for the Agreement States. This requirement satisfies the above recommendation.

Disposition: Resolved.

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* The number of the recommendation is the same as the number of the original case study.

Appendix G

Status of NRC Staff Actions for Events Investigated by Incident Investigation Teams (Nonreactors)

Status of NRC Staff Actions for the Events Investigated by Incident Investigation Teams

In accordance with NRC Manual Chapter 0513, "NRC Incident Investigation Program," dated May 14, 1990, upon receipt of an Incident Investigation Team (IIT) report, the Executive Director for Operations (EDO) shall identify and assign NRC office responsibility for generic and plant-specific actions resulting from the investigation that are safety significant and warrant additional attention or action. Office directors designated by the EDO as having responsibility for resolving issues or concerns are responsible for providing written status reports on the disposition of assigned actions. In addition, followup actions associated with the IIT report do not necessarily include all licensee actions, and they do not cover NRC staff activities associated with normal event followup such as authorization for restart, plant inspections, or possible enforcement actions. These activities are expected to be defined and implemented through the normal organizational structure and procedures.

This appendix provides a written disposition or status, along with appropriate references, for each of the NRC staff action items that the EDO assigned to the various NRC offices associated with the IIT report on the 1990 event at Amersham Corporation and the 1991 event at General Electric Nuclear Fuels and Component Manufacturing Facility.

For each action item, the entry for its "Disposition" indicates whether action for the item is resolved or ongoing. For ongoing actions items, the NRC office assigned the actions item is designated.

AEOD IIT Action Tracking System

Action Source: **IIT Report on Amersham Event of March 9, 1990 (Reference 1)**

Item 6:

Action: Evaluate whether NRC and DOT regulations should be amended to include requirements to report the receipt of shipments of radioactive materials that were improperly prepared, labeled, identified, or classified, or had improper contents. (Responsible Office: NMSS)

Disposition: Ongoing.

On August 13, 1990, the NRC requested that DOT provide comments on the need for a requirement for consignees to report improperly labeled or prepared packages upon receipt. A formal response from DOT is not expected until mid-1992.

The staff performed an evaluation of NRC and DOT reporting requirements (Reference 2) and concluded that requiring licensees to report all mislabeled or misidentified packages would require both the licensees and NRC staffs to expend significant resources in reporting and responding to problems that are of little or no safety concern. However, the staff also concluded that the NRC should be informed and should respond to any situation similar to the Amersham incident. The NRC staff determined that because the new 10 CFR Part 20 requirements will only apply to labeled or damaged packages, the previous situation in which Amersham received a cropped source in a package thought to be empty may not be covered. The NMSS staff will recommend to the Office of Nuclear Regulatory Research that Section 20.906 of 10 CFR Part 20 be amended to require licensees to notify the NRC if the licensee determines that it has received an unlabeled package containing radioactive materials that should have been labeled in accordance with DOT requirements.

Item 9a:

Action: Meet with DOT and determine the purpose and expectation of actions on the part of forwarding agents at the place of United States entry for shipments of radioactive materials, whether such agents are informed of the pertinent DOT requirements, and whether such requirements are realistic and important to the handling of radioactive material shipments and should be enforced. (Responsible Office: NMSS)

Disposition: Ongoing, pending completion of the DOT investigation.

On August 13, 1990, the NRC requested that DOT provide comments on this issue. DOT is still reviewing the Amersham incident, and the investigation is not expected to be completed until mid-1992. NRC licensees were informed of the need to comply with DOT import/export requirements in NRC Information Notice 90-56 (Reference 3). If appropriate, NRC will notify licensees of the DOT investigation findings in a supplemental information notice.

AEOD IIT Action Tracking System

Item 9b:

Action: Pending the results of action Item 9a, initiate action to ensure that Amersham has taken appropriate corrective measures to ensure the completeness and accuracy of information provided to forwarding agents. (Responsible Office: RI)

Disposition: Ongoing, pending completion of the DOT investigation.

Upon completion of the DOT investigation, NMSS and RI will follow up to ensure compliance by Amersham.

References:

1. NUREG-1405, "Inadvertent Shipment of a Radiographic Source from Korea to Amersham Corporation, Burlington, Massachusetts," dated May 1990.

