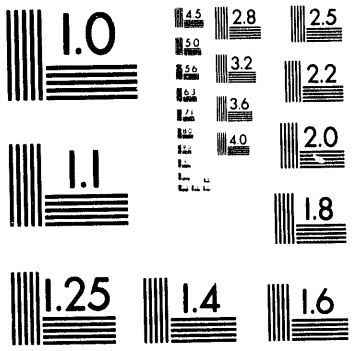
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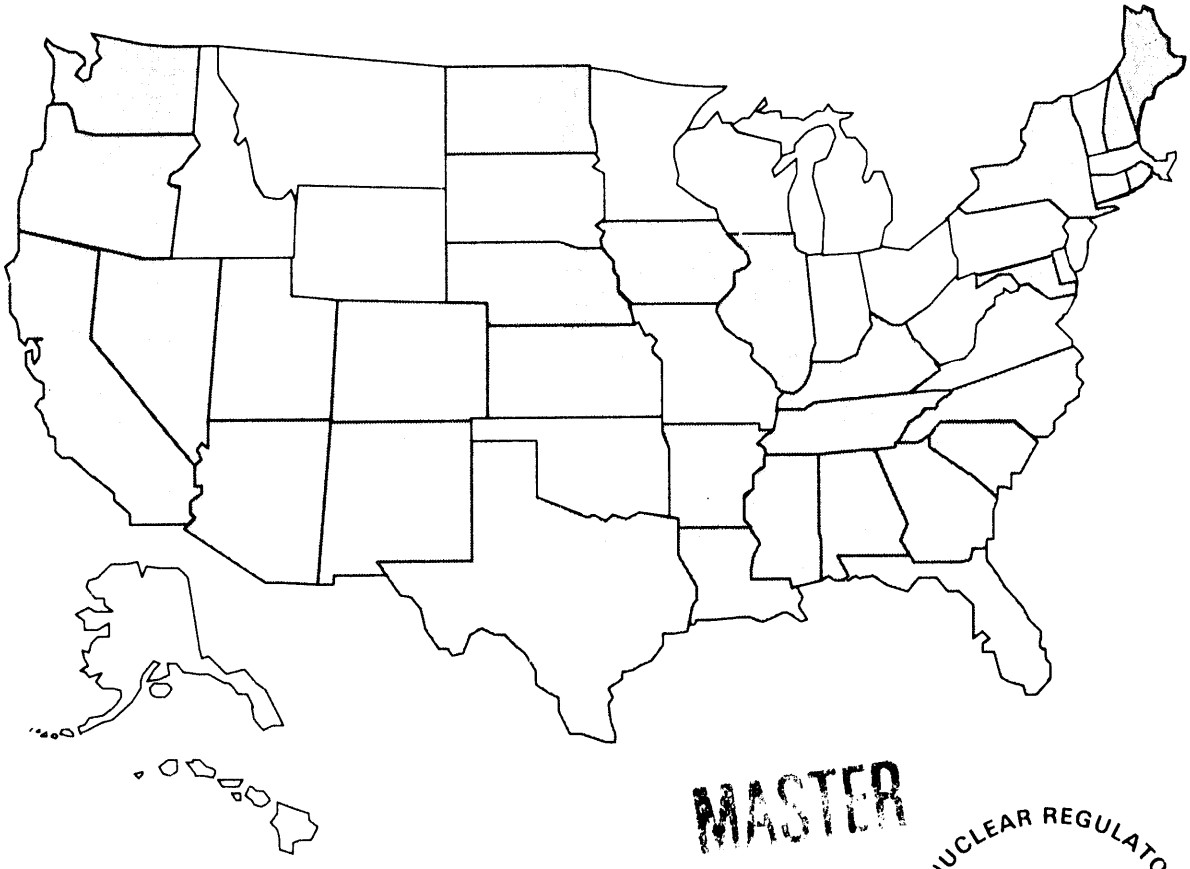
VOL. 7, NO. 2

ANALYSIS AND EVALUATION OF OPERATIONAL DATA



1992 ANNUAL REPORT

NONREACTORS

U.S. NUCLEAR REGULATORY COMMISSION

OCTOBER 1993

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 S/405, 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 of 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*, NUREG-1272, Vol. 4, No. 1, July 1990
- *Office for Analysis and Evaluation of Operational Data 1989 Annual Report*, NUREG-1272, Vol 4, No. 2, July 1990
- *Office for Analysis and Evaluation of Operational Data 1990 Annual Report*, NUREG-1272, Vol. 5, No. 1, July 1991
- *Office for Analysis and Evaluation of Operational Data 1990 Annual Report*, NUREG-1272, Vol. 5, No. 2, July 1991
- *Office for Analysis and Evaluation of Operational Data 1991 Annual Report*, NUREG-1272, Vol. 6, No. 1, July 1992
- *Office for Analysis and Evaluation of Operational Data 1991 Annual Report*, NUREG-1272, Vol. 6, No. 2, August 1992

Abstract

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 1992. The report is published in two separate parts. NUREG-1272, Vol. 7, 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. 7, No. 2, covers nonreactors and presents a review of the events and concerns during 1992 associated with the use of licensed material in nonreactor applications, such as personnel overexposures and medical misadministrations. Both reports also contain a discussion of the Incident Investigation Team program and summarize both the Incident Investigation Team and Augmented Inspection Team reports. Each volume contains a list of the AEOD reports issued for 1981–1992.

Contents

Appendices

Tables

Abbreviations

AEOD	Analysis and Evaluation of Operational Data (NRC Office for)
AIT	Augmented Inspection Team
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
AO	abnormal occurrence
BFI	Browning-Ferris Industries
CAL	confirmatory action letter
CFR	Code of Federal Regulations
CUR	cleanup reactor
DOT	U.S. Department of Transportation
DVRF	decontamination and volume reduction facility
EDO	Executive Director for Operations
FDA	Food and Drug Administration
GE	General Electric Co.
GPCC	Greater Pittsburgh Cancer Center
HDR	high dose rate
HOO	headquarters operations officer
ID	inventory difference
IDR	integrated dry route
IIP	Incident Investigation Program
IIT	Incident Investigation Team
IN	information notice
IRCC	Indiana Regional Cancer Center
MBA	mass balance area
MDCT	mechancial draft cooling tower
NCRP	National Council on Radiation Protection
NMSS	Nuclear Material Safety and Safeguards (NRC Office of)
NRC	U.S. Nuclear Regulatory Commission
NRER	nonreactor event report
OSC	Oncology Services Corporation
PDP	post-doctoral physicist
QA	quality assurance
QC	quality control
QM	quality maangement
QMP	quality management program
RCEP	Radiological Contingency and Emergency Plan
RE	radiological engineer
REIRS	Radiation Exposure Information Report System
RES	Nuclear Regulatory Research (NRC Office of)
RI	Region I
RSO	radiation safety officer
RTT	radiation therapy technologist
SALP	systematic assessment of licensee performance
SI	Systeme International
SNM	special nuclear material
SSD	source-to-skin distance
URU	uranium recycle unit

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 programs involving the use of materials licensed by the U.S. Nuclear Regulatory Commission (NRC), such as reactor-produced isotopes, natural and enriched uranium, and other special nuclear material (SNM). The AEOD review and evaluation identifies safety-significant events and concerns and their causes. When a safety concern is identified, the AEOD staff recommends NRC actions to resolve the problems underlying the safety concern, and tracks these recommendations until they are resolved.

Twenty-nine States have entered into agreements with NRC to assume regulatory authority for byproduct materials, source materials, and small amounts of enriched uranium or other SNMs. These States, known as the Agreement States, regulate the programs of their licensees. The NRC directly regulates the licensees in the remaining 21 States, the District of Columbia, and all the United States (U.S.) territories.

Approximately 7000 licensees are regulated by the NRC and authorized to possess and use licensed materials outside of reactors. About 5000 of these licensees are authorized to use byproduct materials for such applications as radiography, gauges, and well-logging. Approximately 2000 licensees are authorized to administer byproduct materials or radiation from byproduct materials to individuals for medical diagnosis and therapy. Approximately 15,000 users are licensed by the 29 Agreement States. Of these, about 10,000 are authorized to use byproduct materials for radiography, and other industrial and commercial uses. The remaining 5000 Agreement State licensees are authorized to use radioactive materials for medical diagnosis or therapy. In response to a 1991 NRC request for annual submittal of information, all 29 Agreement States submitted summary reports on nuclear material-related events that occurred in 1992.

NRC nuclear material licensees, excluding medical misadministrations, reported 623 events for 1992. In 8 events, 56 individuals received exposures that were greater than those permitted by NRC regulations. One event, a therapeutic misadministration at Indiana Regional Cancer Center (IRCC), Indiana, Pennsylvania, resulted in 94 individuals receiving radiation exposure, of whom 49 individuals received overexposures, and the patient under treatment died. This event was thoroughly investigated by an NRC Incident Investigation Team (IIT) and the findings of the investigation were documented in NUREG-1480, "Loss of an Iridium-192 Source and Therapy Misadministration at Indiana Regional Cancer Center (IRCC), Indiana, Pennsylvania, on November 16, 1992." The 49 overexposures from the IRCC event and an additional overexposure from another event, happened to individuals not employed as radiation workers.

The 29 Agreement States reported 641 events for 1992, excluding medical misadministrations. Of these events, 31 resulted in radiation exposures to 32 individuals in excess of regulatory limits. More than 60 percent of these overexposure events were the result of industrial radiography operations. Most of the remaining overexposures involved medical or academic activities. One individual, not employed as a radiation worker, received an overexposure in a radiography event.

NRC licensed radiographers have been required to use audible alarm ratemeters since January 1991. The number of overexposures for these licensees dropped from nine individuals in 1991 to one in 1992. The use of audible alarm ratemeters may have been a factor in the reduction of this type of overexposure. Agreement States have until January 1994 to promulgate a compatible requirement.

The 1991 amendment to Part 35 of Title 10 of the Code of Federal Regulations (10 CFR 35), which became effective on January 27, 1992, included the Quality Management Program and a revised definition of misadministration. This amendment included a new classification of misadministration, which was defined to include two types of sodium iodide misadministrations, therapeutic and diagnostic. The rule also raised the threshold for diagnostic misadministrations from merely administering a radiopharmaceutical to the wrong patient to administering a radiopharmaceutical that would result in an unscheduled exposure of 500 mSv (50 rem) or more to an organ. This change effectively

eliminated the reporting of diagnostic misadministrations that had no safety significance, and therefore resulted in significantly fewer misadministration events reported for 1992.

For 1992, NRC received 36 medical misadministration reports (excluding diagnostic misadministrations) from its licensees which involved 52 patients. Of these reported events, 7 involved sodium iodide misadministrations to 7 patients, and 29 involved therapeutic misadministrations to 45 patients. The number of misadministrations reported by the NRC licensees during 1992 was less than one-twelfth of the misadministrations reported in 1991, primarily because of the change in reporting requirements.

For 1992, all 29 Agreement States submitted annual summary reports. Of these, 17 Agreement States reported misadministrations, excluding diagnostic misadministrations. Of these events, 7 involved sodium iodide misadministrations to 7 patients, and 10 involved therapeutic misadministrations to 10 patients. The 29 Agreement States reported significantly fewer misadministrations for 1992 than were reported by 19 Agreement States in 1991 (3 of the 19 Agreement States submitted data after the 1991 AEOD Annual Report was published). Although the population of the Agreement States is almost twice that of the NRC regulated area, only 1 of the 16 medical abnormal occurrences was from Agreement State licensees.

As part of operating experience feedback, AEOD prepared two videotapes: "Good Practices in Preparing and Administering Radiopharmaceuticals" and "Good Practices in Co-60 Teletherapy." These tapes were distributed in February 1992 and April 1993, respectively. The AEOD staff sent copies to each NRC licensee and to the Agreement States for distribution to their licensees. A third videotape is being produced on good work practices for radiography, and is scheduled to be completed in 1993 with the support of Argonne National Laboratory. This tape, which will be entitled "Taking Control: Safety Procedures for Industrial Radiography," will demonstrate lessons learned through reenactment of radiography overexposure incidents reported to the NRC.

1 Introduction

The U.S. Nuclear Regulatory Commission (NRC) licenses the use of reactor-produced isotopes, the milling of uranium, the subsequent processing of either natural or enriched uranium, and other special nuclear material (SNM). NRC directly regulates licensees from 21 States plus all licensees in the District of Columbia and U.S.territories. The remaining 29 states, known as the Agreement States, under Section 274 of the Atomic Energy Act, as amended, have entered into agreements with NRC to regulate the use of byproduct materials, source materials, and other SNM.

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. AEOD implements this role for materials applications through the analysis and evaluation of operational experience data associated with the use of radiological materials in nonreactor applications. AEOD publishes studies of specific operational events and, as appropriate, recommends action 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 NRC's incident response, diagnostic evaluation, technical training, and Incident Investigation Program. Incidents of potentially major safety significance are investigated by Incident Investigation Teams (IITs) directed by headquarters offices. Incidents of lesser significance are investigated by Augmented Inspection Teams (AITs) 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 NRC and normally does not duplicate a study unless a particular need or special circumstances exist. Thus, AEOD does not review in depth all materials 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 1992 AEOD Annual Report is published in two separate parts: "Power Reactors" and "Nonreactors." This report on nonreactors, NUREG-1272, Vol. 7, No. 2, is an overview of events reported by the material licensees during 1992, together with a report on the activities of an IIT in the materials area.

The report includes the following appendices:

- Appendix A contains the 1992 material data by event type, excluding misadministration events.
- Appendix B contains the 1992 NRC and Agreement States licensee misadministration events.
- Appendix C contains lists and summaries of the 1992 material abnormal occurrences sent to Congress.
- Appendix D lists AEOD's reports and videotapes issued from 1981 to 1992.
- Appendix E presents the status of recommendations included in AEOD studies.
- Appendix F presents the status of NRC staff actions resulting from the findings of NRC incident investigation teams of materials events.

2 Material Events

During 1992, NRC received reports on a number of material events from the NRC licensees and the Agreement States. This section provides an overview and summary of material events reported to NRC, except for events involving medical misadministrations, which are discussed in Section 3, "Medical Misadministrations." The data discussed in this report refer to events that occurred in 1992, except where indicated.

Table 2.1 lists the States, the District of Columbia, and U.S. territories by the number of material licensees and regulatory program.

Table 2.1 Number of NRC and Agreement State Material Licensees, by State*

State	Number of Licensees Regulated by NRC	Number of Licensees Regulated by Agreement States	State	Number of Licensees Regulated by NRC	Number of Licensees Regulated by Agreement States
Alabama	24	467	Montana	101	0
Alaska	70	0	Nebraska	5	177
Arizona	20	295	Nevada	5	142
Arkansas	11	266	New Hampshire	6	90
California	84	2271	New Jersey	641	0
Colorado	41	436	New Mexico	28	253
Connecticut	257	0	New York	62	1872
Delaware	70	0	North Carolina	22	556
Dist. of Columbia	71	0	North Dakota	6	87
Florida	30	1052	Ohio	715	0
Georgia	22	518	Oklahoma	284	0
Hawaii	65	0	Oregon	16	287
Idaho	114	0	Pennsylvania	936	0
Illinois	83	900	Rhode Island	3	63
Indiana	337	0	South Carolina	9	313
Iowa	8	219	South Dakota	48	0
Kansas	25	341	Tennessee	38	537
Kentucky	20	359	Texas	72	1753
Louisiana	15	550	Utah	16	230
Maine	108	0	Vermont	43	0
Maryland	66	516	Virginia	433	0
Massachusetts	500	0	Washington	27	370
Michigan	616	0	West Virginia	209	0
Minnesota	212	0	Wisconsin	294	0
Mississippi	11	320	Wyoming	96	0
Missouri	370	0	Others**	178	0
			Total	7543	15,240

*Source: NUREG-1350, Vol. 4, "NRC Information Digest."
**Others include U.S. territories.

2.1 Material Events Databases

AEOD collects, reviews, and codes material event information reported by the NRC licensees and the Agreement States. These data are maintained in two databases: a database containing records of medical misadministration events (MISAD database) from approximately 2000 NRC licensees and 5000 Agreement State licensees, and a database containing records of other reported material events (NRER database) from approximately 5000 NRC licensees and 10,000 Agreement State licensees. The NRC licensee events included in the NRER database are coded from reports submitted directly to NRC (regional or headquarters offices) or indirectly obtained from other sources, such as NRC inspection reports. The events that occur in Agreement States are coded from annual summary reports voluntarily submitted to NRC by the Agreement States. NRC requested that the Agreement States submit annual data beginning in 1991.

The systematic review of operational experience is essential to the regulators and licensees to assess activities involving byproduct material to improve performance and to protect the health and safety of the public. The purpose of timely collection and review of events is to identify those concerns that may influence public safety. This information can be used by NRC or the Agreement States to determine the effectiveness of their programs, identify potential precursors to materials events, and identify abnormal occurrences.

For 1992, data are available for the NRC licensees, and all Agreement States have voluntarily submitted summary reports. Because licensees and Agreement States submit revisions, late reports, or retractions, data are updated as appropriate. These updates may cause minor changes in the data published each year.

The NRER database contains approximately 4000 NRC licensee records from 1981 through 1992, and about 1000 Agreement State records from 1991 and 1992. The event reports submitted by the NRC licensees and the Agreement States are catalogued into the following event types: personnel radiation exposures; lost, stolen, or abandoned material; leaking sources; industrial radiography; medical events other than medical misadministrations; manufacturing and distribution (including medical) incidents; well-logging; commercial and industrial measuring systems (excluding well-logging) events; events with consumer products; and events with fuel cycle facilities..

Transportation of radioactive material events that are reportable under 10 CFR Part 71, "Packaging and Transportation of Radioactive Material," are also included in the NRER database. However, other transportation events involving radioactive materials that have no radiological consequences are not maintained in the NRER database but can be found in the U.S. Department of Energy's transportation incident file, which is maintained by the Sandia National Laboratory. The NRER database does not include certain information from fuel cycle licensee reports, such as routine effluent release data.

Many of the NRER database records are associated with more than one category of events. For example, a report from a radiography licensee concerning a personnel radiation overexposure would be entered as a radiation exposure event as well as an event involving radiography. For purposes of this report, AEOD counted each event only once by grouping it into the event type that was most appropriate.

For 1992, the NRER database contains 1264 reports of events, 623 NRC licensee reports and 641 Agreement State reports. Of the 1264 events, 886 events were required to be reported or were violations of regulations. Of these 886 events, 357 events were submitted by the NRC licensees, and 529 events were submitted by the Agreement States. The remaining 378 reports were voluntary submittals of information about events of lesser significance.

Appendix A lists the 357 NRC licensee events that were reportable (about 270 events) or violated regulations or license conditions (about 90 events). These events are discussed in detail through the remainder of this section. Many of the event-type and licensee-type categories have similar names but represent different groups of events. For example, one UF_6 licensee event, which describes a spill from a UF_6 production facility shipment in transit, could be classified as a "fuel cycle" event category, but is more appropriately categorized as a release of material in the "other" event category.

Table 2.2 shows the distribution of the 357 reportable or citable events for the NRC material licensees.

Complete information to develop a similar distribution for the Agreement State licensees is not readily available to NRC. However, a review of the available Agreement State data shows that the distribution of events among the Agreement State licensees, in general, is similar to that shown for NRC licensees in Table 2.2.

Table 2.2 Number of Events Reported by NRC Material Licensees for 1992, by Type of Licensee

Type of Licensee		No. of Reports Received
Academic and medical*		81
Commercial		64
Well-logging	11	
Other	53	
Industrial radiography		19
Irradiator		8
Research and development		23
Source material		59
Mills	2	
UF_6 plants	48	
Other	9	
Special nuclear material (SNM)		52
Fuel fabrication facility	46	
Other SNM	6	
Other		51
Total		357

*Medical misadministration reports are not included

2.2 Material Events Resulting in Radiation Overexposures

The following paragraphs describe the radiation overexposure events by event type that occurred during 1992.

2.2.1 Radiation Exposure Events

The criteria for radiation exposure limits are defined in 10 CFR 20.101, "Radiation dose standards for individuals in restricted areas"; 10 CFR 20.103, "Exposure of individuals to concentrations of radioactive materials in air in restricted areas"; and 10 CFR 20.105, "Permissible levels of radiation in unrestricted areas." Five categories of material licensees that monitor and report exposures of their personnel are: industrial radiography; manufacturing and distribution; low-level waste disposal; independent spent fuel storage; and fuel fabrication and processing. As discussed in Section 4 of this report, the average individual dose for the NRC-licensed material facilities for 1992 ranged from 0.08 mSv (8 mrem) to 3.4 mSv (340 mrem). For 1992, the previously declining trend in the annual average individual dose for the NRC licensees leveled off, with manufacturing and distribution, low level waste disposal, and independent spent fuel storage licensees showing a modest decrease in the average dose. The remaining two licensee types, industrial radiography and the fuel fabrication licensees, showed a modest increase in the average individual dose. This information is described in more detail in Section 4, "Nuclear Material Licensee Performance Review, 1992," of this report.

2.2.1.1 Overexposure Events by Licensee Type

For 1992, NRC received 39 reports of radiation overexposure events in which 88 individuals received exposures in excess of regulatory limits. Table 2.3 is a summary of the NRC licensee and the Agreement State overexposure events by licensee type.

Table 2.3 Number of Overexposure Events* Reported by NRC and Agreement State Material Licensees for 1992

Type of Licensee	No. of Reports			No. of Individuals		
	NRC	Agreement States	Total	NRC	Agreement States	Total
Medical and academic	5	9	14	53	9	62
Radiography	1	19	20	1	20	21
Commercial and industrial	2	3	5	2	3	5
Fuel cycle	0	0	0	0	0	0
Total	8	31	39	56	32	88

*Medical misadministration events are not included.

Table A1-1A in Appendix A-1 and Table A2-1 in Appendix A-2 list the overexposure events for the NRC licensees and for the Agreement State licensees, respectively. Many of these overexposures are extremity or localized skin exposures, which are a lesser health concern, but still important to NRC in assessing the effectiveness of byproduct materials control. Summaries of these events are given in Appendix A-1 and Appendix A-2.

There were an additional 28 NRC licensee events that were grouped as overexposure precursor events. These events did not result in overexposures but were required to be reported, or were a violation of regulatory requirements or license conditions. Table A1-1B in Appendix A-1 lists the overexposure precursor events for the NRC licensees. Agreement States did not submit any reports in this category.

2.2.1.1.1 Medical and Academic Licensees

For 1992, the NRC licensees reported 5 medical or academic events involving 53 individuals who received radiation exposures in excess of the regulatory limits specified in 10 CFR Part 20, "Standards for Protection Against Radiation." On November 16, 1992, a therapeutic misadministration event that occurred at the Indiana Regional Cancer Center (IRCC), Indiana, Pennsylvania, (operated by Oncology Services Corporation, Inc.), led to the death of the patient being treated, and overexposed 48 additional individuals not employed as radiation workers. This event is discussed in this section as a whole body and extremity radiation overexposure event. It also resulted in overexposures to nonradiation workers[1]. Additional details of this event are discussed in Section 4, "Medical Misadministrations"; Section 5, "Abnormal Occurrences"; and Section 7, "Incident Investigation Program," of this report. Four other medical or academic events were responsible for the remaining overexposures: (1) a medical physicist received a 2720 mSv (272 rem) exposure to the hand from handling a ribbon containing iridium-192 (Ir-192) brachytherapy seeds; (2) a researcher's hand became contaminated with phosphorous-32 (P-32) resulting in a 480 mSv (48 rem) dose to the fingers; (3) a technologist's elbow became contaminated with iodine-131 (I-131) while administering the substance to a patient and this resulted in a 256 mSv (25.6 rem) exposure to the technologist's forearm; and (4) a radiological engineer received 420 mSv (42 rem) to his left index finger while changing the source on a high-dose-rate afterloader.

The 29 Agreement States reported 9 medical or academic events involving overexposures to 9 individuals. The highest overexposure reported for these events was a 36 mSv (3.6 rem) whole body dose. Because complete information for the Agreement State licensees was not readily available to NRC, this group of events was not analyzed.

2.2.1.1.2 Industrial Radiography Licensees

For 1992, NRC licensees reported one radiography-related event that caused an individual to receive a 4400 mSv (440 rem) hand exposure while locking a radiographic exposure device with the source exposed. The Agreement States provided summary reports on 19 radiography events, 17 of which involved whole body overexposures to 17 radiography workers; 7 of the 17 events involved radiography workers receiving overexposures of 50 mSv (5 rem) or more. One radiography overexposure event occurred when an individual, who was not employed as a radiation worker, received a whole body dose of 10 mSv (1 rem) from a radiography activity. Another event was a potential overexposure to two radiation workers.

NRC-licensed radiographers have been required to use audible alarm ratemeters since January 1991. The number of overexposures for this category of licensees dropped from nine individuals in 1991 to one in 1992. Although the reduced number of licensees may be one factor (Table 4.1), the use of audible alarm ratemeters may also have been a factor in the reduction of this type of overexposures. Agreement States have until January 1994 to promulgate a compatible requirement. More detailed descriptions of industrial radiography overexposure events are included in the event summaries for Table A1-1A in Appendix A-1 and Table A2-1 in Appendix A-2.

2.2.1.1.3 Commercial and Industrial Licensees

The NRC licensees reported two commercial or industrial events that resulted in overexposures. In one event, a waste processing facility worker received 241 mSv (24.1 rem) localized to the skin from a "hot particle" while compacting radioactive waste. The

[1]A nonradiation worker is an individual who is not employed by a licensee to work with or in the vicinity of nuclear materials and is not monitored for radiation exposure.

second event involved an individual not employed as a radiation worker receiving 5.75 mSv (0.575 rem) whole body dose from an industrial source during transportation.

The Agreement States reported three commercial or industrial events that caused three overexposures. Two of the events resulted in exposures ranging between 12.5 and 40 mSv (1.25 and 4 rem) whole body dose, and one event resulted in an individual receiving 288 mSv (28.8 rem) extremity dose.

More detailed descriptions of commercial and industrial overexposure events are included in the event summaries in Table A1-1A in Appendix A-1 and Table A2-1 in Appendix A-2.

2.2.1.1.4 Fuel Cycle Licensees

For 1992, NRC received no reports of fuel cycle events that resulted in individuals receiving exposures in excess of regulatory limits.

2.2.1.2 Overexposure Events by Exposure Types

The primary concern with the use of radioactive materials is the overexposure to the whole body and/or critical organs that has the potential for causing cancer, or in cases of severe overexposures, even death. Radiation-induced genetic mutations are an equally important long-term consideration. Extremity or localized skin exposures (from hot particles) are a lesser health concern, but are still important to NRC in assessing the effectiveness of byproduct material control.

Table 2.4 shows the distribution of overexposure events by the type and number of individuals reported by the NRC licensees and the Agreement States for 1992.

Table A1-1A in Appendix A-1 and Table A2-1 in Appendix A-2 list the overexposure events for the NRC licensees and the Agreement State licensees, respectively.

2.2.1.2.1 Whole Body Exposures

The NRC licensees reported 50 whole body overexposures to individuals not employed as radiation workers in two separate events: (1) an individual whole body exposure of less than 12.5 mSv (1.25 rem); and (2) 49 whole body exposures from the IRCC therapeutic misadministration event.

The Agreement States reported 31 whole body overexposures including: (1) 1 overexposure of less than 12.5 mSv (1.25 rem) to an individual not employed as a radiation worker; (2) 15 overexposures that ranged between 12.5 and 30 mSv (1.25 to 3.0 rem); (3) 7 overexposures that ranged between 30 and 50 mSv (3 to 5 rem); (4) 1 overexposure that ranged between 50 and 70 mSv (5 to 7 rem); (5) 6 overexposures that ranged between 70 and 120 mSv (7 to 12 rem); and (7) 1 overexposure greater than 120 mSv (12 rem).

Except for the 49 individuals exposed during the IRCC therapeutic misadministration event, most of the 32 remaining whole body overexposures reported by NRC licensees and Agreement State licensees were received by personnel involved in industrial radiography.

Table 2.4 Number of Personnel Overexposures Reported for 1992*

Type of Exposure	Reported by NRC Licensees	Reported by Agreement States	Total
Whole body exposure/quarter			
12.5 mSv (< 1.25 rem)	7	1	8
12.5–30 mSv (1.25–3 rem)	10	15	25
30.0–50 mSv (3–5 rem)	9	7	16
50.0–70 mSv (5–7 rem)	4	1	5
70.0–< 120 mSv (7–12 rem)	10	6	16
< 120 mSv (> 12 rem)	10	1	11
Internal	0	0	0
Extremity	15	1	16
Lens of the eye	0	0	0
Skin	1	0	1

*A number of overexposure events resulted in multiple exposure types; therefore, some events are counted more than once in this table.

2.2.1.2.2 Internal Exposures

For 1992, NRC received no reports of internal overexposures. Medical misadministrations resulting in internal exposures in excess of planned treatments are not categorized as internal exposures; these types of overexposures are discussed in Section 3 of this report.

2.2.1.2.3 Extremity Exposures

Five overexposure events reported by the NRC licensees involved extremity exposures that ranged from 76 to 4400 mSv (7.6 to 440 rem). Ten of the 49 individuals who received whole body overexposures in the IRCC therapeutic misadministration event also received extremity overexposures. An Agreement State reported one extremity overexposure.

2.2.1.2.4 Lens of the Eye Exposures

For 1992, NRC received no reports of overexposures to the lens of the eye.

2.2.1.2.5 Skin Exposures

An NRC licensee reported one overexposure that resulted in a radioactive waste facility worker receiving 241 mSv (24.1 rem) to the skin from a 0.076 megabequerel (MBq) (2.1-microcurie [μCi]) "hot particle."

2.2.2 Lost, Stolen, and Abandoned Source Events

Pursuant to 10 CFR 20.402(a)(1), "Reports of theft or loss of licensed material," licensees are required to report the loss or theft of licensed radioactive sources. The NRC licensees reported 96 incidents involving lost, stolen, or abandoned sources. The Agreement States reported 76 events of this type. Of the 172 lost sources, 31 NRC sources were recovered eventually; Agreement States did not report any recovered sources. Sources that were lost and then recovered are still considered a concern because they represent a loss of control over radioactive material. Table 2.5 shows the distribution of these events by licensee type for the NRC licensees and the Agreement States.

Lost or stolen sources relating to medical and academic applications accounted for about 30 percent of all lost, stolen, and abandoned source events. These lost and stolen medical sources reported by the NRC licensees and the Agreement States involved either the loss of diagnostic or therapeutic radiopharmaceuticals, or misplaced sources from gauges, signs, or pacemakers. These events did not result in any known adverse effect to public health and safety.

Industrial licensees, and research and development licensees reported a combined 93 lost, or stolen source events (about 55 percent). Thirty events of lost gauges (portable and fixed) accounted for about 30 percent of these lost material events. These events included gauges that were stolen or inadvertently discarded. Portable gauges (used for moisture/density measurements) typically contain 370 to 740 MBq (10 to 20 millicurie [mCi]) Cs-137 sources or 1480 to 1850 MBq (40 to 50 mCi) americium-241 (Am-241) sources. Fixed gauges typically contain 3.7E4 to 3.7E5 MBq (1 to 10 Ci) cesium-137 (Cs-137) sources. There were approximately the same number of events involving a lost or stolen portable gauge as were those involving a fixed gauge inadvertently being sent to the steel scrap yard. The loss of 11 NRC-licensed and 6 Agreement State-licensed static eliminators accounted for about 18 percent of the lost material events. The remaining lost material events involved the loss of check-sources, detectors, self-illuminating signs, and one radiography source. None of these events resulted in any known adverse effect on public health or safety.

Table 2.5 Number of Events Reported for 1992 Involving Lost, Stolen, or Abandoned Sources

Type of Licensee	Medical and Academic	Industrial Radiography	Well-Logging	Industrial	Research and Development	Total
NRC	32	0	8	45	11	96
Agreement State	30	1	8	37	0	76
Total	62	1	16	82	11	172

Table A1-2A in Appendix A-1 and Table A2-2A in Appendix A-2 list the lost or stolen source events for the NRC licensees and Agreement State licensees, respectively.

The NRC licensees and the Agreement State licensees are also required to report the location of abandoned well-logging sources. The NRC well-logging licensees reported 8 sources abandoned downhole, and the Agreement States also reported 8 well-logging sources abandoned downhole. These 16 events reported for 1992 did not result in any known adverse effect on public health and safety.

Table A1-2b in Appendix A-1 and Table A2-2b in Appendix A-2 list the well-logging source events for the NRC licensees and the Agreement State licensees, respectively.

2.2.3 Leaking or Contaminated Source Events

Some licensees are required to leak-test sources and report leaking sources under 10 CFR 34.25, "Leak testing, repair, tagging, opening, modification and replacement of sealed sources," or as a condition of their license. In both cases, a removable contamination exceeding the limit for removable contamination, most commonly 1.9E-4 MBq (0.005 μCi), is considered evidence of leakage. For 1992, the NRC licensees and the Agreement States reported 54 leaking sources from medical, academic, industrial, and commercial licensees. Table 2.6 shows the distribution of leaking or contaminated source events.

Sixteen of the 54 (about 30 percent) sources reported to be leaking or contaminated were low activity nickel-63 (Ni-63) foils used in gas chromatography. The other sources were mostly low activity cesium-137 (Cs-137) or barium-133 (Ba-133) check-sources. One radiography source and two brachytherapy sources were also reported leaking. The leaking radiography source was reported by an Agreement State and the leaking brachytherapy sources were reported by the NRC licensees. None of these leaking sources resulted in any known personnel exposures, uptakes, or contamination problems.

Table A1-3 in Appendix A-1 and Table A2-3 in Appendix A-2 list the events involving leaking or contaminated sources reported by the NRC licensees and the Agreement State licensees, respectively.

2.3 Material Events Other Than Radiation Overexposures

The following paragraphs describe the material events that were required to be reported for 1992 but that did not cause any personnel radiation overexposures.

2.3.1 Radiography

Pursuant to 10 CFR 34.30, "Reporting requirements," radiography licensees reported a total of 31 defects or equipment problems, none of which resulted in an overexposure. The NRC licensees reported 14 events, and the Agreement States submitted summaries on 17 events. The requirements of 10 CFR 34.30 became effective for the NRC licensees in 1991. Since the Agreement States are not required to comply, it is likely that Agreement State

Table 2.6 Number of Events Reported for 1992 Involving Leaking or Contaminated Sources

Type of Licensee	Medical and Academic	Industrial and Commercial	Research and Development	Total
NRC	3	8	6	17
Agreement State	8	29	0	37
Total	11	37	6	54

licensees did not report all of the events for 1992 applicable to 10 CFR 34.30. Before Section 34.30 became effective, holders of radiography licenses did not generally report equipment problems that did not result in a radiation overexposure.

Four additional events were reported by NRC licensees. Three of these events involved a failure to adequately monitor radiography personnel and one event involved the lack of an adequate program for evaluating deviations.

Table 2.7 shows the distribution of radiography equipment malfunctions reported by the NRC-licensed and the Agreement State-licensed radiographers.

The radiography equipment problems reported by the NRC licensees are evenly distributed among the different failure mechanisms. However, source connection problems accounted for about 65 percent of the radiography equipment failures reported by the Agreement States. The cause for most of these source connection problems was reported as equipment problems.

Table A1-4 in Appendix A-1 and Table A2-4 in Appendix A-2 list the radiography events for the NRC licensees and Agreement State licensees, respectively.

2.3.2 Medical Events Other Than Medical Misadministrations

For 1992, NRC received 17 reports of medical events that were not misadministrations. Table 2.8 shows the distribution of medical equipment problems reported by the NRC licensees and the Agreement States.

The NRC licensees reported seven events and the Agreement States submitted summaries for three events involving equipment problems with teletherapy machines. Nine of these 10 events involved failure to retract or slow retraction of the teletherapy source following treatment. In all cases, the source eventually retracted, either without further operator intervention or as a result of the operator using emergency procedures. Take-up reel problems were identified as the cause of two of these events. Leaky air cylinder seals were identified as the cause of two other events. No cause was identified for the remaining six events.

Of the ten teletherapy equipment events, one event resulted in a 36-percent increase in the fractionated dose, a 10-percent increase in the total prescribed dose, and minimal exposure to other personnel. Another teletherapy equipment problem resulted in an exposure of 0.7 mSv (70 mrem) to an attending

Table 2.7 Number of Events Reported for 1992 Involving Radiography

Type of Licensee	Drive Cable /Crank-out	Source Connection	Locking Mechanism	Damaged Exposure Device	Other	Total
NRC	1	3	4	4	6	18
Agreement State	2	11	1	1	2	17
Total	3	14	5	5	8	35

Table 2.8 Number of Events Reported for 1992 Involving Failure of Medical Equipment

Type of Licensee	Teletherapy Equipment	Release of Materials	Other	Total
NRC	7	2	5	14
Agreement State	3	0	0	3
Total	0	2	5	17

technologist. All the remaining events involving teletherapy equipment exposed patients to small amounts of additional radiation.

The remaining seven medical events included two events that resulted in a release of licensed material and five events that involved miscellaneous problems such as a patient spilling a dosage on herself during ingestion. These seven events did not result in an overexposure to any of the individuals involved.

Table A1-5 in Appendix A-1 and Table A2-5 in Appendix A-2 list the non-misadministration medical events for the NRC licensees and Agreement State licensees, respectively.

2.3.3 Manufacturing and Distribution Events

For 1992, NRC licensees reported 16 events and the Agreement States submitted 15 reports involving the manufacturing and distribution of licensed materials. Unlike for industrial radiography and medical use programs, there are no reporting requirements specific to this group of licensees. The reporting requirements are generally contained in 10 CFR Parts 20, 30, 40, and 71, or specific requirements are incorporated into their license or into an Order.

Sixteen of the 31 events involved the transportation of radioactive materials as shown in Table 2.9. Nine of these 16 transportation events were accidents involving a vehicle that was transporting radioactive materials or a gauge containing a radioactive source. The remaining seven transportation events involved other violations of 10 CFR Part 71 regulations.

Transportation of radioactive material events that are reportable under 10 CFR Part 71, "Packaging and Transportation of Radioactive Material," are included in the NRER database. However, other transportation events involving radioactive materials that had no potential radiological consequences are not maintained in the NRER database but can be found in the U.S. Department of Energy's transportation incident file, which is maintained by the Sandia National Laboratory.

Of the remaining 15 events, 10 events resulted from radioactive shipments being received with dose rates above prescribed limits, and 5 events were grouped as miscellaneous occurrences such as contamination of a fume hood. The manufacturing and distribution events did not result in any known adverse effects on the public health and safety.

