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Review of Events at Large Pool-Type Irradiators

U.S. Nuclear Regulatory Commission

Office for Analysis and Evaluation of Operational Data

E.A. Trager, Jr.

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REVIEW OF EVENTS AT LARGE POOL-TYPE IRRADIATORS

SUMMARY

Large pool-type gamma irradiators are used in applications such as the "cold" sterilization of medical and pharmaceutical supplies, and recent changes in federal regulations make it possible they will be used extensively in the preservation of foodstuffs. Because of this possible large increase in the use of irradiators, the Office of Nuclear Materials Safety and Safeguards was interested in knowing what events had occurred at irradiators. The event data would be used as background in developing new regulations on irradiators. Therefore, AEOD began a study of the operating experience at large, wet source storage gamma irradiators. The scope of the study was to assess all available operating information on large (≥ 250,000 curie), pool-type irradiators licensed by both the NRC and the Agreement States, and events at foreign facilities.

The study found that about 0.12 events have been reported per irradiator-year. Most of these events were precursor events, in that there was no evidence of damage to the radioactive sources or degradation in the level of safety of the facility. Events with more significant impacts had a reported frequency of about 0.01 event per irradiator-year. However, the actual rate of occurrence of events of concern to the staff may be higher because there are few specific reporting requirements for events at irradiators. We suggest that during development of a regulation for large pool-type irradiators consideration be given to specifying requirements for: reporting breakdowns in access control systems; periodic inspection of the source movement and suspension system; systems to detect source leakage and product contamination; allowable pool leakage; and feedback of information on operational events involving safety-important systems (i.e., requiring reporting of specific events).

1.0 INTRODUCTION

A panoramic, wet source storage irradiator, (American National Standards Institute ANSI N43.10, category IV), is a "controlled human access irradiator in which the sealed source is contained in a storage pool (usually containing water). The sealed source is fully shielded when not in use, and the sealed source is exposed within a radiation volume that is maintained inaccessible during use by an entry control system." The sealed sources contain cobalt-60 (Co-60) or cesium-137 (Cs-137).

Since the 1960's, increased use has been made of large, wet source storage irradiators in applications, such as the sterilization of medical and pharmaceutical supplies. Recent concern over the possibly carcinogenic effects of ethylene oxide residues may make radiation sterilization an even more attractive alternative method of sterilization. In addition, recent changes in federal regulations make it possible that radiation sterilization will become a popular process for preserving foodstuffs.

An AEOD study of operating experience at large irradiators was made as part of an effort to evaluate whether or not current NRC regulatory requirements concerning large irradiators are adequate. The study included a review of all available information on large (≥ 250,000 curie), pool-type irradiators licensed by both the NRC and the Agreement States, and events at foreign facilities.

The focus was on events that have occurred since 1980, because they are considered more representative of events that are likely to occur at irradiator facilities today. 1/

The potential personnel radiation exposure hazard posed by the sources at large irradiators is substantial. For example, the unshielded dose from a 250,000 Ci Co-60 source is approximately 250,000 rem/hr (69 rem/sec) at 4 feet and approximately 25,000 rem/hr (6.9 rem/sec) at 13 feet. Therefore, a lethal dose could be received within minutes.

The integrity of the Co-60 and Cs-137 sealed sources is important because the sealed sources are stored in pools of water and a leaking source could contaminate the storage pool and perhaps the environment. Hence, the integrity of the storage pool must also be assured.

Section 2 of this report includes a brief description of large irradiator facilities that have been operated recently, and Section 3 includes a discussion of events that have occurred at those facilities. Section 4 includes analyses of the events and the lessons learned. Sections 5 and 6 contain the findings and conclusions of this study.

1/ In 1978, NRC regulations were changed [10 CFR 20.203(c)(6) was added] to require improved access controls for irradiators (42 FR 64619, dated December 7, 1977).

2.0 LARGE IRRADIATOR FACILITIES

The radioactive material used most widely in large pool-type irradiators is Co-60, although a number of facilities have begun to use Cs-137 in Waste Encapsulation Storage Facility (WESF) capsules leased from the Department of Energy (DOE). Facilities currently in operation are licensed to possess up to 10 megacuries (10.0 MCi) Co-60 or 30 megacuries (30.0 MCi) Cs-137.

Because the average energy from Cs-137 decay is roughly one-quarter that of Co-60, and because of the source design (the WESF capsule was designed to provide long term containment of material and not to optimize radiation distribution), roughly seven times as many curies of Cs-137 are needed to produce the same dose rate as Co-60. The long half-life of Cs-137 (30 years) compared with that of Co-60 (5 years) makes it easier to maintain a constant curie inventory.

Table 1 lists 48 large irradiator facilities located in the United States. Additional information on the facilities is included in Appendix A. Operations were recently halted at six of the facilities and three of the facilities have not yet begun operations. Fifteen of the 39 currently operating facilities are licensed by the NRC and 24 are licensed by Agreement States. Most of the facilities were designed by Atomic Energy of Canada Limited (AECL) and use Co-60 sources. The 35 facilities using Co-60 are authorized to possess a total of 108 million curies (MCi) Co-60, or an average of about 3.1 MCi per facility. The four facilities using Cs-137 are authorized to possess a total of 58.5 MCi, or about 14.6 MCi per facility. The length of time these irradiators have been operating varies widely. As of December 31, 1987, the average facility had been operating for about 8.6 years; the range is from 1.8 to 23.6 years. Half of the facilities now in operation, (20 of 39), started operations after 1980.

Table 2 lists plant operating experience in recent years for plants that are currently in operation. These data show that the industry has had more operating experience since 1982 (≥180 plant-years), than all the experience up through 1982.

Table 2

YEARS OF IRRADIATOR OPERATING EXPERIENCE
FOR U.S. PLANTS CURRENTLY IN OPERATION

YEARS	PLANT-YRS. OPERATION	CUMULATIVE EXPERIENCE (PLANT-YEARS)
1964-1965	4	4
1966-1970	19	23
1971-1975	35	58
1976-1980	74	132
1981	22	154
1982	26	180
1983	31	211
1984	33	244
1985	37	281
1986	39	320
1987	39	359

3.0 EVENTS AT LARGE IRRADIATORS

The primary sources of information on events at irradiators were reports of events by NRC licensees and inspection reports by the NRC. The Agreement States indicated that very few problems had been reported at irradiators located in those States.