2. Memorandum from J. Glenn to J. Hickey (NRC), "Evaluation of NRC and DOT Reporting Requirements; NMSS Followup to Inadvertent Shipment of a Radiographic Source from Korea to Amersham Corporation (NUREG-1405)," dated October 31, 1990.

3. NRC Information Notice 90-50, "Inadvertent Shipment of a Radioactive Source in a Container Thought To Be Empty," dated September 4, 1990.

AEOD IIT Action Tracking System

Action Source:	**IIT Report on General Electric Nuclear Fuels and Component Manufacturing Facility (GE-Wilmington) Potential Criticality Event of May 29, 1991. (References 1, 2, 3)**
Item 1:	Adequacy of Criticality Safety Reviews.
Action:	(a) Evaluate existing regulatory requirements, guidance, and review standards for criticality safety analyses for fuels facility licensees to make process, procedural and facility changes, and develop new regulatory guidance, requirements and review standards. (Responsible Office: NMSS)
Disposition:	Ongoing The staff will evaluate existing regulatory requirements, guidance, and review standards for criticality safety analyses at fuel facilities regarding the licensees' process, procedural, and facility changes. This evaluation will include the review of 10 CFR Part 70; Regulatory Guide 3.52, "Standard Format and Content for the Health and Safety Sections of License Renewal Applications for Uranium Processing and Fuel Fabrication;" the NMSS Standard Review Plan for Fuel Facilities; ANSI standards; and other regulatory requirements, guidance, and review standards. If these existing documents do not provide adequate guidance, requirements, and review standards, more comprehensive guidance, requirements, and review standards will be developed. Expected completion date is September 30, 1993.
Action:	(b) Evaluate the use of safety operating specifications for radiation and nuclear safety instruments and controls. (Responsible Office: NMSS)
Disposition:	Ongoing The staff will evaluate the use of safety operating specifications for radiation and nuclear safety instruments and controls. The evaluation will include a review of Regulatory Guide 3.52, "Standard Format and Content for the Health and Safety Sections of License Renewal Applications for Uranium Processing and Fuel Fabrication;" the NMSS Standard Review Plan for Fuel Facilities; and the existing Branch Technical Position on Requirements for Operation for Fuel Cycle Facilities, which applies to all fuel cycle facility activities where nuclear criticality safety, radiation safety, process safety, and confinement of both hazardous and radioactive materials must be ensured. Regulatory Guide 3.52 and the Standard Review Plan will be revised following the evaluation. Expected completion date is September 30, 1993.
Action:	(c) Evaluate the need to change the licensing practice of incorporating a license condition by reference in fuel facility licenses. Ensure that the resultant licensing practice is mutually understood by all involved in the process. (Responsible Office: NMSS)
Disposition:	Ongoing

The staff will evaluate the need to change the licensing practice of incorporating a license condition by reference in fuel facility licenses. After the evaluation is completed, the staff will ensure that the resultant licensing practice is mutually understood by all involved in the process by issuing a NUREG-series report or conducting a fuel cycle workshop. Expected completion date is September 30, 1993.

Action: (d) Evaluate the existing NRC programs for the inspection of changes to criticality safety controls at fuel fabrication facilities and develop new guidance. (Responsible Office: NMSS)

Disposition: Ongoing

The staff will evaluate the existing NRC programs for the inspection of changes to criticality safety controls at fuel fabrication facilities. This evaluation will include a review of Regulatory Guide 3.52, "Standard Format and Content for the Health and Safety Sections of License Renewal Applications for Uranium Processing and Fuel Fabrication," and Inspection Manual Chapter 2600, "Fuel Cycle Facility Operational Safety Inspection Program," including Inspection Procedures 88015, "Criticality Safety," and 88025, "Operations Review." These documents will be revised as appropriate after the evaluation is completed. NRC expects that inspector training will be provided under Action 1.e below.

Expected completion date is September 30, 1994.

Action: (e) Evaluate the adequacy of the NRC training and qualification programs to effectively support criticality safety inspections at fuel facilities and develop enhancements to the training program. (Responsible Office: NMSS)

Disposition: Ongoing

The staff is presently obtaining contractor assistance to support the criticality safety program. Part of this support will be to evaluate the status of training and qualifications for criticality safety inspectors. An objective is to develop enhancements to the program, including training where indicated.