Table A1-6 in Appendix A-1 and Table A2-6 in Appendix A-2 list the manufacturing and distribution events for the NRC licensees and Agreement State licensees, respectively.

2.3.4 Gauges and Measuring Device Events

Licensees authorized to possess gauges or measuring devices are required to report failed or damaged shielding, on/off mechanisms, and gauge indicators. They are also required to report when removable contamination is found. Table 2.10 shows the distribution of events reported by the NRC licensees and the Agreement States. The NRC licensees reported 25 events and Agreement States reported 32 events involving industrial gauges. Events involving lost or stolen gauges are addressed in Section 2.2.2 of this report.

Vehicles running over equipment was the dominant cause of damage to gauges or measuring devices, accounting for 36 damaged gauges or about 65 percent of the events. The gauges involved were portable gauges used in the construction industry for

Table 2.9 Number of Events Reported for 1992 Involving Manufacturing and Distribution Problems

Type of Licensee	Transportation Events	Surface Readings	Miscellaneous	Total
NRC	8	5	3	16
Agreement State	8	5	2	15
Total	16	10	5	31

Table 2.10 Number of Events Reported for 1992 Involving Damaged Gauges and Measuring Devices

Type of Licensee	Gauges Damaged by Vehicles	Equipment Problem Involving Shutter Mechanism	Gauges Damaged by Molten Metal or Fire	Other Problems	Total
NRC	13	5	1	6	25
Agreement State	23	3	4	2	32
Total	36	8	5	8	57

measuring moisture and density in compacted materials, and are routinely exposed to heavy equipment traffic. Source integrity was not breached in any of the events reported for 1992, and no radiation exposures were reported as a result of these damaged gauges.

Eight events involved shutter mechanisms that failed to operate properly. No radiation exposures were reported as a result of this failure mechanism.

Five additional gauges were reported to have been damaged by molten metal or fire. These events involved fixed gauges installed in steel mills or foundries. Although low-level radiation was measured in certain cases, no overexposures or contaminations were reported.

For 1992, eight other gauges or measuring devices were involved in events that violated regulations. One example of such an event was the shipping of a measuring device in other than a manufacturer's transportation case as required. No radiation exposures or other contaminations were reported as a result of these damaged gauges or measuring devices.

Table A1-7 in Appendix A-1 and Table A2-7 in Appendix A-2 list the events involving damage to gauges and measuring systems for the NRC licensees and the Agreement State licensees, respectively.

2.3.5 Consumer Product Events

In 1985, the Consumer Product Event category was added to the NRER database. This category includes those events in which radioactive material was found in, or had a reasonable probability of being introduced into, non-licensed consumer products. NRC did not receive any reports for consumer product events for 1992.

2.3.6 Fuel Cycle Events

NRC regulates all fuel cycle facilities. For 1992, NRC licensees reported 91 fuel cycle events of which 46 involved manufacturing of uranium hexafluoride (UF_6) and 45 involved fuel fabrication facilities. Table 2.11 lists the fuel cycle events.

Thirty-two of the 46 UF_6 events involved contamination or release of radioactive materials, or both. Of the remaining events, 6 events involved equipment problems and 8 events were grouped as miscellaneous occurrences. Among miscellaneous UF_6 events are such occurrences as a control room operator's failure to record safety alarms.

Table 2.11 Number of Events Reported for 1992 Involving Fuel Cycle Problems

Type of Event	UF_6 Manufacturing	Fuel Fabrication Facilities	Total
Release/contamination	32	2	34
Criticality control	0	17	17
Equipment problems	6	11	17
Miscellaneous	8	15	23
Total	46	45	91

Table A1-8 in Appendix A-1 lists the UF_6 events and contains a summary of each event.

Of the 45 fuel fabrication facility events, 2 resulted in contamination or release of radioactive materials, or both; 17 events involved the loss or degradation of criticality control, 11 events involved equipment problems, and 15 events were grouped as miscellaneous occurrences. Among miscellaneous fuel fabrication events are such events as fires or a loss of a safety parameter indication.

Table A1-9 in Appendix A-1 lists the fuel fabrication facility events and contains a summary of each event.

2.3.7 Miscellaneous Events

There were 65 other events that did not fit into any specific event category. These events include a variety of occurrences such as a loss of an interlock on an irradiator device and a citation resulting from not reporting an event within the 48 hours allowed by regulations. Table 2.12 shows the distribution of these events.

More than two-thirds of the miscellaneous events were grouped as "other" which included events such as selling a source to an unlicensed individual. The remaining events were divided into three groups: irradiator events, radioactive waste events, and release or contamination events. Irradiator events are potentially significant because the source used in an irradiator is usually 370,000 gigabecquerel (10,000 curie [Ci]) or more, but rarely results in exposures. None of the events in this event type category had any known adverse effect on public health and safety.

Table A1-10 in Appendix A-1 and Table A2-8 in Appendix A-2 list the miscellaneous events for the NRC licensees and the Agreement State licensees, respectively.

Table 2.12 Number of Events Reported for 1992 Involving Miscellaneous Problems

Type of Licensee	Irradiators	Radioactive Waste	Release or Contamination*	Other	Total
NRC	6	2	8	28	44
Agreement State	0	1	1	19	21
Total	6	3	9	47	65

*The release or contamination category excludes those events that resulted in a release of materials but were better grouped as medical or fuel cycle events.

3 Medical Misadministrations

3.1 General

NRC and the Agreement States regulate certain aspects of reactor-produced radioisotopes used in nuclear medicine and therapeutic radiology pursuant to Part 35 of Title 10 of the *Code of Federal Regulations* (10 CFR Part 35), "Medical Use of Byproduct Material." The rule (10 CFR 35.33) became effective on November 10, 1980, and required NRC licensees in medical fields to report medical misadministrations to NRC. This rule was revised in 1987 to require medical licensees in the Agreement States to also report misadministrations to the appropriate regulatory agency in their State. Agreement State agencies have three years to promulgate State rules compatible with those of NRC, making 1991 the first year that the Agreement States were required to report medical misadministrations. The Agreement States have been asked to voluntarily submit misadministration reports to NRC. All information about medical misadministrations is maintained in NRC's MISAD database described in Section 2 of this report.

The Quality Management Program and Misadministrations (QM) Rule, which was published in the *Federal Register* on July 25, 1991 (56 *FR* 34104), and which became effective on January 27, 1992, contained the requirements for a quality management program and revised definitions of, and reporting requirements for, medical *misadministrations*. The Agreement States have until January 27, 1995, to adopt these requirements. As part of this amendment, the definition of a *misadministration* was changed to include the following six types of misadministrations:

Type of Procedure	Misadministration
1. All Diagnostic Radiopharmaceuticals (including < 30 μCi sodium iodide—I-125 or I-131)	• Wrong patient, radiopharmaceutical, route, or dosage, and • Dose > 5 rem Effective Dose Equivalent or 50 rem to an organ
2. Sodium Iodide Radiopharmaceuticals (where > 30 μCi sodium iodide—I-125 or I-131)	• Wrong patient • Wrong radiopharmaceutical • Administered dosage differs from prescribed dosage by > 20 percent and > 30 μCi
3. Therapeutic Radiopharmaceuticals (other than sodium iodide—I-125 and I-131)	• Wrong patient • Wrong radiopharmaceutical • Wrong route of administration • Administered dosage differs by > 20 percent from prescribed dosage
4. Teletherapy	• Wrong patient • Wrong mode of treatment • Wrong treatment site • Calculated weekly dose > weekly prescribed dose by 30 percent • Calculated total dose differs by > 20 percent from prescribed dose • If < 3 fractions, calculated total dose differs by > 10 percent total prescribed dose

Type of Procedure	Misadministration
5. Brachytherapy	• Wrong patient • Wrong radioisotope • Wrong treatment site (excluding migration of permanent implants) • Leaking sources • Failure to remove sources for a temporary implant • Calculated administered dose differs by > 20 percent prescribed dose
6. Gamma Stereotactic Radiosurgery	• Wrong patient • Wrong treatment site • Calculated total administered dose differs by > 10 percent total prescribed dose

As a result of the amendments of 1991 to 10 CFR Part 35, a new classification of misadministration was defined to include two types of sodium iodide misadministrations: those performed for diagnostic purposes that were previously defined as *diagnostic misadministrations*, and those performed for therapeutic purposes that were previously defined as *radiopharmaceutical therapeutic misadministrations*. These types of procedures involve either iodine-125 (I-125) or iodine-131 (I-131) as the sodium iodide radiopharmaceutical in amounts exceeding 1.11 megabecquerel (MBq) (30 microcurie [μCi]).

In 1990, the NRC staff estimated[1] that about 7 million diagnostic procedures, 30,000 radiopharmaceutical therapeutic procedures, and 50,000 brachytherapy procedures were performed annually in the United States. In addition, about 100,000 patients receive cobalt-60 (Co-60) teletherapy treatments each year. The NRC staff estimated (on the basis of population distribution) that the Agreement State licensees perform about 65 percent of these procedures and NRC licensees perform the remaining 35 percent of the procedures.

The term *diagnostic misadministration*, as used in NRC regulations, refers to the misadministration of radioisotopes in such nuclear medicine studies as renal, bone, and liver scans. *Therapeutic misadministration* refers to the misadministration of radiation in the treatment of patients with Co-60 (the external use of radiation from a single Co-60 source for therapeutic treatment), gamma stereotactic radiosurgery (the external use of radiation from about 200 small Co-60 sources for therapeutic treatment), brachytherapy (the insertion or implantation of sealed sources containing radioactive material for therapeutic treatment), or radiopharmaceutical therapy (the ingestion or injection of radioactive materials for therapeutic treatment). The significance of any misadministration is determined by its potential effect on the patient and on the public health and safety.

In a memorandum of February 1, 1993, to John Glenn (NRC), Myron Pollycove, M.D., Visiting Medical Fellow at NRC, presented his position on the risks associated with the misadministration of radiopharmaceuticals in terms of the relative risks associated with radiation therapy, general anesthesia, surgery, and chemotherapy in the treatment of five common malignancies that responded well to treatment. Dr. Pollycove's data showed that mortality risks are of the following order of magnitude: 1:100 or greater for surgery; 1:1000 for general anesthesia; 2:1000 for chemotherapy; 1:100 for radiation therapy, if delivered as prescribed, in the case of cervical cancer, colorectal cancer, and Hodgkin's disease; 1:1400 for radiation therapy in the case of prostate cancer; and 1:167,000 for radiation therapy misadministrations. In a memorandum of March 8, 1993, to John Glenn (NRC), Dr. Pollycove estimated the total annual radiation misadministration rate from sealed and unsealed radioactive sources to be 1:3800.

[1]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 potential or actual effect of a therapeutic misadministration would generally differ from that of a diagnostic misadministration. Therapeutic 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 clinical or investigative procedures requiring comparatively small doses of radiation. However, some misadministrations involving the use of I-125 or I-131 for diagnostic purposes may deliver unintended doses in the therapeutic range to the patient's thyroid.

Not all therapeutic misadministrations result in significant radiation-induced adverse clinical effects. Some misadministrations give the patient too little radiation because of an error in the treatment fraction(s) administered to the correct patient or to the wrong treatment site. In 1992, the NRC licensees reported 15 misadministrations and an Agreement State reported 1 misadministration which met the criteria for abnormal occurrences (AOs). Four (25 percent) of these AOs represented less than the planned or intended exposure level. In such cases, adjustments can usually be made to compensate for the underdosing without any adverse effects on the patient.

AEOD routinely reviews reports of therapy misadministrations and sodium iodide misadministrations because of the potential radiation-induced health effects. The therapeutic and sodium iodide misadministrations, individually and collectively, are more significant than the diagnostic misadministrations. AEOD reviews diagnostic misadministrations, in general, from a collective and statistical viewpoint. AEOD does not review accelerator-produced radioisotopes or accelerator teletherapy misadministrations because they are not regulated by NRC.[2]

3.2. Misadministrations Reported During 1992

Approximately 2000 NRC licensees[3] in 21 States, the District of Columbia, and the U.S. territories are licensed to use radioisotopes in radiation therapy and nuclear medicine applications. In 1992, these facilities submitted 58 misadministration reports (22 diagnostic, 29 therapy, and 7 sodium iodide). The 22 diagnostic misadministration reports which were reported to the NRC from January 1 through 27, 1992, would not be considered misadministrations under the current misadministration reporting requirements (10 CFR Part 35, 1991 Amendments) and are not significant to public health and safety. Of the 29 therapy misadministrations, 5 occurred prior to the effective date of the revised definition of *misadministration*, and 1 of these 5 therapy events does not meet the revised criteria for misadministration. Two of the seven sodium iodide misadministrations also occurred before January 27, 1992, and one does not meet the current criteria for a *misadministration*.

The 29 Agreement States regulate about 5000 medical institutions which include hospitals, clinics, and physicians in private practice. In 1992, Agreement States reported 233 misadministrations (216 diagnostic, 10 therapy, and 7 sodium iodide). The 216 diagnostic misadministrations submitted in 1992 were reported pursuant to the previous definition of *misadministration* (the 1987 revision) which is still applicable in those Agreement States that have not yet adopted NRC-compatible requirements. Currently, these misadministrations need not be reported pursuant to 10 CFR Part 35.

Table 3.1 summarizes the number of medical misadministrations excluding diagnostic misadministrations reported by NRC and Agreement State licensees for 1992.

Table 3.2 summarizes the number of States, the total population for those States, number of medical licensees, number of misadministrations, and number of misadministration AOs reported to Congress for the NRC and Agreement States licensees for 1992. Although the population of the Agreement States is almost twice that of the NRC regulated area, only 1 of the 16 AOs came from an Agreement State.

Table B-1 in Appendix B to this report shows the number of therapy and sodium iodide misadministrations reported by NRC medical licensees in 1992 by State and the population by State and region. Table B-2 in Appendix B gives similar information for misadministration summaries provided by Agreement States for 1992.

[2]The Atomic Energy act of 1954, as amended, limits NRC's regulation of radioactive materials to reactor-produced isotopes.

[3]See Commission paper, "Management Review of Existing Medical Use Regulatory Program," presented by C. J. Paperiello, on June 16, 1993..

Table 3.1 Medical Misadministrations Reported by NRC and Agreement State* licensees for 1992**

	Sodium Iodide**		Therapy		Total	
Item	NRC*	AS	NRC*	AS	NRC	AS
Licensees	7	7	28	10	35	17
Reports	7	7	29	10	36	17
Patients	7	7	45	10	52	17

*One therapeutic misadministration and one sodium iodide misadministration do not meet the current definition of a misadministration which became effective on January 27, 1992. However, they are included in the 1992 misadministration data because they were reported to the NRC in 1992.

**Three of the sodium iodide misadministrations (two reported by NRC licensees and one submitted by an Agreement State licensee) involved the administration of I-131 for therapeutic purposes. These three misadministrations were previously defined by NRC regulations as radiopharmaceutical therapy misadministrations.

***Twenty-nine Agreement States provided annual summary reports for 1992. Seventeen of the 29 states reported misadministrations.

3.2.1 Therapeutic Misadministrations

For 1992, NRC medical licensees submitted 29 therapeutic misadministration reports, of which 16 were teletherapy misadministrations and 13 were brachytherapy misadministrations. There were no radiopharmaceutical therapeutic misadministrations reported by NRC licensees for 1992. Section I of Appendix B to this report describes these misadministrations.

For 1992, 29 Agreement States submitted 10 therapeutic misadministration reports, 3 involving teletherapy, 6 involving brachytherapy, and 1 involving radiopharmaceutical therapy. Details of these misadministrations are discussed in Section II of Appendix B to this report. Table 3.3 presents data on the causes of the misadministrations submitted by the NRC and the Agreement State licensees.

3.2.1.1 Teletherapy Misadministrations

The NRC medical licensees reported 16 teletherapy misadministrations for 1992. This represents an increase in the number of reported teletherapy misadministrations from the 3 events reported in 1991. The reported factors that contributed to these misadministrations were (1) an error in the dose calculation, (2) inadequate review of the patient's chart, (3) miscommunication, (4) misidentification of the prescribed treatment site, (5) lack or misuse of a wedge, and (6) error in selecting the treatment modality.

The Agreement State medical licensees submitted three teletherapy misadministration reports for 1992. The reported factors that contributed to these misadministrations were (1) inadequate review of the patient's chart, (2) misidentification of prescribed treatment site, and (3) an error in selecting or omitting a wedge.

Table 3.2 Misadministrations Reported by NRC and Agreement State Licensees for 1992

Item	NRC	Agreement States	Total
States	21	29	50
Total population (in millions)	87	162	249
Medical licensees	2000	5000	7000
Misadministrations*	36	17	53
Misadministration AOs	15	1	16

*This table does not include the reported diagnostic misadministrations.

Table 3.3 Causes of Misadministrations as Stated by NRC and Agreement State Licensees for 1992

Misadministrations	NRC	Agreement States	Total
Teletherapy			
Error in the dose calculation	8	0	0
Inadequate review of the patients chart	2	1	1
Miscommunication	1	0	1
Misidentification of the prescribed treatment site	2	1	3
Error involving lack of or misuse of a wedge	2	1	3
Error in selecting a treatment modality	1	0	1
Brachytherapy			
Error in selecting and/or verifying source strength	4	1	5
Error in source placement	3	3	6
Error in computer entry	2	0	2
Error in the dose calculation	1	1	2
Failure to perform surveys and/or a weak Radiation Safety Program	2	1	3
Inadequate training of staff	1	0	1
Radiopharmaceutical therapy			
Failure to verify dosage	0	1	1
Total	29	10	39

3.2.1.2 Brachytherapy Misadministrations

NRC medical licensees reported 13 brachytherapy misadministrations for 1992. These 13 reported events represent a continuation in the increasing trend that started in 1987 (3 events). Nine of these misadministrations involved manual loading brachytherapy devices and four of them involved the use of remote afterloading devices. The reported factors that contributed to these misadministrations were (1) an error in selecting and/or verifying brachytherapy source strength, (2) an error in source placement, (3) an error in computer entry, (4) an error in dose calculation, (5) a failure to perform surveys and/or a weak Radiation Safety Program, and (6) inadequate staff training.

Agreement States submitted six brachytherapy misadministration reports for 1992. The reported factors that contributed to these misadministrations included (1) an error in selecting and/or verifying a brachytherapy source strength, (2) an error in source placement, (3) an error in dose calculation, and (4) a failure to perform a survey.

3.2.1.3 Radiopharmaceutical Therapeutic Misadministrations

Pursuant to the current definition of a *misadministration*, NRC licensees did not report any radiopharmaceutical therapeutic misadministration for 1992. However, two misadministrations included in this report as sodium iodide misadministrations involved the administration of I-131 for therapeutic purposes. These misadministrations were previously defined as *radiopharmaceutical therapeutic misadministrations.*

Agreement States submitted a report on one radiopharmaceutical therapeutic misadministration for 1992. The reported factor contributing to this misadministration was failure to verify the dosage.

3.2.2 Sodium Iodide Misadministrations

Sodium iodide misadministration is a new category of misadministration. An event involving sodium iodide (I-125 or I-131) previously reported under therapeutic radiopharmaceutical and diagnostic misadministration is currently required to be

reported as a sodium iodide misadministration. All events in 1992 that involved a diagnostic or therapeutic misadministration of sodium iodide (I-125 or I-131) were grouped under this new category. This included Agreement States' related reports even though a compatible State rule will not be required until January 27, 1995.

Of the seven NRC licensee sodium iodide misadministrations reported in 1992, two NRC licensee cases resulted in an estimated dose to the thyroid of more than 10 Gray (Gy) (1000 rad). In the first NRC licensee case, a communication error between the referring physician's medical assistant and the nuclear medicine technologist resulted in the administration of a dosage of 370 megabecquerel (MBq) (10 millicurie [mCi]) of I-131 for a whole body scan instead of a 7.4-MBq (0.2-mCi) dosage for a thyroid scan. There was no written order for the scan. In this case, the incorrect dosage administered resulted in a 270-Gy (27,000-rad) exposure to the thyroid. In the second NRC licensee case, another error in communication resulted in the administration of a dosage of 152 MBq (4.1 mCi) of I-131 for a whole body scan instead of the prescribed dosage of 5.9 MBq (0.16 mCi) for a thyroid scan and uptake. The resulting overexposure was not documented in the event report.

Causes of the sodium iodide misadministrations reported by the NRC licensees in 1992 included (1) misunderstanding the referring physician's request, (2) miscommunication among licensee staff, and (3) failing to identify the correct patient. Details of these misadministrations are given in Section I of Appendix B to this report.

Of the seven sodium iodide misadministrations reported by the Agreement States, three resulted in an estimated dose in excess of 10 Gy (1000 rad) to the thyroid. One Agreement State reported an event caused by confusion in the type of procedure requested. A patient was administered a dosage for a whole body scan instead of a dosage for a thyroid scan as requested in the written directive. The administered dosage or the resulting overexposure was not reported, but a misadministration of an I-131 dosage for a whole body scan given in place of a dosage for a thyroid scan usually results in an overexposure in excess of 10 Gy (1000 rad) to the thyroid. A second Agreement State reported an event in which a patient received a dosage intended for another patient. The dosage was initially prepared incorrectly, 220 MBq (5.9 mCi) instead of the prescribed 3.7 MBq (0.1 mCi). The dose error was compounded by administering the incorrectly prepared dosage to the wrong patient. A third Agreement State reported an event that occurred when a nuclear medical technologist misinterpreted a requisition. As a result, the patient was administered a dosage of 196 MBq (5.3 mCi) of I-131 for a whole body scan instead of the prescribed 0.37 MBq (0.01 mCi) of I-131 dosage for thyroid scan.

The causes of the sodium iodide misadministrations reported by the Agreement States in 1992 included (1) misunderstanding the referring physician's request, (2) miscommunication among licensee staff, (3) failing to identify the correct patient, and (4) failing to verify the prescribed procedure. Details of these misadministrations are in Appendix B to this report.

3.2.3 Diagnostic Misadministrations

The 1992 revised definition of *misadministration* resulted in a significant reduction in the number of reported diagnostic misadministrations. There were no diagnostic misadministrations reported by NRC licensees after the revised definition of a *misadministration* became effective on January 27, 1992. The 22 reports of diagnostic misadministrations involving 24 patients that were reported to the NRC from January 1 through 27, 1992, were not significant to public health and safety, and are not analyzed further in this report.

Agreement States submitted 216 misadministration reports that are categorized as diagnostic misadministrations pursuant to the 1987 definition of *misadministration*. Because these misadministrations need not be reported to the NRC anymore, they are not analyzed further in this report.

3.2.4 Commercial Radiopharmacies' Diagnostic Misadministrations

In 1991, there were 28 diagnostic misadministrations involving dosages received from commercial radiopharmacies reported by the NRC licensees and 36 similar diagnostic misadministrations reported by 19 of the Agreement States. There were no diagnostic misadministrations involving commercial radiopharmacies reported in 1992. The 64 commercial

radiopharmacy events reported in 1991 were reviewed against the new criteria for *misadministrations*. None of the 1991 diagnostic misadministrations involving commercial radiopharmacies would have met the criteria for a misadministration under the new definition of *misadministration* which became effective on January 27, 1992.

3.3 Trends in Misadministration Reports From 1988 to 1992

Table 3.4 lists the number of misadministrations reported annually from 1987 to 1992, and gives the misadministration rate per 100 medical licensees.

Table 3.4 lists the misadministrations that were reported under the requirements that were in effect at the time of the misadministrations from 1987 to 1992. The requirements for reporting misadministrations were modified in 1987 and again in 1992. The 1987 rule became effective on April 1, 1987. It did not change the definition for a misadministration, but added new criteria for reporting these events. As a result of this change, only those diagnostic misadministrations that resulted in exposures of 20 millisievert (mSv) (2 rem) to an organ or a 5-Sv (500-mrem) whole body exposure were required to be reported. 1988 was the first full year that these requirements were in effect. In 1992 the rule was modified again. This rule change redefined misadministration. This change resulted in the reporting of certain misadministrations which could be important to safety not captured by previous requirements, and practically eliminating the reporting of diagnostic misadministrations that have minimal effects on public health and safety. As a result, the total number of reported medical misadministrations dropped dramatically in 1992. Because of the reporting requirement changes in 1987 and major change in the definition of misadministrations in 1992, a simple comparison of the annual misadministrations would be misleading. The Agreement States have three years to promulgate State rules that will be compatible with those of the NRC. The effective date of the new rule may be different among the States.

Table 3.5 lists the number of misadministration reports according to the type of misadministration for 1987 through 1992. This table also gives the number of patients involved and the number of licensees that submitted misadministration reports for each of the years.

Therapeutic misadministrations reported by NRC licensees during 1992 increased from 19 in 1991 to 29 in 1992. The number reported in 1992 was about twice as high as the average number reported annually in the previous years, from 1987 through 1991. One of the reasons for this apparent increase may be

Table 3.4 Number of Misadministrations Reported Annually by NRC Licensees, 1987 Through 1992

Year	Misadministration Reports	Number of Medical Licensees	Misadministration Reports per 100 Medical Licensees
1987*	423	2600***	16.3
1988	405	2600***	15.6
1989	417	2500***	16.7
1990	467	2400***	19.5
1991	463	2400***	19.3
1992*	36****	2000**	1.8

*In 1987 and again in 1992, the reporting requirements were revised.

**An estimate of the number of the NRC medical licensees based on a Commission paper on "Management Review of Existing Medical Use Regulatory Program," presented by C.J. Paperiello on June 16, 1993.

***Based on previous staff estimates.

****There were 22 diagnostic misadministration reports submitted before the 1992 rule became effective. These are not included in this total because they were not considered important to safety. No diagnostic misadministrations were submitted for 1992 under the new criteria for misadministration.

attributed to the revised definition of *misadministration* that includes new types of misadministrations, such as wrong treatment site and errors in fractions of the treatment plan. Other factors that may have contributed to this apparent increase are (1) heightened awareness in the medical community in general because of escalated enforcement actions against licensees for failure to report; (2) new and complex brachytherapy procedures, including remote afterloading procedures; (3) inadequate staff training in these new procedures; (4) computerized therapeutic treatment plans whereby a program error, if undetected, may propagate to subsequent treatments; and (5) identification of previously unrecognized misadministrations found after the licensee's audit of the departmental quality management (QM) program.

The number of brachytherapy events reported also increased from 11 in 1991 to 13 in 1992. Although an analysis of the data does not reveal any specific reason for this increase, it does represent a sustaining rise in the number of brachytherapy misadministrations beginning in 1987. The increase of brachytherapy procedures in general, and the use of new and more complex brachytherapy equipment such as remote afterloaders, are believed to be the principal causes for the increasing trend.

As a result of the revised definition of misadministration, a new category of misadministration, *sodium iodide misadministrations*, was created to better categorize the misadministrations involving I-125 and I-131 procedures. Seven sodium iodide

Table 3.5 Number of Misadministration Reports Submitted by NRC Licensees for 1987–1992

Type of Misadministration	1987*	1988	1989	1990	1991	1992*	Total	Average
*Therapy*****								
Teletherapy	6	5	4	10	3	16	44	7.3
Brachytherapy	3	5	5	8	11	13	45	7.5
Radiopharmaceutical	0	2	1	6	5	0	14	2.3
						(2)**		
Sodium Iodide Diagnostic	–	–	–	–		7**	7	7.0***
I-131******	5	7	10	13	14	–	49	9.8
						(5)**		
Other	409	386	397	430	430	*****	2052	410.4
Total	423	405	417	467	463	36	2211	368.5
No. of Patients	459	470	486	573	520	52	2560	426.7

*In 1987 and again in 1992, the reporting requirements were revised.

**Data in parentheses represent the distribution of the seven sodium iodide events as they would be grouped based on the previous definition of misadministration.

***Sodium iodide is a new category of misadministrations in the 1992 revised definition of a misadministration. Therefore, there is only one year of data making the average equal to the 1992 total.

****Five of these therapeutic misadministrations reported in 1992 occurred before the effective date of the 1992 rule change (January 27, 1992). One of these five misadministrations does not meet the current definition of misadministration.

*****The 22 diagnostic misadministrations reports submitted prior to January 27, 1992 were not included because they did not meet the new criteria for misadministrations promulgated by the revised rule. No diagnostic misadministrations were reported by the NRC licensees after January 27, 1992, under the new criteria.

******This category of misadministrations no longer exists in the revised misadministrations rule.

misadministration events were reported in 1992. Table 3.5 also indicates what the distribution would have been without the implementation of the QM rule, two radiopharmaceutical therapeutic misadministrations and five I-131 diagnostic misadministrations. The five sodium iodide misadministrations, that would have been considered I-131 diagnostic misadministrations under the old rule, represents a reduction to about one-third of the number reported for 1991. To help understand this reduction in the number of reported events, the 14 I-131 diagnostic misadministrations reported in 1991 were reviewed using the new criteria. Of the 14 events, 12 would have still been considered misadministrations under the new criteria. This explains, in part, the lower rate of I-131 diagnostic misadministrations reported in 1992. The fewer events may also be the result of NRC initiatives to increase licensee awareness of misadministrations, which is discussed below.

The NRC staff has helped to enhance licensee awareness by conducting numerous workshops and meetings with professional societies as part of the QM rule making. In addition, NMSS newsletters, numerous NRC information notices and bulletins, and professional society publications describing NRC requirements, inspection results, examples of misadministration, and enforcement actions, have also contributed to increased licensee awareness.

1991 was the first year that Agreement States submitted information on misadministrations to NRC, which is voluntary. Nineteen Agreement States submitted reports for the first year; 3 of these States submitted their reports after the 1991 AEOD Annual Report was issued. For 1991, the Agreement States provided summaries on 19 therapeutic misadministrations: 3 teletherapy, 11 brachytherapy, and 5 radiopharmaceutical therapy misadministrations. In 1992, all 29 Agreement States submitted annual summaries. Six of the 29 Agreement States submitted 10 therapeutic misadministration reports in 1992. The 10 events reported in 1992 by all the Agreement States is less than the number of therapeutic misadministrations reported by the 19 Agreement States that provided summaries for 1991. The misadministrations reported for 1992 included three teletherapy misadministrations, six brachytherapy misadministrations, and one radiopharmaceutical therapeutic misadministration. The staff will continue to monitor the Agreement State data.

The misadministrations for both the NRC and Agreement State licensees might have been mitigated by establishing procedures that required patient chart review, verification of patient dose calculations, verification of the computer data, improved staff training, verification of the type of prescribed procedure, performance of surveys, improved radiation safety programs, identification of the correct anatomical treatment area, and improved licensee staff communication.

To prevent recurrence, the NRC and the Agreement State licensees took similar corrective actions. These included implementation of procedures established by the licensee's Quality Management Program to ensure:

- verification of the dose calculation
- verification of the written directive
- review of the patient's chart
- verification of the prescribed dose/dosage and procedure
- staff communication
- patient identification staff training
- compliance with the required radiation safety procedures

4 Review of Performance of NRC Materials Licensees, 1992

This section provides an overview of the operational performance of NRC materials licensees for 1992 as compared to that from 1987 through 1991.

NRC regulates the use, milling, and processing of nuclear materials to protect the health and safety of radiation workers and the general public. NRC achieves its objective by ensuring that licensees have qualified staff to adequately control the use and processing of nuclear materials. Inadequately controlled radioactive materials can result in excessive exposure to workers and/or the general public which could result in adverse health effects. NRC also regulates the use of byproduct materials in medical applications.

The primary concern is excess exposure to the whole body and/or critical organs that has the potential for causing cancer, or in cases of severe overexposures, even death. The potential for radiation-induced long-term genetic mutations is also an important consideration. Extremity or localized skin exposures (from hot particles) are a lesser health concern, but are still important to NRC in assessing how adequately byproduct materials are controlled.

One measure of licensees' performance to control regulated materials is the ability to limit the dose received by monitored employees. Material licensees are required to monitor all employees who work with, or may be present in the vicinity of nuclear materials, and who have the potential for radiation exposure. The licensees are also required to monitor and control activities that can lead to exposing their employees or the general public to radiation.

Lost or stolen radioactive materials sometimes lead to unintended personnel exposures. Information on leaking sources can provide insights on design deficiencies or problems with handling specific sources, both of which can 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 radiation exposure. In accordance with the applicable regulations, NRC requires licensees to submit reports on events which meet established criteria. In addition, the licensees are subject to citation for violations of applicable regulations or failure to meet their license conditions.

The major problem with the use of radioactive material in medical applications arises from either the licensee's failure to effectively control a licensed material or from other human errors, such as dispensing a radiopharmaceutical that does not comply with a physician's prescription. This can result in a patient receiving an excessive or non-prescribed dose or a dose to the wrong treatment site. Occasionally, a radiopharmaceutical is administered to the wrong patient. Excessive exposures to monitored employees and uncontrolled exposures to the general public are also a concern in the medical use of radioactive materials. However, such incidents are relatively rare considering that hundreds of thousands of procedures are performed each year.

4.1 Radiation Exposure

People are exposed to naturally occurring radiation and to radiation from man-made applications of radioactive materials including: medical diagnosis and therapy, industrial and commercial activities, nuclear production of electricity, environmental radiation other than naturally occurring sources, and consumer products.[1] According to the National Council on Radiation Protection and Measurements,[2] the total average effective dose-equivalent to a person in the United States is approximately 3.6 mSv (360 mrem) per year. About 1.0 mSv (100 mrem) per year comes from natural background radiation, excluding radon. The importance of naturally occurring radon as the largest source of human exposure, about 2.0 mSv (200 mrem) per year, has only recently received public attention. The average person in the United States receives an effective dose-equivalent of about 0.5 mSv (50 mrem) per year from medical applications. The entire fuel cycle, including reactor operation, contributes less than 0.01 mSv (1 mrem) per year. All the other man-made sources of radiation add up to approximately 0.06 mSv (6 mrem) per year effective dose-equivalent.

[1] Weapons production activities are excluded from discussions in this report.

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

NRC is responsible for regulating both the reactor and the nonreactor applications of nuclear materials. All nuclear material licensees are required to provide radiation monitoring equipment to each individual who has the potential of receiving a dose in any calendar quarter in excess of 25 percent of the allowable limits specified in Part 20 of Title 10 of the *Code of Federal Regulations* (10 CFR Part 20), "Standards for Protection Against Radiation." The performance of power reactors is discussed in NUREG-1272, Vol. 7, No. 1, "Office for Analysis and Evaluation of Operational Data 1992 Annual Report, Power Reactors." That report also compares the performance of power reactors with the performance of material licensees. A more detailed analysis of the NRC material licensee performance is given below.

4.2 Performance of Material Licensees

The personnel exposure data from 1987 through 1992, are given in Tables 4.1 through 4.5 for five categories of material licensees: (1) industrial radiography, (2) manufacturing and distribution, (3) low-level waste disposal, (4) independent spent fuel storage, and (5) fuel fabrication and processing. Exposure data for the Agreement State licensees are not included in these tables because the Agreement States are not required to supply this information to NRC. Because licensees and Agreement States submit revisions, late reports, or retractions, data are updated as appropriate. These changes may cause discrepancies in the data published from year to year. Tables 4.1 through 4.5 include the latest data available and, therefore, may include minor changes from the data presented in the Power Reactor part (NUREG-1272, Vol. 7, No. 1).

As can be seen from these tables, NRC radiography licensees have the highest collective dose (15.4 person-Sv [1540 person-rem] to 4582 individuals) for 1992, followed by manufacturers and distributors (4.6 person-Sv [461 person-rem] to 3779 individuals), fuel fabrication and processing licensees (2.4 person-Sv [237 person-rem] to 3772 individuals), low-level waste disposal licensees (270 person-Sv [27 person-rem] to 467 individuals), and independent spent fuel storage licensees (110 person-Sv [11 person-rem] to 279 individuals) who have relatively low collective doses.

Fuel fabrication and processing licensees were the only group of licensees that showed an appreciable increase in the average dose to a worker in 1992, even though it is generally lower than the other monitored categories. Compared to 1991, the number of individuals monitored by fuel fabrication and processing licensees decreased by about 70 percent in 1992. This sudden decrease reflects the closing of

Table 4.1 Annual Exposure Data for NRC Industrial Radiography Licensees, 1987–1992*

Year	No. of Licensees	No. of Monitored Individuals	No. of Workers With Measurable Doses	Collective Dose Person-Sv (Person-rem)	Average Individual Dose mSv (mrem)	Average Measurable Dose per Worker mSv (mrem)
1987	312	7236	4454	18.4 (1835)	2.5 (250)	4.1 (410)
1988	286	6878	4223	19.8 (1981)	2.9 (290)	4.7 (470)
1989	276	6745	4352	20.7 (2067)	3.1 (310)	4.7 (470)
1990	258	6523	4458	21.2 (2120)	3.3 (330)	4.8 (480)
1991	248	6820	4649	21.6 (2160)	3.1 (310)	4.6 (460)
1992	156	4582	3005	15.4 (1540)	3.4 (340)	4.6 (460)

*Radiation Exposure Information Report System (REIRS) funded by NRC's Office of Nuclear Regulatory Research (RES).

Table 4.2 Annual Exposure Data for NRC Manufacturing and Distribution Licensees, 1987–1992*

Year	No. of Licensees	No. of Monitored Individuals	No. of Workers With Measurable Doses	Collective Dose Person-Sv (Person-rem)	Average Individual Dose mSv (mrem)	Average Measurable Dose per Worker mSv (mrem)
1987	24	3589	2317	7.2 (716)	2.0 (200)	3.1 (310)
1988	16	2177	868	3.4 (343)	1.6 (160)	4.0 (400)
1989	48	4554	2345	7.7 (770)	1.7 (170)	3.3 (330)
1990	55	4195	2272	6.9 (693)	1.7 (170)	3.1 (310)
1991	58	4930	1956	7.2 (721)	1.5 (150)	3.7 (370)
1992	55	3779	1363	4.6 (461)	1.2 (120)	3.4 (340)

*Radiation Exposure Information Report System (REIRS) funded by RES.

Table 4.3 Annual Exposure Data for NRC Low-Level Waste Disposal Licensees, 1987–1992*

Year	No. of Licensees	No. of Monitored Individuals	No. of Workers With Measurable Doses	Collective Dose Person-Sv (Person-rem)	Average Individual Dose mSv (mrem)	Average Measurable Dose per Worker mSv (mrem)
1987	2	778	173	240 (24)	0.3 (30)	1.4 (140)
1988	2	864	171	270 (27)	0.3 (30)	1.6 (160)
1989	2	925	119	350 (35)	0.4 (40)	2.9 (290)
1990	2	784	115	260 (26)	0.3 (30)	2.3 (230)
1991	2	905	147	390 (39)	0.4 (40)	2.7 (270)
1992	2	467	82	270 (27)	0.08 (8)	3.3 (450)

*Radiation Exposure Information Report System (REIRS) funded by RES.