In addition to the 39 large irradiators operating in the United States (U.S.), there are many other large irradiators operated around the world. In March 1986, there were 132 operating in 39 countries worldwide. 2/ However, there was little detailed information available on events that occurred outside the United States. AECL, designer of the majority of the plants in operation today, provided information that was available on events that have occurred at facilities designed by AECL.

The following report subsections include information on the events by event-type and in chronological order. Information on foreign events was included when it was available.

Table 3 lists operational events at irradiators in chronological order. It includes a summary of type of the problem reported, the cause of the problem, and when it was reported. Appendix B contains additional information on these events.

3.1 Personnel radiation overexposures.

This is potentially the most serious type of event at a large irradiator because such an overexposure may be life threatening. However, changes to the regulations that were made effective in 1978 (10 CFR 20.203(c)(6) requires improved access controls for high radiation areas) appear to have been successful in limiting the occurrence this type of event.

Two known fatalities have occurred as a result of radiation overexposures at irradiators: in Italy on May 13, 1975 and in Norway on September 2, 1982. The incident in Italy occurred at a facility where a 30,000 Ci Co-60 source was being used to irradiate corn. That irradiator had been in operation for about three months. An operator had climbed onto the conveyor belt to make an adjustment and was moved under the unit while the source was exposed. When the operator complained of severe pain in his head, his partner attempted to remove him from beneath the unit. However, he ran the conveyor forward rather than in reverse and exposed the victim's entire body to the unshielded source. The victim died 12 days later (ref. 1). The absorbed dose was estimated at greater than 1000 rad (ref. 2).

2/ "World List of Industrial Gamma Irradiators," AECL Industrial Irradiation Division, March 1986.

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TABLE 3

REPORTED OPERATING EVENTS AT LARGE IRRADIATORS

LICENSEE	CITY	ST	EVENTDATE	EXPERIENCE	PROBLEM	CAUSE
ISOMEDIX, INC.	PARSIPPANY	NJ	06/13/74	10 MTHS	RAD OVEREXPOSURE	MANAGEMENT PROB
STIMOS	ITALY	NA	05/13/75	(UNKNOWN)	RAD OE, FATALITY	MANAGEMENT PROB
ISOMEDIX, INC.	MORTON GROVE	IL	03/06/76	2.10 YRS	STUCK SOURCE RAC	UNKNOWN
ISOMEDIX, INC.	MORTON GROVE	IL	05/21/76	2.31 YRS	STUCK SOURCE RAC	UNKNOWN
ISOMEDIX, INC.	PARSIPPANY	NJ	06/09/76	2.82 YRS	CONTAMIN, PIPING	UNKNOWN
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	03/14/77	6.32 YRS	LIC. VIOLATIONS	MANAGEMENT PROB
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	09/23/77	6.85 YRS	RAD OVEREXPOSURE	MANAGEMENT PROB
AMERICAN CONVERTORS	EL PASO	TX	01/19/78	3.6 MTHS	INTERLOCK DEFECT	DESIGN DEFECT
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	03/18/79	8.33 YRS	MALF,SOURCE MECH	UNKNOWN
ETHICON, INC.	SOMERVILLE	NJ	07/30/80	16.21 YRS	FIRE	MANAGEMENT PROB
BECTON-DICKINSON	BROKEN BOW	NE	10/24/80	2.46 YRS	FIRE	MANAGEMENT PROB
DEFENSE NUCLEAR AGENCY	BETHESDA	MD	04/22/81	10.59 YRS	STUCK SOURCE RAC	DESIGN DEFECT
JOHNSON & JOHNSON	SHERMAN	TX	05/14/81	7.45 YRS	STUCK SOURCE RAC	MAINT,INADEQUATE
BECTON-DICKINSON	NORTH CANAAN	CT	05/14/81	11.48 YRS	FIRE	MANAGEMENT PROB
STERITEX CO.	DENMARK	NA	06/01/81	(UNKNOWN)	MALFUNC,SOURCE R	MAINT,INADEQUATE
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	09/15/81	10.83 YRS	CABLE FAILURE	MAINT,INADEQUATE
ISOMEDIX, INC.	SPARTANBURG	SC	09/27/81	3.29 YRS	STUCK SOURCE RAC	UNKNOWN
P.T. GIRI KENCANA JAYA	INDONESIA	NA	01/31/82	(UNKNOWN)	FIRE	MANAGEMENT PROB
BECTON-DICKINSON	OXNARD	CA	05/07/82	2.44 YRS	CABLE FAILURE	UNKNOWN
ISOMEDIX, INC.	PARSIPPANY	NJ	06/18/82	8.85 YRS	RAD OE, BADGE	UNKNOWN
INST FOR ENERGY TECHNOLOGY	NORWAY	NA	09/02/82	(UNKNOWN)	RAD OE, FATALITY	DESIGN DEFECT
INTERNATIONAL NUTRONICS, INC.	DOVER	NJ	10/25/82	11.96 YRS	CONTAMIN, POOL	MANAGEMENT PROB
JOHNSON & JOHNSON PTY LTD.	AUSTRALIA	NA	11/14/82	(UNKNOWN)	FIRE	MANAGEMENT PROB
INTERNATIONAL NUTRONICS, INC.	DOVER	NJ	12/31/82	12.14 YRS	SPILL	MANAGEMENT PROB
INTERNATIONAL NUTRONICS, INC.	DOVER	NJ	11/22/83	13.03 YRS	LIC. VIOLATION	MANAGEMENT PROB
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	09/21/84	13.85 YRS	INTERLK,BYPASSED	MANAGEMENT PROB
JOHNSON & JOHNSON	SHERMAN	TX	11/01/84	10.92 YRS	STUCK SOURCE RAC	UNKNOWN
JOHNSON & JOHNSON	SHERMAN	TX	12/08/84	11.02 YRS	STUCK SOURCE RAC	DESIGN DEFECT
INTERNATIONAL NUTRONICS, INC.	IRVINE	CA	03/08/85	2.04 YRS	STUCK SOURCE RAC	DESIGN DEFECT
AMERICAN CONVERTORS	EL PASO	TX	03/20/85	7.47 YRS	INTERLOCK DEFECT	DESIGN DEFECT
PERMAGRAIN PRODUCTS, INC.	KARTHAUS	PA	05/31/85	7.45 YRS	TORNADO DAMAGE	NAT. PHENOMENA