A review of Inspection Manual Chapter 1245 and related documents will be included in the evaluation. Pending upon completion of the evaluation, the NRC staff will revise training and develop new training to support enhancements to the existing program.

Expected completion date is September 30, 1993.

Action: (f) Evaluate GE's response to the IIT report with respect to the site-specific corrective actions. Include in this evaluation, the adequacy of (a) the current license, (b) the Facility Change Request process and its implementation, and (c) the criticality safety margins. (Responsible Office: NMSS)

Disposition: Ongoing

The staff will evaluate GE's response to the IIT report with respect to the site-specific corrective actions. This evaluation will include the adequacy of the current license, the facility change request process and its implementation, and criticality safety margins. NRC will conduct inspections to verify that corrective actions have been made.

Expected completion date is September 30, 1993.

Item 2: Adequacy of Facility Operational Safety.

Action: (a) Upgrade existing inspection guidance related to management controls and oversight, including audits, personnel training and, procedural adequacy and compliance for major materials licensees. (Responsible Office: NMSS)

Disposition: Ongoing

The staff will evaluate the existing inspection guidance related to management controls and oversight, including audits, personnel training, and procedural adequacy and compliance for major materials licensees. This evaluation will include guidance presently in Inspection Manual Chapters 2600 and 2800. If the evaluation determines that new guidance is appropriate, NRC will issue new guidance.

Expected completion date is September 30, 1994.

Action: (b) Determine the need for regulatory requirements, guidance, and standard review plans regarding management controls and oversight to include audits, personnel training, and procedural adequacy and compliance for major materials licensees. Conduct reviews or inspections at selected licensees to collect additional information on management controls and practices. The staff will, if necessary, on the basis of these assessments, develop new guidance, requirements, and standards as appropriate. (Responsible Office: NMSS)

Disposition: Ongoing

The staff will evaluate the need for regulatory requirements, guidance, and standard review plans for management controls and oversight, including audits, personnel training, and procedural adequacy and compliance for major materials licensees. This evaluation will include the review of 10 CFR Parts 30, 40, and 70, applicable regulatory guides and standard review plans, and other applicable regulatory requirements. The NRC staff will revise existing requirements, guidance, and review plans as appropriate.

Expected completion date is September 30, 1993.

Action: (c) Examine the overall inspection process for monitoring and collecting fuel facility safety performance information. Include in the evaluation the merits of (a) a resident inspector program, (b) more frequent inspections, including use of team inspections, and (c) establishment of a systematic performance appraisal and feedback program analogous to the SALP program for 10 CFR Part 50 licensees. (Responsible Office: NMSS)

Disposition: Ongoing

The staff will examine the overall inspection process for monitoring and collecting fuel facility safety performance information, including the merits of (a) a resident inspector program, (b) more frequent inspections, including the use of team inspections, and (c) establishment of a systematic performance appraisal and feedback program analogous to the SALP program for Part 50 licensees.

Expected completion date is September 30, 1994.

Action: (d) Evaluate the adequacy of the NRC training and qualification programs to effectively support fuel cycle facility inspections and to develop enhancements to the training program. (Responsible Office: NMSS)

Disposition: Ongoing

The NRC is evaluating the NRC training and qualification program with the support of contractors. The staff will subsequently revise the existing training program, if necessary. A review of Inspection Manual Chapter 1245 and related documents will be included in the evaluation. After completing its evaluation, the staff will revise existing training and will develop new training to support enhancements to the existing program. See also actions planned for 1.E above.

Estimated completion is September 30, 1992.