4 of the 11 fuel facilities and the general decrease in production requirements for the remaining 7 facilities. Of the 3772 individuals monitored in 1992, a higher fraction (44 percent) received a measurable dose than 11,702 monitored in 1991 (34 percent). For fuel facilities, these changes have resulted in a lower

Table 4.4 Annual Exposure Data for NRC Independent Spent Fuel Storage Licensees, 1987–1992*

Year	No. of Licensees	No. of Monitored Individuals	No. of Workers With Measurable Doses	Collective Dose Person-Sv (Person-rem)	Average Individual Dose mSv (mrem)	Average Measurable Dose Per Worker mSv (mrem)
1987	2	129	64	410 (41)	3.2 (320)	6.4 (640)
1988	2	217	57	250 (25)	1.2 (120)	4.4 (440)
1989	2	190	102	330 (33)	1.7 (1.70)	3.3 (330)
1990	2	56	22	60 (6)	1.1 (110)	2.7 (270)
1991	2	41	24	40 (4)	1.0 (100)	1.7 (170)
1992	2	279	84	110 (11)	0.4 (40)	1.3 (130)

*Radiation Exposure Information Report System (REIRS) funded by RES.

Table 4.5 Annual Exposure Data for NRC Fuel Fabrication and Processing Licensees, 1987–1992*

Year	No. of Licensees	No. of Monitored Individuals	No. of Workers With Measurable Doses	Collective Dose Person-Sv (Person-rem)	Average Individual Dose mSv (mrem)	Average Measurable Dose Per Worker mSv (mrem)
1987	10	10,370	3994	5.1 (514)	0.5 (50)	1.3 (130)
1988	10	11,994	3869	4.6 (455)	0.4 (40)	1.2 (120)
1989	8	11,583	2992	2.4 (243)	0.2 (20)	0.8 (80)
1990	11	14,505	3871	4.2 (422)	0.3 (30)	1.0 (100)
1991	11	11,702	3929	3.8 (378)	0.3 (30)	1.1 (110)
1992	7	3772	1654	2.4 (237)	0.6 (60)	1.4 (140)

*Radiation Exposure Information Report System (REIRS) funded by RES.

collective dose and a higher average dose per person in 1992 than in 1991. The decreasing trend in the number of individuals monitored and the individuals that receive a measurable dose is generally consistent among all the other licensee types, except for independent spent fuel storage licensees. There are only two independent spent fuel storage licensees, but their number of monitored individuals in-

creased from 41 in 1991 to 279 in 1992. The number of employees receiving measurable doses increased from 24 to 84, while the average individual dose decreased.

Over the 6-year period, 1987 through 1992, the average measurable dose declined for independent spent fuel storage licensees, and has remained relatively constant for radiography, fuel fabrication and processing, and manufacturing and distribution licensees. For the low-level waste disposal licensees, the average measurable dose per person has been increasing slowly during this period.

For 1992, of the five categories of material licensees that report collective radiation exposures for monitored individuals, industrial radiography has the highest average measurable dose per worker. For each category of licensee, including industrial radiography, the average measurable dose per worker is far below the allowable limits established in 10 CFR Part 20.

4.3 Material Licensee Overexposures, 1987–1991

A second measure of licensee performance to control regulated materials is by monitoring the number and the extent of overexposures reported by licensees. Overexposures in reactor applications are discussed in the AEOD "1992 Annual Report, Reactor," NUREG-1272, Vol. 7, No.1. The number of reports from, and the number of occupational overexposures in, NRC-licensed facilities for power reactors and material licensees for the years 1987 through 1992 are listed in Table 4.6. Data for Agreement States are not included in this table because this information is not readily available. As can be seen, more people receive occupational overexposures from materials applications in 1992 than from being at reactor sites.

NRC and the Agreement States set and enforce limits for exposure to radiation workers and the public. The exposure limits for occupational workers are based on a desire to minimize occupational exposure, to limit the potential for adverse health effects. Although these workers, whose occupation involves work with or in the vicinity of nuclear materials, have accepted the risk of low-level exposure at the licensee's facility, licensees have programs to ensure that doses are as low as reasonably achievable (ALARA). The licensee's ability to achieve ALARA is a measure in their ability to control their licensed materials. Monitoring radiation workers provide a quantitative measure of exposure to each radiation worker and a means of evaluating licensee performance in this area.

Members of the public are not expected to receive benefit by unintended exposure to radiation. A member of the public receiving a whole body

Table 4.6 Number of Occupational Overexposure Events Reported by Reactor and NRC Materials Licensees, 1987–1992*

Type of Licensee	1987		1988		1989		1990		1991		1992	
	Reports	People	Reports	People	Reports	People	Reports	People	Reports	People	Reports	People
Reactors	5	5	6	7	1	1	1	1	0	0	5	5
Medical/ Academic	4	4	6	6	3	5	3	3	3	3	3	3
Radiography	2	2	3	3	4	5	6	8	2	2	1	1
Commercial/ Industrial	2	2	3	3	1	1	1	2	1	1	2	2
Fuel cycle	1	2	1	1	0	0	0	0	0	0	0	0
Other	2	2	3	4	1	1	0	0	1	1	0	0

*Radiation Exposure Information Report System (REIRS) funded by RES

Note: Occupational overexposures exclude exposures to patients and the general public

exposure that exceeds 10 CFR Part 20 limits may possibly be subjected to an increased risk of stochastic effects (e.g., cancer, genetic effects). Thus a whole body exposure of 5 mSv (0.5 rem) in any calendar year may demonstrate a significant failure of the radiation protection program and may indicate that the licensee has lost some control of radioactive materials; thus, such an exposure warrants reporting to Congress as an abnormal occurrence (AO). These reported exposures are estimates based on best available information and are not verifiable.

Patients are deliberately exposed to radiation for medical diagnosis and therapy. There are anticipated intrinsic benefits to the individuals undergoing these procedures. The doses used for therapeutic purposes in treating cancer are customarily at the limits of tolerance. Since the radiation doses directly kill cells, deterministic effects (harmful health effects in which the severity varies with the dose and for which a threshold is believed to exist, e.g., cataracts, organ damage, etc.) might be expected within the radiation dose prescribed by the physician authorized to do so. Some of the tissue outside the target area is expected to be irradiated, but members of the public and people who work with these patients should not be exposed to this radioactivity. The prescribed doses used for medical applications (diagnostic and therapeutic) are not regulated by NRC or Agreement States. However, NRC and Agreement States regulate certain aspects of reactorproduced radioisotopes in nuclear medicine and therapeutic radiology applications pursuant to 10 CFR Part 35, "Medical Use of Byproduct Material." In almost all cases, these planned doses exceed the AO reporting criteria for exposures of members of the public and may frequently exceed the AO reporting criteria for occupationally exposed individuals.

In general, the NRC determines whether an event is an AO by using the criteria promulgated in an NRC policy statement published in the *Federal Register* on February 24, 1977 (42 *FR* 10950). That policy statement contained no examples of medical misadministrations. NRC published misadministration reporting requirements in 1980 (10 CFR Part 35). In 1981, the Commission developed AO guidelines for medical misadministrations that were in effect for about two years. On the basis of the two-year experience using these guidelines, the Commission decided to revise the guidelines again. The staff amended an NRC Management Directive on July 18, 1984, to incorporate the revised guidance. The current guidelines for reporting events as AOs use different criteria for exposure of a member of the general public, exposure of an occupationally exposed individual, and exposure of a patient to a medical misadministration. As mentioned previously, the threshold of 5 mSv (0.5 rem) whole body dose for a member of the public is based on a possible increased risk of stochastic effects due to loss of control of radioactive material. The thresholds for occupationally exposed workers of 250 mSv (25 rem) whole body, 1500 mSv (150 rem) to the skin of the whole body of an individual, or 3750 mSv (375 rem) to the feet, ankles, hands, or forearms of any individual, are based, in part, on these same risks, but primarily on the fact that such overexposures may demonstrate a major failure of the radiation protection program. On the other hand, patients are deliberately exposed to radiation for diagnostic or therapeutic (treat disease, alleviate pain, or minimize spread of disease) purposes. The doses used for therapeutic purposes in treating cancer are customarily at the limits of tolerance for normal tissue, and therefore, since the radiation doses directly kill cells, harmful effects might be expected within the radiation dose prescribed. The difference between the intended and the misadministered dose of radiation has little added effect on long-term risk because high doses of radiation are more likely to kill cells than to cause cancer or mutations. Therefore, the threshold for reporting an AO is at doses that may result in major adverse effects that exceed the expected short-term clinical outcome. In addition, misadministrations involving two or more patients attributable to a single cause may signify a programmatic failure that might lead to an unacceptable risk, and hence, warrants reporting to Congress as an AO. The AOs are for 1992 discussed in Section 5, which follows.

4.4 NRC Initiatives

As noted earlier, in 1992, as well as in the preceding five years, the industrial radiography licensees had the highest individual and collective average exposures. The radiological problems of industrial radiography have been recognized for many years. In September 1982, NRC published a special guidance/training document for radiographers, NUREG/

BR-0024, "Working Safely in Gamma Radiography."

As part of operational experience feedback, the AEOD staff prepared two video-tapes: "Good Practices in Preparing and Administering Radiopharmaceuticals," and "Good Practices in Co-60 Teletherapy"; these were distributed in February 1992 and April 1993, respectively. Copies of these videos were sent to each NRC medical licensee and to the NRC Office of State Programs who provided copies to the Agreement State licensees. A third videotape is being produced on good work practices for radiographers. This videotape will demonstrate "lessons learned" through reenactment of radiography overexposure incidents reported to the NRC. The video, "Taking Control: Safety Procedures for Industrial Radiography," is scheduled to be completed by the end of 1993. The staff has been preparing the videotapes with support from Argonne National Laboratories.

5 Abnormal Occurrences

The Office for Analysis and Evaluation of Operational Data (AEOD) prepares the quarterly "Report to Congress on Abnormal Occurrences," NUREG-0090. This effort requires coordinating staff activities and review, submitting the report to the Commission for approval, and publishing two *Federal Register* notices. The quarterly report may include recurring events, generic concerns, or other incidents that the Commission determines to be significant to the public health and safety.

The four abnormal occurrence (AO) reports published in calendar year 1992 included 16 medical misadministration incidents and one radiation overexposure incident. Fifteen of the medical misadministrations were reported by NRC licensees and one was reported by an Agreement State. An event involving radiation overexposure was reported by an NRC-licensed facility. Appendix C of this report includes summaries of the AOs. The AOs reported by NRC licensees included the following:

Medical Misadministrations

- A teletherapy misadministration that involved poor communication between personnel involved in the procedure.
- Two teletherapy misadministrations resulting from the wrong identification of the prescribed treatment site.
- Two teletherapy misadministrations resulting from an error in the dose calculation.
- A brachytherapy misadministration involving a failure to perform a survey prior to implantation and failure to promptly inventory sources upon removal.
- Two brachytherapy misadministrations involving a failure to properly train staff in handling brachytherapy sources.
- A brachytherapy misadministration involving difficulties in the ultrasound guided placement technique.
- Two brachytherapy misadministrations involving errors in computer data entries.
- A brachytherapy misadministration involving a failure to verify source strength.
- A brachytherapy misadministration involving a failure to perform surveys after completion of a brachytherapy procedure, and weakness in the licensee's radiation safety program.
- A brachytherapy misadministration involving a failure of the nursing staff to follow instructions for brachytherapy procedures.
- A radiopharmaceutical misadministration involving poor communication between staff and a referring clinic.

Radiation Overexposure

- Extremity overexposure of a radiographer that resulted from the failure of the radiographer to use an audible alarm exposure measuring device as required by NRC regulations.

AO for Agreement State Licensees

- The AO for Agreement State licensees was a diagnostic misadministration involving a technologist's confusion regarding the prescribed procedure.
- The AOs that occurred in 1992 at nuclear power plants and research reactors are summarized in Appendix B to the AEOD annual report on reactors (NUREG-1272, Vol. 7, No. 1, "Power Reactors").

6 Operating Experience Feedback

The Office for Analysis and Evaluation of Operational Data (AEOD) coordinates the collection, compilation, and analysis of reactor and nonreactor operational data. AEOD maintains a database of information form reports submitted on material events by the NRC licensees and annual summary reports submitted on nonreactor events by the Agreement States. The Agreement States began submitting annual reports on medical misdaministrations and other material events in 1991, the first year they were requested to report such information. However, since the Agreement States have begun to submit the data only for the past 2 years, the AEOD staff has analyzed only a limited amount of materials operational experience.

6.1 AEOD Studies

From 1982 through 1993, the AEOD staff has evaluated nonreactor operational experience reported by the NRC licensees, and has documented its findings and conclusions in several reports. In the past 11 years, AEOD published 6 case studies, 1 technical review report, 25 engineering evaluations, and 2 special study reports on medical misadministrations and other incidents (Appendix D).

6.2 Videotapes

As part of operating experience feedback, the AEOD staff prepared two videotapes discussed in Section 4 of this report.

7 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. The NRC implements the IIP to respond 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. For an event of lesser safety significance, the cognizant NRC Regional Administrator may establish an Augmented Inspection Team (AIT) to investigate the event. In addition, other NRC offices, including the Office of Nuclear Material Safety and Safeguards (NMSS), are responsible for reviewing AIT reports for generic safety implications, initiating followup actions, and tracking issues as appropriate. AEOD independently reviews AIT reports to provide additional assurance that potential generic lessons are learned and communicated to the industry.

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. The guidelines for administering incident investigative activities for the NRC are prescribed in NUREG-1303, "Incident Investigation Manual," which includes the procedure for conducting an AIT.

Of the approximately 300 reported nonreactor events during 1992, one event, involving the Indiana Regional Cancer Center, Indiana, Pennsylvania, was judged to have a sufficiently high level of safety significance to warrant an IIT investigation. An event at a Nuclear Fuel Service Inc. facility was also judged to be safety significant, but only at a sufficient level to warrant an AIT.

Appendix F presents the status of staff actions for previously performed IITs, as assigned by the EDO to the various NRC offices.

7.1 Incident Investigation Team Events

On December 1, 1992, the Indiana Regional Cancer Center reported to NRC's Region I that it believed a 1.37E+11-becquerel (3.7-Curie) iridium-192 source from its Omnitron 2000 high-dose-rate remote brachytherapy afterloader had been found at a transfer station for biohazard waste in Carnegie, Pennsylvania. After notifying the NRC, this cancer center, one of several operated by the licensee, Oncology Services Corporation, retrieved the source, and Region I dispatched an inspector and a supervisor to investigate the event.

The source was first detected when it triggered radiation alarms at a waste incinerator facility in Warren, Ohio. The licensee informed the NRC that the source wire had apparently broken during treatment of a patient on November 16, 1992, and that the source remained in the patient for approximately 5 days. Recognizing the severity of the incident, the NRC responded by sending an IIT, which completed its investigation in February 1993 and issued NUREG-1480, "Loss of an Iridium-192 Source and Therapy Misadministration at Indiana Regional Cancer Center, Indiana, Pennsylvania, on November 16, 1992."

The IIT concluded that the patient who died on November 21, 1992, received a severe misadministration and that more than 90 people were exposed to radiation from November 16 to December 1, 1992. In a press release dated January 26, 1993, the Indiana County Coroner stated that the cause of death listed in the official autopsy report was "acute radiation exposure and consequences thereof."

On December 7, 1992, an almost identical source wire failure occurred with an afterloader in Pittsburgh, Pennsylvania, but this time there were minimal radiological consequences. This incident was included in the investigation. In the report, the IIT discussed the failure of the source wire in the Omnitron 2000 high-dose-rate afterloader, the reasons why the failure was not detected by the Indiana Regional Cancer Center, the consequences to the patient, the estimated radiological doses to workers and the public, and regulatory aspects of this incident.

The team noted the following findings and conclusions concerning the event:

- The patient suffered severe radiological consequences and many members of the public suffered significant radiological consequences.
- Weaknesses in Oncology Services Corporation's radiation protection program were a contributing cause to the severity of the event and the consequences of radiation exposure.
- Weaknesses existed in the design and testing of the Omnitron 2000 remote afterloader system and its source wire.
- Oncology Services Corporation and Indiana Regional Cancer Center lacked critical safety awareness with respect to high dose rate brachytherapy.
- Overall regulatory oversight was weak.

The team concluded that no regulatory guidance existed for nonradioactive waste collectors. In addition, the Carnegie, Pennsylvania commercial waste disposal company, Browning-Ferris Industries, failed to adhere to its own radiation control policies.

In NUREG-1480, "Loss of an Iridium-192 Source and Therapy Misadministration at Indiana Regional Cancer Center, Indiana, Pennsylvania, on November 16, 1992," the team documented the inspection process, findings, and recommendations.

7.2 Augmented Inspection Team Events

Table 7.1 presents information on the two inspections conducted by AITs in 1992. On September 9, 1992, an AIT began an inspection at a facility licensed to Nuclear Fuel Services, Inc., where a chemical reaction and fire in a dissolver unit had occurred.

On June 8, 1992, facility operators removed a fuel element from the University of Michigan's (the licensee) Ford research nuclear reactor facility in Ann Arbor, Michigan while the reactor was critical. The event occurred while the licensee was conducting tests to measure changes in reactivity after moving fuel elements. The correct sequence was to (1) move the fuel while subcritical, (2) bring the reactor to low power, (3) collect data, and (4) shut down the reactor. The fuel was moved while the reactor was critical, contrary to procedure, because of poor communications and failure to follow procedures.

As a result of an AIT investigation of this event, the NRC issued Information Notice (IN) 92-73 "Removal of a Fuel Element From a Research Reactor Core While Critical," on November 4, 1992. The IN alerted licensees to the need for clear communications, the importance of following procedures, and the danger in operators becoming so involved in a task that they fail to maintain adequate control of the reactor.

Table 7.1 Events for which AITs were conducted, 1992

Event Date	Site	Event Description
6/17/92	University of Michigan	Removal of fuel elements from the reactor while critical
9/10/92	Nuclear Fuel Services	Chemical reaction and fire in a dissolver unit

8 Data From the Nuclear Regulatory Commission's Operations Center for 1992

The NRC Operations Center in Bethesda, Maryland, serves as the focal point for communicating with NRC 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.

In 1992, the NRC Operations Center received notifications in accordance with NRC's prompt notification requirements; 243 of these notifications were for events related to nuclear materials. These notifications included 66 fuel facility, 9 nonpower reactor, 58 hospital, 26 radioactive material, 25 transportation, and 59 miscellaneous nuclear materials events. Nine of these notifications involved events that the licensees classified under one of the four classes of emergencies: "Unusual Event," "Alert," "Site Area Emergency," or "General Emergency." Table 8.1 shows the distribution of events reported to the Operations Center in 1992.

Table 8.2 lists four events at NRC-licensed fuel facilities in which a Site Area Emergency (one event) or an Alert (three events) was declared. An event classified as a Site Area Emergency in the licensee's initial assessment 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. An event classified as an Alert indicates actual or potential substantial degradation of facility safety.

Actions taken by the NRC HOO in response to these notifications ranged from making a log entry and the 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 NRC's Incident Response Plan. In 1992, the NRC entered a Monitoring Mode during an event at Sequoyoh Fuels involving the offsite release of nitric acid fumes.

8.1 Number of Events Reported to the Operations Center in 1992

Event Types	Power Reactor	Fuel Facility	Non-Power Reactor	Hospital	Transport/ Materials	Other	Total
Non-emergency events	1886	59	7	58	51	59	2120
Unusual Event	130	3	2	0	0	0	135
Alert	17	3	0	0	0	0	20
Site Area Emergency	0	1	0	0	0	0	1
General Emergency	0	0	0	0	0	0	0
Total	2033	66	9	58	51	59	2276

Table 8.2 Site Area Emergency and Alert Events Reported at NRC-Licensed Fuel Facilities in 1992

Event	Event No.	Date	Description	Duration*	Response
Site Area Emergency					
Sequoyah Fuels	24616	11/17/92	Offsite release of nitric acid fumes	1 hr, 3 min	Monitoring
Alert					
Sequoyah Fuels	23383	05/01/92	Release of UF_2 at facility	2 hr, 34 min	Enhanced at region
B&W Fuels, Lynchburg	23879	07/15/92	Sounding of emergency evacuation alarm	1 hr, 10 min	N/A
B&W Fuels, Lynchburg	24086	08/21/92	Sounding of radiation alarm	1 hr, 32 min	N/A

*Time from commencement of to termination of emergency class
Notes: The NRC established a new response mode, called Monitoring Mode, on July 1, 1992. NA means not applicable.

Appendix A

Material Data by Event Type

A–1 NRC Licensee Events

A–2 Agreement State Licensee Events

Appendix A-1

NRC Licensee Events

NRC Licensee Events

Table A1-1A Personnel radiation overexposures, 1992

Licensee	Licensee Number	Location	Event Date	Number Exposed	Number of mSv	Type of Exposure
Alaron Corporation	372082601	Wampum, PA	12/18/92	1	241	Skin
Berthold Systems, Inc.	372122601	Hopewell, PA	07/01/92	1	5.75	Whole body
Beth Israel Hospital	290304701	Passaic, NJ	05/22/92	1	2720	Extremity
Health and Human Services, Dept. of	190029610	Bethesda, MD	11/17/92	1	480	Extremity
MQS Inspection, Inc.	120062207	Trenton, MI	07/06/92	1	4400	Extremity
Oncology Services Corporation	372854001	Indiana, PA	11/18/92	49		Multiple
University of Connecticut Health Center	061302202	Farmington, CT	08/28/92	1	276	Extremity
Yale-New Haven Hospital	060081903	New Haven, CT	02/26/92	1	420	Extremity

Table A1-1B Personnel radiation overexposure precursors, 1992

Licensee	License Number	Location	Event Date	Type of Exposure
Allied-Signal, Inc.	SUB-526	Metropolis, IL	01/11/92	Internal
Army, Department of the	290102214	Fort Monmouth, NJ	10/03/92	Whole body
Army, Department of the	120072206	Rock Island, IL	07/23/92	Unknown
Binax, Inc.	182816701	South-Portland, ME	02/12/92	Internal
H. J. Heinz Company	370053302	Pittsburgh, PA	06/18/92	Other
Health and Human Services, Department of	190029610	Bethesda, MD	06/16/92	Skin
Honolulu Medical Group	531642101	Honolulu, HI	11/16/92	Other
Indianapolis Power and Light	131721701	Petersburg, IN	08/19/92	Unknown
LFE Corporation	200138202	Clinton, MA	02/01/92	Extremity
Mallinckrodt, Inc.	240420601	Maryland Heights, MO	04/03/92	Unknown
Michigan, University of	210021504	Ann Arbor, MI	09/12/92	Other
Northern Michigan Hospitals	211673201	Petoskey, MI	04/03/92	Internal
Ponce I & M Engineering Labs	522490801	Cot Laure,PR	10/21/92	Other
Process Technology of North Jersey	291361302	Rockaway, NJ	11/30/92	Whole body
Pike Community Hospital	342140901	Waverly, OH	09/03/92	Internal
Polyclinic Medical Center	370035805	Harrisburg, PA	05/13/92	Other
Quivira Mining Company	SUA1473	Oklahoma City, OK	05/18/92	Internal
Rutgers University	290521831	New Brunswick, NJ	09/17/92	Extremity
Shadyside Hospital	370252303	Pittsburgh, PA	05/22/92	Whole body
St. Mary's Hospital	292059701	Orange, NJ	04/28/92	Whole body
University of Tulsa	350677606	Tulsa, OK	12/15/92	Other
Testing Technologies, Inc.	452500701	Woodbridge, VA	10/06/92	Other
Testwell Craig Laboratories	291915501	Fairfield, NJ	06/26/92	Other
University of Connecticut Health Center	061302202	Farmington, CT	04/23/92	Other
Veterans Administration Medical Center	311351105	Northport, NY	06/01/92	Whole body
Veterans Administration Medical Center	310289203	Brooklyn, NY	07/13/92	Other
Veterans Administration Medical Center	050140102	Denver, CO	09/28/92	Other
Wisconsin Industrial Testing	481748001	Brookfield, WI	01/11/92	Extremity

Table A1-2A Lost or stolen sources, 1992

Isotope*	Location	Licensee	License Number	Event Date	Probable Disposition
Am-241	Lathrup, CA	Army, Department of the	210122205	02/19/92	Found
Am-241	Indianapolis, IN	Alt & Witzig Engineering, Inc.	131868501	02/26/92	Found
Am-241	Indianapolis, IN	Alt & Witzig Engineering, Inc.	131868501	09/22/92	Unknown
Am-241	Indianapolis, IN	Atec Associates, Inc.	131773201	02/29/92	Found
Am-241	Greenbelt, MD	NASA	190574802	01/17/92	Other
Am-241	Kalamazoo, MI	Heart Institute of Michigan	211891201	12/15/92	Unknown
Am-241	Warren, MI	Army, Department of the	210122205	04/30/92	Found
Am-241	Warren, MI	Army, Department of the	210122205	02/19/92	Southeast Asia
Am-241	Lindenwold, NJ	Martin A. Ackley & Associates	292791101	05/01/92	Unknown
Am-241	Summit, NJ	Ciba-Geigy Corporation	290045903	08/18/92	Waste Hauler
Am-241	Cincinnati, OH	H.C. Nutting, Company	341888201	10/28/92	Unknown
Am-241	Columbus, OH	CTL Engineering, Inc.	341853301	02/24/92	Found
Am-241	Huber Heights, OH	Bowser-Morner, Inc.	341739001	05/24/92	Recovered
Am-241	Norristown, PA	E. L. Conwell & Co.	371763702	10/22/92	Found
Am-241	San Juan, PR	Caribbean Soil Testing Co.Inc	521790201	10/23/92	Found
Am-241	Green Bay, WI	Foth & Van Dyke Associates	481891602	05/14/92	Unknown
Am-241	La Crosse, WI	G. Heileman Brewing Co.	GL	06/05/92	Commercial Waste
Am-241	St. Albans, WV	Triad Engineering	471774201	09/23/92	Found
Am-241	Rock Spring, WY	Aspen Mountain, Inc.	492743201	04/08/92	Unknown
Ba-133	Youngstown, OH	St. Elizabeth Hospital Med. Ctr.	340113101	03/25/92	Unknown
C-14	Princeton, NJ	FMC Corporation	290103501	04/02/92	Commercial Waste
Cd-109	Gambier, OH	Kenyon College	341410901	09/16/92	Unknown
Co-60	Willimanti, CT	Windham Community Mem. Hosp.	061520301	03/12/92	Unknown
Co-60	Cleveland, OH	Advanced Medical Systems, Inc	341908901	04/03/92	Other
Cs-137	New Haven, CT	Yale-New Haven Hospital	060081903	11/30/92	Found
Cs-137	Marion, IN	Ogdon-Martin Systems	NL	10/13/92	Found in Scrap
Cs-137	Ann Arbor, MI	Michigan, University of	210021504	12/22/92	Unknown
Cs-137	Newbury, OH	Bicron Corporation	341384501	08/10/92	Commerrcial Waste
Cs-137	Dallas, TX	V. A. Medical Center	420022006	06/15/92	Found
DU	St. Louis, MO	Valentec Olivette	SUC1517	06/25/92	Found
H-3	Oakland, MI	Oakland University	211072503	07/30/92	Unknown
H-3	Cleveland, OH	V. A. Hospital	340020303	02/06/92	Unknown
H-3	Fairborn, OH	Red Roof Inn, #205	GL	06/06/92	Unknown
H-3	Allentown, PA	Air Products & Chemicals, Inc	370510507	03/27/92	Unknown

Table A1-2A (cont.)

Isotope*	Location	Licensee	License Number	Event Date	Probable Disposition
H-3	Madison, WI	Ben Heifetz Scrap Metal	NL	02/26/92	Scrap Metal
I-125	New Haven, CT	Yale University	060018303	07/15/92	Incineration
I-125	New Haven, CT	Yale University	060018303	01/15/92	Unknown
I-125	Gary, IN	Methodist Hospital of Gary, IN	131655801	10/01/92	Commercial Waste
I-125	Boston, MA	Boston University Medical Cnt	200221501	12/25/92	Down Toilet /Trash
I-125	Farmington, MI	Detroit Biomedical Lab.	211576603	09/01/92	Commercial Waste
I-125	Dayton, OH	St. Elizabeth Medical Center	340217601	12/04/92	Incineration
I-125	Dayton, OH	Miami Valley Hospital	340034106	01/23/92	Unknown
I-131	Honolulu, HI	St. Francis Medical Center	531196601	10/23/92	Found
I-131	Worcester, MA	Medical Center of Central MA	200245201	01/20/92	Found
I-131	Bethesda, MD	Navy, Department of the	452364501	08/28/92	Commercial Waste
I-131	Rahway, NJ	Rahway Hospital	291210901	03/03/92	Unknown
Ir-192	Tripler, HI	Army, Department of the	530045804	07/01/92	Unknown
Ir-192	Boston, MA	New England Medical Center	200385706 Hospital	11/03/92	Commercial Waste
Mo-99	Shreveport, LA	Veterans Administration Med.Ctr.	171227301	12/01/92	Commercial Waste
Ni-63	Greenbelt, MD	Agriculture, Dept. of	190091506	09/07/92	Unknown
Ni-63	Avondale, PA	Hewlett Packard	370700202	04/08/92	Unknown
Ni-63	Avondale, PA	Hewlett Packard	370700202	07/08/92	Unknown
P-32	Ann Arbor, MI	Michigan, University of	210021504	08/11/92	Commercial Waste
P-32	Philadelphia, PA	Lankenau Hospital	370790504	11/06/92	Incineration
Po-210	Indianapolis, IN	United Medical Manufacturing	GL	03/13/92	Unknown
Po-210	Kokomo, IN	Delco Electronics	GL	02/24/92	Unknown
Po-210	Fall River, MA	Globe Manufacturing	GL	09/21/92	Unknown
Po-210	Evart, MI	Evart Products Company	GL	10/28/92	Unknown
Po-210	Evart, MI	Evart Products Company	GL	01/23/92	Unknown
Po-210	Chaska, MN	Olsen Tool and Plastics	GL	02/04/92	Commercial Waste
Pu-239	England AFB, LA	Air Force, Department of the	422353901	10/29/92	Commercial Waste
SNM	Harrisburg, PA	Syncor Corporation	371958601	01/01/92	Commercial Waste
Sr-90	Fort Monmouth,NJ	Army, Department of the	290102214	01/09/92	Found
Sr-90	Aguadilla, PR	Marten-Ellis Md., Newton	521637601	05/06/92	Unknown
Sr-90	San Antonio, TX	Air Force, Department of the	422353901	10/24/92	Unknown

Table A1-2A (cont.)

Isotope*	Location	Licensee	License Number	Event Date	Probable Disposition
Tc-99m	Honolulu, HI	Pacific Radiopharmacy	531699101	12/04/92	Commercial Waste
Tc-99m	Wahiawa, HI	Wahiawa General Hospital	531783901	11/26/92	Found
Tc-99m	Woburn, MA	Syncor Corporation	202122701	06/23/92	Found
Tc-99m	St. Louis, MO	Mallinckrodt, Inc.	241745001	04/06/92	Unknown
Tc-99m	Toledo, OH	Riverside Hospital	341323401	02/01/92	Incineration
Tc-99m	Bloomsburg, PA	Del-Med, Inc.	NL	03/08/92	Found
Tc-99m	Sharon, PA	Del-Med, Inc.	NL	05/11/92	Found
Tc-99m	Rice Lake, WI	Shared Medical Technology	481754301	01/28/92	Found
U	Henderson, KY	Hi-Rail	NL	10/16/92	Found
Xe-133	Anchorage, AK	Anchorage Diagnostic Imaging	502321401	04/27/92	Unknown
Xe-133	Jessup, MD	Dupont Merck Pharmaceutical	202859801	11/02/92	Unknown
Z	Bourbonnai, IL	Birmingham Steel Corporati	NL	03/19/92	Found
Z	Columbus, IN	Como Plastics Corporation	GL	02/17/92	Unknown
Z	Michigan C, IN	Fostereprints	GL	01/15/92	Other
Z	Terre Haute, IN	Digital Audio Disc Corp.	GL	02/11/92	Unknown
Z	Battle Creek, MI	Lafarge Corporation	212582301	04/08/92	Found
Z	Farmington, MI	Kenco Plastics, Inc.	GL	01/28/92	Unknown
Z	Royal Oak, MI	William Beaumont Hospital	210133301	09/03/92	Found
Z	Warren, MI	Army, Department of the	210122205	04/03/92	Found
Z	Clark, NJ	AT&T	GL	09/09/92	Unknown
Z	Newark, NJ	St. James Hospital	291299701	04/24/92	Found
Z	Pitman, NJ	Decorating Resources Inc.	GL	12/03/92	Commercial Waste
Z	Ridley Park, PA	Taylor Hospital	371650702	04/20/92	Unknown

*DU indicates depleted uranium, SNM indicates special nuclear material, Z indicates unspecified

Table A1-2B Abandoned well-logging sources, 1992

Isotope	Location	Licensee	License Number	Event Date
Am-241	Offshore, LA	Schlumberger Technology Corp.	420000003	11/17/92
Am-241	Offshore, LA	Schlumberger Technology Corp.	420000003	12/20/92
Am-241	Offshore, LA	Schlumberger Technology Corp.	420000003	02/20/92
Am-241	Offshore, LA	Schlumberger Technology Corp.	420000003	01/15/92
Am-241	Offshore, LA	Schlumberger Technology Corp.	420000003	03/18/92
Am-241	E. Cammeron, TX	Sperry-Sun Drilling Services	422684401	12/06/92
Cs-137	Offshore, LA	Halliburton Logging Services	420106807	06/10/92
Cs-137	Offshore, LA	Halliburton Logging Services	420106807	01/15/92

Table A1-3 Leaking sources, 1992

Isotope	Location	Licensee	License Number	Event Date	Manufacturer /Model
Am-241	Columbus, OH	ABB Process	340025503	12/28/92	Amersham/S-16
Cd-109	Waltham, MA	Panametrics, Inc.	200718101	06/24/92	New England Nuc./465
Co-60	Lima, OH	St. Rita's Medical Ctr.	341210001	03/07/92	Neutron Products, Inc.
Cs-137	Burlington, MA	Amersham Corporation	201283601	10/22/92	Amersham/ 77302
Cs-137	Mount Pleasant, MI	Central Michigan University	210143202	06/15/92	Unknown
Cs-137	Atlantic City, NJ	Atlantic City Medical Center	290862204	02/27/92	Nuclear Associates
Cs-137	Norfolk, VA	Depaul Medical Center	450098601	06/22/92	Nuclear Assoc./67805
H-3	Rock Island, IL	Army, Department of the	120072206	07/14/92	Unknown
H-3	Fort Bragg, NC	Army, Department of the	120072204	06/03/92	Unknown
Ni-63	Winchester, MA	Health and Human Services, Department of	200836101	01/15/92	Perkin-Elmer/ 6000 204
Ni-63	Univ. Park, PA	Pennsylvania State University	370011811	04/06/92	NRD/1001
Ni-63	West Point, PA	Merck Sharp & Dohme Res. Labs	290011706	06/19/92	Unknown
Ni-63	Lionville, PA	Roy F. Weston, Inc.	371937801	06/23/92	Hewlett Packard
Ni-63	Avondale, PA	Hewlett Packard	370700202	07/28/92	Unknown
Ni-63	Avondale, PA	Hewlett Packard	370700202	09/22/92	Hewlett Packard/19233
Sr-90	Buchanan, NY	New York Power Authority		02/19/92	Eberline/DA1-8
Tc-99m	Waltham, MA	Panametrics, Inc.	200718101	10/05/92	Unknown

Table A1-4 Radiography events, 1992

Isotope*	Location	Licensee	License Number	Event Date	Section of 10 CFR
DU	Palmas, PR	Alonso & Carus Iron Works, Inc.	522135001	02/26/92	34.30
Ir-192	Groton, CT	General Dynamics Corp.	060178108	11/19/92	34.30
Ir-192	Elk Grove, IL	MQS Inspection, Inc.	120062207	06/06/92	34.30
Ir-192	Natick, MA	Conam Inspection, Inc.	200107403	09/01/92	34.30
Ir-192	Minneapolis, MN	Braun Intertech Engineering	221653702	02/19/92	34.30
Ir-192	Rosemount, MN	Twin City Testing	220137602	09/22/92	34.30
Ir-192	St Paul, MN	Twin City Testing	220137602	07/23/92	34.30
Ir-192	St. Paul, MN	Twin City Testing	220137602	03/06/92	34.30
Ir-192	Cleveland, OH	Herron Testing Laboratories	340068103	10/22/92	34.30
Ir-192	North Canton, OH	Glitsch Field Service/NDE, Inc.	341407101	05/12/92	34.30
Ir-192	Newport News, VA	Newport News Shipbuilding	450942802	08/04/92	34.30
Ir-192	Eau Claire, WI	Twin City Testing	220137602	06/19/92	34.30
Z	Durango, CO	H & G Inspection Company	422683801	01/08/92	34.30
Z	Paradis, LA	Eagle Inspection and Testing	172683101	03/05/92	34.33
Z	Burlington, MA	Amersham Corporation	201283601	03/11/92	21.21
Z	Kansas, MO	Piping Specialists, Inc.	242442601	04/22/92	34.33
Z	Port Reading, NJ	Canspec Testing, Inc.	292865901	04/23/92	34.33
Z	Louisville, OH	Sam-Son Inspection & Technical	342589801	05/03/92	34.30

*DU indicates depleted uranium, Z indicates unspecified

Table A1–5 Medical events, 1992

Isotope*	Location	Licensee	License Number	Event Date	Type of Event**
Co–60	Indianapolis, IN	Indiana University Med. Ctr.	130275208	09/10/92	TPY
Co–60	Bronx, NY	Veterans Administration Medical Center	310063602	04/09/92	TPY
Co–60	Lawton, OK	Southwestern Medical Center	351066901	06/18/92	TPY
Co–60	Beaver, PA	Triangle Radiation Oncology Association	372075801	10/21/92	TPY
Co–60	Lackland, TX	Air Force, Department of the	422353901	03/04/92	TPY
Co–60	Lackland, TX	Air Force, Department of the	422353901	06/22/92	TPY
Co–60	Lynchburg, VA	Virginia Baptist Hospital	451054202	03/02/92	TPY
I–131	Lewiston, ID	St. Joseph Regional Medical	112737101	07/08/92	RLM
I–131	Philadelphia, PA	Hahneman University	370046734	10/07/92	RLM
I–131	Temple, TX	Veterans Affairs, Department of	471073903	04/08/92	MSC
Tc–99m	Williamsport, PA	Williamsport Hospital	370418501	02/24/92	MSC
Tc–99m	Hato Rey, PR	Hato Rey Community Hospital	521770401	03/30/92	MSC
Xe–133	Alexandria, VA	Alexandria Hospital	450935802	02/27/92	MSC
Z	Norristown, PA	Montgomery Hospital	371211002	12/03/92	MSC