LICENSEE	CITY	ST	EVENTDATE	EXPERIENCE	PROBLEM	CAUSE
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	02/26/86	15.28 YRS	INTERLK,BYPASSED	MANAGEMENT PROB
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	06/23/86	15.61 YRS	LIC. SUSPENDED	MANAGEMENT PROB
RADIATION STERILIZERS, INC	SCHAUMBERG	IL	07/17/86	5.04 YRS	STUCK SOURCE RAC	MAINT,INADEQUATE
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	09/22/86	15.85 YRS	SPILL	MANAGEMENT PROB
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	11/13/86	16.00 YRS	LIC. VIOLATIONS	MANAGEMENT PROB
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	01/08/87	16.15 YRS	MALFUNC,CONVEYOR	UNKNOWN
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	01/08/87	16.15 YRS	DAMAGE, SOURCE	UNKNOWN
RADIATION STERILIZERS, INC.	WESTERVILLE	OH	01/14/87	3.10 YRS	LIC. VIOLATIONS	MANAGEMENT PROB
JOHNSON & JOHNSON	SHERMAN	TX	05/14/87	13.45 YRS	STUCK SOURCE RAC	UNKNOWN
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	05/28/87	14.53 YRS	CONTAMIN, BURIED	MANAGEMENT PROB
ISOMEDIX, INC.	PARSIPPANY	NJ	08/19/87	14.02 YRS	INTERLK,BYPASSED	MANAGEMENT PROB
ETHICON, INC.	SOMERVILLE	NJ	08/27/87	23.29 YRS	INTERLOCK DEFECT	DESIGN DEFECT
ISOMEDIX, INC.	SANDY CITY	UT	09/17/87	2.70 YRS	EARTHQUAKES	NAT. PHENOMENA
PERMAGRAIN PRODUCTS, INC.	KARTHAUS	PA	12/01/87	9.95 YRS	FIRE	UNKNOWN
PRECISION MATERIALS CORP.	MINE HILL	NJ	02/11/88	2.87 YRS	LIC. REVOKED	MANAGEMENT PROB
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	03/19/88	17.35 YRS	LIC. VIOLATIONS	MANAGEMENT PROB
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	03/07/88	17.31 YRS	CABLE FAILURE	UNKNOWN
INTERNATIONAL NUTRONICS, INC.	PALO ALTO	CA	05/31/88	19.29 YRS	LOSS OF CONTROL	MANAGEMENT PROB
RADIATION STERILIZERS, INC.	DECATUR	GA	06/03/88	3.42 YRS	CONTAMIN, POOL	UNKNOWN

In Norway at the Institute for Energy Technology, a service technician was exposed to a 65,000 Ci Co-60 source. The technician died from radiation injury 13 days later. The irradiator was a conveyor belt, continuous type, operating 24 hours a day, and unattended at night. The conveyor belt jammed at night and the sources failed to automatically retract to the shielded position. The technician had arrived at work in the morning to find a green indicator light (source shielded signal) and an unbarred door interlock, and entered the irradiation room while the source was in the unshielded position. A radiation monitor normally located in the room was out for repair (ref. 3; also, NRC IN 83-09).

An investigation found that the safety interlock system did not fully meet the single failure criterion (that is, a system is designed to withstand a single failure if it continues to function as required following the failure of a single component in the system), although it was required. The irradiation room door lock was a common component in both the radiation interlock system and the source position interlock system. In this event, the failure of a single microswitch in the source position indication system caused a "source shielded" signal to be displayed and released the barring of the door lock. The radiation monitor that was part of the radiation interlock system was out of service for maintenance. Therefore, when the technician arrived, he saw the "source shielded" signal displayed and was able to unlock the door with the operational key because it was not barred.

The earliest reported radiation overexposure occurred on June 13, 1974, at an Isomedix facility formerly operated in Parsippany, New Jersey. Without using normal operating procedures, an operator entered a hot cell with the source exposed. He realized his error and left. He received from 185-400 Rem in 3-10 seconds exposure. While this 3-10 second radiation exposure did not result in a lethal dose, it might have under different circumstances. A number of factors contributed to this event including design deficiencies (the facility in which the event occurred was actually a hot cell and lacked safety features that might have prevented the event), and failure to follow procedures. It is also possible that the worker was not sufficiently vigilant because he was working alone at a late point in his work cycle. The operator made the error on the twelfth hour of the fourth straight day on which he worked 10 to 12 hours. To prevent recurrence, the design was changed to incorporate safety features. This event appears to have had a significant impact on the future of the industry. It showed the need for automatic safety systems and the importance of following procedures.

On September 23, 1977, a radiation overexposure occurred at the Radiation Technology Incorporated (RTI) facility in Rockaway, New Jersey, because an operator entered the irradiation chamber following a shift change while the source was unshielded. This occurred because the facility management had decided to allow the source to be raised with both interlock and safety devices inoperable. The operator averted a more serious overexposure because he felt a "tingling sensation" after he had worked near the exposed 500,000 curie Co-60 source for about 10 seconds and rapidly left the area (ref. 5). It was estimated that the employee received a 150-300 Rem whole body dose from this exposure (Abnormal Occurrence 77-10).

In an event on June 18, 1982, at the facility operated by Isomedix in Parsippany, New Jersey, a film badge indicated an exposure to radiation exceeding the dose limit. Because the overexposure was not supported by the worker's activities nor by medical examination results, the licensee concluded that there was reason to suspect that the badge had been exposed by an unknown person (ref. 6).