Action: (e) Evaluate GE's response to the IIT report with respect to the site-specific corrective actions for management practices and controls. Include in this evaluation the adequacy of actions taken to address deficiencies identified in the areas of management presence, safety attitude, quality assurance oversight, supervisory and operator training, and procedural adequacy and compliance for operations during normal and potential criticality conditions. (Responsible Office: RII)

Disposition: Resolved

Region II advised GE by letter dated August 13, 1991 (Reference 5), that the region had lead for followup of site-specific actions. The region reviewed and authorized restart activities for the Uranium Recycle Unit (less solvent extraction). A summary of the regional restart inspection activities is presented in Inspection Report No. 70-1113/91-03 (Reference 6). Many of the corrective actions already taken by GE pertained to management practices and controls in general. GE presented their specific plans for startup of the solvent extraction process in September 1991 (Reference 7). Inspection of licensed activities were scheduled at least every other week through October 1991. The focus of the inspections were management controls, procedural compliance, and training programs. The region was to monitor licensee intermediate and long-term corrective actions, which were incorporated into a performance improvement program. NRC and GE managers were to meet (generally on a quarterly basis) to review performance improvement program status and accomplishments.

GE responded specifically to the IIT report in writing by letters dated August 26, 1991, (Reference 8) and August 27, 1991, (Reference 9). These letters discussed general issues. In addition, GE conducted their own investigation of the event, developed conclusions, and initiated corrective actions. NMSS's and RII's review of their investigation shows no significant differences on facts or technical issues between GE's investigation and the IIT's (References 10 and 11).

The specific GE actions to improve the safety of operations have been communicated in a series of meetings and correspondence that outline actions to be completed. GE identified the corrective actions and divided them into short-term items to be completed before restart of the solvent extraction system and longer term actions to be completed on an established schedule. At a management meeting on September 25, 1991, GE outlined the actions to be completed before restart of the solvent extraction process (Reference 7).

The actions outlined included improvements in management presence, safety attitude, quality assurance oversight, supervisory and management training, and procedural adequacy and compliance. An onsite inspection team reviewed the licensee's corrective actions as they were implemented. On the basis of these actions, Region II authorized restart of the solvent extraction process on October 18, 1991 (Reference 12).

The licensee is continuing program improvements through implementation of a Performance Improvement Program (PIP). The PIP includes, among other items, a criticality re-review of specified systems, improvements to the audit program, assessments of organization and staffing, and improvements in the configuration management system. The licensee is also conducting a review of NUREG-1450, "Potential Criticality Accident at the General Electric Nuclear Fuel and Component Manufacturing Facility," and identifying those findings that should be incorporated into the PIP. The additional items have not yet been submitted to the NRC but will be by late January 1992. GE will also incorporate items identified by an internal investigation group that was independent of the Wilmington facility. The staff will continue to monitor GE's progress through frequent inspections and quarterly management meetings.

Item 3: Adequacy of Emergency Preparedness.

Action: (a) Ensure the proposed final Regulatory Guide DG-3005, "Standard Format and Content for Emergency Plans for Fuel Cycle and Material Facilities," addresses potential criticality events. (Responsible Office: RES)

Disposition: Resolved

The staff addressed potential criticality events in final Regulatory Guide DG-3005, Appendix A, "Examples of Initiating Events." This final guide was issued December 1991 as Regulatory Guide 3.67, "Standard Format and Content for Emergency Plans for Fuel Cycle and Materials Facilities" (Reference 13).

Action: (b) Reevaluate the adequacy of the GE fuels facility Radiological Contingency and Emergency Plan (RCEP) and implementing procedures for emergency planning and event classification and notifications. Ensure the RCEP and implementing procedures are revised as necessary. (Responsible Office: NMSS)

Disposition: Ongoing

The NRC staff reviewed GE's revised RCEP against Regulatory Guide 3.67, issued in December 1991. On January 7, 1992, the NRC staff requested additional information from GE (Reference 14).

Expected completion date September 30, 1992.

Item 4: Adequacy of Operating Experience Reviews

Action: (a) Reevaluate regulatory requirements and guidance for event reporting for fuels facilities as it relates to potential criticalities and failed contingencies (barriers). Develop additional guidance and requirements as appropriate. (Responsible Office: NMSS)

Disposition: Ongoing

The staff is continuing to reevaluate the regulatory requirements and guidance for event reporting for fuel facilities as it relates to potential criticalities and failed contingencies (barriers).

The staff issued NRC Bulletin 91-01, "Reporting Loss of Criticality Safety Controls" on October 18, 1991. On November 19, 1991, the staff conducted a 1-day workshop for all fuel cycle and uranium fuel research and development licensees. The workshop was to assist licensees in their understanding of the bulletin. All licensees were required to submit their responses to the bulletin by January 16, 1992. The staff is presently reviewing licensee responses (Reference 15).