*Z indicates unspecified
**MSC indicates miscellaneous, RLM indicates release of materials, TPY indicates teletherapy malfunction

Table A1-6 Manufacturing and distribution, 1992

Isotope*	Location	Licensee	License Number	Event Date	Type of Event**
Am-241	Minneapolis, MN	Inspec, Inc.	222480901	03/19/92	DOT
Am-241	Albuquerque, NM	Troxler Electronics Lab.	320599803	06/09/92	Accident
I-125	Boston, MA	Whitehead Institute	200153702	04/01/92	DOT
I-125	Fort Atkinson, WI	Norland Corporation	481340301	05/05/92	DOT
I-131	Glen Ellyn, IL	MPI Pharmacy Services, Inc.	482624001	06/23/92	DOT
SNM	San Jose, CA	General Electric Co.	SNM-1270	08/13/92	Levels
SNM	Erwin, TN	Nuclear Fuel Services	SNM-124	02/24/92	DOT
Tc-99m	Cincinnati, OH	MPI Pharmacy Services, Inc.	342623901	07/24/92	Other
Tc-99m	Milwaukee, WI	MPI Pharmacy Services, Inc.	482624001	12/01/92	Levels
Tc-99m	Jackson, WY	St. John's Hospital	491827601	05/23/92	Levels
U	Fernald, OH	Energy, Department of	461217801	03/26/92	Other
U	Barnwell, SC	Ranger Transportation	NL	06/03/92	Other
Z	Danbury, CT	Nuclear Energy Services	062077501	01/09/92	DOT
Z	Waterford, CT	Millstone Nuclear Unit 1	DPR-21	07/20/92	Levels
Z	Tulsa, OK	Burlington Northern Railroad	NL	04/17/92	DOT
Z	Mount Pleasant, PA	Frick Community Health Center	371708001	02/11/92	Levels

*SNM indicates special nuclear material, Z indicates unspecified
**Accident indicates vehicle accident, DOT indicates failure to follow Department of Transport Regulations, Levels indicates packages with high levels of radiation or contamination

Table A1-7 Gauge events, 1992

Isotope*	Location	Licensee	License Number	Event Date	Event Type**
Am-241	Waterton, CO	Canonie Environmental Services	131614302	09/23/92	Portable Damaged
Am-241	Indianapolis, IN	Howard, Needles, Tammen & Bergendoff	132342501	06/19/92	Portable Damaged
Am-241	Ann Arbor, MI	Midwestern Consulting, Inc.	212600201	06/09/92	Portable Damaged
Am-241	Saginaw, MI	Geo-Test Ltd.	212587001	09/12/92	Portable Damaged
Am-241	Jefferson, MO	Missouri Highway and Transportation	242041501	06/10/92	Portable Damaged
Am-241	St. Louis, MO	Geotechnology, Inc.	242445901	10/01/92	Portable Damaged
Am-241	St. Peters, MO	Soil Consultants, Inc.	242003901	04/28/92	Portable Damaged
Am-241	Cincinnati, OH	Ohio, Department of Transportation	340523901	06/29/92	Portable Damaged
Am-241	Scottsdale, PA	Donohue & Associates, Inc.	481860802	06/30/92	Portable Damaged
Am-241	Clarksburg, WV	Test Well Craig Peters	312145601	06/12/92	Portable Damaged
Co-60	Marion, OH	Marion Steel Company	342112301	09/09/92	Fixed Damaged
Cs-137	Cleveland, OH	G. R. Osterland Company	342603701	10/02/92	Portable Damaged
Cs-137	Franklin, OH	Georgia-Pacific Corporation	341753201	03/04/92	Malfunction
Cs-137	Danville, PA	Merck & Co., Inc.	370195103	03/30/92	Malfunction
Cs-137	Johnstown, PA	Pennsylvania Electric Co.	370683603	03/09/92	Fixed Damaged
Cs-137	Hato Rey, PR	Geo Cim, Inc.	521777602	04/15/92	Portable Damaged
Cs-137	El Paso, TX	Border Steel	NL	05/22/92	Melted in Scrap
Cs-137	Racine, WI	J. I. Case Company	481560903	04/22/92	Other
Cs-137	WI Rapids, WI	Consolidated Papers, Inc.	480111701	01/11/92	Malfunction
Fe-55	Kokomo, IN	Haynes International	132596501	03/30/92	Malfunction
Z	Indianapolis, IN	Atec Associates, Inc.	132636901	05/07/92	Other
Z	Whispering, MO	Soil Consultants, Inc.	242003901	08/14/92	Portable Damaged
Z	Kalispell, MT	Kalispell, City of	252684001	04/30/92	Other
Z	Aspers, PA	Cadbury Schweppes, Inc.	372856101	01/02/92	Malfunction
Z	Columbia, PA	Susquehanna Water Pollution	NL	09/29/92	Other

*Z indicates unspecified

Table A1-8 UF_6 production facilities events, 1992

Licensee	Docket Number	Event Date	Location
Allied-Signal, Inc.	4003392	03/24/92	Metropolis, IL
Sequoyah Fuels Corporation	4008027	01/20/92	Gore, OK
Sequoyah Fuels Corporation	4008027	01/30/92	Gore, OK
Sequoyah Fuels Corporation	4008027	02/12/92	Gore, OK
Sequoyah Fuels Corporation	4008027	02/19/92	Gore, OK
Sequoyah Fuels Corporation	4008027	02/26/92	Gore, OK
Sequoyah Fuels Corporation	4008027	03/06/92	Gore, OK
Sequoyah Fuels Corporation	4008027	03/10/92	Gore, OK
Sequoyah Fuels Corporation	4008027	03/19/92	Gore, OK
Sequoyah Fuels Corporation	4008027	03/23/92	Gore, OK
Sequoyah Fuels Corporation	4008027	03/31/92	Gore, OK
Sequoyah Fuels Corporation	4008027	04/04/92	Gore, OK
Sequoyah Fuels Corporation	4008027	04/23/92	Gore, OK
Sequoyah Fuels Corporation	4008027	04/24/92	Gore, OK
Sequoyah Fuels Corporation	4008027	04/29/92	Gore, OK
Sequoyah Fuels Corporation	4008027	05/01/92	Gore, OK
Sequoyah Fuels Corporation	4008027	05/15/92	Gore, OK
Sequoyah Fuels Corporation	4008027	05/25/92	Gore, OK
Sequoyah Fuels Corporation	4008027	05/30/92	Gore, OK
Sequoyah Fuels Corporation	4008027	06/01/92	Gore, OK
Sequoyah Fuels Corporation	4008027	06/06/92	Gore, OK
Sequoyah Fuels Corporation	4008027	06/09/92	Gore, OK
Sequoyah Fuels Corporation	4008027	06/09/92	Gore, OK
Sequoyah Fuels Corporation	4008027	06/12/92	Gore, OK
Sequoyah Fuels Corporation	4008027	06/24/92	Gore, OK
Sequoyah Fuels Corporation	4008027	06/25/92	Gore, OK
Sequoyah Fuels Corporation	4008027	06/26/92	Gore, OK
Sequoyah Fuels Corporation	4008027	06/29/92	Gore, OK
Sequoyah Fuels Corporation	4008027	07/01/92	Gore, OK
Sequoyah Fuels Corporation	4008027	07/01/92	Gore, OK
Sequoyah Fuels Corporation	4008027	07/03/92	Gore, OK
Sequoyah Fuels Corporation	4008027	07/08/92	Gore, OK
Sequoyah Fuels Corporation	4008027	07/18/92	Gore, OK
Sequoyah Fuels Corporation	4008027	07/18/92	Gore, OK
Sequoyah Fuels Corporation	4008027	07/23/92	Gore, OK
Sequoyah Fuels Corporation	4008027	07/23/92	Gore, OK
Sequoyah Fuels Corporation	4008027	07/29/92	Gore, OK
Sequoyah Fuels Corporation	4008027	08/06/92	Gore, OK
Sequoyah Fuels Corporation	4008027	08/06/92	Gore, OK
Sequoyah Fuels Corporation	4008027	08/14/92	Gore, OK
Sequoyah Fuels Corporation	4008027	08/18/92	Gore, OK
Sequoyah Fuels Corporation	4008027	09/14/92	Gore, OK
Sequoyah Fuels Corporation	4008027	09/14/92	Gore, OK
Sequoyah Fuels Corporation	4008027	09/30/92	Gore, OK
Sequoyah Fuels Corporation	4008027	10/13/92	Gore, OK
Sequoyah Fuels Corporation	4008027	11/17/92	Gore, OK

Table A1–9 Uranium fuel fabrication facility events, 1992

Licensee	Docket Number	Event Date	Location
Babcock & Wilcox Co. (naval)	7000027	04/07/92	Lynchburg, VA
Babcock & Wilcox Co.	7000027	04/20/92	Lynchburg, VA
Babcock & Wilcox Co. (naval)	7000027	04/23/92	Lynchburg, VA
Babcock & Wilcox Co.	7000027	06/01/92	Lynchburg, VA
Babcock & Wilcox Co.	7000027	06/22/92	Lynchburg, VA
Babcock & Wilcox Co.	7000027	07/15/92	Lynchburg, VA
Babcock & Wilcox Co.	7000027	08/21/92	Lynchburg, VA
Babcock & Wilcox Company	7000027	10/28/92	Lynchburg, VA
Babcock & Wilcox Co.	7000027	11/04/92	Lynchburg, VA
Babcock & Wilcox Co.	7000027	12/16/92	Lynchburg, VA
Nuclear Fuel Services	7000143	02/07/92	Erwin, TN
Nuclear Fuel Services	7000124	03/31/92	Erwin, TN
Nuclear Fuel Services	7000143	05/04/92	Erwin, TN
Nuclear Fuel Services	7000143	05/21/92	Erwin, TN
Nuclear Fuel Services	7000143	09/10/92	Erwin, TN
Nuclear Fuel Services	7000143	10/13/92	Erwin, TN
Nuclear Fuel Services	7000143	10/26/92	Erwin, TN
Nuclear Fuel Services	7000143	11/09/92	Erwin, TN
Nuclear Fuel Services	7000143	11/25/92	Erwin, TN
Nuclear Fuel Services	7000143	12/03/92	Erwin, TN
General Atomics	7000734	03/23/92	San Diego, CA
General Electric Co.	7001113	01/06/92	Wilmington, NC
General Electric Co.	7001113	03/19/92	Wilmington, NC
General Electric Co.	7001113	03/22/92	Wilmington, NC
General Electric Co.	7001113	07/16/92	Wilmington, NC
General Electric Co.	7001113	07/29/92	Wilmington, NC
General Electric Co.	7001113	08/12/92	Wilmington, NC
General Electric Co.	7001113	09/30/92	Wilmington, NC
Westinghouse Electric Corp.	7001151	01/03/92	Columbia, SC
Westinghouse Electric Corp.	7001151	03/03/92	Columbia, SC
Westinghouse Electric Corp.	7001151	03/03/92	Columbia, SC
Westinghouse Electric Corp.	7001151	03/09/92	Columbia, SC
Westinghouse Electric Corp.	7001151	05/27/92	Pittsburgh, PA
Westinghouse Electric Corp.	7001151	06/10/92	Columbia, SC
Westinghouse Electric Corp.	7001151	07/08/92	Columbia, SC
Westinghouse Electric Corp.	7001151	07/30/92	Columbia, SC
Westinghouse Electric Corp.	7001151	08/21/92	Columbia, SC
Babcock & Wilcox Fuel Co	7001201	04/07/92	Lynchburg, VA
Siemens Nuclear Power Corp.	7001257	03/02/92	Richland, WA
Siemens Nuclear Power Corp.	7001257	05/21/92	Richland, WA
Siemens Nuclear Power Corp.	7001257	07/06/92	Richland, WA
Siemens Nuclear Power Corp.	7001257	08/08/92	Richland, WA
Siemens Nuclear Power Corp.	7001257	10/04/92	Richland, WA
Siemens Nuclear Power Corp.	7001257	10/13/92	Richland, WA
Siemens Nuclear Power Corp.	7001257	10/27/92	Richland, WA

Table A1-10 Other events, 1992

Isotope*	Location	Licensee	License Number	Event Date	Type of Event**
Am-241	Newfield, NJ	Shieldalloy Metallurgical Co	SMB-743	05/08/92	MSC
Am-241	Houston, TX	Halliburton Logging Services	420106807	03/10/92	MSC
Co-60	Bethesda, MD	Defense Nuclear Agency	190833003	03/19/92	IRR
Co-60	Minneapolis, MN	Minnesota, University of	220018708	06/01/92	IRR
Cr-51	Denver, CO	Veterans Administration Medical Center	050140102	09/10/92	MSC
Cs-137	Boston, MA	Boston University Medical Center	200221503	06/15/92	IRR
Cs-137	Cleveland, OH	Cleveland Fire Department	NL	10/02/92	MSC
Cs-137	Columbus, OH	Indiana Michigan Power	131869601	03/30/92	WAS
Cs-137	Brooks AFB, TX	Air Force, Department of, Brooks	422353901	07/08/92	IRR
DU	Savanna, IL	Army, Department of the	SUC-1394	08/17/92	MSC
DU	Picatinny, NJ	Army, Dept. of Armament Research	SUB-348	03/10/92	WAS
H-3	Sterling Heights, MI	General Dynamics Corp.	212106801	07/28/92	RLM
I-131	Togus, ME	Veterans Administration Medical Center	180756101	05/06/92	MSC
I-131	Pittsburgh, PA	Shadyside Hospital	371107901	06/29/92	RLM
Ir-192	Burlington, MA	Lahey Clinic Medical Center	200576602	10/14/92	MSC
Ni-63	Athens, GA	Environmental Protection Agency	101014601	04/28/92	CNT
Ni-63	New York, NY	Chemtech Consulting Group, Inc	NL	04/03/92	MSC
Ni-63	Oklahoma City, OK	Federal Aviation Administration	350701401	06/11/92	MSC
Pu-238	Mount Olivet, MD	Washington Hospital Center	SNM-1446	06/22/92	MSC
SNM	Pleasanton, CA	General Electric Co.	SNM-960	08/25/92	MSC
SNM	Stoughton, MA	Goddard Memorial	200949601	02/09/92	MSC
SNM	Raleigh, NC	North Carolina State University	R-120	06/25/92	MSC
Sr-90	Sterling Falls, NY	Cintichem, Inc.	SNM-639	04/02/92	RLM
Tc-99m	Washington, DC	Howard University	080307507	03/02/92	MSC
Tc-99m	New York, NY	New York City Department of Health	NL	07/31/92	MSC
Th	Branford, CT	Aircraft Components, Inc.	STB-1526	08/26/92	MSC
Th	Curtis Bay, MD	General Services Administration	STC-133	02/29/92	CNT
Th	Royal Oak, MI	Norco Alloys Corporation	212333202	10/21/92	MSC
Z	Denver, CO	Pathfinder Mines/Lucky McMine	SUA-672	08/03/92	MSC
Z	Whiting, IN	Amoco Oil Company	130015510	10/09/92	MSC
Z	Gore, OK	Sequoyah Fuels Corporation	SUB-1010	12/01/92	CNT
Z	Cambridge, MA	Massachusetts Inst. of Tech.	SNM-986	07/02/92	MSC
Z	Detroit, MI	Henry Ford Hospital Detroit	210410916	09/02/92	IRR
Z	Swartz Creek, MI	Syncor International Corp.	212114101	04/23/92	MSC
Z	Rochester, MN	Mayo Foundation	220051903	10/15/92	CNT
Z	Crawford, NE	Ferret Exploration Co. of Neb	SUA-1534	01/15/92	MSC
Z	Whippany, NJ	Isomedix, Inc.	291976903	08/10/92	IRR
Z	Newburgh, OH	Chemetron Corporation	SUB-1357	05/05/92	CNT
Z	Bristol, PA	Lower Bucks Hospital, The	SNM-1800	05/12/92	MSC
Z	University Park, PA	Pennsylvania State University	370018504	01/07/92	MSC
Z	Ponce, PR	Hospital de Damas	521027001	02/12/92	MSC
Z	Arlington, TX	Halliburton Logging Services	420106807	06/08/92	MSC
Z	Richmond, VA	Reynolds Metal Company	NL	05/22/92	MSC
Z	Casper, WY	Total Minerals Corporation	SUA-1341	03/20/92	MSC

*DU indicates depleted uranium, SNM indicates special nuclear material, Z indicates unspecified
**CNT indicates contamination, IRR indicates irradiator, MSC indicates miscellaneous, RLM indicates release of material, WAS indicates waste

Table A1-1A Event Summaries

On December 18, 1992, an individual at Alaron Corporation was overexposed. While operating a baling press, compacting dry active waste which was marked "Contains Hot Particles," the individual received an overexposure from a hot particle. A 0.076 megabecquerel (MBq) (2.055 microcurie [μCi]) hot particle was discovered, on him when he was leaving the work area. Using a worst-case estimate, this resulted in an exposure to the skin of 241 milliseivert (mSv) (24.1 rem). Subsequent surveys of the protective clothing, as it returned from the laundry, revealed hot particles on the inside seams of several sets of clothing, which indicated to the licensee that the hot particle may have come from the nuclear laundry.

On July 1, 1992, Berthold Systems received a package containing a gauging device which contained a 37,000-MBq (1-Curie [Ci]) cesium-137 (Cs-137) source. A receipt survey of the package revealed a level of 35 mSv (3.5 rem) per hour on contact. Upon opening the package, it was discovered that the handle used to secure the gauge shutter in the closed position was broken and the shutter was partially open. A worst-case estimate of the exposure to the driver of the transport vehicle gave a dose of 5.75 mSv (0.575 rem).

On May 22, 1992, a medical physicist at Beth Israel Hospital received a dose of 2720 mSv (272 rems) to the hand when she coiled a ribbon containing 20 brachytherapy seeds and held it in her hand. A brachytherapy patient was being implanted with two ribbons, one containing 15 seeds (1087 MBq [29.37 mCi]) of iridium-192 (Ir-192) and a second containing 20 seeds (1449 MBq [39.16 mCi]) of Ir-192. The medical physicist handed the wrong end of the first ribbon (the portion of the ribbon which does not contain the radioactive sources) to the attending physician. This caused the ribbon to be inserted backwards. The other ribbon was inserted correctly. The physician then cut off the excess lengths of ribbon and the medical physicist coiled them and held them in her hand, unaware that one ribbon contained 15 seeds. The medical physicist held the ribbons in her hand until the completion of the procedure, estimated at 10 minutes. The ribbons were then disposed of in a waste basket located in the waiting room across the hall from the patient's room creating a radiation level in excess of 10 CFR 20.105(b)(1) limits. The loss of the seeds was revealed 12 hours post-explantation, when the seeds were inventoried. The licensee estimated an exposure to the medical physicist's hand of 2720 mSv (272 rem).

On November 17, 1992, a researcher at the U.S. Department of Health and Human Services was overexposed. The researcher (researcher A) working with radioactive adenosinetriphosphate was unable to close a vial and asked another researcher (researcher B) for assistance. Researcher B noted some moisture on the vial as well as wet spots on the absorbent pad behind the plexiglass shield. The wet spots were found to be hot. Both researchers cleaned up the area. Researcher A surveyed himself after the cleanup; researcher B did not. The next day, researcher B detected contamination on his hand. The contamination was localized to a 7.5-cm^2 area near the tip of the index finger with a calculated total activity of 0.024 Mbq (0.644 μCi) of phosphorous-32 (P-32). Some minor contamination was also found on the steering wheel of researcher B's car, a shoestring, and a zipper. An NRC inspector calculated that the individual received 480 mSv (48 rem) to a 1-cm^2 area of the skin, a dose in excess of the extremity exposure limits. A radiographer at MQS Inspection received an extremity overexposure on July 6, 1992. After performing a radiograph about 6 meters (m) (20 feet [ft]) above the ground, the radiographer retracted the source. The radiographer approached the device in a powered personnel lift. The radiographer performed the proper surveys with no unusual readings. He then grabbed the control cable with his right hand close to the lock of the exposure device, turned the device toward himself, and locked the device with his left hand. He then reached to the front of the device with his left hand and disconnected the guide tube. Upon disconnecting the guide

tube, he noticed the source protruding several inches out the front of the device. The radiographer descended immediately. Through a concerted effort the source was retracted with minimal additional exposure. The licensee's calculation of the radiographer's exposure indicated a 4400-mSv (440-rem) dose to the hand, and a 1.7-mSv (0.17-rem) dose to the whole body.

Forty-nine individuals were overexposed when Indiana Regional Cancer Center (operated under the license for Oncology Services Corporation) lost control of a 136,900-MBq (3.7-Ci) iridium-192 (Ir-192) source. A malfunction occurred during a high-dose-rate remote afterloading treatment. The licensee's personnel did not realize that the source had broken off and was lodged in the patient's body. Treatment was terminated, and the patient was returned to the nursing home. Four days later, the catheter containing the radioactive source fell out of the patient and was removed as "red bag" waste. The patient died the next day. The source set off a radiation detector at the BFI waste facility on November 27, 1992. The nursing home was contacted on December 1, 1992, and it contacted the NRC the same day. This event resulted in no overexposures of occupational radiation workers; however 49 nonoccupational workers and members of the public received exposures calculated to be in excess of 5 mSv (0.5 rem), which is in excess of regulatory limits. A subsequent report by NRC's Incident Investigation Team stated that more than 94 persons associated with the event were exposed. Whole body radiation doses received by these individuals ranged between 0.4 mSv and 220 mSv (40 mrem and 22 rem), with a total collective dose ranging between 1.8 person-Sv and 3.16 person-Sv (180 person-rem and 316 person-rem). The highest extremity dose was calculated to be between 730 mSv and 1600 mSv (73 to 160 rem) to the hands of one of the nursing assistants. No people or property were contaminated and no occupational worker received a whole body radiation dose above the NRC occupational limit of 12.5 mSv (1.25 rem). While members of the public received radiation doses above applicable limits, no one received a dose at which acute radiation injury or clinical signs are expected. The patient died with acute radiation exposure as a contributing factor.

On September 18, 1992, the University of Connecticut Health Center reported the overexposure of a technologist. The exposure of 276 mSv (27.6 rem) was to the technologist's left forearm and occurred during the third quarter of 1992. The majority of the exposure was received following an administration of 925 MBq (25 mCi) of iodine-131 (I-131) to a patient. The patient wiped his lips on a paper bib which he then tossed to the technologist. The bib apparently contaminated the technologist's left forearm but his survey did not detect the contamination. Later, the technologist was also found to have a thyroid burden of 370 becquerel (Bq) (10 nanocurie [nCi]).

On February 26, 1992, a radiological engineer (RE) at Yale-New Haven Hospital received 420 mSv (42 rem) to his left index finger while changing the source on an Isotopen Technik gamma Med IIi high dose rate (HDR) afterloader. Removal of the old source went smoothly except for the fact that the RE inadvertently unlocked the well for the new source when he was locking in the old source. At this point, the Radiation Safety Officer and the medical physicist left and the RE and a post-doctoral physicist (PDP) began loading the new source. Part way into the process, the RE had difficulty and referenced the manual. At this point he had connected the guide tube in the wrong order. The guide tube should have been attached to the source container first and then to the HDR unit port. The RE then thought that he could "fool" the HDR unit by attaching the guide tube to the port thereby causing the unit to grip the guide wire. Unfortunately, he had previously unlocked the well which held the new source, and as he attempted to attach the guide tube to the HDR unit port, a radiation monitor alarmed. He noticed that the source was exposed, and he yelled for the PDP to leave the room. He then grabbed the guide wire and attempted to replace the source back into the source container. He was eventually successful; however, in the process, he received an overexposure to the left index finger.

Table A1-4 Event Summaries

A radiographer at Alonso & Carus was unable to extract the source from the exposure device at the beginning of radiographic operations on February 26, 1992. The manufacturer was contacted, and the presence of uranium showed that the S-tube was worn through.

General Dyanmics Corporation reported that on November 19, 1992, a radiography camera became stuck in the locked, exposed position. A radiographer had opted to lock the control unit in the exposed position for a 10-minute exposure. By manipulating the key several times he was able to unlock the control unit and retract the source.

On June 6, 1992, MQS Inspection experienced a source disconnect. While cranking the source in, the radiographer's assistant felt a "snap." The source assembly had "bird-caged," frayed, and severed between the source lock ball and the source assembly connector. The source was recovered without any overexposures.

Conam Inspection reported that during radiographic operations on September 1, 1992, a shooting stand, which held the collimator and guide tube in position, fell to the ground resulting in a kink in the guide tube. This kink prevented source retraction. The licensee shielded the source with lead and hammered the kink out, allowing the source to be retracted.

On February 19, 1992, Braun Intertech Engineering personnel experienced an incident where they were unable to retract the source. A magnetized base plate fell on the guide tube and crimped it. The source was covered with shielding materials, and the crimped section of guide tube was cut out. The source was then retracted.

Twin City Testing reported an incident on September 22, 1992, when the source hung up 7.5 to 10 centimeters (cm) (3 to 4 inches [in.]) outside the exposure device. Apparently, the radiographer had too tight a bend in the guide tube because the Radiation Safety Officer recovered the source by straightening out the guide tube which then permitted source retraction. The guide tube was checked and found to be free of defects.

On July 23, 1992, a locking mechanism at Twin City Testing failed. While the licensee was unlocking an exposure device, the key cylinder pulled out of the housing and would not go back into the lock mechanism. The empty camera was shipped back to Amersham.

Twin City Testing reported the failure of a locking mechanism on March 6, 1992. While the licensee was unlocking an exposure device, the key cylinder pulled out of the housing and would not go back into the locking mechanism. The empty camera was shipped back to Amersham.

On May 12, 1992, Glitsch Field Service experienced a source disconnect. Because of rust and dirt buildup on the pigtail connector assembly, the locking pin was prevented from closing completely. Also, excessive wear of the selector ring allowed rotation to the "operate" position while the source was not properly connected. Finally, the radiographer failed to test the locking pin. The source was recovered with no overexposures.

On October 22, 1992, Herron Testing Laboratories experienced a source disconnect. During radiographic operations on a roller coaster, the crankset, which was being lowered to a fully suspended position, inadvertently fell about 3 meters (m) (12 feet [ft]). After this incident, the licensee was unable to retract the source because the drive cable was pulled from the female end of the connector. The source was recovered.

On August 4, 1992, Newport News Shipbuilding reported an incident where a lead collimator fell on the source tube preventing source retraction. The licensee shielded the source, uncrimped the tube enough to crank out, and, after cutting the end off the guide tube, pushed the source forward into a source changer.

On June 19, 1992, Twin City Testing reported the failure of another locking mechanism. Following radiographic operations, the licensee was unable to depress the key cylinder of the locking mechanism completely. The source was secured in

the camera, and the empty camera was returned to Amersham.

On January 8, 1992, H & G Inspection reported a faulty J-connector. The radiographer noted that the source was catching while he cranked it in and out. No exposures or disconnects resulted.

Eagle X-ray was cited for violations which included the failure to document field examinations.'

Amersham Corporation was cited under 10 CFR 21.21 because it did not complete an evaluation on a failed drive cable within 60 days. The source disconnect which was caused by the failure of this cable occurred on February 19, 1992.

On April 22, 1992, the NRC issued an order revoking the license of Piping Specialists, Inc., because of the licensee's gross violations and falsification of records.

Canspec was cited for performing radiography on February 27, 1992, without the proper alarming ratemeters, as required by 10 CFR 34.33.

On May 3, 1992, a Sam-Son Inspection radiographer was unable to retract the source. While the radiographer was performing radiography, a source stand and collimator fell, and the guide tube was crimped. The source was retrieved by cutting away the crimped portion and taping the ends together, thus allowing the source to be retracted.

Table A1-8 Event Summaries

Allied-Signal Incorporated

On March 24, 1992, discrepancies were found in the cylinder recertification program. Several cylinders did not meet American National Standards Institute (ANSI) standards for wall thickness. Although these cylinders had been tagged "DO NOT USE FOR SHIPPING CYCLE TO BE DESTROYED," they had been used.

Sequoyah Fuels Corporation

In response to more stringent surface contamination criteria, two areas in the warehouse had to be posted as controlled access on January 20, 1992.

The licensee was cited for failing to secure that licensed materials, which were stored in an unrestricted area would not be removed. Specifically, as of January 30, 1992, several contaminated items in the Carlile training center had not been secured against removal.

On February 12, 1992, the licensee discovered that pond 3E, an ammonium nitrate storage pond in an unrestricted area of the property, was contaminated. The contamination was first found on the boots of employees who had been working around the pond. The boots were decontaminated and the pond was designated a controlled access area. The licensee found a dry residue on the pond liner.

On February 19, 1992, a foam deluge system, a "continually operable" system in the solvent extraction building, was disconnected from its activation mechanism for maintenance. During this time, a fire watch was posted.

On February 26, 1992, contamination was discovered behind the instrument panel in the control room. The contamination was discovered as the result of new contamination criteria and a comprehensive site survey. Access to the area behind the control panel was restricted.

On March 6, 1992 the licensee removed a contaminated valve from a restricted area without performing a proper survey.

On March 10, 1992, the licensee discovered contamination in used piping and piping floats. The pipes were used in the raffinate treatment program and are now in a restricted area.

On March 19, 1992, the licensee reported the contamination of its emergency basin and north ditch. Natural uranium oxide in solid form was the contaminant.

During an inspection on March 23, 1992, the licensee noted three release of material events. On January 10, 1992, 0.6 kilogram (kg) (1.36 pounds [lbs]) of depleted uranium was released from the stack of the depleted uranium tetrafluoride (DUF_4) building. On February 4, 1992, elevated levels of uranium were identified in the HF off-gas scrubber exhaust. Analysis of a 24-hour monitor sample indicated a value 483 times the unrestricted maximum permissible concentration. On March 12, 1992, contaminated liquid from a steam condensate drain line was found to be missing its catch basin and dripping directly onto the ground. The area was decontaminated.

On March 31, 1992, contamination was discovered in the solvent extraction yard. Contamination was the result of piping leaks over time. The contaminant involved was natural uranium in the oxide and nitrate form.

On April 4, 1992, during the monthly testing of the emergency communication system, the licensee found that the system was inoperable.

On April 23, 1992, the licensee failed to perform the adequate surveys in order to evaluate the exposure of a worker.

On April 24, 1992, the licensee requested and was granted permission to initiate uranium hexafluoride (UF_6) plant operations.

On April 29, 1992, the licensee was cited for because a worker who was working in a restricted area failed to wear a personal dosimeter.

On May 1, 1992, an alert was declared at the DUF_4 building. The cause of the alert was a leak of depleted uranium hexafluoride (DUF_6) from a nitrogen purge system flange. The leak was caused by the pressurization of an isolated segment of DUF_6 piping which had become blocked with solidified DUF_6. Local heat-tracing had been turned off in the recent past to support maintenance activities. The pipe was being reheated by heat tracing, and the vaporization of the DUF_6 (due to reheating) in the blocked pipe segment resulted in local overpressurization. This overpressurization was relieved by a leaking flange joint.

On May 15, 1992, insulation removed from a section of piping for corrective maintenance in the depleted uranium tetrafluoride facility exposed a buildup of contaminated material around a check valve cover. The licensee examined the cover gasket and found no obvious defects.

On May 25, 1992, contamination was discovered near the solvent extraction decanters. The contaminant involved was natural uranium in the oxide and nitrate form. Contamination was both fixed and removable.

Early on May 30, 1992, contamination was discovered following a packing leak at a cooling screw; however, licensee staff failed to decontaminate the flange until June 3, 1992. The licensee's failure to decontaminate equipment as soon as possible was cited. Smearable contamination in excess of 20,000 and 5000 disintegrations per minute (dpm)/100 cm^2 beta/gamma and alpha, respectively, was found on the flange of the cooling screw located on the second level of the depleted uranium tetrafluoride facility.

On June 1, 1992, the licensee performed work in an airborne contamination area without using a portable high-volume air sampler as required by the hazardous work permit. The licensee was cited for this violation.

On June 6, 1992, an operator failed to fully understand the actions he was taking in response to alarms. Specifically, a smoke detector alarmed when the heat-tracing short-circuited and caused some smoke. The operator believed the alarm was associated with a compressor low-pressure condition, a non-critical alarm, and therefore, reset the alarm. In response to this incident, the licensee performed a root cause investigation.

On June 9, 1992, a boildown tank, the immediate area, and two levels of the main process building were contaminated when a flange leaked aqueous uranium oxide. The area was posted as requiring full-face respiratory protection.

Also on June 9, 1992, removable contamination was discovered on the first and second floors of the hydrofluorination unit in the licensee's main process building. The source of the contamination was unknown.

On June 12, 1992, a new level transmitter was installed on the vaporizer and released for leak check at 3:40 a.m. An operator assigned to check the level transmitter opened the isolation valves and left the room although she remained in the area for a short period of time. After several minutes, the operator was asked to reenter the room to check a valve at the top of the vaporizer. As she was climbing a ladder to the top level of the vessel, she heard a noise, looked down, and noted a small cloud of hydrogen fluoride (HF) coming from piping at the level transmitter. She closed the manual isolation valves and left the room. She was still wearing full protective clothing although she had discarded her respiratory protection equipment. She later denied any respiratory problems. It was discovered that the technician who replaced the O-ring had transcribed the number incorrectly on a parts list provided to the warehouse. The correct O-ring is made of teflon; whereas the O-rings obtained from the warehouse were made of silicon. The silicon O-rings came in contact with the concentrated HF solution and failed within minutes.

On June 24, 1992, a slurry pump room was posted as a controlled access area when visual inspection identified uranium yellowcake slurry deposits.

On June 25, 1992, an area, including a parking lot near a new administration area, was found to be contaminated. Contaminant was natural uranium in the oxide form. The area was posted.

On June 26, 1992, the licensee discovered contamination of the roadway adjacent to the

main process building. The contamination was discovered during a routine visual survey of the area. The contaminant was natural uranium in the form of uranyl nitrate.

On June 29, 1992, a small hole developed in the bellows of the No. 3 fluorination tower and released UF6 and HF in the third level of the main process building. Local exhaust fans pulled the material to the roof where it was exhausted outdoors. The release was estimated to have lasted about 3 minutes before it was observed by Sequoyah Fuels Corporation staff, and the fluorination towers were shut down.

On July 1, 2, and 7, 1992, control room operators failed to record the cause of either critical safety or safety alarms. The operators also failed to record all the actions taken in response to these alarms, in the appropriate log for several such alarms received from the depleted uranium tetrafluoride and uranium hexafluoride production areas.

An inspection on July 27, 1992 noted that on July 1, 1992, an operator collected a sample of uranium hexafluoride in a model 2S sample cylinder while draining a cleanup reactor cold trap. The operator noted that the net sample weight of 2979 g (6.55 lb) was above the cylinder rated weight of 2220 g (4.88 lb). The operator was interviewed, and two possible scenarios for the overfill emerged. The filling operation involves the opening and closing of valves in series. The operator apparently did not close the sample tube inlet valve completely before opening the outlet valve. The scenario involved the operator bumping the outlet valve as he opened the inlet valve. Two other overfills were also noted.

Date	Amount	Overfill
07/01/92	2984 g (6.27 lb)	784 g (1.72 lb)
07/27/92	703 g (1.55 lb)	503 g[1] (1.11 lb)
08/17/92	686g (1.509 lb)	486 g[1] (1.07 lb)

[1]Although neither of these incidents represent an overfill past the maximum net weight of the cylinger, they do not represent an overfill past the "High" net weight of 200 g (0.44 lb) specified on the process parameter sheet. The most probable cause for the overfilling was failure of the operator to pay close enough attention to details of the sampling operation to ensure that the valves were properly positioned as per procedure. The July 27, 1992, overfill may also have been caused by valve leakage.

On July 3, 1992, breaker #1772 tripped when the operator attempted to restart a cooling tower recirculation pump (#772). Simultaneous to this breaker tripping, the main breaker for motor control #3 tripped. Resetting both breakers resulted in a short in box #772 which produced sufficient heat to cause the insulation surrounding the circuit breaker to smolder.

On July 8, 1992, an operator was preparing to remove a small sample cylinder from the south drain station when he noted vapor leaking from piping near the cylinder connection. The operator attempted to control the leak with a vacuum hose, but as he held the hose to the sample cylinder piping and tried to close the valve, the vapor escaping the piping increased, and he was unable to control the leak. The operator left the room, donned respiratory protection, and returned and closed the valve. An Unusual Event was declared. The licensee also reported that on July 8, 1992, as a result of a survey of soil areas adjacent to the restricted area fence, (north of the north gate of the depleted uranium tetrafluoride plant) contamination was discovered. The discovery of contamination was the result of the implementation of additional radiological controls.

On July 18, 1992, the licensee discovered that algae growing on the inside of the external walls of the mechanical draft cooling tower (MDCT) was contaminated. The MDCT is a closed cooling system that supplies cooling water throughout the facility. The licensee stated that the contamination could be the result of pinhole leaks in the cooling coils which pass through the digester. The digester proccesses yellow cake.

During a pre-job survey on July 18, 1992, the licensee discovered contamination of the cooling tower. The contaminant was uranium in oxide form.

At 11:42 pm on July 23, 1992, an Unusual Event was declared when a hose blew off its nozzle on the slurry recirculation header and sprayed yellowcake slurry over a large portion of the yellowcake storage pad.

On July 23, 1992, the emergency fire-fighting foam system in the solvent extraction plant was actuated. An operator inadvertently hit a valve

handle, actuating the plant's fire-fighting foam system.

On July 29, 1992, 1.36 kg (3 lb) of uranium dioxide powder were released through the conveyor seal on the B-line reduction reactor unit. The area was decontaminated.