There are a number of important lessons to be learned from these radiation overexposure events. First, irradiator safety systems must be installed that prevent radiation overexposures that might result from human performance problems (for example, simple human error) and must be designed to meet the single failure criterion. Second, facility personnel must thoroughly understand the equipment being operated and the requirements regarding the safety systems. Finally, the facility personnel must be aware of the responsibilities under the license and must understand the primary importance of having management that is committed to operating and maintaining the facility in accordance with license requirements.

3.2 Improper functioning of safety interlocks.

Seven events were reported in which interlocks were defective or were bypassed. Five of these have been reported since 1983.

3.2.1 Interlock Defects

The earliest interlock defect condition was identified on January 19, 1978, at the American Converters facility, when it was discovered that the source rack could move from the shielded to the unshielded position with the failure of two door interlock switches. This problem was corrected with a wiring modification (ref. 7).

Another interlock defect condition was identified at American Convertors on March 20, 1985. A poor connection in an electrical subsystem of both the master and overdose timers could prevent the timers from timing down and lead to static radiation condition which could result in a fire. The components were replaced (ref. 8, 18). This event was identified in a Part 21 report (ref. 8).

The most recent interlock defect was identified at Ethicon in Somerville, New Jersey, on August 27, 1987. In that event, a tote jammed which caused a microswitch to short out and the 24 volt AC control circuit to trip. The source then began to move to the shielded position. However, with the control power out, the source cable drum continued to turn when the source plaque assembly reached the fully shielded (submerged) position and began raising the source by winding the cables on the drum in reverse until the motor stalled when the source assembly reached the full-up position. The source had to be hand-cranked to the shielded position (ref. 9, 10).

3.2.2 Bypassed Interlocks

Most of the events reported to the NRC in which interlocks were bypassed (3 of 4) took place at the RTI facility in Rockaway, New Jersey. As was noted in Section 3.1, the September 23, 1977, radiation overexposure at this facility occurred at the time of a management decision to allow the source to be raised with the interlock and safety devices inoperable. The license was suspended by the NRC from September 23, 1977, to October 14, 1977. During an inspection on September 21, 1984, an NRC inspector found that the licensee had been operating the irradiator with an inoperable safety interlock. Because of a problem with switches in the interlock system, the licensee had posted a memo on April 4, 1984, requiring that the conveyor doors be wired open during the automatic mode of operation (ref. 11). On September 26, 1984, the licensee committed to operate the facility only if all safety interlocks were operable, and to cease operations if any safety interlock failed to function. On February 26, 1986, an NRC inspector found the licensee had operated the facility with a malfunctioning radiation monitor (ref. 12).

The fourth case in which interlocks were found to be bypassed occurred at the Isomedix facility in Parsippany, New Jersey. During a routine inspection on August 19, 1987, NRC inspectors found that the licensee had been operating the walk-in irradiator since May 1987 without the radiation detector that sensed elevated radiation levels. The detector operated a door interlock that prevented personnel from entering a high radiation area. The inspectors also learned that operation without the detector had occurred on previous occasions for shorter periods of time (ref. 13).

To summarize, several events occurred in which safety systems failed or malfunctioned or were degraded. The failures or malfunctions did not result in problems because other safety systems functioned, and operating procedures were followed, and correction of these problems has resulted in improved systems. Only a small number of facilities were involved in the reports of events in which interlocks were bypassed.

3.3 Other Equipment Malfunctions

Other equipment malfunctions included improper source movement, source plaque problems, cable failures, and conveyor failures. These are events in which there is the potential for more serious problems if personnel do not respond correctly. These include failures and malfunctions that may have been due to an inadequate design or maintenance. Eighteen events fell into this category making this the most frequently reported problem.

AECL records indicate a source mechanism malfunction occurred at RTI, Rockaway, New Jersey, on March 18, 1979, but no details were available (ref. 15). There are 14 additional reports of the source rack becoming stuck, and in two of these, a fire resulted (see Section 3.5, below). The best documented of these events took place at the Armed Forces Radiobiological Research Institute (AFRRI) facility in Bethesda, Maryland, in which a robot was used to return the stuck source to the pool (ref. 17). This event was less of a potential problem than it might have been at another facility because the AFRRI facility was designed to be flooded, if necessary.

Stuck source racks have been reported most frequently at the Johnson & Johnson facility in Sherman, Texas (ref. 15, 18). The reported causes of these events were design defect, inadequate maintenance, and unknown (twice).

On March 3, 1985, a source plaque became stuck in an exposed location at the International Nutronics, Inc., facility in Irvine, California, because the aluminum shroud had become distorted and caught on the plaque frame. This was later determined to be the result of a design problem, although inadequate maintenance was a contributing factor (ref. 19; NRC IN 87-29, Item 6).

On July 17, 1986, a source plaque at the RSI Schaumberg, Illinois, facility became stuck in a less than fully shielded position, because the cable had become frayed and jammed. The fraying problem had been identified earlier, but a decision had been made to wait to correct this until the scheduled maintenance. Employees cut the cable and let the source plaque free-fall into the pool (NRC IN 87-29, Item 5). The licensee contacted NRC Region III at the conclusion of this event although it believed, and NRC Region III agreed, that this event was not reportable under existing reporting requirements.

On the early part of the night shift (7-11 p.m. on November 13, 1986), at the RTI Rockaway facility an operator noticed a slow movement of the source to the fully unshielded position. The source was raised but could not be lowered by normal or emergency means. The operator believed this was due to a frozen control valve in the line supplying air to raise or lower the source, took action, and freed the source by 2:34 a.m. The inspection report (ref. 20), noted that this involved two violations (1) failure to immediately notify the RSO when the source failed to return to the shielded position; and, (2) failure to obtain authorization and approval of repairs to a safety-related component of the irradiator (ref. 21). This was categorized as a license violation.

Cable failures were reported at RTI, Rockaway, New Jersey, on September 15, 1981, (ref. 14), and at Becton-Dickinson, Oxnard, California, on May 7, 1982 (ref. 15). The RTI cable failure was found to be the result of abrasion against the cable housing rather than cable fatigue, and the action to prevent recurrence included an improved maintenance program. A report was not available on the cause of the Becton-Dickinson cable failure.