The staff will reevaluate regulatory requirements and guidance for event reporting for fuel facilities. The reevaluation will include a critical review of existing licensee reports to determine what information is required to determine the need for additional guidance and reporting requirements. After completing the reevaluation, the staff will develop additional guidance as appropriate.

Expected completion date is September 30, 1992.

Action: (b) Reevaluate NRC operating experience review and feedback program for fuels facilities. Revise the program as appropriate. (Responsible Office: NMSS)

Disposition: Ongoing

The staff will reevaluate the NRC operating experience review and feedback program for fuel facilities. After completing the evaluation, the staff will revise the program as appropriate.

Expected completion date September 30, 1994.

Action: (c) Develop NRC inspection guidance for licensee event reporting and reviews for fuels facilities. Issue new guidance as appropriate. (Responsible Office: NMSS)

Disposition: Ongoing

The staff will evaluate the need to develop NRC inspection guidance for licensee event reporting and reviews for fuel facilities and will issue new guidance. This evaluation will primarily include the guidance presently in: Inspection Manual Chapter 2600, "Fuel Cycle Facility Operational Safety Inspection Program."

Expected completion date September 30, 1994.

Action: (d) Extend the independent NRC operating experience program to nuclear fuel fabrication facilities. Examine the existing operating experience review program for other licensee groups not in the scope of AEOD activities. Revise the program as appropriate. (Responsible Office: AEOD)

Disposition: Ongoing

AEOD currently reviews reports from fuel fabrication facilities as well as inspection reports to obtain information on operating events. The AEOD Annual Report of Nonreactor Events (NUREG-1271, Volume 2) includes a brief discussion of the events. The NRC is revising the reporting threshold. New reporting requirements (Part 70 revision and the bulletin on criticality reports) will provide additional information to identify precursors.

The staff (contractor)will visit fuel fabrication plants and audit licensee internal event reviews for adequacy. The audit will also include the adequacy of reporting requirements to provide NRC with the information necessary to assess important safety significant events.

AEOD reviews event reports and inspection reports for all licensee groups licensed by NRC. Efforts are currently underway to obtain reports of events from Agreement States on a timely basis so that they can be added to the operating experience base. This program was in place in late 1991.

AEOD will review Agreement State data, in conjunction with Non-Agreement State data, to determine whether the AEOD review program needs revision to include classes of licensees that exist only in Agreement States.

The full implementation of this item requires completion of Action 1.A. and implementation of reporting of incidents pursuant to 10 CFR Part 70 and agreements with State Programs.

Expected completion date is September 30, 1994.

Action: (e) Evaluate GE's response to the IIT report with respect to the licensee's program for determining the causes of incidents and corrective actions and determine the program's adequacy. (Responsible Office: RII)

Disposition: Resolved

The startup inspection team revised in detail the procedures and instructions GE used for incident investigation before the May 29 incident. The site-level procedure used to classify and investigate incidents at the facility was being revised at the time of the review to include instructions on problem-cause analysis. Two lower-level instructions contained guidance for investigating and documenting incidents and guidance on analysis techniques that could be used for incident investigation.

The team reviewed the training provided to individuals who were designated as leaders of investigation teams and found that each had received training in at least one type of problem solving/root-cause analysis technique. In addition, the team reviewed investigation reports that the licensee had prepared before and following the May 29 incident.

On the basis of this review, the team concluded that although some weakness still existed in the licensee's program for root-cause analysis, GE had sufficiently improved the program to permit restart of the solvent extraction system. The licensee also identified that additional longer term improvements in the area of root-cause analysis were necessary.

At the time of the review, the licensee was considering using a contractor to train selected personnel in courses such as Management Oversight and Risk Tree (MORT) Analysis, Hazard and Operability Analysis (HAZOP), Failure Modes and Effects Analysis (FMEA), or some other such course.

The staff obtained a commitment from the licensee to continue with the implementation of additional enhancements in their ability to determine the root cause of incidents. These additional longer term improvements were to be incorporated into the January update of the GE Performance Improvement Program. These improvements will be tracked to completion by the staff (Reference 12).