On August 6, 1992, the failure of the bellows section on the No. 2 fluorination tower resulted in the declaration of an Unusual Event. As a result of the bellows failure, process material was released into the building. Operators terminated the release and decontaminated the area. The inspector's review of documentation revealed that neither of the two cleanup reactors (CURs) was on line for the 48 hours preceding the bellows failure because of operational difficulties. Operations procedures allow the CURs to be bypassed, and operations supervisors made the decision to do so. The CURs are used to remove excess fluorine from the fluorination tower offgas stream. When the CURs are taken off line, system parameters for the fluorination towers are adjusted to increase fluorine burn in the towers, thereby reducing the amount of excess fluorine in the offgas stream. The increased fluorine burning efficiency results in less-efficient burning of the uranium tetrafluoride and this, in turn, leads to increased ash production within the towers with a potential for blockage. Operations documentation indicated blockage in several of the towers during the period in which the CURs were not on line. (Documentation also revealed that the bellows in tower #5 had also failed earlier in the day; however, since the amount of material released in this earlier event was not large, an Unusual Event was not declared.)

On August 6, 1992, an operator discovered a leak on the uranyl nitrate (UNH) transfer header valve at the UNH surge tank. The release was terminated, and the area was decontaminated. A work order had been issued approximately one month earlier to rebuild valves at each end of the newer UNH transfer header line. The work was completed on June 26, 1992, and involved checking the ball and putting in a new seal kit. The licensee theorized that non-stainless steel parts were used to rebuild the valve and that these parts could not withstand the acidic environment of the UNH solution. An Unusual Event was declared on August 6, 1992, because of packing gland leakage from the #3 denitrator. The area was placed on full-face respiratory protection, and the first and the second levels of the denitrator were decontaminated in less than 8 hours. The source of the leakage was steam condensate intrusion into the shutdown #3 denitrator, which caused liquid leakage from the packing.

On August 14, 1992, the licensee reported contamination on several lamp posts, a pipe flange, an electrical panel and a culvert in the unrestricted area.

An Unusual Event occurred on August 18, 1992, when 0.45 kg (1 lb) of uranium hexafloride escaped from a bellows. This was due to a fluorination tower failure.

On September 14, 1992, the area under a slurry line in the overhead piping west of the main process building in the restricted area was posted as a controlled access area due to a leak.

Following a leak from a solvent extraction raffinate pipe on September 14, 1992, surveys of a drainage ditch adjacent to the solvent extraction and yellowcake storage pads revealed contamination. The licensee reported contamination levels in excess of administrative limits.

On September 30, 1992, a small amount of natural uranium in the form of uranium dioxide powder was released when a vertical screw conveyor access port was opened. The release was on the fourth level of hydrofluorination in the main process building.

On October 13, 1992, the licensee reported the detection of contamination on the second and third levels of the miscellaneous digest building. The contaminant was natural uranium in the form of uranium dioxide (UO_2), and the source of the contamination was recycled UO_2 powder being fed into the miscellaneous digestion process.

On November 17, 1992, the licensee reported the release of nitric acid fumes. There was no indication of a radiological release. It appears that a motoroperated gate valve at the top of the

#2 digester tank was stuck partially open during the midnight shift. As a result, about 3636 kg (8000 lb) of yellow cake was transferred into tank #2 instead of into the intended #3 digester tank. Operators were preparing to start a new batch in the #2 tank, adding about 5678 liters (1500 gallons [gal]) of acid as required by procedure. When the agitator was started, the reaction initiated, and because of the large amount of yellowcake in the tank, the release ensued. The normal procedure is to put the 5678 liters (1500 gal) of acid into the digester tank, to heat the acid to 65.6 °C (150 °F) and then meter the yellowcake into the tank at a controlled rate. This limits the rate of production of nitrous oxides to a quantity that the offgas system can handle.

Table A1-9 Event Summaries

Babcock & Wilcox Company

On April 7, 1992, two electrically operated valves on the waste line to the receiving tank failed to close during testing. The valves are supposed to close on low radiation levels (failsafe function).

During an inspection on April 20, 1992, it was discovered that the licensee had no approved written procedures to describe the location of criticality dosimeters. There were no approved written procedures describing when to collect dosimeters and which of them are to be collected in the event of an accident. The licensee was cited for this violation.

On April 23, 1992, the licensee discovered, during quarterly surveillance, that the "Bay 10" emergency evacuation system alarm was inoperable. The cause was a blown fuse, which was subsequently replaced.

On June 1, 1992, the licensee notified NRC Region II that it was investigating possible falsification of labels on special nuclear material containers. While investigating the matter, the licensee determined the following information.

- Inventory period from September to October 1991: The mass balance area (MBA) S2 inventory difference (ID) should have been a gain but the reported ID was a loss. A decreasing adjustment was made to the last 5-gallon container of residues generated during this period, based on the incorrect assumption that three of the seven cans within the 5-gallon bucket contained residues generated after the physical inventory date. The area foreman, who would normally have been consulted before this adjustment made, was in the hospital at the time. The MBA custodian was consulted; however, a communications breakdown led to the custodian not fully comprehending the facts.

- Inventory period from November to December 1991: Since the perpetual inventory value for the 5-gallon container involved in the incorrect reconciliation adjustment for the previous period was not altered, this period's ID for MBA S2 also showed a larger-than-normal ID gain. The same inventory technician made a similar adjustment to the last 5-gallon container of residues (containing three cans of residues) generated in this period. The reported ID for S2 MBA was a gain but was smaller than the true MBA gain.

- Inventory period from January to February 1992: The inventory technician, who made the incorrect adjustments for the two previous periods, was not involved in the S2 MBA physical inventory for this period because he had been transferred to another MBA. The original gain that should have been reported for the October physical inventory was now in the January-to-February period (because the official and correct value for the 5-gallon container generated at the end of the November-to-December period had not been changed). Thus, the reported ID for the MBA for this period was the correct gain. The S2 MBA gain for the January-to-February 1992 period did not trigger any NRC or Babcock & Wilcox limits, but it was significantly larger than normal.

During a June 22, 1992, inspection, the licensee effluent estimates were discussed. The licensee's estimates for liquid effluent concentration were found to be biased 4 to 7 times lower than the concentrations reported by the independent vendor or the State of Virginia.

A lightning strike on July 15, 1992, caused the actuation of the secondary fire system and the evacuation alarm system. The plant was cleared.

The evacuation alarm was sounded on August 21, 1992, when a detector pair had a low and a high alarm. The system logic then activated the evacuation alarm.

Between October 28 and November 11, 1992, the licensee failed to report to Nuclear Criticality Safety personnel that a measuring system required for nuclear criticality safety was functioning in a questionable manner. The system was the waste treatment U-235 inventory system

balance, and it was indicating a negative balance when the licensee determined U-235 was present in the system.

On November 4, 1992, the concentration of the uranyl nitrate hexahydrate column was found to be above the administrative limit of 400 grams of U-235 per liter (g U-235/l). The column contents were at 440 g U-235/l. The licensee stated that the columns have been proven safe up to 1200 g U-235/l.

On December 16, 1992, NRC Region II was informed that the licensee was unable to provide documentation or demonstration that there was sufficient poison (Raschig rings) in unfavorable geometry tanks in the uranium scrap recovery facility. The licensee uses the Raschig rings as a nuclear criticality control in large vessels. The vessels are filled with borosilicate-glass Raschig rings to occupy a percent volume fraction. The licensee's uranium concentration limit for uranium recovery operations is based on the fraction of the volume occupied by the Raschig rings in each tank. The licensee was operating the facility with a limit of 400 g uranium/liter based upon 32-percent occupied volume. The licensee determined that an accurate measurement of the volume occupied by the Raschig rings may have not been performed since 1978.

Nuclear Fuel Services

On February 7, 1992, the licensee experienced a problem in the decontamination and volume reduction facility (DVRF) that required the evacuation of that facility. A plastic bag, which is used to collect small debris generated in the DVRF compactor, ruptured, setting off the Alpha 3 monitor located next to the bag. The facility was evacuated and, once the licensee had verified that the building ventilation was not compromised, the contamination was found and cleaned up.

During an inspection conducted from March 31 to May 1, 1992, it was discovered that the licensee was failing to meet station limits for separation of material. Specifically, two bottles in a glovebox were only 20 cm (8 in.) apart when the posted station limit is a minimum of 30 cm (12 in.).

On May 4, 1992, the licensee was cited for failing to notify individuals of radiation exposure upon termination of employment within the required time.

On May 21, 1992, the incinerator scrubber recirculation line broke and sprayed radioactive water on the walls and floor of the scrubber equipment enclosure. The contamination was contained using spill pillows and the area was decontaminated.

On September 10, 1992, an explosion and fire occurred in a tray dissolver. The tray dissolver, a safe geometry vessel, contained 22 liters (l) (5.81 gal) of concentrated processing waste which in turn contained 1700 g (3.74 lb) of highly enriched uranium. The tray was located in a hood that had a partial plexiglass shield, and the explosion blew the liquid out of the tray damaging the shield on the hood as well as the shield on the adjacent hood. Radiation monitor A (a person) responded when he saw the smoke, donned a respirator, and extinguished the fire. He was found to have no external exposure and his internal exposure was 5 MPC-hours (the limit is 40 MPC-hours/week). This event did not breach the building. The licensee's investigation and an NRC Augmented Inspection Team concluded that the cause of the explosion was an oxidizing agent in the solution. The cylinder in which it was stored was incorrectly marked "BL" when it should have been marked "BK." This incorrectly marked cylinder had been transferred to the dissolver tray, and the heating caused an explosion. The licensee identified a precursor event. Operators had noted flames on the surface of the liquid and on the stirrer rod. At that point, more water was added to the solution.

On October 13, 1992, a column operator in the high-enriched uranium recovery facility inadvertently transferred 430 liters (114 gal) of raffinate to a non-favorable geometry vessel without the requisite two sample analyses.

On October 26, 1992, a failed ion resin column was discovered. The column, 20.32 cm (8 in.) in diameter and 0.3 meter (m) (10 feet [ft]) long, had shattered, spilling dry ion resin. The typical contamination of this material is 0.001 g

uranium/liter. The licensee cleaned up the contaminant.

On November 9, 1992, the licensee informed the NRC resident inspector of a problem with the in-line monitoring system for both the T-2/T-3 and 704/705 tanks. The licensee was modifying the computer software packages for these systems.

In the inspection report of November 25, 1992, the licensee was cited for permitting an outside contractor to remove earth from a contaminated area without preparing the appropriate Radiation Work Permit.

On December 3, 1992, a licensee employee was sprayed with an acid/uranium mixture, and was transported to the local hospital for treatment. On December 5, 1992, upon returning to the plant, the individual was found to be contaminated. The employee apparently was not adequately decontaminated before being transferred to the local hospital for treatment of his burns. The licensee surveyed the hospital and found no contamination there.

General Atomics

In a March 23, 1992, inspection report, NRC cited the licensee for failure to review and approve a measurement procedure before use.

General Electric Company

On January 6, 1992, while a batch of scrap material was being processed in the uranium recycle unit (URU) dissolvers, a high uranium concentration was detected when the dissolver solution was sampled. The sample result was 385 grams U/liter (g U/liter). The process operation limit for the dissolver vessel (a favorable geometry vessel) is 350 g U/liter. When the URU operator received the sample results he suspended operations and notified management. The cause was found to be a faulty dissolver vessel level indicator. The level reading was at 108 percent as opposed to the approximate 70 percent visual reading. The false level reading prevented the process computer from adding the required diluting water to bring the concentrations to within operating limits.

On March 19, 1992, a portion of the criticality warning system, which monitors the waste treatment system, failed when ac power was lost during a lightning storm.

On March 22, 1992, a relay logic controller prematurely transferred a pair of fluoride waste tanks. The quarantine tanks were transferred before analysis of the liquid's uranium concentration was complete. Two relays were involved in causing the transfer. The failure of one relay in the process control was attributed to debris on the relay; the cause of the other relay failure was unknown.

On July 16, 1992, the rubber boot on a uranium dioxide (UO_2) powder blender, connecting the discharge of the blender and baghouse to a 3-gallon (11-liter) can inside the 5-percent enrichment facility, came loose. Approximately 38 kg (84 lb) of UO_2 powder was released—18.9 kg (42 lb) fell onto the floor inside the hood, 2 kg (4 lb) fell onto the floor outside the hood, and the remaining powder remained inside the can. All spilled powder was cleaned up. One person had external contamination which was removed. Another individual had an intake below the action level.

On July 29, 1992, a pipe fitting on the high enrichment skid was observed leaking near a weld joint. Further investigation showed an unusual amount of corrosion near the weld in the heat-affected zone. A day later, a fitting on a transfer line was found to be leaking and showed heavy corrosion. After the second leaking fitting was found, the system was shut down and the licensee initiated an investigation. The problem was caused by the use of the wrong grade of stainless steel for the intended service. The end result of the investigation was the replacement of 150 fittings. Four other incidents were reported to NRC during which clamps on hoses had failed, resulting in uranium oxide powder spilling into equipment enclosures. The root cause was found to be a poor design for the clamped joint between transfer hoses and fittings. Numerous defects in the transfer hoses were found during the inspections.

On August 12, 1992, the licensee responded to Information Notice 92-58, regarding the Trinity Industries 48Y cylinder coupling weld deviations.

The licensee does not possess any of these cylinders however, a hold was put on the Trinity 30B cylinders until the safety of these cylinders could be verified.

On September 30, 1992, the licensee declared an Unusual Event when a waste tank, half full of etch waste received some non-compatible basic waste. The tank gave off fumes and smoke. The chemical tank is shared between gE Aircraft and gE Nuclear.

Westinghouse Electric Corporation

On January 3, 1992, uranium contamination was discovered beneath the floor of the fuel fabrication facility. The contamination appeared to be restricted to the scrap recovery area within an area of 9.1 m by 4.0 m (30 ft by 13 ft) and to a depth of 3.7 m (12 ft); the most significant concentration was in the area beneath the dissolver.

On March 3, 1992, the licensee discovered contamination in the uranium hexafluoride bay trench. Access to the area was restricted for more than 24 hours. The licensee does not know the source of the contamination.

On March 3, 1992, the licensee inadvertently shipped one fuel assembly, with a nominal 4.40 weight percent enrichment, in a shipping container that was not licensed for such a shipment. The fuel assembly enrichment was 0.1 percent above the licensed limit for the container. Because the fuel assembly contained a cluster of "burnable poison" rods, the equivalent assembly enrichment was below 4.0 weight percent. Therefore, the licensee determined that this did not constitute a criticality concern.

On March 9, 1992, due to reduced ventilation flow rates, the licensee decided to shut the operation down and clean the hydrolysis system vent piping. The decision was made to clean the vent piping at the point where the 6-inch hydrolysis vent line connects into the 30-inch scrubber system header. When the door on the 30-inch header ducting, which is opposite the point where the 6-inch line connects, was opened, operators found a build-up of uranyl fluoride (UO_2F_2) crystalline solid material. They subsequently cleaned out 128 kg (282 lb) of material from the 30-inch duct and placed the material in 14 polypaks.

On May 27, 1992, the licensee was cited for failure to adequately document actions taken in response to an out-of-control condition. Two of these out-of-control conditions related to the weighing of a rod standard.

On June 10, 1992, a "Local Emergency" was declared at the Westinghouse Fuel Fabrication Facility. The incident began on June 9, 1992, between 2200 and 2400 hours when the water supply to the SO1X I stripping column was reduced by approximately two-thirds. The water supply was reduced because of an instrument malfunction. The stripper column strips the uranium from the solvent to the water, forming a uranyl nitrate hexahydrate (UNH) solution with a typical concentration of 2 g U-235/liter. The UNH feeds into the favorable geometry product concentrator (83.3-liter [22-gal] capacity) to be concentrated to between 4 and 4.5 g U-235/liter. After being concentrated, the solution is pumped through a concentration analyzer to favorable geometry UNH product holding tanks (1514-liter [400-gal] capacity). The concentration process is adjusted, based on the UNH feed rate. In this instance, because the feed rate was reduced, the UNH in the product concentrator was overconcentrated. The operation continued until 0730 hours on June 10, 1992, when the oncoming chief operator recognized that a process upset condition was in progress. The chief operator proceeded to shut down the system and dilute the favorable geometry concentrator and product tanks to acceptable levels (< 3.6 g U-235/liter). The high concentration reported for the concentrator product tank was 20.1 g U-235/liter at 0545 hours. The limit on the favorable geometry tanks is 15 g U-235/liter. At no time was a high concentration solution discharged from the favorable geometry tanks.

On July 8, 1992, the licensee discovered that the condensate level in an Integrated Dry Route (IDR) UF6 vaporizer was approximately 20 cm (8 in.) (normal level is 10 cm [4 in.]). The licensee concluded that the gravity drain line at 10 cm (4 in.) was plugged and that the condensate level probe alarm at 12.5 cm (5 in.) was nonfunctional. The licensee unplugged the drain line and

monitored condensate level via log keeping. The licensee found that this event was reportable under Bulletin 91-01.

On July 30, 1992, a fire broke out in the ADU conversion line 4 fitzmill product overflow cleanout hood. The fire was the result of oxidation of uranium dioxide powder. The polypak, plastic boot, and plexiglass door of the ventilated cleanout hood were damaged. The fire was extinguished immediately without the need to activate the site emergency plan or the emergency brigade.

On August 21, 1992, a nuclear criticality safety control parameter in the ammonium diuranate vaporizers was lost. The loss of control over the water level in the bottom of the vaporizer was detected when the licensee found approximately 37.9 liters (10 gal) of water in the vaporizer. This occurred because of insufficient flow through the drain lines and inoperability of the water level probe. One barrier to preclude an accidental criticality, which remained intact, was the integrity of the uranium hexafluoride cylinder itself. ADU vaporizers were shut down.

Babcock & Wilcox Co.

On April 7, 1992, the licensee experienced a loss of electrical power to certain bays. The outage was apparently due to a short in an onsite electrical line. Some friskers and hoods were without power.

Siemens Nuclear Power Corporation

During an inspection from March 2, 1992 to March 10, 1992, the licensee was found in violation of several regulations. One of the violations involved the failure of a maintenance worker to obtain safety precautions prior to cutting open a contaminated process line. A subsequent survey of this individual indicated low-level alpha contamination of the left nasal passage indicating a potential uptake of uranium.

On May 21, 1992, during a design review for new equipment installation, the licensee identified a criticality safety issue. Specifically, a vessel that can hold up to 3000 kg of less than 5 percent enriched uranium has a plastic viewing port. If a fire were to occur in the vicinity, the plastic view port could melt and subsequent fire-fighting activities could introduce water. The area was designated a water exclusion area.

On July 6, 1992, 16 of 24 drums of used sandblasting grit that were sent to a public landfill, had potential internal contamination. Most of the drums were recovered and these had no internal contamination.

On August 8, 1992, uranium dioxide powder was transferred into an unfavorable geometry vessel using the wrong sample results. The moisture content results were mistakenly thought to be for slab hopper 4 (they were actually for slab hopper 3); therefore, the lead operator transferred slab hopper 4 to the unfavorable geometry vessel.

On October 4, 1992, the licensee found a bulge (maximum distortion 9.5 millimeters [mm] [0.375 in.]) on the side of a safe slab storage hopper used to store uranium dioxide powder. The hopper was emptied, and 5 to 6 additional hoppers were taken out of service. None of these exceeded critical dimensions.

On October 13, 1992, 4 in. of UO_2F_2 liquid (70 g U/liter) was found in a vaporization chest and an unspecified amount was found on the floor of the conversion line "1" vaporization room. The spill occurred when a hydrolysis tank was overfilled. The liquid was discharged via a ventilation line in a common process offgas system. The concentration of the liquid was 85 g U/liter, which is a safe concentration as far as criticality safety is concerned (enrichment was 4 percent). No personnel contaminations, radiation releases, or inadvertent criticality occurred.

On October 27, 1992, the licensee discovered 6.5 kg (14.3 lb) of 5-percent-enriched uranium in a dissolver in the uranium nitrate hexahydrate process building. The licensee postulated that if the process were running the K_{eff} would still be below 0.95.

Appendix A-2

Agreement State Licensee Events

Agreement State Licensee Events

Table A2-1 Personnel radiation overexposures, 1992

Licensee	Location	Event Date	Number of Individuals	Number of mSv Exposed	Type of Overexposure
Babcock & Wilcox	Paris, TX	05/06/92	1	114.5	Whole Body
BIX Testing Laboratories	Baytown, TX	03/01/92	1	30.80	Whole Body
Blount Memorial Hospital	Marville, TN	10/01/92	1	19	Whole Body
Dameron Hospital Association	CA	05/15/92	1	12.7	Whole Body
Doctors Hospital	TX	09/01/92	1	20.00	Whole Body
Eagle X-Ray	Mont Belvieu, TX	06/11/92	1	32.80	Whole Body
Eagle X-Ray	Mont Belvieu, TX	08/08/92	1	22.12	Whole Body
Geocon	CA	01/10/92	1	19	Whole Body
Gray Wireline Service, Inc.	Levelland, TX	09/01/92	1	32.17	Whole Body
Guardian NDT Services	Corpus Christi, TX	03/01/92	1	33.34	Whole Body
Guardian NDT Services	Corpus Christi, TX	01/21/92	1	52.44	Whole Body
Guardian NDT Services	Corpus Christi, TX	07/30/92	1	109.3	Whole Body
H & G Inspection Company	Houston, TX	07/01/92	1	112.8	Whole Body
H & H X-Ray Services	Tyler, TX	03/01/92	1	16.50	Whole Body
H & H X-Ray Services	Tyler, TX	09/01/92	1	145.9	Whole Body
High Plains Baptist Hospital	Amarillo, TX	07/01/92	1	36.10	Whole Body
Huntington Memorial Hospital	CA	03/27/92	1	20	Whole Body
NDC Systems	CA	04/13/92	1	14	Whole Body
Non-Destructive Inspection Co.	Clute, TX	07/10/92	1	42.80	Whole Body
Owensby & Kritikos, Inc.	Cretna, LA	11/23/92	1	81	Whole Body
Pacific Coast Testing	Eureka, CA	06/02/92	1	77.65	Whole Body
RSNP	Salt Lake City, UT	01/01/92	1	288	Extremity
Saint Joseph Hospital	Houston, TX	03/01/92	1	22.70	Whole Body
Southwestern Laboratories	Houston, TX	03/01/92	1	37.80	Whole Body
St. Luke's Episcopal Hospital	Houston, TX	06/01/92	1	14.20	Whole Body
Technical Welding Laboratory	Pasadena, TX	04/01/92	1	94.10	Whole Body
Technical Welding Laboratory	Pasadena, TX	03/01/92	1	16.90	Whole Body
Testing Engineers Inc.	CA	05/28/92	1	10	Whole Body
Thomason Hospital	El Paso, TX	03/30/92	1	21.2	Whole Body
Unknown	OR	05/14/92	2	13	Whole Body
Wadley Regional Medical Center	Texarkana, TX	03/30/92	1	15.80	Whole Body

Table A2-2A Lost or stolen sources, 1992

Isotope*	Location	Licensee	Event Date	Probable Disposition
Am-241	CA	Schlumberger	06/25/92	Unknown
Am-241	Liberal, KS	Schlumberger	09/11/92	Commercial Waste
Am-241	Baltimore, MD	Lane Construction Corporation	10/24/92	Unknown
Am-241	RTP, NC	Troxler Electronics	06/19/92	Unknown
Am-241	Queens, NY	Kupper & Co.	11/10/92	Unknown
Am-241	Grand Prairie, TX	ATL Laboratories	06/19/92	Unknown
Ba-133	IL	Mcdonough District Hospital	03/18/92	Commercial Waste
Cd-109	Lubbock, TX	Texas Instruments	10/13/92	Unknown
Co-60	Little Rock, AR	Master Halco	01/24/92	In Fencing Parts
Co-60	Oak Ridge, TN	Martin Marietta/DOE	05/05/92	Unknown
Cs-137	Morenci, AZ	Phelps-Dodge	04/16/92	Scrap Metal
Cs-137	IL	Rockford Memorial Hospital	08/27/92	Unknown
Cs-137	IL	Pekin Memorial Hospital	09/17/92	Unknown
Cs-137	Albuquerque, NM	UNM Ed. Nuclear Engineering	02/21/92	Unknown
Cs-137	El Paso, TX	W. Silver Recovery, Inc.	09/03/92	1 Found/1 Unknown
Fe-55	IL	Illinois, University of	02/17/92	Unknown
H-3	Naples, FL	Consolidated Electric Supply	01/12/92	Unknown
H-3	Orlando, FL	Walt Disney World	03/10/92	Commercial Waste
H-3	NC	Miller Brewing	02/06/92	Unknown
H-3	Winston Salem, NC	NC Baptist Hospital	10/22/92	Commercial Waste
H-3	Dallas, TX	Isolite Corporation	10/21/92	Unknown
H-3	Salt Lake, UT	Self Powered Lighting	Unknown	Unknown
I-125	IL	Nuclin Diagnostics, Inc.	04/06/92	Unknown
I-125	IL	Amersham Corporation	09/24/92	Unknown
I-125	NC	Memorial Mission Medical Center	01/19/92	Medical Waste
I-125	Charlotte, NC	UNC-CH	04/24/92	Commercial Waste
I-125	Westchester, NY	Westchester County Medical Center	01/01/92	Unknown
I-125	Providence, RI	Roger Williams Hospital	05/15/92	Commercial Waste
I-125	Houston, TX	Baylor College of Medicine	Unspecified	Commercial Waste
I-125	Bellingham, WA	St. Joseph Hospital	02/28/92	Commercial Waste
I-131	Des Moines, IA	Iowa Methodist Medical Center	10/15/92	Incineration
I-131	Rochester, NY	Genesee Hospital	12/09/92	Commercial Waste
Ir-192	CA	Cleveland X-Rays	06/26/92	Unknown
Ir-192	CA	Little Company of Mary Hospital	08/07/92	Unknown
Ir-192	IL	Loyola University Medical Center	01/13/92	Unknown
Kr-85	CA	Sigma Test Labs	02/25/92	Unknown
LLW	Las Cruces, NM	Southwest Cardiovascular Center	02/05/92	Commercial Waste
Ni-63	CA	Cutter GRP - Miles Labs	04/16/92	Unknown
P-32	CA	UCLA	01/05/92	Unknown
P-32	GA	Emory University School of Medicine	08/04/92	Unknown
P-32	IL	Amersham Corporation	11/11/92	Unknown
P-32	Houston, TX	Texas Children's Hospital	Unspecified	Commercial Waste
P-32	San Antonio, TX	University of Texas Health Center	05/05/92	Recycling Company
Po-210	Clearwater, FL	Hercules Defense Electronics	06/16/92	Unknown
Po-210	Clearwater, FL	Paramax Systems Corporation	07/02/92	Unknown
Po-210	Melbourne, FL	Harris Semiconductor Corp.	01/30/92	Unknown
Po-210	College Park, MD	Stone Industrial	03/08/92	Unknown
Po-210	Lincoln, NE	Kawasaki Motors Corporation	06/12/92	Commercial Waste
Po-210	Dover, NH	Davidson Tech./Textron	Unknown	Commercial Waste

Table A2-2A (cont.)

Isotope*	Location	Licensee	Event Date	Probable Disposition
Pu-238	Topeka, KS	Stromont Vail Hospital	07/18/92	Interred with Patient
Pu-239	Fort Worth, TX	General Dynamics	11/06/92	Radioactive Waste Disposal
S-35	Miami, FL	Dade County Municipal Inciner.	07/15/92	Incineration
S-35	OR	Unknown	06/26/92	Commercial Waste
Sr-90	CA	Private Citizen	05/07/92	Unknown
Tc-99m	CA	Woodbridge Animal Hospital	09/05/92	Commercial Waste
Tc-99m	South Miami, FL	Larkin General Hospital	06/14/92	Unknown
Z	CA	Soils Southwest Inc.	12/21/92	Unknown
Z	CA	UCSF	01/02/92	Commercial Waste
Z	CA	Wilson & Associates	01/24/92	Unknown
Z	CA	Private Citizen	01/29/92	Unknown
Z	CA	UC Riverside	02/14/92	Commercial Waste
Z	CA	Children's Hospital	03/06/92	Commercial Waste
Z	CA	UCD Medical Center	03/23/92	Commercial Waste
Z	CA	Patrick & Henderson, Inc.	03/26/92	Unknown
Z	CA	Pacific Soils Engineering	03/30/92	Unknown
Z	CA	USC	04/13/92	Unknown
Z	Chattanooga, TN	TN D.O.T.	07/07/92	Unknown
Z	Houston, TX	Baylor College of Medicine	Unspecified	Commercial Waste

*LLW indicates low-level waste, Z indicates unspecified

Table A2-2B Abandoned well-logging sources, 1992

Isotope	Location	Licensee	Event Date
Am-241	Albuquerque, NM	Schlumberger	08/13/92
Am-241	Houston, TX	Schlumberger	03/01/92
Am-241	Houston, TX	Schlumberger	05/29/92
Am-241	Houston, TX	Sperry-Sun Drilling Services	10/15/92
Am-241	Tyler, TX	Logtech Wireline Services	09/24/92
Cs-137	Charleston, AR	Halliburton Logging	09/15/92
Cs-137	Smith County, MS	Western Atlas	02/07/92
Cs-137	Houston, TX	Halliburton Logging	10/21/92

Table A2-3 Leaking sources, 1992

Isotope*	Location	Licensee	Event Date	Manufacturer/Model
Ba-133	CA	Syncor International Corp.	02/13/92	Unknown
Ba-133	IL	Highland Park Hospital	03/05/92	Unknown
Cd-109	IL	Amersham Corporation	09/22/92	Unknown
Cs-137	CA	Isotope Products Labs	07/17/92	Unknown
Cs-137	IL	Amersham Corporation	05/20/92	Unknown
Cs-137	OR	Unknown	06/29/92	Unknown
Fe-55	IL	Amersham Corporation	06/24/92	Unknown
Fe-55	Austin, TX	Asoma Instruments	06/23/92	Amersham/1EC.A1
Fe-55	Austin, TX	Asoma Instruments	08/24/92	Amersham/1EC.A1
Fe-55	Austin, TX	Asoma Instruments	10/01/92	Unknown
Fe-55	TX	Asoma Instruments	11/11/92	Amersham/8620
Gd-153	IL	Amersham Corporation	06/22/92	Unknown
H-3	Valhalla, NY	Self Powered Lighting	01/29/92	Unknown
I-125	IL	Amersham Corporation	06/12/92	Unknown
I-125	IL	Amersham Corporation	07/10/92	Unknown
Ir-192	TX	Longview Inspection, Inc.	12/10/92	INC/32
Ni-63	Santa Barbara, CA	U. of C., Santa Barbara	12/04/92	Unknown
Ni-63	CA	UCI	02/28/92	Unknown
Ni-63	IL	North Shore Sanitary District	04/15/92	Perkin Elmer/115 G.C.
Ni-63	IL	Allied Laboratories, Ltd.	03/18/92	Hewlett Packard
Ni-63	Rochester, NY	University of Rochester, NY	05/20/92	Unknown
Ni-63	OR	Unknown	07/01/92	Unknown
Ni-63	Nashville, TN	TN Public Health Div. of Labor	07/20/92	Unknown
Ni-63	Amarillo, TX	Southwestern Public Service	04/23/92	Unknown
Ni-63	Houston, TX	Houston, University of	10/14/92	Unknown
Ni-63	Salt Lake City, UT	University of Utah	07/14/92	Amersham/NBCD
Po-210	IL	Amersham Corporation	07/10/92	NRD
Po-210	Rochester, NY	Faro Industries	Unspecified	NRD/P-2051
Sr-90	Victoria, TX	Citizens Medical Center	09/02/92	Manning Research/B1
Z	CA	Disc Manufacturing Co.	05/19/92	Unknown
Z	CA	INC	07/02/92	Unknown
Z	CA	Lockheed	07/14/92	Unknown
Z	CA	Gamma Metrics	07/17/92	Unknown
Z	CA	Beckman	09/01/92	Unknown
Z	CA	Syncor International Corp.	02/26/92	Unknown
Z	CA	Rockwell International	05/15/92	Unknown
Z	Long View, TX	INC	12/14/92	Unknown

*Z indicates unspecified

Table A2-4 Radiography events, 1992

Isotope*	Location	Licensee	Event Date	Section of 10 CFR
Co-60	NC	Edwards Valves	06/26/92	34.30
Ir-192	NC	CP&L Radiography	06/08/92	34.30
Ir-192	Houston, TX	MQS Inspection, Inc.	03/20/92	34.30
Ir-192	Pasadena, TX	Technical Welding Laboratory	06/01/92	34.30
Ir-192	Lake Jacks, TX	Southern Technical Services	01/08/92	34.30
Ir-192	Pasadena, TX	Technical Welding Laboratory	02/13/92	34.30
Ir-192	Baytown, TX	BIX Testing Laboratories	06/12/92	34.30
Ir-192	Houston, TX	H & H Inspection Company	06/25/92	34.30
Ir-192	Mont Belvieu, TX	Eagle X-Ray	08/08/92	34.30
Ir-192	Houston, TX	H & G Inspection Company	08/20/92	34.30
Ir-192	Pasadena, TX	Texas Industrial X-Ray	08/25/92	34.30
Ir-192	Houston, TX	H & G Inspection Company	07/14/92	34.30
Ir-192	Pasadena, TX	Technical Welding Labs	06/25/92	34.30
Ir-192	Clute, TX	NDIC	09/29/92	34.30
Ir-192	Beaumont, TX	Applied Standards Inspection	09/25/92	34.30
Ir-192	Beaumont, TX	Applied Standards Inspection	09/26/92	34.30
Z	Corpus Christi, TX	Corpus Christi Insp. & Eng.	06/26/92	34.30

*Z indicates unspecified

Table A2-5 Medical events, 1992

Isotope	Location	Licensee	Event Date	Type of Event*
Co-60	Gainesville, GA	Northeast GA Medical Center	03/05/92	TPY
Co-60	Topeka, KS	St. Francis Hospital	05/26/92	TPY
Co-60	Kansas City, KS	Kansas University Medical Center	04/28/92	TPY

*TPY indicates teletherapy malfunction

Table A2-6 Manufacturing and distribution, 1992

Isotope*	Location	Licensee	Event Date	Type of Event**
Gd-153	IL	Amersham Corporation	04/24/92	Levels
H-3	College St, TX	Texas A & M University	02/06/92	Levels
I-125	Bluevelt, NY	Becton-Dickinson	01/15/92	Accident
Ir-192	Miami, FL	Nucletron Corporation	08/11/92	Other
Mo-99	Pensacola, FL	Officer Ron Horn	12/08/92	Levels
Mo-99	JFK Airport, NY	Cintichem	07/31/92	Other
Tc-99m	Anaheim, CA	MPI-PSI	07/24/92	Levels
Tc-99m	Sacramento, CA	MPI Pharmacy Services	08/01/92	Levels
Tc-99m	Hialeah, FL	Syncor International	07/08/92	Accident
Tc-99m	Ft Lauderdale, FL	Mallinckrodt Medical	06/03/92	Accident
Tc-99m	Metarie, LA	Syncor	09/26/92	Accident
Tc-99m	Lancaster, SC	Syncor International	11/13/92	Accident
Xe-133	Lexington, KY	Syncor	08/14/92	Accident
Y	Beaumont, TX	Syncor International Corp.	06/05/92	Accident
Z	San Antonio, TX	Syncor International	10/16/92	Accident

*Y indicates multiple, Z indicates unspecified
**Accident indicates vehicle accident, DOT indicates failure to follow Department of Transportation Regulations, Levels indicates packages with high levels of radiation or contamination

Table A2–7 Gauge events, 1992

Isotope*	Location	Licensee	Event Date	Type of Event
Am-241	Denver, CO	CTL/Thompson, Inc.	01/03/92	Damage
Am-241	Brooksville, FL	Tampa Bay Engineering	12/18/92	Damage
Am-241	Ft. Lauderdale, FL	Broward CPHU	09/01/92	Malfunctioning
Am-241	Nassau Cty, FL	Florida D.O.T.	04/06/92	Damage
Am-241	Fort Myers, FL	Pioneer Concrete (SC)	01/08/92	Damage
Am-241	Miami, FL	All State Engineering & Test	01/21/92	Damage
Am-241	Fortson, GA	Southern Asphalt	01/17/92	Damage
Am-241	Abbeville, GA	Georgia Dept. of Transport.	06/23/92	Damage
Am-241	IL	Trow Mirza	05/15/92	Damage
Am-241	IL	Professional Service Ind.	01/06/92	Damage
Am-241	IL	Alfred Benesch & Co.	10/30/92	Damage
Am-241	Baltimore, MD	Penniman & Browne, Inc.	03/14/92	Damage
Am-241	Charlestown, NH	Soils Engineering, Inc.	11/19/92	Damage
Am-241	Bedford, NH	Heynen Teale Engineers, Inc.	11/17/92	Damage
Am-241	Nashville, TN	TN D.O.T.	09/30/92	Damage
Am-241	Beaumont, TX	Professional Service Ind.	04/23/92	Damage
Am-241	Houston, TX	Mcbride-Ratcliffe & Associate	06/04/92	Damage
Am-241	Waco, TX	Trinity Engineering Testing	08/14/92	Damage
Am-241	St. George, UT	Southwest Testing Lab	06/11/92	Damage
Co-60	NC	Hoechst Celanese	04/28/92	Malfunctioning
Cs-137	Fresno, AR	Arkansas State Highway	02/04/92	Malfunctioning
Cs-137	IL	Testing Service Corporation	10/27/92	Damage
Cs-137	N. Hampton, NC	NC D.O.T.	06/18/92	Damage
Cs-137	Austin, TX	TX D.O.T.	03/05/92	Damage
Cs-137	Beaumont, TX	Mobil Chemical Company	01/07/92	Malfunctioning
Cs-137	Texarkana, TX	International Paper	10/20/92	Damage
Cs-137	Tri Cities, WA	Agrinorthwest	08/29/92	Damage
Z	Santa Clara, CA	Santa Clara County Transportation	06/25/92	Damage
Z	CA	Asham & Associates	09/10/92	Damage
Z	CA	San Bernadino County Transportation Department	03/18/92	Damage
Z	Santa Fe, NM	NM Hwy Commission	09/30/92	Damage
Z	Jackson, TN	Florida Steel Company	04/24/92	Damage

*Z indicates unspecified

Table A2-8 Other events, 1992

Isotope*	Location	Licensee	Event Date	Type of Event**
Am-241	Lakeland, FL	Florida D.O.T.	10/12/92	GAU
Am-241	Deland, FL	Florida D.O.T.	09/28/92	GAU
Am-241	Miami, FL	Florida D.O.T.	08/31/92	GAU
Am-241	Deland, FL	Florida D.O.T.	07/12/92	GAU
Am-241	Lakeland, FL	Florida D.O.T.	06/03/92	GAU
Am-241	W. Palm Beach, FL	Professional Service Ind.	05/13/92	GAU
Am-241	Brevard, FL	Florida D.O.T.	04/27/92	GAU
Am-241	St Johns C, FL	Florida D.O.T.	04/17/92	GAU
Am-241	Ft. Lauderdale, FL	Florida D.O.T.	03/01/92	GAU
Am-241	Lake City, FL	Florida D.O.T.	04/01/92	GAU
Am-241	Tampa, FL	Florida D.O.T.	02/07/92	GAU
Am-241	Myrtle Beach, SC	Professional Service Ind.	07/30/92	GAU
Am-241	Fort Worth, TX	Southwestern Laboratories	04/29/92	GAU
Cs-137	Nashville, TN	TVA	02/19/92	WAS
Cs-137	Fort Worth, TX	Professional Service Ind.	08/28/92	GAU
Cs-137	Tri Cities, WA	Agrinorthwest	08/29/92	GAU
Ir-192	Englewood, CO	Intermountain Testing	01/27/92	RAD
Mo-99	Pensacola, FL	Officer Ron Horn	12/08/92	MSC
U-238	Las Vegas, NV	Clark County Fire Dept.	03/15/92	MSC
Z	Oak Ridge, TN	DOE	01/04/92	CNT
Z	Oak Ridge, TN	Theragenics Corporation	01/27/92	MSC

*Y indicates multiple
**CNT indicates contamination, GAU indicates gauge, MSC indicates miscellaneous, RAD indicates radiography, WAS indicates waste

Table A2-1 Event Summaries

On May 6, 1992, a radiographer at Babcock & Wilcox, while performing radiography, was distracted by personnel. He failed to return the source to the shielded position and failed to survey before entering the bay to change the film. As a result, the radiographer received both an extremity and a whole body overexposure.