An NRC inspection report noted that difficulties were experienced with conveyor movement at the RTI Rockaway facility on January 8, 1987, and that the operator physically shook the conveyor to get the boxes to move into position around the maze (ref. 16).

At 2 a.m. on March 7, 1988, the source cable broke at the RTI facility in Rockaway, New Jersey. As a result, a source module bent and the pencils could only be removed with difficulty. All the modules were inspected, squared, reloaded, and reinstalled in the source assembly. A new cable was installed and the equipment made ready for operation by 9 p.m. (ref. 48). While there was no clear requirement that the event be reported, NRC Region I requested that a report be submitted when it became aware of the uncontrolled drop of the source assembly and the subsequent damage.

To summarize, although equipment malfunctions have been the most frequently reported events, there have been no radiation overexposure or facility contamination events that were solely the result of an equipment malfunction or failure.

This event category is important because it contains precursor events. However, these events are generally not required to be reported. For example, 10 CFR 20.403(b)(3) 3/ requires that an event be reported if it results in loss of one day or more of operation of the facility.

3.4 Release of Radioactive Material

These events are those in which material was, or might have been, released to on-site and off-site areas.

In 1976, at the Isomedix Parsipanny, N.J. facility, a cover over the storage pool caught fire as a result of welding operations, and a chemical fire extinguishing material was used to put out the fire. It was believed that chemicals in the fire extinguishing material contaminated the pool water and caused corrosion and leaking of a source(s). The pool water was processed to remove the Co-60 and was released to the sewer system. Some piping became contaminated (ref. 22).

In October 1982, high levels of Co-60 were reported to be present in the storage pool of the International Nutronics Incorporated (INI) facility in Dover, New Jersey, (ref. 23, 24), and efforts were undertaken to clean up the pool. It was later found that a source had been damaged in 1974, but had not been reported because measured pool Co-60 levels never exceeded 5.0E-5 microcuries per milliliter. On December 31, 1982, during unattended clean up operations at the facility, a pool clean up system line broke and pool water was released to the facility floors and to the soil outside. It cost approximately $2 million to clean up the facility.

At about 6:00 a.m. on September 22, 1986, an operator entering the RTI facility in Rockaway, New Jersey, observed that a low water level alarm had been activated, possibly indicating low water levels in both of the storage pools.

He then found the pool purification system had failed during unattended operations. Water from the pool was discharged to the purification pump room and drained to the site's sanitary sewer system (ref. 25). The pool water did not contain elevated levels of Co-60.

Excavations conducted at the RTI Rockaway facility site during June 1987, uncovered radioactive contamination and toxic chemicals. However, evidence indicated that the radioactive material was generally contained and had not migrated (ref. 26). Prior to 1981, burial of low level contamination might have been permitted, but such burial had to be documented.

3/ If the licensee finds that less than one day's operation is lost, then the licensee need not report the event.

On June 7, 1988, DOE reported possible leakage of WESF Cs-137 capsules at the Radiation Sterilizers facility in Decatur, Georgia. Elevated radiation levels above the surface of the pool indicated leakage from one or more capsules (ref. 49). The initial information on this capsule leakage problem indicated that source capsules containing Cs-137 in such a soluble form may not be suitable without better leak detection systems. However, the investigation of this was only beginning while this report was being prepared.

Although releases of radioactive material have rarely been reported, and the resulting contamination was contained expensive clean up operations have resulted, even when there was no appreciable leakage from the pool. The problems lead to a number of principles for design and operation of irradiators:

- storage pool water must be pure and leakage of the pool water minimized;
- representative sampling of pool water is necessary to identify contamination promptly;
- consideration should be given to having the purification system drain back to the storage pool if any failure occurs; and
- written procedures should exist for operation of the pool purification system, including the conditions necessary for unattended operation

3.5 Fires

Several fires have been reported at U.S. and foreign irradiators.

The earliest reported fire occurred on July 30, 1980, at the Ethicon facility in Somerville, New Jersey, while the facility was shutdown for maintenance. A dose-mapping study was underway that consisted of static irradiation of corrugated cardboard boxes filled with corrugated filler material. About 10 minutes after the source had been returned to the pool, personnel entering the radiation room noticed an odor of "toasted" cardboard. After rearranging the carriers for operation, two attempts were made to start the conveyor system, with the system shutting down after each attempt. After a third shutdown, smoke began emanating from the irradiation room, and a call was made for the fire brigade at 4:43 p.m.. The fire brigade members, wearing Scott air packs and carrying a fire hose, a flashlight, and a radiation survey instrument attempted to enter the irradiator and extinguish the fire, but could enter only part way because of the smoke. After a crane was used to remove the two roof plugs (each weighed about five tons), the smoke cleared from the room and the fire was extinguished shortly after 8:00 p.m. (ref. 27).

Ethicon later concluded that the fire resulted from the static dose mapping during which there was no tote carrier movement for time periods of from 22 minutes up to 7 hours. Calculations indicated that a portion of the corrugated material had absorbed a dose of over 50 megarads and that the temperature of the filler may have increased to the ignition temperature, estimated at about 450 degrees F. It was thought that the deteriorated condition of the boxes and elevated concentrations of ozone may have increased the likelihood of the fire (ref. 28). This event occurred because possible consequences of the dose mapping were not adequately considered before the mapping was initiated.

On October 24, 1980, a fire occurred at the Becton-Dickinson facility in Broken Bow, Nebraska. At about 11:50 a.m., personnel found they could not return the source rack to the storage pool and a number of unsuccessful attempts were made to free the source rack. Personnel contacted AECL about 1:00 p.m. and requested assistance, and took the actions recommended, but without success. The fire broke out at about 9:00 p.m. At 10:40 p.m., a sprinkler head inside the cell fused, sounding the fire alarm, and putting the fire out. The water was turned on twice between then and 1:30 p.m., October 25, to put out other fires. When AECL representatives arrived on the site about 1:10 p.m. on October 25, thick smoke was still coming from the cell. They successfully freed the sources in about one-half hour. An investigation found that the source rack had become jammed because damaged product totes interfered with source movement (ref. 29).