References:

1. NUREG-1450, "Potential Criticality Accident at the General Electric Nuclear Fuel and Component Manufacturing Facility, May 29, 1991," August 1991.

2. Memorandum from J. Taylor to NRC Staff, "Staff Actions Resulting From the Investigation of the Potential Criticality Accident at the General Electric Nuclear Fuel and Component Manufacturing Facility, May 29, 1991 (NUREG-1450)," August 13, 1991.

3. Memorandum from E. Jordan to J. Taylor, "Staff Actions in Response to the Investigation of the Potential Criticality Accident at the General Electric Nuclear Fuel and Component Manufacturing Facility Findings (NUREG-1450)," September 6, 1991.

4. Memorandum from R. Bernero to J. Taylor, "Staff Action Plan Responding to the Investigation of the May 29, 1991, Incident at the General Electric (GE) Nuclear Fuel and Component Manufacturing Facility (NUREG-1450)," September 9, 1991.

5. Letter from S. D. Ebneter to W. Ogden, "NRC Incident Investigation Team Report Followup (NUREG-1450)," August 13, 1991.

6. NRC Inspection Report No. 70-1113/91-03, August 12, 1991.

7. Letter from J. Stohr to W. Ogden, "Management Meeting Summary," October 2, 1991.

8. Letter from B. Wolfe to J. Taylor, August 26, 1991.

9. Letter from W. Ogden to J. Taylor, August 27, 1991.

10. NRC Inspection Report No. 70-1113/91-04, December 23, 1991.

11. NRC Inspection Report No. 70-1113/91-09, January 15, 1992.

12. NRC Inspection Report No. 70-1113/91-06, January 22, 1992.

13. Regulatory Guide 3.67, "Standard Format and Content for Emergency Plans for Fuel Cycle and Materials Facilities," January 1992.

14. Letter from G. Bidinger to T.P. Winslow, January 7, 1992.

15. NRC Bulletin No. 91-01, "Reporting Loss of Criticality Safety Controls," October 18, 1991.

NRC FORM 335 (2-89) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.)
NUREG-1272
Vol. 6, No. 2

2. TITLE AND SUBTITLE
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1991 Annual Report – Nonreactors

3. DATE REPORT PUBLISHED
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4. FIN OR GRANT NUMBER

5. AUTHOR(S)

6. TYPE OF REPORT
Annual summary of regulatory activities for nonreactors

7. PERIOD COVERED (Inclusive Dates)
CY 1991

8. PERFORMING ORGANIZATION – NAME AND ADDRESS (If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)
Office for Analysis and Evaluation of Operational Data
U.S. Nuclear Regulatory Commission
Washington, DC 20555

9. SPONSORING ORGANIZATION – NAME AND ADDRESS (If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)
Same as in item 8

10. SUPPLEMENTARY NOTES

11. ABSTRACT (200 words or less)

The annual report of the U.S. Nuclear Regulatory Commission's Office for Analysis and Evaluation of Operational Data (AEOD) is devoted to the activities performed during 1991. The report is published in two separate parts. NUREG-1272, Vol. 6, No. 1, covers power reactors and presents an overview of the operating experience of the nuclear power industry from the NRC perspective, including comments about the trends of some key performance measures. The report also includes the principal findings and issues identified in AEOD studies over the past year and summarizes information from such sources as licensee event reports, diagnostic evaluations, and reports to the NRC's Operations Center. The reports contain a discussion of the Incident Investigation Team program and summarize the Incident Investigation Team and Augmented Inspection Team reports for that group of licensees. NUREG-1272, Vol. 6, No. 2, covers nonreactors and presents a review of the events and concerns during 1991 associated with the use of licensed material in nonreactor applications, such as personnel overexposures and medical misadministrations. Each volume contains a list of the AEOD reports issued for 1981–1991.

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)

nuclear plants
operating experience
abnormal occurrences
significant events
reactor trips
performance indicators
engineered safety features
new plant experience
IIT staff action status
AEOD recommendations
AEOD report listing

13. AVAILABILITY STATEMENT
Unlimited

14. SECURITY CLASSIFICATION
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