BIX Testing Laboratories ascribed a radiographer's first quarter 1992 overexposure to numerous short exposures and panoramic shots under confined conditions.

Blount Memorial Hospital reported a 19-mSv (1.9-rem) film badge reading for the fourth quarter of 1992.

Dameron Hospital Association of California reported an overexposure.

Doctors Hospital of Texas reported an overexposure.

On June 11, 1992, a radiographer at Eagle X-Ray was overexposed when he failed to perform a lockout survey after cranking the source in. The radiographer set up for the next shot and then noticed his meter was pegged out.

On August 8, 1992, a trainee at Eagle X-Ray proceeded to change the film without performing an adequate survey. The source was disconnected and this led to the trainee's overexposure.

Geocon of California reported a fourth quarter 1992 overexposure.

Gray Wireline Service requested the deletion of an employee's third quarter 1992 overexposure claiming that the badge was left on the dashboard of his vehicle. The deletion request was denied.

Guardian NDT was unable to determine the cause of a first quarter 1992 overexposure to a radiography trainee.

During the January 1992 monitoring period, a radiography trainee at Guardian NDT was overexposed. The trainee failed to completely retract the source after the previous exposure.

On July 30, 1992, a radiographer at Guardian NDT Services was overexposed when a trainee retrieved the equipment without performing an adequate survey. Investigation determined that there was a slight crimp near the connector of the source tube which kept the source from returning to the shielded position.

H & G inspection staff claimed that a radiographer's badge was overexposed in July 1992 because the radiographer dropped his badge while performing radiography. An investigation by the Agreement State was unable to substantiate this claim and, therefore, the licensee was cited for the overexposure.

H & H X-Ray Services was unable to determine the cause of a radiographer's first quarter 1992 overexposure.

A radiographer at H & H X-Ray noted nothing unusual happening during the third quarter of 1992. His overexposure was high energy as opposed to the licensee's historically medium energy exposures. A 50-percent deletion was granted which still constituted an overexposure.

High Plains Baptist Hospital stated that the overexposure of an employee for the month of July 1992 may have been caused by the film badge being left in a car. No deletion was requested and the licensee was cited.

Huntington Memorial Hospital of California reported an unreported overexposure.

NDC Systems of California reported an April 13, 1992, overexposure.

Non-Destructive Inspection Company ascribed the overexposure of a trainee on July 10, 1992, to his failure to perform a 360-degree lockout survey.

On November 23, 1992, an Owensby & Kritikos radiographer failed to retract a source to the fully shielded position. As a result, the radiographer received a whole body overexposure.

On June 2, 1992, a radiographer at Pacific Coast Testing was overexposed when he failed to retract the source completely and failed to perform a survey before walking in front of the exposure device.

RSNP reported that an individual was overexposed on January 1, 1992, as a result of handling iridium-192 (Ir-192) seeds which were being transported to a new facility.

A technologist at Saint Joseph Hospital who worked with the teletherapy unit had an overexposure in March 1992. The badge company stated that the badge was probably not worn during the exposure. The teletherapy unit was operating properly. The licensee did not wish to amend the exposure record. The licensee was cited.

The licensee could not explain an overexposure to a radiographer during the March 1992 monitoring period. There were no unusual events. Southwestern Laboratories' request for a deletion, however, was denied.

An employee at St. Luke's Episcopal Hospital was overexposed in the second quarter of 1992. The licensee was unable to explain the exposure and did not request a deletion. The licensee was cited.

A radiographer at Technical Welding Laboratory was overexposed during the second quarter of 1992. The licensee was unable to identify any unusual events.

Technical Welding Laboratory was unable to explain the overexposure of a radiographer in the first quarter of 1992. The licensee was cited.

Testing Engineers of California reported the whole body overexposure of a nonradiation worker on May 28, 1992.

During the first quarter of 1992, a technologist who assists in nuclear medicine at Thomason Hospital was overexposed.

An Oregon licensee reported high readings of a machinist's and a secretary's film badge for May 1992. The licensee believes that the badges may have been left on site during night radiography of a large equipment.

A technologist at Wadley Regional Medical Center was overexposed during the first quarter of 1992. The employee had received a therapeutic dose of iodine-131 (I-131) during the monitoring period. No deletion was requested.

Table A2-4 Event Summaries

On June 26, 1992, a radiographer at Edwards Valves entered a shooting booth and found that the source was exposed even though the "safe" position was indicated. As a result, the radiographer received an 0.8-rem exposure.

CP & L radiography personnel reported a drive cable failure. On June 8, 1992, while performing a source changeout from a Tech Ops 660 to a 650 source changer, the ball on the drive cable broke off. The source remained in the camera and no one was overexposed. The licensee is investigating the incident.

Eagle X-Ray reported the disconnect of a 1,665,000 MBq (45 Ci) radiography source. On August 10, 1992, a radiography trainee proceeded to change the film without performing an adequate lockout survey. The trainee noticed that his meter was off-scale. The trainer determined that the source was disconnected and secured the area. The source was recovered.

On March 20, 1992, a radiographer at MQS cranked the source in, locked the camera, and then discovered that the source was still in the exposed position. He unlocked the camera and cranked the source in.

On June 1, 1992, Technical Welding Laboratories experienced a source disconnect. The radiography camera was falling and the radiographer caught the crankout with no apparent damage to the equipment. However, after the next shot, the source would not retract. It was discovered that the source had become disconnected from the drive cable.

An improper connection of the drive cable to the pigtail caused an incident at Southern Technical Services. On January 8, 1992, a radiographer was unable to crank the source in or out. The Radiation Safety Officer was able to recover the source. The drive cable and pigtail were inspected and found to be in good condition. All the licensee's radiographers were instructed to manipulate the drive cable after connection to ensure proper connection.

A source disconnect on February 13, 1992, at Technical Welding Laboratories, was apparently due to a malfunctioning spring lock in the pigtail connector. No overexposures resulted and the licensee was able to recover the source without further incident.

On June 12, 1992, BIX Testing Laboratories experienced a source disconnect which resulted in no excessive exposures. The licensee believes that the connector end was defective. The licensee held a safety meeting to advise all employees of the incident and all crankouts were inspected for defects.

On June 25, 1992, H & H Inspection Company experienced a source disconnect that was apparently caused by the spring connector on the pigtail jamming and not locking the pigtail to the drive cable. The source was recovered with no overexposures. The spring connector was cleaned and appeared to operate properly.

H & G Inspection Company could not find the cause of the August 20,1992, source disconnect. The Radiation Safety Officer (RSO) recovered the source with no overexposures. The RSO could not find anything wrong with the source connection or the drive cable connector.

On August 25, 1992, Texas Industrial X-Ray experienced a source disconnect when the cable on the source pigtail broke. The licensee believes that the cable was defective. An analysis of the cable break determined the failure was the result of a combination of corrosion and metal fatigue.

On July 14, 1992, H & G Inspection Company experienced a source disconnect. The source became disconnected from the drive cable because the ball connector broke off. No overexposures resulted.

On June 25, 1992, a radiographer at Technical Welding Labs was unable to retract a radiography source. The crankout failure was caused by the separation of the inner liner of conduits connecting the gear box assembly. The source was recovered and no overexposures resulted.

On September 29, 1992, NDIC experienced a source disconnect. The disconnect was caused by a defective spring connector. Specifically, the spring was too weak to prevent the pigtail from disconnecting. The source was recovered and no excessive exposures resulted. The source was returned to the manufacturer.

On September 29, 1992, Applied Standards experienced a source disconnect. The source became jammed in the outlet nipple of the camera. When the radiographer attempted to return the source to a shielded position, the source became disconnected. The RSO returned the source to the shielded position. He found that there was excessive wear in the outlet nipple of the camera. The licensee replaced the outlet nipple.

On September 26, 1992, Applied Standards experienced a source disconnect. It was determined that the source had not been connected to the drive cable when the cranks were connected by the radiography trainer. The trainer and trainee were reprimanded and the incident was discussed at a safety meeting.

On June 26, 1992, Corpus Christi Inspection & Engineering reported that the pigtail became stuck in the shielded position on three occasions. The licensee replaced the locking mechanisms and this corrected the problem.

Appendix B

1992 NRC and Agreement State Licensee Misadministration Events

1992 NRC and Agreement State Licensee Misadministration Events

Table B–1 Misadministrations Reported by NRC Licensees in 1992*

Region and State	Sodium Iodide	Therapy	Population** (in Millions)	Number of Licensees***
Region 1	**3**	**16**	**35.6**	**794**
CONNECTICUT	0	3	3.3	77
DELAWARE	0	1	0.7	20
MARYLAND	1	0	4.8	4
MASSACHUSSETTS	1	3	6.0	133
NEW JERSEY	0	6	7.7	195
PENNSYLVANIA	1	2	11.9	319
VERMONT	0	1	0.6	18
WASHINGTON, D.C.	0	0	0.6	28
Region 2	**0**	**1**	**11.5**	**244**
PUERTO RICO	0	1	3.5	73
VIRGINIA	0	0	6.2	115
WEST VIRGINIA	0	0	1.8	56
Region 3	**3**	**7**	**40.0**	**988**
INDIANA	0	2	5.5	134
MICHIGAN	2	1	9.3	267
MINNESOTA	0	0	4.4	72
MISSOURI	0	1	5.1	152
OHIO	1	3	10.8	260
WISCONSIN	0	0	4.9	103
Region 4	**0**	**4**	**6.1**	**157**
IDAHO	0	0	1.0	21
MONTANA	0	0	0.8	24
OKLAHOMA	0	2	3.1	79
SOUTH DAKOTA	0	0	0.7	19
WYOMING	0	2	0.5	14
Region 5	**1**	**1**	**31.5**	**45**
ALASKA	0	0	0.6	8
CALIFORNIA	1	0	29.8	15
HAWAII	0	1	1.1	22
TOTAL	**7**	**29**	**124.7**	**2228**

* This table includes NRC Federal medical licensees located in Agreement States.
** U.S. Bureau of Census, U.S. Department of Commerce, 1990, Census of U.S. Population.
*** NRC (NMSS) files on "Active NRC Licenses by State and Program Code," January 11, 1993.

Table B-2 Misadministrations Identified by Agreement States in 1992

Region and State	Sodium Iodide	Therapy	Population* (in Millions)	Number of Licensees
Region 1	**2**	**6**	**26.0**	**960**
MAINE	0	1	1.2	28
MARYLAND	0	0	4.7	147
NEW HAMPSHIRE	0	0	1.1	35
NEW YORK	1	5	18.0	721
RHODE ISLAND	1	0	1.0	29
Region 2	**1**	**1**	**44.9**	**1493**
ALABAMA	0	0	4.1	128
FLORIDA	0	0	12.7	579
GEORGIA	0	0	6.4	189
KENTUCKY	0	0	3.7	109
MISSISSIPPI	1	0	2.6	91
NORTH CAROLINA	0	0	6.7	150
SOUTH CAROLINA	0	1	3.5	68
TENNESSEE	0	0	4.9	179
Region 3	**1**	**1**	**13.8**	**303**
ILLINOIS	1	1	11.0	246
IOWA	0	0	2.8	57
Region 4	**1**	**1**	**34.4**	**1144**
ARKANSAS	0	0	2.4	87
COLORADO	0	0	3.3	78
KANSAS	0	0	2.5	104
LOUISIANA	0	0	4.4	171
NEBRASKA	0	0	1.6	53
NEW MEXICO	0	0	1.5	46
NORTH DAKOTA	0	0	0.5	17
TEXAS	1	1	17.0	557
UTAH	0	0	1.7	31
Region 5	**2**	**1**	**41.3**	**1044**
ARIZONA	1	1	3.6	100
CALIFORNIA	0	0	29.0	777
NEVADA	0	0	41.1	30
OREGON	0	0	2.8	69
WASHINGTON	1	0	4.8	68
TOTAL	**7**	**10**	**160.4**	**4944**

*U.S. Bureau of Census, U.S Department of Commerce, 1990, Census of U.S. Population.

I Medical Misadministrations Reported by NRC Licensees During 1992

I.A Therapy Misadministrations

NRC licensees reported 29 therapy misadministrations during 1992. Of these misadministrations, 16 involved teletherapy, and 13 involved brachytherapy. In addition, there were seven sodium iodide misadministrations.

I.A.1 Teletherapy Misadministrations

- **Greenwich Hospital Association, Greenwich, CT**

  A patient was prescribed a cobalt-60 teletherapy treatment of a dose of 7680 centigray (cGy) (7680 rad) to the larynx in 64 fractions of 120 cGy (120 rad) each. Two fractions were to be delivered each day. After 18 treatments were delivered, the oncologist revised the treatment plan to reduce the field size and bring the radiation field off of the spinal cord. The radiation therapy technologist made an error in the calculation of the treatment time for the revised plan and the patient received twice the prescribed dose in each of the next 22 treatment fractions. As a result, the patient received a dose of 5280 cGy (5280 rad) instead of the intended 2640 cGy (2640 rad). The physicist reviewed the treatment plan and patient charts weekly but failed to identify the error until the third review. The patient's treatment was immediately suspended. The licensee determined that the patient received a total dose of 7440 cGy (7440 rad) in 40 fractions rather than the prescribed 7680 cGy (7680 rad) in 64 fractions. Corrective actions included: (1) disciplinary actions against the teletherapy physicist and the two technologists involved, (2) hiring of a new teletherapy physicist, (3) establishment of a policy that no new treatment will be initiated until two different individuals have calculated and independently verified the treatment time and calculations, (4) establishment of a new policy having a sign-off sheet for the individuals making the calculations, and (5) plans to have two quality assurance audits performed in a year. The referring physician decided not to notify the patient of the misadministration, but did notify the family.

- **Jersey Shore Medical Center, Neptune, NJ**

  A patient was prescribed a cobalt-60 teletherapy treatment of a dose of 4140 cGy (4140 rad) for a palliative treatment of the lung in fractions of 180 cGy (180 rad) for 23 days. However, because of an incorrect fractionated dose, the patient received 1500 cGy (1500 rad) instead of the prescribed 900 cGy (900 rad) in the first five treatments. The teletherapy physicist made an error by selecting a 300 cGy/day (300 rad/day) regime instead of the 180 cGy/day (180 rad/day) as prescribed by the oncologist. Since the error occurred in the first week of therapy, the treatment plan was modified and the patient received five additional treatments of 300 cGy/day for a total of 3000 cGy (3000 rad).

  To prevent a recurrence of this error, the licensee provided training for the radiation therapy staff. The licensee has also modified the chart check procedures to ensure early recognition of errors. On the advice of the patient's personal physician, the patient was not notified of the misadministration.

- **Carlisle Hospital, Carlisle, PA**

  A patient was prescribed a cobalt-60 teletherapy treatment consisting of a single fraction of a dose of 800 cGy (800 rad) to the left hip. The treatment time was calculated by a technologist using an outdated source-skin distance technique for measuring radiation exposure time. This resulted in an incorrect treatment time. Before the treatment, a second technologist checked the calculations and made the same error. As a result, the incorrect time was used and the patient received 960 cGy (960 rad) instead of the intended 800 cGy (800 rad).

  To prevent a recurrence of this error, the licensee instituted additional employee training in performing calculations. Also, the licensee obtained outside temporary assistance to help employees perform the new calculations. The

referring physician and the patient were notified of the misadministration.

- **Medical Center Hospital of Vermont, Burlington, VT**

  A patient was prescribed to receive a cobalt-60 teletherapy treatment. The total prescribed dose of 3750 cGy (3750 rad) consisted of 15 fractions of 250 cGy (250 rad) each. However, the patient's treatment time was incorrectly transcribed from a computer printout into the treatment chart. As a result, the patient received 394 cGy (394 rad) per treatment for the first 10 treatments instead of the intended 250 cGy (250 rad) per treatment. This error was noted at the first chart check, after the tenth fraction, and the treatment was terminated. The patient received 3940 cGy (3940 rad) in the 10 treatments rather than the prescribed 3750 cGy (3750 rad) in 15 treatments.

  To prevent a recurrence of this error, the licensee has modified the standard operating procedures. The treatment time, which is initially written in the patient's chart, will be confirmed and initialed by a second individual before the beginning of the first treatment. In addition, the patient treatment chart will be checked weekly. The referring physician and the patient were notified of the misadministration.

- **G. Anthony Doener, M.D. , Freehold, NJ**

  Thirteen patients who were prescribed cobalt-60 teletherapy treatments received doses that were about 15 to 40 percent lower than the intended doses. The licensee stated that the misadministrations resulted from an error in the treatment time used. The error was introduced by the licensee's previous consulting teletherapy physicist who had prepared the tables used for treatment times. The licensee stated that probable causes of these misadministrations were: (1) failure of the previous physicist to perform a secondary check of treatment times for charts prepared for July 1990 through December 1990 and (2) failure of the authorized user to identify the previous physicist's error on treatment time charts through independent verification.

  To prevent a recurrence of this error, the licensee corrected the treatment time charts. Also, treatment times will be independently verified by the current teletherapy physicist on a weekly basis or when treatment times for a patient being treated are changed. The licensee submitted a Quality Management Program to the NRC. The licensee stated that the treatment time for one patient undergoing a treatment was adjusted to correct for the error before completion of the treatment. Also, the licensee noted that three of the patients are deceased and that the remaining eight patients would not be adversely affected. The patients were notified of the treatment error. The licensee has since ceased teletherapy operations and the license was terminated in April 1993.

- **Berkshire Medical Center, Pittsfield, MA**

  A patient was prescribed a cobalt-60 teletherapy treatment to the right lung. The treatment plan called for 30 fractions of 200 cGy (200 rad) each for a total treatment dose of 6000 cGy (6000 rad). After the 18th fraction, the technologist recorded the cumulative dose as 2600 cGy (2600 rad), instead of the actually administered dose of 3600 cGy (3600 rad). The technologist failed to recognize the error and continued to give 200-cGy (200-rad) fractions until what was thought to be the total prescribed dose was administered. This led to the patient receiving a total of 7000 cGy (7000 rad) in 35 fractions instead of the prescribed 6000 cGy (6000 rad). The error was discovered when the patient returned for additional radiation treatment.

  To prevent a recurrence of this error, the licensee instructed the technologists to review the written directive and treatment plan daily. Also, the licensee has employed additional staff to assist with the weekly chart checks. The referring physician and the patient were notified of the treatment error.

- **Massachussetts General Hospital, Boston, MA**

  A patient was prescribed a cobalt-60 teletherapy treatment of 1655 cGy (1655 rad). The

treatment required two fields using 30-degree wedges. However, because the physicist failed to record the wedges in the setup portion of the patient's chart, the wedges were not used during the treatment. This caused the patient to receive a dose of 2297 cGy (2297 rad) to the treatment area in 5.5 fractions, instead of the prescribed 1655 cGy (1655 rad).

To prevent a recurrence of this error, the licensee stated that documentation related to each patient's wedge information will be completed before the treatment begins. Also, the physicist will verify the wedge information during weekly chart checks. The patient was not notified of the misadministration because the patient's physician determined that notification was not in the patient's best interest.

- **University of Connecticut Health Center, Hartford, CT**

A patient was prescribed a cobalt-60 teletherapy treatment to the larynx. The total prescribed dose was 7000 cGy (7000 rad). The patient was to receive 35 fractions of 200 cGy (200 rad) each. The treatment plan called for a change in technique for fractions 28 through 35, using a 30-degree wedge. Before the 32nd treatment, a technologist noted that the 30-degree wedge had not been used for the four previous treatments. The technologist used the wedge for the 32nd treatment as prescribed. The treatment was terminated after the 32nd fraction. The absence of the wedge caused the fractional dose to be 300 cGy (300 rad) instead of the intended 200 cGy (200 rad). The licensee stated that the dose over the final five days of treatment (this includes the period when the wedge was not used) was 1408 cGy (1408 rad) instead of the prescribed 1000 cGy (1000 rad). As a result, the total treatment dose was 6776 cGy (6776 rad) instead of the prescribed 7000 cGy (7000 rad).

To prevent a recurrence of this error, the licensee provided training for the technologists which emphasized the need to check the treatment plan prior to drawing up a daily plan and the need for clear communication with the physician regarding the prescribed dose. The patient's physician and the patient were notified of the misadministration.

- **Medical Center of Delaware, Wilmington, DE**

A patient was prescribed a cobalt-60 teletherapy treatment of 4000 cGy (4000 rad) to the pelvic region. The dose was to be delivered in 20 fractions of 200 cGy (200 rad) each. During the 14^{th} treatment, the patient received 165 cGy (165 rad) to the pelvic region in a rotational mode. This caused the patient to receive 80 to 110 cGy (80 to 110 rad) and 60 to 70 cGy (60 to 70 rad) to the left and right sides of the pelvic area, respectively. The licensee attributed this misadministration to a breakdown in the Quality Management Program (QM) procedures. The licensee's QM procedures require that two radiation therapy technologists check the patient setup to ensure correctness. In this case, only one technologist checked the setup and he did not notice that the teletherapy unit was still set up for the rotational treatment from the previous treatment. Additionally, the therapy technologist failed to visually check the operation of the treatment unit after the beam-on switch was activated. The physician determined on the day of the misadministration, that the treatments should be stopped at 3000 cGy (3000 rad), which was reached on the day of the misadministration.

To prevent a recurrence of this error, the licensee provided a training session for all radiation therapy technologists in the QM procedures. The licensee increased the supervisory review and evaluation of present procedures to ensure their comprehension and implementation. The referring physician and the patient were notified of the misadministration.

- **Harper Hospital, Detroit, MI**

A patient undergoing cobalt-60 teletherapy treatment received 180 cGy (180 rad) to the wrong side of the chest area. Eight fractions were delivered without incident. However, for the ninth treatment, the technologist inadvertently used a leveling tattoo on the left shoulder instead of the right as prescribed to center the supraclavicular port. During the setup for the tangential fields, it was noticed that the

port treatment had been to the wrong side. Factors contributing to this error included the symmetrically placed leveling tattoo on the left shoulder. Also, the patient was extremely nervous and talkative, requiring constant attention.

To prevent a recurrence of this error, the licensee now requires that in cases where patients have multiple tattoos, the setup tattoos will be circled and the leveling tattoos will be marked with crosses. The licensee also implemented a program to ensure that the manual defining misadministration is kept current. The referring physician was notified of the misadministration. He chose not to inform the patient.

- **Bothwell Regional Health Center, Sedalia, MO**

A patient was prescribed a palliative cobalt-60 teletherapy treatment of 20 fractions of 200 cGy (200 rad) each. The prescribed source-to-skin distance (SSD) was 70 centimeters (cm) (27.6 inches [in.]). The usual SSD used by the licensee for treatments was 80 cm (31.5 in.). The consulting physicist who performed the patient dose calculations used an incorrect inverse square correction factor. This led to a 70 percent miscalculation of the teletherapy dose. The patient received 340 cGy (340 rad) per fraction instead of the intended 200 cGy (200 rad) for the first eight fractions. The calculations were not checked until after the eighth fraction when a junior physicist discovered the mistake. The next fractions were reduced to compensate for the excess dose in the earlier treatments.

To prevent a recurrence of this error, the licensee modified the procedure requiring that calculations be checked before the third fraction for treatments consisting of more than three fractions, or before the first fraction in cases where three or fewer fractions will be administered. Also, in the case where the physicist is the only person involved in the dose calculations, calculations will be rechecked on the first or the second day of the treatment. The referring physician and the patient were notified of the misadministration.

- **St. John's Medical Center, Anderson, IN**

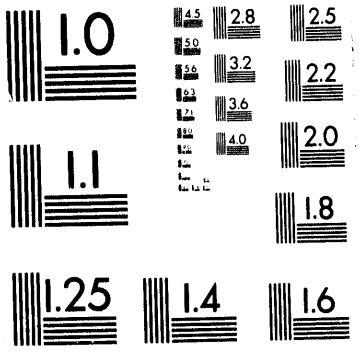
A patient was prescribed a cobalt-60 teletherapy treatment of 3000 cGy (3000 rad) to the brain delivered in 10 treatments of 300 cGy (300 rad) each. However, due to an error in dose calculation, the patient was administered 2550 cGy (2550 rad) in five treatments. The dosimetrist calculated the dose to the brain at a depth of 16 cm (6.3 in.) rather than the prescribed depth of 8 cm (3.1 in.). This resulted in the patient receiving 510 cGy (510 rad) instead of the intended 300 cGy (300 rad) per treatment. The therapy physicist discovered the error at the end of the fifth treatment during a review of the dose calculations. When the error was discovered, the patient's physician decided to discontinue treatments.

To prevent a recurrence of this error, the licensee stated that in cases where the treatment consists of more than three fractions, the dose calculations will be checked within two working days. If the prescribed dose is to be administered in three fractions or fewer, the dose calculations will be checked before administering the first treatment. The referring physician and the patient were notified of the misadministration.

- **Indiana University School of Medicine, Indianapolis, IN**

A 31-month-old child was prescribed cobalt-60 teletherapy treatment to the brain. The total prescribed dose was 300 cGy (300 rad) to be delivered in two treatments of 150 cGy (150 rad) each. The dosimetrist mistakenly prepared the dose for 300 cGy (300 rad) per treatment. Three additional individuals reviewed the calculations before the treatment started and failed to note the error. As a result, the patient received a total dose of 600 cGy (600 rad). The error was discovered by a student therapy technologist during a review of the treatment plan.

To prevent a recurrence of this error, the licensee has instructed all personnel involved with this misadministration on the necessity of reading prescriptions. The members of the radiation oncology staff were instructed to


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
6.3
7.1

2 of 2

review the forms used for writing prescriptions to determine any possible improvements. The patient's physician and the patient's guardian were informed of the misadministration.

- **St. John's Medical Center, Tulsa, OK**

  A patient was prescribed a cobalt-60 teletherapy treatment. The treatment consisted of 10 fractions of 300 cGy (300 rad) each. However, due to an error in identifying the prescribed treatment site, the patient was administered the first two fractions of the treatment to a site other than that prescribed. Reconstruction of the first two treatments revealed that 80 percent of the prescribed volume was not treated.

  To prevent a recurrence of this error, the licensee held a staff meeting to discuss methods of localizing posterior oblique fields and the associated required documentation. All prescribing physicians were briefed on methods to properly localize treatment sites. The licensee's Quality Management Program was amended to require physician approval of the first-day port films before the patient's second treatment. The referring physician and the patient were notified of the misadministration.

- **Jane Phillips Episcopal Memorial Hospital, Bartlesville, OK**

  A patient was prescribed a cobalt-60 teletherapy treatment to two different treatment sites. The two sites were to be treated concurrently with the first site receiving 240 cGy (240 rad) each day for 20 days and the second site receiving 250 cGy (250 rad) each day for 10 days. The two technologists involved in this procedure misunderstood the physician's verbal instruction concerning the patient's treatment plan and failed to recognize the differing number of treatment fractions between the two treatment sites. This error caused the second site to receive an extra 4 days of treatment before the authorized user recognized the error. These additional four treatment fractions resulted in an unprescribed dose of 1000 cGy (1000 rad).

  To prevent a recurrence of this error, the licensee incorporated a new method of installing "stop" marks on the specific treatment charts. The referring physician and the patient were notified of the misadministration.

- **Sharlin Radiological Association, Hackensack, NJ**

  A patient was prescribed a one-time teletherapy dose of 700 cGy (700 rad) to be delivered in two fractions of 350 cGy (350 rad) each to the patient's left hip. The treatment depth was entered into the computer incorrectly as 7 cm (2.8 in.) rather than the intended depth of 10 cm (3.9 in.). Due to a miscommunication between the two technologists involved, the patient was given a dose of 572 cGy (572 rad) rather than the desired 700 cGy (700 rad). The referring physician stated that the dose given to the patient was satisfactory and no additional treatment was necessary.

  To prevent a recurrence of this error, the licensee now requires that treatment parameters be input into the computer by the same technologist who determines these parameters and that the data be checked by the technologist for accuracy before administration of treatment. The licensee also requires that treatment parameters be checked by a physicist before the administration of the first fraction, when only a single fraction is prescribed, and within 24 hours of the administration of the first fraction when more than one fraction is prescribed. The referring physician and the patient were notified.

I.A.2 Brachytherapy Misadministrations

- **Beth Israel Hospital, Passaic, NJ**

  A patient was prescribed a brachytherapy treatment for an endobronchial implant using iridium-192 (Ir-192) seeds. The prescribed dose for the patient was 1500 cGy (1500 rad). However, the licensee stated that the patient received about 400 cGy (400 rad). The procedure required the use of two ribbons containing a total of 35 Ir-192 seeds. One ribbon contained 15 seeds and the other ribbon contained 20 seeds, with a total activity for both ribbons of 2536 megabecquerel (MBq) (68.54 millicurie [mCi]). During the implant procedure, the medical physicist gave the attending physician

the wrong end of the 15-seed ribbon (the portion that did not contain the seeds) and the wrong end was then inserted into the patient. The 20-seed ribbon was inserted correctly. No makeup dose was given to the patient.

To prevent a recurrence of this error, the licensee now requires the radiation Safety Officer or his designee to be present during every implant and removal of radioactive materials. In addition, the licensee stated that management is more deeply involved in the affairs affecting radiological safety and is conducting an audit of the radiation safety program. Neither the patient nor the referring physician were notified of the misadministration.

- **St. Clares Riverside Medical Center, Denville, NJ**

A patient was prescribed a brachytherapy treatment using Ir-192 seeds. The patient was implanted with two ribbons each containing six Ir-192 seeds with total activity of 1785 MBq (48.25 mCi). The patient was prescribed to receive 1500 to 2000 cGy (1500 to 2000 rad) to the tumor site. However, after the implant procedure, the patient's nurse noticed that the dressing to the treatment area had become soaked with drainage from the catheters. The nurse changed the dressing. Several hours later, another nurse noted that the dressing was wet again and that the ribbons were not in the catheters. The nurse did not recognize that the ribbon contained the Ir-192 seeds and coiled the ribbons and taped them to the patient's abdomen. Approximately, 6 hours later when an x-ray was requested to determine the position of the ribbons relative to the catheters, it was noted that the ribbons were no longer in the catheters. When the licensee realized what had happened, the ribbons were removed from the patient. The patient received a dose of 1032 cGy (1032 rad) to the skin of the abdomen and 1145 cGy (1145 rad) to the prescribed treatment site. The nurse who taped the ribbons to the patient received 7 cGy (7 rad) to the skin of her hand.

To prevent a recurrence of this error, the licensee implemented the following corrective actions: (1) committed to have a new Radiation Safety Officer in place before another brachytherapy procedure was performed, (2) developed a nurse's procedure manual, (3) conducted formal inservice training, and (4) required a written directive before ordering radioactive material. Both the patient and the patient's nurse were notified of the misadministration.

- **Lahey Clinic Foundation, Burlington, MA**

A patient was prescribed a brachytherapy treatment with a Gamma Med 12i High Dose Rate (HDR) Afterloader using a 210,900-MBq (5.7-Curie [Ci]) Ir-192 source. The patient was prescribed three treatments of 700 cGy (700 rad) each to the main stem bronchus area. During the second treatment, the physicist made an error and programmed the HDR unit to place the source 7 millimeters (0.28 in.) from the end of the catheter rather than the intended 7 cm (2.8 in.). This caused 90 percent of the prescribed dose to be administered to the wrong site. The last treatment was modified to compensate for the error.

To prevent a recurrence of this error, the licensee retrained the physicist on the use of the HDR afterloading equipment and the proper measurement units used in programming the equipment. The referring physician and the patient were notified of the misadministration.

- **Oncology Services Corporation, Harrisburg, PA**

A patient was prescribed three 600 cGy (600 rad) treatments using an Omnitron 2000 High Dose Rate (HDR) unit loaded with a 159,100-MBq (4.3-Ci) Ir-192 source. Five catheters were placed in the tumor and the source was placed at various positions in each catheter. During the first treatment, the licensee experienced difficulty placing the source wire into the fifth catheter. An area radiation monitor was alarming, but this alarm was disregarded because the HDR unit console indicated "safe." The licensee believed the source was in the lead shield and assumed the area radiation monitor was malfunctioning. The source wire had actually broken and the

source remained in the patient. The patient, with the source still in the catheter, was transported back to the nursing home. The source remained in the patient's body for almost 4 days at which point the catheter containing the source fell out. As a result of this misadministration, the patient received a dose at 1 cm (0.4 in.) of 1,600,000 cGy (1,600,000 rad) instead of the prescribed 1800 cGy (1800 rad) at 1 cm (0.4 in.). The nursing home staff placed the catheter in a medical waste storage area and it was transferred that same day to another storage location. The medical waste was later removed by Browning-Ferris Industries (BFI). The source was discovered when it tripped a fixed monitor at a BFI medical waste incinerator. An NRC medical consultant determined that the radiation exposure was at least a probable contributing cause of death in this patient and the autopsy report stated the cause of death as "acute radiation exposure and the consequences thereof." The loss of the source caused radiation exposures to 94 individuals, including individuals at the cancer clinic, people at the nursing home, ambulance staff, and BFI personnel associated with this event.

The NRC initiated an Incident Investigation Team and issued a Bulletin to users of Omnitron 2000 HDR afterloading unit. NRC is reviewing the licensee's corrective actions to prevent a recurrence of this error.

- **Yale-New Haven Hospital, New Haven, CT**

On December 2, 1992, NRC was notified by the Yale-New Haven Hospital, New Haven, Connecticut, the licensee, that it had recovered a 1295-MBq (35-mCi) brachytherapy source that was discovered to be missing earlier that day. On December 3, 1992, NRC Region I was notified that the source had probably been lost before or during a brachytherapy treatment, resulting in a therapeutic misadministration. A female patient, was to receive 1848 cGy (1848 rads) to the cervix for cancer treatment. One of the sources that was prescribed was either never inserted or was removed from the applicator during treatment. Assuming maximum deviation from the planned treatment, the actual dose to the patient was only 1235 cGy (1235 rads). The licensee stated that a source was also misplaced and was in contact with one of the patient's legs for a period of time, resulting in an estimated dose to the leg of 260 cGy (260 rads). The physicians responsible for the treatment, after reviewing the dose estimates, decided no additional treatments were necessary. The misplaced source was inadvertently put with hospital linen. The linen with the brachytherapy source was taken to an offsite laundry facility, from which it was subsequently recovered. The referring physician and patient were notified of the misadministration.

The licensee failed to recognize the significance to radiation safety of a procedural change that eliminated the use of disposable pads in favor of reusable linen pads. Previously, the licensee disposed of pads by putting them in infectious waste, which stayed in the room until after the final radiation survey was performed, after removal of the radiation sources. The reusable pads, when changed, were placed in laundry bags in the hallway, which were taken to the laundry facility daily. The nursing staff failed to follow the procedure that prohibited removing anything from the patient's room that had not been checked for the presence of a brachytherapy source.

The licensee has taken the following steps to prevent a recurrence of this error: (1) physicians have been instructed to visually confirm that sources are properly loaded into applicators, (2) dosimetrists have been instructed to observe the loading process and confirm that applicators are correctly loaded, (3) a linen hamper will be placed in each brachytherapy patient's room so that linen will not, generally, be removed until after the final room survey to confirm that no sources have been lost, (4) soiled linen that cannot be left in the room until the end of treatment will be surveyed to ensure that no sources are in the linen being removed from the patient's room, and (5) physicians have been instructed to visually check for the presence of sources at the time they are removed from the patients.

NRC retained a medical consultant to review the case to provide clinical assessment of this misadministration. NRC Region I staff

conducted a special inspection on December 3 and 4, 1992, and identified three violations of NRC requirements: (1) failure to survey soiled linen pads before removing them from a patient's room, (2) loss of control of the radioactive source, and (3) existence of radiation levels above the regulatory limit in unrestricted areas.

- **Cooper Hospital/University Medical Center, Camden, NJ**

  Five patients were underdosed because of an error introduced into the treatment planning computer. Specifically, the source calibration was specified in non-Systeme International (SI) units. However, the operator instructed the computer to use SI units. This resulted in a 14 percent underdose to all five patients. The following is a brief description of the five misadministrations.

  - A patient was prescribed a brachytherapy bronchial implant of 1043 cGy (1043 rad), but the patient received only 916 cGy (916 rad).
  - A patient received 1112 cGy (1112 rad) instead of the prescribed dose of 1266 cGy (1266 rad).
  - A patient received 4063 cGy (4063 rad) instead of the intended 4628 cGy (4628 rad).
  - A patient received 1888 cGy (1888 rad) instead of the intended 2150 cGy (2150 rad).
  - A patient received 1756 cGy (1756 rad) as opposed to the intended dose of 2000 cGy (2000 rad).

  To prevent a recurrence of this error, the licensee will verify the calibration factors typed in for the implant source inventory. Also, the licensee distributed an instruction sheet to all physics and dosimetry personnel emphasizing the importance and mechanics of these procedures. The patients were not notified of the misadministrations.