On May 14, 1981, a fire occurred at the Becton-Dickinson facility in North Canaan, Connecticut. At about 5 p.m. aluminum totes jammed into the source rack, and several unsuccessful attempts were made to free the source by manually raising and lowering the hoist cable. Eventually, the panel lights indicated the source was down, but radiation levels in the cell remained high. AECL was then contacted. On the morning of Friday, May 22, (8 days later), AECL was notified that the sprinklers had actuated and that smoke was coming from the cell. At that time, AECL personnel travelled to the facility. The source rack was raised and lowered until it came loose and was lowered into the pool. A TV camera found the top center module and some pencils from the lower center module were missing from the source storage rack. The module and pencils were located and returned to the pool, using mirrors and tools through holes in the roof. The aluminum totes were redesigned to increase strength and a shroud was installed around the source rack. Both this event, and the earlier fire at Broken Bow, resulted because damaged totes were being used to convey material (ref. 30, 31). It is not clear whether personnel at the Becton-Dickinson facility in North Canaan were aware of the fire at Broken Bow six months earlier.

On January 31, 1982, a fire occurred at an irradiator facility in Indonesia. The source had become stuck in the unshielded position because of interference between the source and product or product conveyors. After a number of unsuccessful attempts were made to free the source, a decision was made to let the product deteriorate sufficiently to free the source. When the fire broke out 11 days later it was extinguished but only after the facility was completely destroyed. The replacement facility that was ordered was to have a source shroud (ref. 32).

Shortly after 2 p.m. on November 13, 1982, a box being loaded into the product carrier became jammed during unattended operations at the Johnson & Johnson, Sydney, Australia, facility. At about 5 a.m. on November 14, 1982, a fire broke out that damaged the goods being irradiated and the irradiator itself. The fire occurred because of the product jam and the failure of a protective interlock to shutdown the unit. This malfunction was thought to be the result of a modification by the facility operator in which a 115V relay was used to replace a 12V relay. In spite of this, the ensuing fire would probably not have occurred if the console timer system had been of the proper design or the in-cell temperature sensor had been correctly installed (ref. 33, 34).

The most recently reported fire occurred on the Permagrain facility site in Karthaus, Pennsylvania, on December 1, 1987. The fire occurred in an auxiliary building that was used to store sawdust, and did not affect irradiator operations (ref. 35; not reported by LER).

The events point out a number of principles for large irradiator design and operation. The events illustrate the need for a shroud to separate the source and product carriers. The Ethicon fire event shows the need to preplan operations, including considerations of gamma heating, (it seems unlikely that the dose mapping that was performed would have been authorized). The Becton-Dickinson fires show the need to inspect and maintain equipment and the value of reviewing operating events at other facilities in order to make the changes necessary, to avoid those events. The fire at the Johnson & Johnson facility is clear evidence of the need to operate and maintain an irradiator facility in accordance with the approved design and procedures.

3.6 Management Deficiencies

Management problems have resulted in license violations and suspensions.

3.6.1 International Nutronics Incorporated (INI), Dover, NJ

The International Nutronics facility in Dover, New Jersey, was plagued with a number of incidents that appear to have been the result of management decisions. As was noted in Section 3.4, in October 1982, a high contamination level in the storage pool was discovered that was thought to be the result of damage that had been done to the sources in 1974. When efforts were made to clean up the storage pool, a spill occurred during unattended clean up operations, and INI employees tried to conceal the fact (ref. 36). The corporation and a management employee (a Corporate Vice President and Corporate Radiation Safety Officer of INI) were prosecuted for this and found guilty (ref. 37). The conviction resulted in a fine for the corporation and two years probation for the management employee. The $2 million dollar cost of clean up and decommissioning of the facility were paid by Lexington Insurance Company. The license was terminated on November 10, 1986 (ref. 37, 38).

3.6.2 Radiation Technology Incorporated (RTI), Rockaway, NJ

Deficiencies in management have been the apparent cause of reported problems at the Radiation Technology Incorporated, facility in Rockaway, New Jersey. An inspection of the facility in October 1976 identified a number of violations for which the licensee was fined (ref. 39a). As was noted in Section 3.1, a significant radiation overexposure occurred in September 1977, because safety interlocks were bypassed. In September 1984 it was again found that the safety interlocks were being bypassed. As a result, a Confirmatory Action Letter was issued that required that RTI operate the facility only if all safety interlocks were operable, and shut down operations if any safety interlock failed to function as required.

In February 1986 an NRC Region I inspection again found that the Rockaway facility had been operated with a required radiation monitor inoperable. On March 3, 1986, Region I issued an order suspending the RTI Rockaway license (ref. 39b), but on March 13, 1986, issued a conditional rescission of the order because the licensee agreed to third and fourth party oversight of facility operations with uncensored performance reported directly to the NRC. On March 20, 1986, during a special, unannounced inspection, another violation was identified. On March 13, 1986, the licensee had used licensed material prior to NRC receipt and verification of the licensee's contract with its consultant. The NRC determined that these and earlier RTI problems constituted an abnormal occurrence because they were due to a breakdown in licensee management control.

On June 23, 1986, Region I issued an order suspending RTI's license, based on the results of an investigation that had been conducted in response to concerns expressed by the third party oversight organization (ref. 39b). The investigation found that the third party had not been informed of all equipment malfunctions. The licensee deliberately bypassed safety interlock systems. RTI admitted the violation and proposed a corrective action program that included changes in management. On August 22, 1986, the NRC lifted the suspension for a six-month probationary period (ref. 40). On March 16, 1988, the current president of RTI pleaded guilty on behalf of the company to two felony charges involving safety violations, including charges that the company had submitted falsified memorandums to the NRC (ref. 41).

3.6.3 Radiation Sterilizers Incorporated (RSI).

On January 14 and 27, 1987, the NRC performed unannounced, routine safety inspections at Radiation Sterilizers' Schaumberg, Illinois, and Westerville, Ohio, irradiator facilities (ref. 42). During the inspections, a number of license violations were identified, including: (1) Failure to test smoke and temperature alarms; (2) Failure to maintain an operable warning beacon in the maze entrance, and, (3) Failure to maintain operable control panel water level indication and an operable system to detect and shutdown the irradiator in the event of excessive water loss from the pool. The NRC determined that these problems constituted an abnormal occurrence because they were the result of a breakdown in the management oversight and control (ref. 43).

3.6.4 Precision Materials Corporation (PMC), Mine Hill, NJ

During an inspection on July 23 and 24, 1987, Region I became aware of a high rate of water loss from the storage pool of the Precision Materials Corporation facility in Mine Hill, New Jersey (the storage pool did not have a stainless steel liner). As a result, the licensee agreed to monitor the rate of make up (leakage) and measure the Co-60 concentration in the storage pool more frequently. At a meeting with Region I on August 31, 1987, the licensee noted that the pool was leaking at the rate of about 20 gallons per hour, and because of financial difficulties the company was experiencing, the company officers and the RSO planned to resign momentarily. As a result of these problems, on September 4, 1987, the facility was ordered to suspend operations;

to monitor the pool to maintain level and to detect radioactive contaminants; and to either (1) provide a basis for the resumption of licensed activities, or (2) transfer the sources to another authorized licensee (ref. 44). The licensee chose to transfer the sources. After the sources were removed and the facility released for unrestricted use, the license was revoked on February 11, 1988, (ref. 45). This event was important for a number of reasons. First, it showed that specification of an "impermeable" pool liner may not be sufficient to ensure that leakage will not occur, because certain types of liner materials may degrade with time. Second, this event shows the importance of monitoring pool inventory and make up to ensure that leakage is not occurring. Third, this event shows the need for licensees to fully understand their responsibilities. Licensees must be aware of, and committed to, carrying out the conditions of the license. Finally, this event is important because it shows how changes, such as changes to finances, can adversely effect a licensee's performance.

3.6.5 INI, Palo Alto, CA

As the result of bankrupcy proceedings, the inventory of sources had been sold and removed from the storage pool of the International Nutronics, Inc., facility in Palo Alto, California. In May 1988, while the pool was being drained, radiation levels increased to about 25 mr/hr with five feet of water still in the pool. The draining was stopped. Analysis of the pool water showed the radiation was not due to contaminants in the water. Further investigation found the elevated radiation level was due to sources still in the pool that were not part of the facilities inventory (ref. 50).

This loss of accountability for the sources in the storage pool shows the need for quality inventory records.

3.7 Natural phenomena

There were two events reported that were the result of natural phenomena. Neither event was significant from a safety standpoint.

There was a tornado at about 8 p.m. on May 31, 1985, near the Permagrain Products facility in Karthaus, Pennsylvania. Although there was minor damage to property, there was no damage to the irradiator itself (ref. 46).

The Isomedix facility in Sandy City, Utah, reported that six separate earthquakes of magnitude, 3.9 to 4.8 on the Richter Scale, centered approximately 120 kilometers northwest of the facility. The largest event in the sequence occurred on September 24, 1987. The largest had a peak horizontal acceleration of 0.01g. A state inspection on October 7, 1987, verified the facility had sustained no damage and that there had been no increase in make up water volume (ref. 47). The facility has a stainless steel pool liner.

3.8 Summary of Root Causes

Table 4 lists types of events that have occurred in the United States and the causes of those events.

Table 4

ROOT CAUSES OF EVENTS AT LARGE POOL-TYPE IRRADIATORS
LOCATED IN THE UNITED STATES

	Management	Design Defect	Maintenance	Natural Phenomena	Unknown
Radiation Overexposure					
Real	2				
Badge OE					1
Safety Interlocks					
Defective		3			
Bypassed	3				
Equipment Problems					
Source Mechanism		3	2		6
Cable Failure			1		2
Conveyor Malfunction					1
Source Assembly Damage					1
Material Release					
Contamination	2				2
Spill	2				
Fires	3				1
License Problems (Violations,etc)	7				
Miscellaneous					
Loss of Accountability	1				
Operating Conditions				2	
	20	6	3	2	14
Total	45				

4.0 ANALYSIS OF EVENTS AND LESSONS LEARNED

Only a few of the 45 events identified at U.S. irradiators were significant from a safety standpoint, that is, had an impact on health and safety. Most of the events fall into the category of precursor events, and the outcome might have been significant under different circumstances.

In Section 3 of this report, the events at the large irradiators were classified by the type of events. To assess the contributions of specific systems and management practices to events, in this section the events have been aggregated into events stemming from system problems, management deficiencies, and natural phenomena.

- Events stemming from system problems -- this category includes all events in which a system failed to operate as designed, even if the failure is ascribed to inadequate maintenance programs, etc.

- Events stemming from management deficiencies -- this category contains only those events in which there was no system failure or in which management bypassed an inoperable access control system.

- Natural phenomena and other site problems -- this category contains only those two events containing information on the ability of irradiators to withstand natural phenomena and another event involving a fire at a site.

Of the 45 events discussed in Section 3, 31 involved the failure, malfunction, or degradation in the performance of some irradiator system. These systems include: access control; source mechanism (movement and suspension); source encapsulation; and pool (leakage and clean up). An additional ten events stemmed from management deficiencies. There were three events involving natural phenomena and other site problems. One event, a badge overexposure, was not reviewed in this section.

4.1 Events Stemming from System Problems

4.1.1 Access Control Systems

The regulations (10 CFR Part 20.403 (c)) which became effective in 1978, required improved access controls for irradiators. The two overexposure events that occurred in 1974 and 1977 occurred with access control systems that did not meet these Part 20 criteria. In addition, in both cases, the access control system was not operating as designed when the overexposures occurred. In the 1974 event, the operator entered a hot cell with the source exposed. When he entered the cell he did not use a survey meter and the audible remote area alarm had unknowingly been turned off at the main console in front of the cells. 4/ In the 1977 event, construction activity resulted in the source-up warning light being obscured from vision; in addition, the electrical interlock on the door was not in order.