- **Hospital Metropolitano, Rio Piedra, PR**

  A patient was prescribed brachytherapy gynecological treatment using cesium-137 (Cs-137) sources. The prescribed dose consisted of 4500 cGy (4500 rad) to the cervix. However, five Cs-137 sources in storage awaiting disposal were inadvertently used in a brachytherapy treatment. A new employee, who had not performed the task since 1984, loaded the wrong sources into a Henschke applicator under the supervision of a senior technologist. An NRC consultant evaluated the dose to the patient to be a maximum of 450 cGy (450 rad) to the wrong treatment site. The patient and the referring physician were notified of the misadministration.

  To prevent a recurrence of this error, the licensee has: (1) labeled the storage area for brachytherapy sources awaiting disposal, (2) provided training to the technologists regarding the correct loading of the applicator, and (3) instructed the authorized users on NRC reporting requirements and applicable regulations.

- **Cleveland Clinc Foundation, Cleveland, OH**

  A patient was prescribed a brachytherapy gynecological treatment of 2676 cGy (2676 rad) using Cs-137 sources. However, because the wrong sources were selected, the patient received a dose of 4205 cGy (4205 rad). A Fletcher-Suit applicator was to be loaded with five Cs-137 sources with a total activity of 55.9 milligrams radium-equivalent. Because of faded color coding of the sources, the individual selecting the sources made a mistake while selecting two of the five sources. This caused the total activity to be 77.9 milligrams radium-equivalent. The incorrect selection was not detected by the individual performing the independent verification of source selection. The final dose was adjusted for the patient to receive the correct total dose.

  To prevent a recurrence of this error, the technologists were given a review of their duties when helping the physicist to remove Cs-137 sources from storage. The licensee also

repainted the color coding of the sources. The referring physician and patient were notified of the misadministration.

- **The Christ Hospital, Cincinnati, OH**

  A patient was prescribed a brachytherapy procedure using 58 iodine-125 seeds for a prostate implant. The prescribed dose was 12,000 cGy (12,000 rad). However, the patient received a dose of 5000 cGy (5000 rad). Each seed had a nominal activity of 11.5 MBq (0.31 mCi). They were "ultrasonically guided" with a transrectal ultrasonic probe and were permanently implanted in the prostate area of the patient. The patient's x-ray and computerized axial tomography scans taken subsequent to the implant procedure revealed that two of the seeds had been eliminated in the patient's urine. It was also revealed that 21 of the 56 remaining seeds were located in tissue surrounding the prostate and not in the prostate.

  To prevent a recurrence of this error, the licensee stated that in the future: (1) pretreatment ultrasonography would be more thorough, (2) the Foley catheter should not be used during the treatment, and (3) several measurements would be made of seed insertion depth. The patient and the referring physician were notified of the misadministration.

- **Memorial Hospital of Laramie County, Cheyenne, WY**

  A patient was prescribed a brachytherapy prostate gland treatment using Ir-192 sources. The patient was prescribed to receive 3258 cGy (3258 rad). However, due to an error, the patient received 5669 cGy (5669 rad). The error was noted during the review of the shipping documents associated with a brachytherapy implant. The licensee ordered Ir-192 brachytherapy ribbons containing seven seeds per ribbon with an activity of 29 MBq (0.79 mCi) per seed. However, the vendor delivered Ir-192 brachytherapy ribbons containing seven seeds but with an activity of 50 MBq (0.79 milligram radium-equivalent [1.36 mCi]) per seed. The dosimetrist who checked the prescription and the shipment failed to note the difference in the units of measurement.

  To prevent a recurrence of this error, the licensee has revised the department's procedures regarding verification of source strengths before using them. The referring physician was notified and chose not to notify the patient.

- **Memorial Hospital of Laramie County, Cheyenne, WY**

  A patient was prescribed a brachytherapy treatment using Ir-192 sources. The patient was prescribed a dose of 2880 cGy (2880 rad) to the prostate using a transperineal interstitial implant containing a total of 70 Ir-192 seeds encased in 10 nylon ribbons. The licensee ordered Ir-192 brachytherapy ribbons containing seven seeds per ribbon with an activity of 29 MBq (0.79 mCi) per seed. However, the vendor delivered Ir-192 brachytherapy ribbons containing seven seeds but with an activity of 50 MBq (0.79 milligram radium-equivalent [1.36 mCi]) per seed. Ten 14-gauge catheters were placed in the desired treatment site and were loaded with the sources that were of the wrong strength. During the course of the treatment, two catheters were dislodged and were subsequently removed by the physician. As the treatment progressed, the patient developed some decompensated dementia, became confused, and removed four of the catheters. These were recovered by the attending nurse and the treatment was discontinued. Because of the higher strength of the sources and the early removal of the catheters, the administered dose was estimated to be 3520 cGy (3520 rad).

  To prevent a recurrence of this error, the licensee revised procedures for verifying source strength preceding treatment. The licensee believes that this is not a misadministration and has chosen not to notify the patient. The NRC has determined that this was a misadministration

- **Queens Medical Center, Honolulu, HI**

  A patient was prescribed a brachytherapy treatment to the nasopharynx of 3000 cGy (3000 rad) using Ir-192 sources. However, because the catheter used for the treatment was bent, the patient received 2250 cGy (2250 rad). The licensee stated that the Ir-192

ribbon had been pushed down the afterloading catheter until it could be pushed no further. It was assumed that this was the end of the catheter. However, it was just a bend in the catheter preventing the ribbon from further insertion.

To prevent a recurrence of this error, sources will be marked with a reference point to ensure proper insertion. The licensee will also review the revised procedure and the Quality Management Program with radiation oncologists and dosimetrists. The referring physician and the patient were notified of the misadministration.

- **Riverside Methodist Hospital, Columbus, OH**

A patient was prescribed a brachytherapy treatment of 3248 cGy (3248 rad) using a Cs-137 Low Dose Rate Afterloader brachytherapy unit. The medical physicist mistakenly calculated the treatment time using Ir-192 characteristics instead of the intended Cs-137 characteristics. The patient received a dose of 2200 cGy (2200 rad). The licensee stated that this misadministration resulted because the wrong isotope button was activated which resulted in a treatment plan using Ir-192 instead of Cs-137.

To prevent a recurrence of this error, the licensee: (1) restructured the isotope selection board which requires more than one step when selecting an isotope and (2) instituted independent verification of all treatment plans and calculations. The referring physician and the patient were notified.

I.A.3 Sodium Iodide Misadministrations

- **Baystate Medical Center, Springfield, MA**

A patient who was prescribed a dosage of 0.592 MBq (16 microcurie [Ci]) of iodine-131 (I-131) for a thyroid uptake and scan was administered 152 MBq (4.1 mCi) of I-131. The licensee's departmental procedure for an I-131 uptake and scan directs the use of 0.592 MBq (16 Ci) of I-131 and 370 MBq (10 mCi) of technetium-99m. A whole body scan requires that approximately 148 MBq (4 mCi) of I-131 be given to the patient. The licensee stated that because of a miscommunication, a whole body scan rather than the prescribed I-131 thyroid uptake and scan was ordered. The authorized user was not consulted to review the study and prepare a written directive preceding administration, as is required by 10 CFR 35.32. As a result, the nuclear medicine technologist administered 152 MBq (4.1 mCi) of I-131 for a whole body scan without following the department's procedures. The misadministration was discovered later that day when the procedure request order card arrived at the Nuclear Medicine Department and was found to request a different study than that administered.

To prevent a recurrence of this error, the licensee conducted an in-service meeting with clinical and administrative staff and reasserted the departmental policy of therapeutic and diagnostic orders being written by the authorized user. The licensee is also streamlining the distribution of request order cards to ensure the prompt processing of requests. The referring physician and the patient were notified of the misadministration.

- **Cleveland Clinic Foundation, Cleveland, OH**

A patient was administered an I-131 dosage for a 24-hour thyroid uptake and scan rather than the intended 24-hour thyroid uptake only. As a result, the patient was administered a dosage of 3.1 MBq (83.5 Ci) of I-131 instead of the prescribed dosage 0.6 MBq (15.0 Ci) of I-131.

To prevent a recurrence of this error, the licensee plans a review of the departmental procedures for all technologists involved in the use of radioactive material. The referring physician and the patient were notified of the misadministration.

- **Marquette General Hospital, Marquette, MI**

A dosage of 1.1 MBq (30.4 Ci) of I-131 was administered to the wrong patient. The administering technologist had been given instructions to locate the patient based on the patient's attire. The technician found a patient who seemed to fit the description and assumed that she was the patient scheduled for testing.

During uptake monitoring, the error was discovered and a blocking agent was administered.

To prevent a recurrence of this error, the technologist received verbal and written reprimands. The licensee has implemented a new policy requiring positive identification before administration of radiopharmaceuticals. The attending physician and the patient were notified of the misadministration.

- **Ingham Medical Center, Lansing, MI**

A patient received 370 MBq (10 mCi) of I-131 for a whole body scan as the referring physician had requested orally. A whole body scan is used for the diagnosis of thyroid cancer. The patient had no such diagnosis. The nuclear medicine technologist questioned the request during a telephone conversation with the referring physician's staff. The referring physician's staff again requested a whole body scan. The patient was treated. A thyroid uptake scan generally requires 740 MBq (20 mCi) of technetium-99m. The licensee estimated the patient received about 27,000 cGy (27,000 rad) to the thyroid. An NRC medical consultant concluded that available evidence suggested that the patient had developed permanent hypothyroidism.

To prevent a recurrence of this error, the licensee now requires a handwritten specific order by any referring physician when a whole body (I-131) scan is requested. The referring physician and the patient were notified of the misadministration.

- **V.A. Pettis Memorial Hospital, Loma Linda, CA**

A patient was prescribed to receive a 5550 MBq (150 mCi) dosage of I-131. However, due to scheduling delays the dosage had decayed to 4292 MBq (116 mCi). The physician ordered additional I-131 to bring the dosage to 6616 MBq (178.8 mCi). The physician administered the 6616 MBq (178.8 mCi) dosage to the patient and later revised the written directive to show the revised dosage after the radiation Safety Officer had pointed out the error.

To prevent a recurrence of this error, the licensee has enforced closer scrutiny by the Radiation Safety Officer and prescribed additional training for the nuclear medicine staff. The patient was not notified because the referring physician believed that to do so would be harmful to the patient. This event is still under review by the NRC for final determination as a misadministration event.

- **Allegheny General Hospital, Pittsburgh, PA**

A patient suffering from persistent hyperthyroidism was prescribed a 333 MBq (9 mCi) dosage of I-131. During post-administration assaying, it was discovered that 74 MBq (2 mCi) remained in the vial used to dispense the dosage. Due to confusion in communications, the discovery was not brought to the attention of the licensee. The licensee identified the key item in this misadministration to be the failure to communicate. In addition, the licensee stated that a failure of the delivery system to adequately dispense the dose may have contributed to this misadministration.

To prevent a recurrence of this error, technologists were given refresher training emphasizing the importance of reporting these results to the licensee. The referring physician and the patient were notified of the misadministration.

- **National Naval Medical Center, Bethesda, MD**

A patient was prescribed 185 MBq (5.0 mCi) of I-131 for a diagnostic neck and chest metastasis survey study. However, the patient was administered only 57.4 MBq (1.55 mCi) because a previously unused I-131 survey dosage which had undergone about 12 days of decay was inadvertently used (I-131 has an 8-day physical half-life). A nuclear medicine technologist failed to measure the dosage in a dose calibrator before it was administered to the patient.

To prevent a recurrence of this error, the licensee took the following corrective actions: (1) provided training to all radiation safety and nuclear medicine staff in established clinical and quality management procedures which require verification of dosages in a dose

calibrator preceding administration, (2) modified iodine dose assay procedures to require independent verification by a technologist and a physician to assure that the assayed activity agrees with the prescribed dose listed on the physician's written directive, and (3) modified handling procedures for unused radiopharmaceutical dosages. The referring physician and the patient were notified of the misadministration.

I.B Diagnostic Misadministrations

No diagnostic misadministrations were reported to the NRC after January 27, 1992, when the revised definition of this type of misadministration became effective.

II Medical Misadministrations Submitted by Agreement State Licensees During 1992

II.A Therapy Misadministrations

Agreement State licensees reported 10 therapy misadministrations during 1992. Of these misadministrations, three involved teletherapy, six involved brachytherapy, and one involved radiopharmaceutical therapy. In addition, there were seven sodium iodide misadministrations.

II.A.1 Teletherapy Misadministrations

- **Rush Presbyterian—St. Lukes Medical Center, Chicago, IL**

  A patient was scheduled to receive 2000 cGy (2000 rad) in ten fractions. After the first five fractions had been administered, the therapist changed the treatment plan to 1600 cGy (1600 rad). The change was written in the patient's chart, but the therapy technologist failed to note it. The patient, therefore, received 2000 cGy (2000 rad) instead of the intended dose of 1600 cGy (1600 rad). The licensee concluded that it is unlikely that any significant health concerns will result from the excess dose. The radiation Safety Officer immediately investigated the event and recommended procedural changes.

  To prevent a recurrence of this error, the Departmental Quality Assurance Committee discussed several procedural changes including improved communication between the physicians and the therapy technologists. The referring physician was notified, but he chose not to inform the patient.

- **Unspecified Facility, NY**

  A patient was prescribed a cobalt-60 teletherapy treatment to be administered to the right axilla. However, the first five treatments of 200 cGy (200 rad) each were given to the left side in error.

  The licensee did not mention any actions taken to prevent a recurrence of this error. The licensee did not mention whether the patient and the physician were informed of this misadministration.

- **Unspecified Facility, NY**

  A patient was prescribed a cobalt-60 teletherapy treatment. A wedge was not used as prescribed in the treatment plan, resulting in a 50 percent error in a fraction. The licensee stated that technologists will be given in-service training concerning treatment records. Treatment was altered for the patient to be within 2 percent of the total prescribed dose.

  The licensee did not mention any actions taken to prevent a recurrence of this error. The licensee not mention whether the physician and the patient were notified of the misadministration.

II.A.2 Brachytherapy Misadministrations

- **St. Mary's Hospital, Tucson, AZ**

  A patient removed a Cs-137 source from the tandem during implant. A 1658-MBq (44.8-mCi) source had been placed in the

tandem and ovoids of a 73-year old patient. A nurse caring for the patient found a plastic tube (which contained the source) between the legs of the patient. The physician was notified. The physician reinserted the source and stated that the patient had removed the source. The doctor estimated that the source was out of position for approximately one hour. The treatment time was adjusted accordingly.

The licensee did not mention any actions taken to prevent a recurrence of error. The licensee did not mention whether the referring physician and the patient were informed of the misadministration.

- **Richland Memorial Hospital, Columbia, SC**

  A patient was undergoing a 42-hour Cs-137 insertion with tandem and ovoid applicators. The tandem applicator had three sources of 15-, 10-, and 10- milligram radium-equivalent Cs-137 and each of the two ovoids of the applicator were to have one 15-milligram radium-equivalent source. After the sources were inserted, the attending nurse discovered a 15-mCi Cs-137 source in the patient's bed. The patient later developed an ulceration beneath her right thigh. Interviews with the staff and the patient led to the following explanations: either (1) the source fell out of the applicator as it was being inserted, and it was not noticed, or (2) a person on the staff opened the applicator out of curiosity and improperly reinserted the source, resulting in a loose source. This was to be the patient's first of two fractionated treatments, and since the underdose could be compensated for with the subsequent treatment, the licensee believed that this did not constitute a misadministration. A second insertion was not attempted because the patient was unable to cooperate enough to undergo a second treatment.

  To prevent a recurrence of this error, the nursing staff was given refresher radiation safety instruction regarding the use and treatment with radioactive Cs-137. The licensee stated that procedures have been changed to require the presence of two individuals during the insertion of low dose rate brachytherapy sources. All tandem and ovoid applicators will be taped with tamper resistant tape. The licensee did not mention whether the referring physician and the patient were informed of the misadministration.

- **Maine Medical Center, Portland, ME**

  A patient was prescribed a brachytherapy dose of 3500 cGy (3500 rad) to the lung using 13 seeds of Ir-192. A kink developed in the catheter used to insert the seeds and they were placed 26 cm (10.2 in.) away from the prescribed position. The licensee did not discover this error until the seeds were removed. As a result of the error, the hypopharynx received 3500 cGy (3500 rad) and the prescribed treatment site received 10 cGy (10 rad).

  To prevent a recurrence of this error, the licensee has taken the following precautions: (1) the desired distance will be verified using dummy seeds and (2) an x-ray will be taken of the area to be treated after the radioactive seeds are inserted, to ensure that they are in the correct location. The referring physician and patient were notified of the misadministration and a subsequent treatment was prescribed. The licensee expects no long-term effects.

- **Unspecified Facility, NY**

  A patient was underdosed while receiving a brachytherapy treatment. The patient was to receive a dose of 5000 cGy (5000 rad) but instead received 3500 cGy (3500 rad). The therapy physician calculated the dose from a 2.0 cm (0.79 in.) cylinder instead of a 2.5 (0.98 in.) cm cylinder.

  To prevent a recurrence of this error cylinders will be properly labelled. The licensee did not mention whether the referring physician and the patient were informed of the misadministration.

- **Unspecified Facility, NY**

  A Cs-137 brachytherapy source removed from a patient was left in the patient's room, causing an additional exposure of 1.3 percent of the prescribed dose.

The licensee did not mention any corrective actions to prevent a recurrence of this error. The licensee did not mention whether the physician and the patient were informed of this misadministration.

- **Unspecified Facility, NY**

  A patient was prescribed a brachytherapy ovoid implant dose of 25 milligrams radium-equivalent Cs-137. Upon unloading the sources and placing them in storage, it was discovered that the patient had been actually loaded with nominal 20-milligram radium-equivalent sources instead of the correct 25 milligram radium-equivalent sources.

  To prevent a recurrence of this error, the licensee has instituted source verification checks. The licensee did not mention whether the physician and the patient were informed of this misadministration.

II.A.3 Radiopharmaceutical Therapy Misadministrations

- **Unspecified Facility, NY**

  A patient was administered 303 MBq (8.2 mCi) of phosphorus-32 (P-32) instead of 185 MBq (5 mCi). The patient was discharged in stable condition.

  To prevent recurrence of this error, the doses for P-32 (and for I-131) therapy were clarified, and in-service training of technologists was provided. The attending physician and the patient were notified of the misadministration.

II.A.4 Sodium Iodide Misadministrations

- **Southwest Texas Methodist Hospital, San Antonio, TX**

  A patient was prescribed an I-131 thyroid scan. The technologist confused the thyroid scan requested with a whole body scan. As a result, the patient was administered 185 MBq (5 mCi) of I-131 for a whole body scan instead of the prescribed 3.7 MBq (100 Ci) of I-131. The licensee stated that the patient received 4000 cGy (4000 rad) to the thyroid. The referring physician was notified and was advised that the dose could result in the development of hypothyroidism. The referring physician plans to follow the patient accordingly.

  To prevent a recurrence of this error, the licensee has established a policy that the administration of any dosage of I-131 greater than 3.7 MBq (100 Ci) must be reviewed by a staff radiologist licensed to administer radioactive materials who has full knowledge of the clinical problem. In addition, the significance of the error was discussed with the technologist. The licensee did not mention whether the patient was informed of the misadministration.

- **Mayo Clinic Scottsdale, Scottsdale, AZ**

  A technologist drew up a patient's dosage from a vial of 44.4 MBq (1.2 mCi) of I-131 metaiodobenzylquanidine (MIBG). She assumed that the amount sent in the vial was the approximate amount to be administered to the patient. The amount drawn in the syringe was 38.5 MBq (1.04 mCi). The patient was administered lugols solution the day preceding the day of injection. The patient was administered 29.7 MBq (804 μCi) of I-131 MIBG instead of the prescribed 18.5 MBq (500 μCi).

  To prevent a recurrence of this error, employees were reinstructed on proper dose requirements. Radiopharmaceutical dosages were posted at the dispensing station in the hot lab area. The licensee did not mention whether the physician and the patient were informed of the misadministration.

- **Roger Williams Hospital, Providence, RI**

  A patient was to be administered 259 MBq (7 mCi) of I-131. The dose was in the form of two 130-MBq (3.5-mCi) capsules, and was so indicated on the vial label. The previous doses had been administered in the form of one 259-MBq (7-mCi) capsule. When the vial was inverted by the technologist, only one of the two capsules fell out. The technologist assumed this was the entire dose. Later, when disposing of the vial shield, the other capsule was discovered. As a result, the patient received 50 percent of the prescribed dose.

  To prevent a recurrence of this error, employees were instructed to check labels

more carefully, label the top of the vial with both dose and number of capsules, and assay the vials after the administration of dosages. The patient was not notified because the dose administered would be sufficient to accomplish the required treatment.

- **Inland Imaging, Spokane, WA**

  A patient was to receive 0.296 MBq (8 μCi) of I-131 for a thyroid uptake and scan. The technologist administering the treatment misinterpreted the intended dose as a whole body scan. As a result, the patient received 196 MBq (5.3 mCi) of I-131.

  To prevent a recurrence of this error, the licensee revised the procedures for reviewing and approving I-131 administration. In addition, an internal audit was conducted of all thyroid studies performed over a 6-month period. The patient and the patient's physician were notified of the misadministration.

- **Grenada Lake, Grenada, MS**

  A patient was to receive 3.7 MBq (100 μCi) of I-131 for a scan. The wrong patient was selected and administered 218 MBq (5.9 mCi) of I-131. The patient was administered potassium iodide by the physician.

  The licensee did not mention any actions taken to prevent a recurrence of this error. The licensee did not mention whether the physician and the patients were informed of the misadministration.

- **Unspecified Facility, NY**

  A patient was administered a dose of 3.03 MBq (82 μCi) of I-131 in a capsule form instead of the prescribed 2.04 MBq (55 μCi). The licensee stated that human error accounted for the mistake and that 3.03 MBq (82 μCi) was within the guidelines for the administration.

  To prevent a recurrence of this error, a registered pharmacist will check and initial every prescription order. The licensee did not mention whether the physician and the patient were informed of the misadministration.

- **Illinois Masonic Medical Center, Chicago, IL**

  A patient was prescribed to receive a dose of Tc-99m in the form of sulfur colloid. When the wrong syringe was selected from the cart, the patient was inadvertently administered 4.07 MBq (110 μCi) of I-131 hippuran.

  The report did not mention any corrective action. The licensee did not mention whether the physician and the patient were informed of the misadministration.

II.A.B Diagnostic Misadministrations

There were no diagnostic misadministrations submitted to the NRC by Agreement States that meet the current definition of a misadministration.

Appendix C

Summary of Abnormal Occurrences, 1992 (Nonreactors)

Summary of Abnormal Occurrences, 1992 (Nonreactors)

92–1 Medical Therapy Misadministration at St. John Medical Center in Tulsa, Oklahoma

On January 21, 1992, the licensee notified NRC Region IV that on January 20, 1992, a medical misadministration was discovered that involved two therapeutic radiation doses to a part of a patient's body that was not intended to be treated. The treatments were administered on January 13 and 14, 1992, by a cobalt-60 (Co-60) teletherapy unit. The patient was scheduled to receive 10 treatments of 3 Gray (Gy) (300 rad) each to the right scapula. After the second treatment was performed by the therapists, the oncologist reviewed the port film and noticed that 80 percent of the intended area had been missed. An investigation by the licensee determined that in simulating the treatment to be performed on the patient, the oncologist placed a mark on the patient's chest as indicated by the ceiling laser position. During treatment, however, the back pointer on the teletherapy unit was positioned on this mark. As the back pointer and ceiling laser result in different angles to the Co-60 radiation beam, the tissue volume treated was medial to the intended treatment site. The oncologist amended the original prescription to include two additional treatment fractions to the appropriate area, bringing the total treatment dose to that area to the intended 30 Gy (3000 rad).

The patient was notified of the treatment error. The licensee stated that the misadministration should have no adverse effect on the patient. There was a breakdown in communication between the oncologist and therapist during simulation. Either proper instruction was not given regarding patient positioning and which indicator to use, or it was not carried out correctly.

The licensee has reviewed this incident with all staff members and communicated by memo to all prescribing physicians explaining the different localization methods. In addition, the licensee's Quality Management Program was amended to require review of port films after the first treatment in a series; this would not have prevented a misadministration, but might have identified the error prior to the administration of the second treatment.

An NRC inspection was conducted on February 13–14, 1992, to review the circumstances associated with the misadministration. The inspection report was forwarded to the licensee by a letter dated April 6, 1992. Although no violations of NRC requirements were identified, the NRC was concerned that the misadministration was a result of a verbal miscommunication between the oncologist and the therapist. The licensee was requested to describe corrective actions taken to prevent such miscommunications among staff members.

92–2 Medical Therapy Misadministration at Harper Hospital in Detroit, Michigan

On March 16, 1992, the licensee notified NRC Region III that on February 24, 1992, a patient with cancer had received a therapeutic radiation dose to the incorrect side of the chest area. The patient was scheduled to receive 28 daily treatments of 1.8 Gy (180 rad) each to the right collar bone area and 0.9 Gy (90 rad) each to tangential areas of the right breast. The treatments began on February 12, 1992, and eight treatments were delivered as prescribed. On February 24, 1992, however, the radiation therapists erroneously treated the left collar bone area instead of the intended treatment area on the right. The therapists discovered the error as they prepared to treat the two tangential areas of the left breast.

The therapist repositioned the patient to treat the prescribed right breast. The treatment plan was then continued until the balance of the prescribed 28 treatments was completed. The treating physician stated that in her judgment the misadministration did not compromise the patient's health or treatment, either from an underdose to the prescribed site or from the inadvertent dose to the incorrect area.

The radiation therapy technologists stated that the error occurred because they confused a leveling tattoo on the left collar bone area with the treatment tattoo on the right collar bone area. They also did not follow the procedures for confirming the accuracy of the treatment site for agreement with the prescribed treatment site as specified in the licensee's Quality Management Program. In regard to the lateness of reporting the event to the NRC, the misadministration had been promptly reported to hospital management. However, the person responsible for reviewing the incident to determine if an NRC report was required used an incorrect draft of the hospital's policy manual which contained an error in its definition of a misadministration. The incident was not determined to be a misadministration and was therefore not reported to the NRC until March 16, 1992. The remaining treatments in the patient's treatment series were performed by three technologists to assure treatment accuracy. The licensee is now using different tattoos for the treatment area and for leveling.

The licensee had implemented a written Quality Management Program on January 27, 1992. The program requires that before a treatment is administered, the details of the treatment must be checked for agreement with the prescription and plan of treatment and the accuracy of the treatment site must also be confirmed. Therapists were provided further instruction on appropriate policies and procedures. The incomplete policy manual has been updated, and personnel have been trained on NRC misadministration reporting requirements.

An NRC special inspection was conducted on March 26–27, 1992, to review the circumstances associated with the misadministration. On April 22, 1992, NRC issued a Notice of Violation. Two violations of NRC requirements were identified: (1) failure to follow the instructions of the Quality Management Program, and (2) failure to report the misadministration no later than the next day following its discovery.

92–3 Multiple Medical Therapy Misadministrations at G. Anthony Doener, M.D., Facility in Freehold, New Jersey

On March 18, 1992, the current consulting teletherapy physicist for the licensee informed NRC Region I of numerous therapeutic misadministrations that occurred between July 1990 and February 28, 1992. The physicist reported that patients who had received external beam therapy from a Picker Corporation Model 6103 (C–1000) teletherapy unit may have been underdosed by about 15 to 40 percent of the intended doses. The misadministrations appeared to have resulted from an error introduced by the licensee's previous consulting teletherapy physicist into tables of treatment times he generated for various field sizes and treatment depths. The erroneous treatment times were then used by the licensee in treating patients. According to the licensee, approximately 13 patients were involved. One patient was undergoing treatment when the error was identified on February 28, 1992, and this patient's treatment time was adjusted to correct for the error prior to completion of treatment. The previous teletherapy physicist was contacted by telephone on March 18, 1992 and interviewed by NRC Region I on April 2, 1992. On both occasions, the previous teletherapy physicist stated that he had discovered in late 1990 the error in the treatment time charts he had prepared for January through December 1991. He stated that he had mailed corrected time charts for 1991 along with a handwritten note to the licensee the first week of January 1991. He did not recall what the note stated nor did he maintain a copy of the note. He did not send the charts via certified mail nor did he attempt to contact the licensee by telephone to inform the licensee of the error. He was not aware that a similar error had occurred in charts he provided to the licensee for the period July 1990 to December 1990. The authorized user and office manager stated that they had not received corrected time charts for either 1990 or 1991.

The licensee has submitted all required documentation/reports of the misadministrations to the NRC. Based on the licensee's review of patient

treatment charts, two patients have received supplemental treatment. Three of the patients are deceased and the licensee reported that the remaining eight patients would not be adversely affected. According to the licensee, the patients were notified of the treatment error by phone and in writing. The probable causes are (1) failure of the authorized user to identify the previous physicist's error on treatment time charts through independent verification, and (2) failure of the previous physicist to perform a secondary check of treatment times for charts prepared for July 1990 through December 1990. These charts are currently being used by the licensee. The current teletherapy physicist will provide treatment time charts to the licensee on a bi-monthly basis. Treatment times will be independently verified by the current teletherapy physicist on a weekly basis or when treatment times for a patient currently being treated are changed.

NRC inspections were conducted at the licensee's facility on March 19 and April 22, 1992. Activities authorized by the licensee were inspected. In addition, actions taken in response to the NRC's Confirmatory Action Letter (CAL) were reviewed. An NRC inspector verified by calculation that the treatment time charts contained errors and that the error began on the July 1990 time chart. The average error determined by the inspector was 20 percent. The inspector was unable to verify that corrected treatment time charts had been provided to the licensee for 1991. The licensee learned that the misadministrations had occurred on March 13, 1992, but did not report this misadministration to NRC Region I until March 18, 1992. Records of misadministrations required by 10 CFR Part 35 were properly maintained by the licensee. Corrected treatment time charts provided by the current teletherapy physicist were checked by the inspector and found to contain accurate treatment times. The inspector reviewed treatment charts for patients currently being treated and found that corrected treatment times were being used. The inspector found that seven of the eight commitments listed in the CAL had been completed at the time of the inspection. The action not completed by the licensee was to have the teletherapy physicist independently review all patient charts from the date the misadministrations began through December 1991 to identify all patients subjected to a misadministration. A letter from the licensee, dated May 1, 1992, stated that patient charts from July 1990 through December 1991 have been sent to the current teletherapy physicist for review. The CAL is considered closed and authorization was given to the licensee to resume patient treatments.

The misadministrations did not appear to be the result of violations of NRC requirements. However, the inspector identified a number of apparent violations of licensed activities, including: (1) failure to perform a full calibration at intervals not to exceed 1 year; (2) failure to notify NRC Region I by telephone within 24 hours of a therapeutic misadministration; (3) failure of monthly spot checks to include a determination of timer on-off error and timer linearity over the range of use; (4) failure of the licensee to require the teletherapy physicist to review teletherapy spot check results within 15 days; (5) failure to perform an adequate accuracy test of the dose calibrator; and (6) failure to mathematically correct dose calibrator reading for a linearity error exceeding 10 percent. Items 3, 4, and 5 above are repeat violations. A Notice of Violation was issued. The licensee's Quality Management Plan has been submitted to the NRC and is being reviewed. The NRC medical consultant is currently reviewing the incident.

92-5 Medical Therapy Misadministration at Beth Israel Hospital in Passaic, New Jersey

During a routine inspection conducted on May 22, 1992, it was discovered that the therapeutic misadministration, as well as an overexposure to a radiation worker's hand, had not been reported to the NRC.

On August 23, 1990, a patient was scheduled to have an endobronchial implant procedure that required two ribbons containing a total of 35 iridium-192 (Ir-192) seeds 2536 megabecquerel [MBq] (68.54 millicurie [mCi]) to be implanted into the patient. One ribbon contained 20 Ir-192 seeds and the other contained 15 Ir-192 seeds. The medical physicist gave the attending physician the wrong end (portion that does not include radioactive sources) of one of the two ribbons and the physician inserted the wrong end into the patient. The other ribbon containing 20 Ir-192 seeds was

inserted correctly. The remaining extra lengths of these ribbons were cut off by the physician and given to the medical physicist. The medical physicist, assuming that these pieces of ribbons contained no radioactive material, coiled them and held them in her hand. One of these pieces contained 15 Ir-192 seeds (1087 MBq [29.37 mCi]). The medical physicist, following the completion of the procedure, discarded these pieces of ribbons into a waste basket located in a waiting room across from the patient's room thus creating a radiation dose rate of up to approximately 0.63 millisievert (mSv) (63 millirem [mrem]) per hour in an unrestricted area. This radiation level was well above the regulatory limit of 0.02 mSv (2 mrem) in any one hour for unrestricted areas. The implant was performed at 2:30 p.m. and the patient was scheduled to have a dose of 1.5 Gy (1500 rad). The physician decided to remove the ribbons from the patient earlier than planned because the dose rate was higher than what he normally administers. The ribbons were removed at 8:30 p.m., on August 23, 1990. Neither the medical physicist nor the hospital's Radiation Safety Officer (RSO) was present during the removal procedure.

The following morning at approximately 8:30 a.m., the medical physicist inventoried the sources removed from the patient and found that one of the ribbons contained no seeds. She immediately informed the RSO, who conducted a search for the missing radioactive material and at approximately 11:00 a.m. found the two pieces of ribbon in the waste basket. The licensee determined that the dose to the hand of the medical physicist was approximately 2.72 Gy (272 rad) assuming that she held the ribbon containing Ir-192 seeds in her hand for about 5 minutes. The physician stated that the patient received a dose of approximately 4 Gy (400 rad) (which was only about 50 percent of the intended dose.) No makeup dose was given to the patient. Neither the therapeutic misadministration nor the overexposure to the physicist's hand was reported to NRC. Neither the medical physicist nor the physician performed a survey of the ribbons before implanting into the patient. The licensee did not inventory the sources promptly after removal from the patient. Also, the licensee failed to follow established procedures involving the removal of temporary implants in that the RSO or his designee was not present during the removal of temporary implants from the patients.

The licensee's corrective actions include a mandatory requirement that the RSO or his designee must be present during all implant and removal of radioactive materials. The licensee's management is now more deeply involved in the radiological safety affairs. The licensee is conducting an audit of its radiation safety program by an independent person.

NRC Region I inspectors continued the inspection of the circumstances surrounding this misadministration on June 2, 1992. Numerous apparent violations were identified. A CAL was issued on June 5, 1992. An enforcement conference was held with the licensee in Region I on June 25, 1992, to discuss the violations and the corrective actions proposed and implemented by the licensee.

92-6 Medical Therapy Misadministration at Hospital Metropolitano in Rio Piedras, Puerto Rico

On April 8, 1992, the licensee informed the NRC that on March 24, 1992, a brachytherapy misadministration occurred involving a patient receiving a therapeutic dose to the wrong part of the body. The misadministration occurred when incorrect, no longer-in-use, cesium-137 (Cs-137) sources were placed in a brachytherapy applicator and administered to the patient. Because all the sources were smaller in diameter than the intended sources, they slipped from the prescribed position and irradiated normal tissue not intended to be irradiated. The applicator was loaded by a technologist who had never performed the procedure. The technologist was supervised by a second technologist who had not performed the procedure in 8 years, when the incorrect sources were in active use. The incorrect sources were discovered at the midpoint of the treatment by the licensee's medical physicist during an unplanned training session for a new physicist. The incorrect sources were promptly removed from the patient and the treatment restarted and completed as directed by the authorized user.

The licensee estimated the dose to normal tissue was approximately 4-5 Gy (400-500 rad). The li-

censee advised NRC that no adverse effects to the patient are anticipated as a result of the misadministration. The causes are attributed to the licensee's failure to: (1) properly train individuals handling brachytherapy sources; (2) adequately implement a Quality Management Program (QMP); (3) develop and implement adequate QMP procedures; and (4) properly label the storage vault for the brachytherapy sources.

The licensee's corrective actions included: revision of the QMP policies and procedures; training all supervised individuals on brachytherapy procedures and in the revised QMP; arranging safe storage for the sources no longer in use; posting a map of the source storage vault indicating the type of source at each storage point; and enhancing source accountability practices.

NRC Region II reviewed the circumstances associated with the misadministration and the licensee's immediate corrective actions during a reactive inspection on April 10, 1992, and a followup inspection on April 22 and 23, 1992, which included NRC consultants in the areas of medical physics, oncology, and risk assessment.

92–7 Medical Diagnostic Misadministration at Baystate Medical Center, Incorporated, in Springfield, Massachusetts

On May 20, 1992, the licensee notified the NRC by telephone that a medical misadministration involving iodine-131 (I-131) radiopharmaceuticals had occurred at the licensee's facility on the previous day. A diagnostic dose was intended; however, a therapeutic dose was administered. The details of the event are described below.

A nurse from the referring endocrine clinic called Baystate to make an appointment for a patient for a thyroid scan and I-131 uptake study. Baystate's departmental procedure for a thyroid scan and I-131 uptake is to perform the study using 0.6 MBq (16 microcurie [Ci]) of I-131 and 370 MBq (10 mCi) of technetium-99m (Tc-99m). A whole body scan requires that approximately 148 MBq (4 mCi) of I-131 be given to the patient. Apparently, the order was entered in the patient's scheduling chart as a whole body scan rather than the thyroid scan and I-131 uptake study which was intended. Questions were raised on several occasions by licensee personnel because the patient was diagnosed with an enlarged thyroid and generally an I-131 whole body scan is not indicated for this diagnosis. Also, an authorized user was not consulted to review the study and prepare a written directive prior to the administration of greater than 1.11 MBq (30 Ci] of I-131, as required by 10 CFR 35.32. A nuclear medicine technologist administered 152 MBq (4.1 mCi) of I-131 for a whole body scan without following the department's procedures for administration of iodine-125 (I-125) or I-131. The licensee evaluated the dose to the patient's thyroid to be approximately 143 Gy (14,300 rad) based on an uptake of 66 percent and the dose to the whole body to be approximately 6.25 centigray (cGy) (6.25 rad).

One of the causes of the misadministration was a miscommunication between staff at both the referring endocrine clinic and Baystate. Other causes were failure of the staff at Baystate to follow regulatory procedures involving radioiodine doses greater than 1.11 MBq (30 Ci) which require that an unauthorized user prepare a written directive prior to the administration. Baystate's departmental procedures also require that when an order for a requested study is unclear or illegible, the referring physician be contacted prior to the performance of the study.

The licensee's corrective actions included: (1) instruction of nuclear medicine staff in the departmental procedures and regulatory requirements for radioiodine studies; (2) preparation, prior to the administration, of a written directive by the Director of Endocrinology, or a designated authorized user before any iodine study using greater than 1.11 MBq (30 Ci) is performed; (3) prompt transmittal of written requests for nuclear medicine studies from the clinics to the Baystate Medical Center, Nuclear Medicine Division, to compare the request with the computer entry prior to the administration; and (4) review of this patient's progress once every 6 weeks for 3 months.

An NRC Region I inspector conducted an inspection on May 27 and 28, 1992, to determine the circumstances associated with the misadministration. An NRC medical consultant worked with the licensee to provide to NRC a clinical assessment of the misadministration. Although the medical consultant calculated the thyroid dose to be con-

siderably less than the licensee's estimate, his evaluation of the event and consequences to the patient were similar to the licensee's evaluation. They were in agreement that because the patient was diagnosed as having Graves' disease, the ultimate therapy would be treatment with about 370 MBq (10 mCi) of iodine-131 (compared to about 148 MBq (4 mCi) that were mistakenly administered). Therefore, the patient did not suffer adverse health effects from the misadministration any worse than those normally associated with treatment of Graves' disease.

The NRC inspector identified two apparent violations of NRC requirements: (1) failure of authorized user to prepare a written directive, and (2) failure to follow procedures. An enforcement conference was held on June 23, 1992. Enforcement action is pending.

92-8 Medical Therapy Misadministration at The Christ Hospital in Cincinnati, Ohio

On May 29, 1992, the licensee performed an implant of radiation seeds for treatment of a patient's prostate cancer. The patient had previously received radiation treatment to the prostate using a linear accelerator. The implant treatment plan called for placement of 58 seeds, each containing 11.47 MBq (0.31 mCi) of iodine-125. The seeds were to be implanted in the prostate using needles guided by an ultrasound image. The implanted seeds were to deliver a dose of 120 Gy (12,000 rad) to the prostate. The 58 seeds were implanted, but a subsequent computerized tomographic scan showed that 21 seeds were implanted in tissue surrounding the prostate rather than the intended sites. Two seeds were eliminated with the patient's urine. The licensee calculated that the mispositioning of the seeds resulted in the patient receiving a 50 Gy (5000 rad) dose to the prostate rather than the intended 120 Gy (12,000 rad) dose.

The principal consequence of this misadministration is the potential effects of the underdosage to the prostate. In addition, tissue surrounding the prostate received a greater radiation dose than intended. The prescribing physician concluded that the delivered dose from the implanted seeds and from the previous linear accelerator treatment was sufficient. An NRC medical consultant, retained to evaluate the circumstances and response to the misadministration, noted: "Tumor recurrence is the greatest risk, and it will be monitored closely." The consultant also concluded that there was not a high probability of radiation damage to the rectum, which would be the area of principal concern.

The misadministration resulted from the difficulties in the ultrasound placement technique. The ultrasound image is difficult to interpret in guiding the placement of the seeds with the implanting needles. The prescribing physician, who is the authorized user in the NRC license, had been trained and certified in the ultrasound guided implant technique, but had not actually performed the procedure. The physicians recommended several improvements in the implanting technique, including more detailed pretreatment planning, steps to improve the quality of the ultrasound image, and enhancements to the seed positioning technique.

NRC Region III conducted a special inspection on June 17 and 18, 1992, to review the circumstances of the misadministration and to evaluate the licensee's followup activities. No violations of NRC requirements associated with the misadministration were identified.

92-9 Medical Therapy Misadministration at Cooper Hospital/University Medical Center in Camden, New Jersey

From November 11, 1991 to January 7, 1992, Cooper Hospital/University Medical Center, Camden, New Jersey, performed five therapeutic misadministrations involving Ir-192 wire. The licensee had discovered the error, which caused a 12.2-percent underdosing of the patients, on January 24, 1992, after the review of patient charts in preparation for the Quality Management Program submittal. On January 27, 1992, NRC Region I was notified of the events.

During the period reported, four patients received external beam therapy (linear accelerator) in addition to the radiation received from the Ir-192 implants. Patient A was to receive 1043 centigray (cGy) (1043 rad) from an Ir-192 intracavitary bronchial implant for the treatment of lung cancer and received 916 cGy (916 rad). Patient A later

received 5576 cGy (5576 rad) from external beam therapy. Patient B was to receive 1266 cGy (1266 rad) to the head and neck from an Ir-192 interstitial implant for the treatment of cancer and received 1112 cGy (1112 rad). Patient B later received 4600 cGy (4600 rad) from external beam therapy. Patient C was to receive 2150 cGy (2150 rad) from an Ir-192 interstitial implant for the treatment of breast cancer and received 1888 rad. Patient C later received 5940 cGy (5940 rad) from external beam therapy. Patient D was to receive 2000 cGy (2000 rad) to the tongue for the treatment of cancer from an Ir-192 interstitial implant and received 1756 cGy (1756 rad). Patient D later received 5940 cGy (5940 rad) from external beam therapy. The licensee has determined that the above patient's treatments were not compromised by the small decrease in the total dose received when the external beam therapy treatment is factored into the assessment. One patient did not receive external beam therapy. On November 21, 1991, Patient E was prescribed to receive 4628 cGy (4628 rad) to the pelvis for the treatment of cancer from an Ir-192 interstitial implant and received 4063 cGy (4063 rad). Patient E's attending physician had originally calculated a desired dose between 40 and 45 Gy (4000 and 4500 rad) and wanted to include hyperthermia treatment. Hyperthermia treatment required insertion of interstitial microwave antennae so that heat treatment was terminated within 1 hour before the implants were inserted and was initiated within 1 hour after the implants were removed. The attending physician was informed by the licensee's staff that the implants would have to be removed at unreasonable times in order to fall within the attending physician's desired dose range. The attending physician then agreed to give 46.28 Gy (4628 rad) so that the second hyperthermia treatment could be given at a more reasonable time. Since the actual delivered dose fell within the attending physician's initial range, the licensee does not foresee any adverse effects for Patient E.

It was determined that the cause of the misadministration was an input error into the treatment planning computer. Specifically, the source calibration factor was in non-Systeme International (SI) units (non-metric); however, the computer was set to receive the data in SI units and the setting was not changed.

The licensee's corrective action was to include the calibration factor that is used during treatments in their records for implant source inventory-source type characteristics so that the licensee can verify that the proper factors are used.

An NRC Region I inspector conducted an inspection of the incident on August 5, 1992, to determine the circumstances associated with the misadministration. The inspector's findings were in agreement with the licensee concerning the cause of the misadministration. The inspector determined that the licensee's corrective actions were adequate to prevent recurrence.

92-10 Extremity Overexposure of a Radiographer at MQS Inspection, Inc., Field Site in Trenton, Michigan

On July 6, 1992, at a temporary radiography field site in Trenton, Michigan, a licensee radiographer was assigned to radiograph various pipes at a construction site. Radiography is a non-destructive testing technique which uses a sealed radiation source to make x-ray-like images of heavy metal objects. The configuration of this job required that the radiography exposure device (camera) be suspended 6.1 meters (20 feet) above the floor. The radiation source is exposed using a remote cable to make the film image and then is retracted into the shielded camera. After an exposure, the radiographer used an aerial platform to reach the camera. He performed a radiation survey as he approached to assure that the source was in the shield. The radiographer was wearing his audible alarm radiation measuring device, but it was turned off.

The radiographer then moved the camera to reach the camera port to lock the radiation source inside. When he removed the tube which guides the source, he discovered that the radiation source was exposed about 10 centimeters (cm) (4 inches [in.]) outside the camera. The source had apparently shifted into the unshielded position when the radiographer moved the camera to lock it. The source was locked into place in its exposed condition. The radiographer immediately returned to

ground level, but later returned to the camera to unlock it so that the radiation source would be retracted into its shield.

The incident was subsequently reenacted by the licensee's Radiation Safety Officer (RSO) and NRC inspectors to evaluate the radiation exposure received by the radiographer. The calculation by the RSO, based on a series of reenactments, indicated a minimum 440 cGy (440 rem) exposure to the individual's hand. NRC inspectors estimated that the dose was about 880 cGy (880 rem). The radiation measuring device worn by the worker indicated a whole body radiation exposure of about 0.25 cGy (250 millirem). The worker's hand was evaluated and monitored by medical radiation specialists at an area medical center. No short-term physical changes to the skin of the hand were observed. The NRC limit for extremity exposures is 18.75 cGy (18.75 rem) in a calendar quarter. Therefore, the reenactment showed that the extremity exposure received was substantially over the limit. The whole body radiation exposure was within the NRC limit of 3 cGy (3 rem) in a calendar quarter.

The overexposure occurred as a result of the failure of the radiographer to use an audible alarm exposure measuring device as required by the NRC regulations. The locking mechanism allowed the source to be locked in place while it was still exposed.

The radiographer was wearing an audible alarm device required by NRC for radiography work, but the device was turned off. The device had been turned off to conserve battery power while the radiographer was doing paperwork, but had not been turned back on for the remainder of the day. Use of an operable alarm device could have avoided or minimized the overexposure.

The licensee alerted its staff to the potential problem with the locking mechanism of this type of radiography camera. It also provided additional training on the use of the required audible alarm radiation devices and including verification that the devices are turned on during routine internal audits of radiography activities. The radiographer was restricted indefinitely from further work with radioactive materials.

The NRC Region III conducted a special inspection of the licensee's activities from July 8 to 10, 1992. The inspection identified three violations of NRC requirements associated with the overexposure incident: (1) the extremity exposure in excess of the 18.75 cGy (18.75 rem) limit for a calendar quarter; (2) failure of the radiographer to wear an operable audible radiation monitoring device; and (3) failure to perform an adequate radiation survey of the radiography camera in that the radiographer did not survey the full circumference of the camera. The first two violations were classified as a Severity Level I problem, and the third as a Level IV violation (on a scale in which Severity Levels I through V are the most and least significant, respectively). On October 9, 1992, a $5,000 fine was proposed for the first two violations. No fine was proposed for the third violation. On November 2, 1992, the licensee paid the civil penalty.

92-11 Medical Therapy Misadministration at the Medical Center of Delaware, Incorporated, in Wilmington, Delaware

On August 11, 1992, at the Medical Center of Delaware, Incorporated; Wilmington, Delaware, a therapeutic misadministration involving a Co-60 teletherapy unit occurred. On August 11, 1992, NRC Region I was notified by telephone by the licensee's RSO of the event. The physician's written directive called for 3015 cGy (3015 rad) in 15 fractions to be delivered to the central area of the pelvic region with the teletherapy machine set up in a fixed modality. During the fourteenth fraction, the radiation therapy technologist (RTT) did not ensure that the teletherapy machine was set in the fixed modality and started the treatment. The previous patient had received treatment in the rotational modality and the setting of the machine was not changed. The patient received a total of 160 cGy (160 rad) to the pelvic treatment areas instead of the prescribed 200 cGy (200 rad). In addition, the licensee estimates that the patient received an estimated dose of 80 to 110 cGy (80 to 110 rad) to the left side of the pelvis outside of the treatment areas and between 60 to 70 cGy (60 to 70 rad) to the right side of the pelvis outside of the treatment area. The licensee has determined that the patient will not suffer any adverse effects

in the areas that received an unintended radiation dose. The licensee will increase the prescribed dose for the fifteenth fraction to make up for the underdosing during the fourteenth fraction.

It was determined that the cause of the misadministration was the failure of the licensee to follow the department's QMP. The licensee's QMP calls for two RTTs to be present when a patient is being set up to ensure that the setup is done properly. The first RTT did not ensure that the setup was done correctly and the second RTT was out of the department getting another patient.

The licensee's corrective action was to provide a training session to all RTTs on the requirements of the QMP.

An NRC Region I inspector conducted an inspection on November 19, 1992, to determine the circumstances associated with the misadministration. The inspection findings have been reviewed by NRC, and enforcement action is under consideration.

92-14 Medical Therapy Misadministration at Memorial Hospital of Laramie County in Cheyenne, Wyoming

On August 19, 1992, at the Memorial Hospital of Laramie County, Cheyenne, Wyoming, a therapeutic misadministration occurred involving a brachytherapy implant procedure utilizing Ir-192 as seeds encased in nylon ribbon (small sealed radiation sources utilized for interstitial treatment of cancer). The proposed treatment included a prescribed dose of 3258 centigray (cGy) (3258 rad) for the patient's prostate gland. On October 21, 1992, while reviewing the shipping documents associated with the implant performed on August 19, 1992, the licensee's dosimetrist noted a discrepancy in the units of measurement between what she had ordered as opposed to what she had received. The licensee ordered brachytherapy ribbons containing 29.23 MBq (0.79 mCi) per ribbon. However, the vendor delivered brachytherapy ribbons containing 50.32 MBq (0.79 milligram-radium-equivalent [1.36 mCi]) per ribbon. When the shipment was received, the dosimetrist checked the prescription order against what was received and noted that the quantities (0.79) matched, but she failed to note that the amount received was measured in milligram-radium-equivalent rather than the requested millicurie units. As a result, the radiation dose to the patient's prostate gland was 5669 cGy (5669 rad) rather than the prescribed 3258 cGy (3258 rad). On October 22, 1992, the licensee notified NRC Region IV of the event.

The referring physician was notified who chose not to inform the patient. The patient was examined during subsequent follow-up visits and has shown no adverse effects due to the increased radiation exposure. The licensee does not anticipate any significant effects to the patient as a result of the misadministration.

The cause is attributed to human error by the licensee's staff resulting in the failure to perform an adequate verification of source strengths prior to implanting the brachytherapy sources. The licensee's dosimetrist had checked the prescription order against the receipt records but failed to note the discrepancy in units of measurement. Additionally, miscommunication between the licensee and the vendor also appears to have contributed to the error.

The licensee implemented corrective measures to prevent recurrence of administering implants without complete verification of brachytherapy source strengths. This includes an implant checklist that must be completed and initialed to ensure that units of measurement received correspond to that which was ordered. Additionally, the licensee's physicists will verify source strengths by direct measurement prior to implantation.

An NRC Region IV inspector conducted a special safety inspection on November 19 and 20, 1992, to review the circumstances associated with the misadministration and to review the licensee's corrective actions. The licensee's determination of the cause of the event was considered accurate based upon interviews of the individuals involved. The inspection revealed violations associated with the failure of the licensee's authorized user to instruct individuals under his supervision in the licensee's QMP. Enforcement action is under consideration.

92-15 Medical Therapy Misadministration and Unplanned Exposure at St. Clares Riverside Medical Center in Denville, New Jersey

On October 2, 1992, at the St. Clares Riverside Medical Center, Denville, New Jersey, a therapeutic misadministration involving the implant of two Ir-192 ribbons occurred. At 2:30 p.m. on October 1, 1992, a patient was implanted with 1785 MBq (48.25 mCi) of Ir-192, contained in two nylon ribbons. The ribbons were inserted into catheters that extended from the patient's abdomen into the common bile duct. The procedure was scheduled to last 20 to 23 hours during which a dose of 1500 to 2000 cGy (1500 to 2000 rad) would be delivered to a colon tumor obstructing the common bile duct. After implanting the Ir-192 ribbons into the two catheters, the implant site was dressed and instructions were given to nursing personnel not to change the dressing. These instructions were not detailed on the patient's chart. Due to excessive drainage of bile at the implant site during the evening and early morning hours, the patient's dressings were changed several times and then reinforced with additional absorbent. At 4:15 a.m. on the morning of October 2, 1992, the nurse on duty noted that the dressing was completely displaced and acted to replace the dressing. The nurse noticed that the two ribbons were displaced but, not knowing what they were, coiled the ribbons in her hand and taped the ribbons to the patient's abdomen. A routine x-ray identified that the seeds were no longer implanted, and the coiled ribbons were removed from the surface of the patient's abdomen by a physician at approximately 12:00 p.m. on October 2, 1992.

The licensee estimated that the patient received 1145 cGy (1145 rad) to the targeted tumor site, between 172 to 1032 cGy (172 and 1032 rad) to the skin of the abdomen, 19.9 cGy (19.9 rad) to the liver and small bowel, 12.7 cGy (12.7 rad) to the kidneys, 50.9 cGy (50.9 rad) to the colon, and 6.7 cGy (6.7 rad) to the testes. The licensee estimated that the nurse who coiled the ribbons and taped them to the patient's abdomen received approximately 7.6 cGy (7.6 rad) to her hands. The licensee expects no adverse clinical effects as a result of the reduced dose to the target organ since this brachytherapy treatment was a booster to the external beam dose that was yet to be administered.

On October 2, 1992, the licensee notified the NRC by telephone of the event.

The misadministration was caused by: (1) lack of oversight of the procedure by the licensee's Radiation Safety Officer (RSO); and (2) inadequate training of the nursing staff in that they were unable to identify the brachytherapy source ribbon.

The licensee initiated an expanded training program that includes familiarization of personnel with the size and appearance of the radioactive sources used in brachytherapy treatments at the licensee's facility. The licensee stated that a manager will be responsible for ensuring that personnel on all shifts involved in the care and treatment of radiation therapy patients receive this training. The licensee decided to name a new RSO because the current RSO was unable to devote sufficient time to the radiation safety program due to his other responsibilities. The licensee's actions also included: (1) committing that a new RSO would be in place before another brachytherapy procedure is performed; (2) developing a nurses' procedure manual; (3) conducting formal inservice training in radiation safety with all nursing unit workers; and (4) requiring a written directive be initiated before ordering radioactive material.

NRC Region I conducted an inspection on October 5, 6, 7, and 9, 1992, and held an enforcement conference on November 5, 1992, to discuss the inspection findings. The licensee's corrective and preventive actions will be reviewed during the next inspection of the licensed program. Several violations of NRC requirements were identified including: (1) failure to adequately train nursing personnel to recognize brachytherapy procedures; (2) failure to train personnel on potential radiological emergencies for brachytherapy procedures; and (3) failure to implement radiation safety and quality management programs to ensure adequate safety. A civil penalty of $10,000 was proposed in an NRC letter dated January 11, 1993. The licensee paid the civil penalty on February 5. 1993.

92-16 Medical Therapy Misadministration at the Lahey Clinic Medical Center in Burlington, Massachusetts

On October 14, 1992, at the Lahey Clinic Medical Center in Burlington, Massachusetts, a therapeutic misadministration involving a high dose rate (HDR) remote afterloader occurred. A patient was scheduled to receive brachytherapy treatment to the right main stem bronchus in three fractions using a Gamma Med HDR. Each fraction was to deliver 700 cGy (700 rad) to the targeted tumor site. On October 7, 1992, the patient was administered the first treatment as prescribed. On October 14, 1992, the therapist made an error during input of the offset distance into the treatment computer, entering an offset distance of 7 millimeters (mm) (0.28 in.) rather than 7 cm (2.8 in.) as required. This error resulted in the second fraction delivering 90 percent of the prescribed fractionated radiation dose to unintended tissues, away from the tumor site, and underdosing the tumor site. The underdose was made up during the administration of the third fraction on October 22, 1992. The physician stated that he expected no adverse clinical effect on the patient due to underdosing the tumor site as the dose was made up in the third and final fraction. The referring physician and patient were both notified of the misadministration.

On October 19, 1992, the licensee notified the NRC Operations Center of the event.

The licensee followed established procedures; however, the procedure did not include a mechanism to verify data entries on the HDR console at the time of treatment.

The licensee instituted a new procedure that requires that a second individual verify the data input on the HDR console prior to the therapy administration.

NRC Region I conducted a routine inspection at the facility on December 3, 1992. The inspection resulted in the identification of six apparent violations: (1) failure to have a QMP to meet the regulatory requirements; (2) failure to make timely notification to NRC; (3) failure to provide radiation safety training to workers; (4) failure to perform the required tests of the dose calibrator; (5) failure to perform radiation surveys; and (6) failure to maintain the prior exposure record of a new employee. NRC proposed enforcement action consisted of issuance of Notice of Violation with one Severity Level III violation, three Severity Level IV violations and two Severity Level V violations. Region I recommended complete mitigation of civil penalty.

92-17 Medical Therapy Misadministration at Indiana University Medical Center in Indianapolis, Indiana

On November 13–14, 1992, at the Indiana University Medical Center in Indianapolis, Indiana, a 31-month old patient, being treated for a brain tumor, was to receive two cobalt-60 (Co-60) teletherapy treatments of 150 centigray (cGy) (150 rad) each for a total dose of (300 cGy (300 rad) to reduce swelling behind the patient's eye. The dosimetrist mistakenly prepared the dose calculations for 300 cGy (300 rad) per treatment. The patient was treated on November 13 and 14, 1992, with 300 cGy (300 rad) per treatment for a total dose of 600 cGy (600 rad). Prior to the treatment, the treatment plan was reviewed by the treating physician. Following the treatments, the dose calculations were reviewed by a medical physicist and approved. The error was discovered by a student technologist during a monthly chart review on December 2, 1992. Both the patient's referring physician and guardian were informed of the misadministration. The treatment accomplished its intended purpose and the swelling was reduced. The licensee reported that no adverse medical effects were expected because of the additional radiation exposure.

The error was caused by the incorrect calculations by the dosimetrist and by inadequate review by the physician before the treatment began. The doses normally used for this type of treatment are 300 cGy (300 rad) per treatment, and this further contributed to the failure to identify the error before the treatments occurred. There was also a problem with the legibility and format of the treatment plan.

The licensee has provided additional training to treatment personnel to eliminate the types of problems that contributed to the misadministra-

tion. The licensee also intends to revise the treatment form to make it more understandable.

NRC retained a medical consultant to review the case and to provide clinical assessment of the misadministration. NRC Region III conducted a special inspection on December 14 and 15, 1992, to review the circumstances surrounding this misadministration.

92-18 Loss of Iridium-192 Source and Medical Therapy Misadministration at Indiana Regional Cancer Center in Indiana, Pennsylvania

On November 16, 1992, at the Indiana Regional Cancer Center (IRCC) in Indiana, Pennsylvania, the licensee, Oncology Services Corporation (OSC), stated that they were notified by a local nursing home that a manager from Browning-Ferris Industries (BFI), a biological and hazardous waste handler, found radioactive material in the biowaste that was picked up from the nursing home. The licensee performed radiological surveys of the high dose rate (HDR) and noted that the Ir-192 source was missing.

On December 1, 1992, the licensee notified NRC Region I of the loss of an approximately 136,900-MBq (3.7-Ci) sealed Ir-192 source from their HDR remote afterloader unit at their IRCC.

On December 1, 1992, NRC Region I dispatched a section chief and inspector to the IRCC to ascertain the facts surrounding the loss of the Ir-192 source and how it was transferred to BFI facilities. On December 3, 1992, NRC upgraded its response to an Incident Investigation Team (IIT). On February 8, 1993, the IIT presented its findings (NUREG-1480) to NRC. The following are synopses of the Region I inspection and IIT findings.

On November 16, 1992, an elderly patient was treated for anal carcinoma at the IRCC in Indiana, Pennsylvania, using HDR brachytherapy. The patient died on the evening of November 21, 1992, 5 days after the treatment. Before the treatment, five catheters were placed in the tumor. During the treatment, an approximate 3.7 Ci (136,900 MBq) Ir-192 source was placed at various positions in each catheter to irradiate the tumor by use of a remotely controlled Omnitron 2000 HDR remote afterloader. This treatment was the first of a series of three 600-cGy (600-rad) treatments planned by the physician, and the five catheters were to remain in the patient for subsequent treatments.

On November 16, 1992, after a trial run through the five catheters with a dummy wire, the Ir-192 source wire was placed in four catheters without difficulty. After several unsuccessful attempts to insert the source wire and the dummy wire into a fifth catheter, the treatment was terminated. An area radiation monitor in the treatment area was observed in an alarm condition at various times when the source should have been retracted during the unsuccessful attempts to insert the source wire through the catheter. Although three technologists and the physician attending the patient were aware of the alarm condition, no one conducted a survey for radiation levels with the available portable radiation survey instrument. The only action taken was to check the control console of the HDR remote afterloader. Because the console indicator showed "safe," they believed the source to be fully retracted into the lead shield and assumed the area radiation monitor was malfunctioning. They were unaware that the source wire had broken, leaving the source in one of the catheters in the patient. The patient was transported by ambulance, with the source, to a local nursing home.

The source remained in the patient's body for almost 4 days. The catheter with the source came loose on the fourth day and, eventually, the catheter fell out early on the morning of November 20, 1992. It was placed in a medical biohazard bag (red-bag) in a storage room by nursing home personnel who did not know it contained the radioactive source. Later, on the same day, the catheter containing the source was moved to another storage location at the nursing home and placed in a box with other red bags. From November 16 to 25, 1992, numerous residents, employees, and visitors to the nursing home were unknowingly irradiated. The ambulance staff who returned the patient to the nursing home were irradiated along with employees and patients at the IRCC.

On November 25, 1992, a driver from BFI picked up the red-bag biowaste and transported it to a

BFI facility in Carnegie, Pennsylvania, and from there, it was transported to a BFI medical waste incinerator in Warren, Ohio. At the Warren facility, fixed radiation monitors identified radiation emanating from the trailer, and, on facility personnel direction, the trailer was returned to Carnegie on the same day. It was left there over the weekend and on Monday, November 30, 1992, the BFI staff searched the truck for the radiation source. They identified the box with the radiation source and looked at individual red bags to identify the origin of the waste. On December 1, 1992, BFI successfully identified a name found with the red-bag waste in the box, and traced it to the nursing home.

After being notified by BFI, the nursing home called the IRCC on December 1, 1992. The cancer center had not used the HDR afterloader after the single treatment on November 16, 1992. Upon being informed of the source discovery, the medical physicist determined that no source was present in the HDR afterloader and notified NRC Region I of this fact. The physician and the medical physicist drove to Carnegie and retrieved the source.

On December 7, 1992, a second Omnitron 2000 source wire broke at the Greater Pittsburgh Cancer Center (GPCC) of OSC on December 7, 1992. This wire broke in the same approximate location as the first wire. The GPCC medical physicist who was conducting the treatment was aware of the first incident and immediately recognized the problem and promptly and appropriately intervened, thereby preventing significant radiation exposure to the patient or the GPCC staff.

An NRC medical consultant concluded that an analysis of the medical records and physical dosimetry would indicate that the massive radiation dose was a probable contributing cause of the patient's death. The licensee reported that the prescribed dose at 1 cm (0.4 in.) was 18 Gy (1800 rad) to be delivered in three treatments, and that the delivered dose was 160 cGy (1,600,000 rad) to the same point, that is, an overdose of about three orders of magnitude. The licensee stated that the effect on the patient would have been significant local tissue damage and possible significant tissue damage to organs outside the treatment area, depending upon the progression of radiation damage with time before the patient expired. The licensee stated that the dose was of sufficient magnitude and believed that it was highly probable that the radiation exposure was at least a contributing factor to the patient's death. In a press release, dated January 26, 1993, the Indiana County Coroner stated that the cause of death listed in the official autopsy report was "Acute Radiation Exposure and Consequences Thereof."

In addition to the patient, the team evaluated unplanned radiation exposure to 94 persons associated with the IRCC event. Radiation exposure received by these individuals ranged between 0.4 and 220 mSv (40 mrem and 22 rem). Of these individuals, nine residents who were involved in recreational activities at the Scenery Hill Manor Nursing Home were not notified regarding the exposure they had received. The IIT was unable to determine their identity. The rest of the individuals were notified either by NRC or were monitored by their employer for occupational dose. Cytogenetic studies were also performed on a number of these exposed individuals and the results were consistent with calculated doses within the limits of accuracy required by the applicable techniques. The highest extremity dose was calculated to be between 730 to 1600 mSv (73 to 160 rem) to the hands of one of the nursing assistants. No personnel or property contamination occurred and no occupational worker received a whole body radiation dose above the NRC occupational limit of 12.5 mSv (1.25 rem). While members of the public received radiation doses above applicable limits, no one received a dose at which acute radiation injury or clinical signs are expected to occur.

The event was caused by the following:

1. OSC had weaknesses in its radiation safety program that were a major contributing cause of the seriousness of the event and radiation exposure consequences. Some of these were a result of a rapid expansion in their HDR brachytherapy program from one facility to 10 facilities in less than a year. The Radiation Safety Officer (RSO) failed to ensure that the staff at all facilities received adequate radiation safety training, and that all management instructions relating to HDR were being followed. Informal and unwritten procedures

that may have been adequate when the licensee possessed one HDR unit under the direct control of the RSO were ineffective for the expanded program.

2. A number of weaknesses were found in the design and testing of Omnitron 2000 HDR afterloader. Weaknesses were identified in the testing and validation of source-wire design, and in the design of certain safety features of the HDR afterloader. These could allow the undetected retraction and further use of a broken wire with no warning to the user. Although not contributing to this event, weaknesses were found in Omnitron's quality assurance/quality control (QA/QC) program. The cause of the wire failure is not known with certainty at this time. The vender believes that it has evidence to show that storage of the source wire in teflon, if moisture is present, causes degradation of the teflon with release of fluorine or hydrogen fluoride that causes degradation of the Nitinol (nickel-titanium alloy) wire. NRC and its consultant are still evaluating this hypothesis and conducting further studies.

3. The safety culture at IRCC contributed significantly to the event. Technologists routinely ignored the PrimAlert-10 alarm. Its problems were worked around and not fixed. Technologists did not survey patients, the afterloader, or the treatment room following HDR treatments. No one was sure who was responsible for radiation safety training or the radiation safety program. The authorized user failed to wear a film badge on both occasions when the source was encountered.

4. Overall regulatory oversight was weak. NRC regulations do not directly address HDR brachytherapy to the extent that teletherapy and low-dose-rate brachytherapy are addressed. Licensing guidance for HDR has been unchanged since 1986 in spite of significant changes in medical regulations and other medical licensing guidance. Inspection guidance for medical licensees does not specifically address HDR brachytherapy. Although inspected by NRC Region I within a year of initial licensing, the inspection program does not require early reinspection in cases where licensees significantly expand the scope of their program through license amendments. The regulatory interaction between NRC, FDA, and the Agreement States involved in the regulation and authorization of the Omnitron 2000 HDR afterloader is poorly defined.

Licensee actions to prevent recurrence are still undergoing NRC review.

NRC initiated the IIT. NRC issued Bulletin 92-03 to the users of Omnitron 2000 HDR afterloaders, Information Notice 92-84 to all NRC licensees, and Confirmatory Action Letters curtailing the use of Omnitron 2000 HDR afterloader, and providing safety precautions. On January 20, 1993, NRC issued an Order suspending license (effective immediately) to preclude the licensee from performing licensed activities at any of its facilities pending further order. Issuance of this Order does not preclude additional enforcement action.

92-19 Medical Therapy Misadministration and Temporary Loss of Brachytherapy Source at Yale-New Haven Hospital in New Haven, Connecticut

On December 2, 1992, NRC was notified by the Yale-New Haven Hospital, New Haven, Connecticut, the licensee, that it had recovered a 1295-MBq (35-mCi) brachytherapy source that was discovered to be missing earlier that day. On December 3, 1992, NRC Region I was notified that the source had probably been lost before or during a brachytherapy treatment, resulting in a therapeutic misadministration. A female patient, approximately 39 years old, was to receive 1848 cGy (1848 rad) to the cervix for cancer treatment. One of the sources that was prescribed was either never inserted or was removed from the applicator during treatment. Assuming maximum deviation from the planned treatment, the actual dose to the patient was only 1235 cGy (1235 rad). The licensee stated that a source was also misplaced and was in contact with one of the patient's legs for a period of time, resulting in an estimated dose to the leg of 260 cGy (260 rad). The physicians responsible for the treatment, after reviewing the dose estimates, decided no additional treatments were necessary. The misplaced source was inadvertently put with hospital linen. The lin-

en with the brachytherapy source was taken to an offsite laundry facility, from which it was subsequently recovered. The referring physician and patient were notified of the misadministration.

The licensee failed to recognize the significance to radiation safety of a procedural change that eliminated the use of disposable pads in favor of reusable linen pads. Previously, the licensee disposed pads by putting them in infectious waste, which stayed in the room until after the final radiation survey was performed, after removal of the radiation sources. The reusable pads, when changed, were placed in laundry bags in the hallway, which were taken to the laundry facility daily. The nursing staff failed to follow the procedure that prohibited removing anything from the patient's room that had not been checked for the presence of a brachytherapy source.

The licensee has taken the following steps: (1) physicians have been instructed to visually confirm that sources are properly loaded into applicators; (2) dosimetrists have been instructed to observe the loading process and confirm that applicators are correctly loaded; (3) a linen hamper will be placed in each brachytherapy patient's room so that linen will not, generally, be removed until after the final room survey to confirm that no sources have been lost; (4) soiled linen that cannot be left in the room until the end of treatment will be surveyed to ensure that no sources are in the linen prior to its removal from the patient's room; and (5) physicians have been instructed to visually check for the presence of sources at the time they are removed from the patients.

NRC retained a medical consultant to review the case to provide clinical assessment of this misadministration. NRC Region I conducted a special inspection on December 3 and 4, 1992, and three violations of NRC requirements were identified: (1) failure to survey soiled linen pads prior to removing them from a patient's room; (2) loss of control of the radioactive source; and (3) existence of radiation levels above the regulatory limit in unrestricted areas.

Agreement State Licensees

AS 92-1 Medical Diagnostic Misadministration at Southwest Texas Methodist Hospital in San Antonio, Texas

On January 30, 1992, an I-131 thyroid scan was requested for a patient to further evaluate a suspected right paratracheal mass to determine if the mass was a substernal goiter. The technologist confused the thyroid scan requested with a whole body scan because the mass to be imaged was in the chest. As a result, the patient was administered 185 MBq (5 mCi) of I-131 for a whole body scan instead of 3.7 MBq (100 Ci) of I-131 for the prescribed procedure for a thyroid scan with substernal mass. Because of the high activity in the thyroid at the time of the imaging on January 31, 1992, a doctor was asked to review the examination. He discovered the dose error. The doctor reported that based on a normal thyroid uptake of 15 percent for I-131, a dose of 185 MBq (5 mCi) would deliver exposures of 4000 cGy (4000 rad) to the thyroid and 2.35 cGy (2.35 rad) to the whole body. The misadministration was reported to the patient's referring physician, and he was advised that a radiation dose of this magnitude to the thyroid could result in development of hypothyroidism. The referring physician plans to follow the patient accordingly.

The misadministration occurred because a nuclear medicine technologist confused the requested partial body thyroid scan procedure with a whole body scan because of the location of the mass to be imaged.

The licensee established a policy that the administration of any dosage of I-131 greater than 3.7 MBq (100 Ci) must be reviewed by a staff radiologist licensed to administer radioactive materials with full knowledge of the clinical problem. The significance of the error was discussed with the technologist.

The licensee was cited by the Texas Bureau of Radiation Control for the misadministration in violation of license procedures. This item is considered closed.

Appendix D

Reports and Videotapes Issued From 1981 Through 1992 (Nonreactors)

Nonreactor Reports Issued From 1981 Through 1992

Nonreactor Reports Issued in 1992

Engineering Evaluations

Date	Title	No.	Author
08/92	Report on 1991 Nonreactor Events	__[1]	K. Black
08/92	Medical Misadministration Report—Medical Misadministrations Reported to NRC From January 1991 Through December 1991	__[2]	H. Karagiannis

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

Video Tape

Date	Title	No.	Author
02/91	Good Practices in Preparing and Administering Radiopharmaceuticals	__[1]	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

[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."

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
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 Report

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

[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 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 Study

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

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
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 1981	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
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
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 E

Status of AEOD Recommendations

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.

Appendix F

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

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

In accordance with NRC Management Directive 8.3, "NRC Incident Investigation Program," dated August 12, 1992, upon review 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. The 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 includes 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 action items, the NRC office assigned the action item is designated.

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

Item 6: **Adequacy of Reporting Requirements**

Action: Evaluate whether NRC and the U.S. Department of Transportation (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, 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 the NRC and the DOT reporting requirements (Reference 2) and concluded that requiring licensees to report all mislabeled or misidentified packages would require both the licensees and the 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 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 9: **Adequacy of Shipper Instructions**

Action: (a) 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, 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.

Action: (b) Pending the results of Item 9(a), 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," 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)," October 31, 1990.

3. NRC Information Notice 90-56, "Inadvertent Shipment of a Radioactive Source in a Container Thought To Be Empty," September 4, 1990.

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.

The Materials Regulatory Review Task Force issued NUREG-1324, "Proposed Method for Regulating Major Materials Licensees," in February 1992. The report contained ap-

proximately 30 recommendations related to regulations, licensing, inspection, regulatory guidance, and training. The respondents included public and industry groups, a State government, licensees, and applicants. The industry members who provided comments generally agreed with most of the report's recommendations, although there were some concerns about implementation, particularly with regard to cost.

The staff held its fourth Fuel Cycle Workshop in September 1992 during which a presentation and discussion on NUREG-1324 took place. Additionally, the staff briefed the Commissioners on NUREG-1324 on November 13, 1992. The staff is currently reviewing the recommendations in NUREG-1324 in conjunction with the comments received to date. Based upon this review, more comprehensive guidance, requirements, and review standards will be developed if found appropriate. 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. In addition, the reviews and evaluations associated with NUREG-1324, mentioned in Item 1(a) above, will be included in this review. NRC expects that inspector

training will be provided under Item 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. In addition, the reviews associated with NUREG-1324, mentioned in Item 1(a) above, will be included in this review. Pending 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 (1) the current license, (2) the Facility Change Request process and its implementation, and (3) 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. In addition, the reviews associated with NUREG-1324, mentioned in Item 1(a) above, will be included in this evaluation. 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. In addition, the reviews associated with NUREG-1324, mentioned in Item 1(a) above, will be included in this evaluation. 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 (1) a resident inspector program, (2) more frequent inspections, including use of team inspections, and (3) establishment of a systematic performance appraisal and feedback program analogous to the systematic assessment of licensee performance (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 (1) a resident inspector program, (2) more frequent inspections, including the use of team inspections, and (3) establishment of a systematic performance appraisal and feedback program analogous to the SALP program for Part 50 licensees. In addition, the reviews associated with NUREG-1324, mentioned in Item 1(a) above, will be included in this examination. 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 Item 1(e) above. Estimated completion is September 30, 1993.

Item 3: **Adequacy of Emergency Preparedness**

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 is March 31, 1993.

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).

In addition, the staff conducted the fourth Fuel Cycle Workshop in September 1992. Comments received following this workshop will be included in this review.

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, 1993.

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 is 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 is 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. A brief discussion of the related events of 1992 is provided in No. 2 of this report. 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 an evaluation of 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 under way 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 Item 4(a) and implementation of reporting of incidents pursuant to 10 CFR Part 70 and agreements with the Office of State Programs. Expected completion date is September 30, 1994.

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 the 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.

16. NUREG-1324, "Proposed Method for Regulating Major Materials Licensees," February 1992.

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