4/ Another aspect of the event is the fact that the hospital to which the overexposed individual was taken was initially unaware of procedures for admitting the patient or what dangers to hospital staff did or did not exist. Approximately two hours elapsed before knowledgeable hospital staff arrived on the scene.

There was a third event reported in 1978 that involved the access control system. It was discovered that failure of two door interlock switches could cause the source to move from the safe storage to the exposed position.

The exposure event at the Norway irradiator that resulted in the death of an individual involved an access control system that was not functioning properly. A review of the event states that the facility design included safety signals and operational signals that were not segregated and that were not optimally designed from a human factors standpoint. At the time of the accident, a microswitch had failed, which permitted the locked door to the irradiator cell to be opened. In addition, the failure of the particular microswitch also produced a 'source shielded' signal. A separate positional display gave the correct signal that the source was exposed.

The three American events and the Norwegian event point to the need for potential licensees to perform a detailed safety analysis of the access control system to assure that the system meets the criteria of 10 CFR 20.203 (c)(6). It should also be noted that although 10 CFR 20.203 (c)(6) required that access controls be operational, there is no requirement that licensees report or record the nonfunctioning of the controls.

4.1.2 Source Movement and Suspension

The greatest number of events that occurred at American irradiators concerned events in which the source movement was impeded or the source suspension (cable) system was damaged.

There were of 13 events that involved interference with source movement and seven events that involved the source suspension cables.

4.1.2.1 Source Movement

Of the 13 events in which source movement was impeded, there were insufficient data in five events to ascribe a cause to the event. In six events, the product carriers interfered with the movement of the source plaque. In five of these six events the effect of the interference was direct. In one event, the interference was indirect. In that event, as a pneumatic ram attempted to push a tote from a conveyor into a tote carrier, it became jammed. The jammed tote flexed and resulted in the tripping of a circuit breaker of the control circuit. The source began lowering itself into the shielded position; since loss of the control circuit caused the loss of the source-down position sensor, the source cable drum continued to rotate and raised the source to the full up position before the motor stalled. The source was lowered manually.

There were two events involving degradation of the source movement capabilities that had unique causes: at a research irradiator, interference between an experiment and the source impeded movement of the source; and low temperatures at one irradiator appear to have been responsible for impeding movement of the source.

Most of these events were benign in that there is no known impact on the facility except possible loss of production. Two of the events in which movement of the source plaque was impeded did result in fires inside the irradiation chamber, and two events resulted in individual source pencils coming loose from the source plaque. One event resulted in distortion of the source plaque.

Although the events were benign, their occurrence represents some increased risk of damage to the radioactive source and some small decrease in the safe operation of the facility.

Little information was available on licensee actions to reduce the occurrence of these events. For the two events in which fires resulted from the events, the licensees committed to an improved inspection program for the product totes, with deformed totes being taken out of service for maintenance.

4.1.2.2 Cable Problems

There were six reports of problems with source suspension cables. In three of the events, the cable broke; in two, the cable frayed. In one event the cable came off its pulley. There were no known deleterious effects of any of these events. As with the events in which the source movement was impeded, cable problems do represent an increased risk of damage to the facility and the sources.

In two of the events involving cable failure, there are indications of some deficiencies in maintenance practices. In one event, the cable was known to be frayed; in the other, the cable had not been inspected for at least three years. Commitment by licensees to some regular inspection program for the source suspension system, including the entire length of the cable, should reduce the probability of cable failures.

It should be noted that some licensees have considered that cable failures need not be reported to the NRC. To obtain uniform reporting of these events would require specific mention in the regulations.

4.1.3 Encapsulation

There have been four events in which the encapsulation of the radioactive sources appears to have failed, resulting in contamination of the storage pool. In one event, an event early in the facility life resulted in the chemical contamination of the pool water. The licensee hypothesized that this chemical contamination ultimately led to corrosion of the source encapsulation and subsequent contamination of the pool water. In a second event, a source was damaged in 1974 from mishandling. An excessive contamination level in the pool was reported in 1982. The contamination was not uniformly distributed throughout the depth of the pool.

Late in 1976, an irradiator facility determined that the Co-60 concentration in the water of a research and development pool was 0.0013 uCi/ml. The licensee stated that the activity level may have been the result of corrosion scale activity from a batch of Co-60 sources recently installed in the pool or activity from one source that had a loose cap. Demineralization of the pool water successfully reduced the activity of the pool to normal operational levels. The suspect source was stored.

A recent event involved the leakage of a Cs-137 source, with the resulting release of 10 or so curies of Cs-137 to the pool. This event led to fears that contaminated product might have been shipped from the plant. No contaminated product had been shipped (ref. 51).

The two leaking source events demonstrate that pool sampling must be representative to detect source leakage; and, although 10 CFR Part 20.203 (c) requires licensees to have the capability to detect radioactivity leaving the irradiation cell, the recent Cs-137 leak raises the question of whether this detection system is adequate to detect product contamination or whether pool contamination level or rate of increase of pool contamination would give an earlier signal that the potential exists for contamination of packages.

4.1.4 Pool Leakage and Pool Purification System

There were three events that involved pool leakage or pool clean up system failure (leakage). In the case of the leaking pool, the existence of a high rate of water loss from the storage pool was noted by an NRC inspector during an inspection that NRC Region I performed in response to allegations. After discussions with the NRC, the licensee agreed to monitor the rate of pool leakage. This event suggests that licensees be required to develop actions that will be taken if pool make up reaches some licensee-specified amount.

There were two events in which there were failures in the pool water purification system. In one event, the piping on the discharge side of the purification system pump failed. In the first failure, the piping was suitable for cold temperatures, but the pool temperature was 120°, and joints had recently been torqued.

In addition, the leak developed when the irradiator was unmanned and there was apparently no low pool level shutoff on the purification pump. In the second event involving a pool purification system leak, a line separated and contaminated water spilled into the facility. Small amounts of contamination were later found outside of the facility. The purification system was being operated unattended in this event.

It is obvious that systems should be designed to operate under the conditions that they will experience; i.e., material properties should be adequate for the plant conditions that the materials will see. There are other lessons demonstrated by the pool purification system failures: there should be an automatic shutdown

of the system if the pool level reaches some low level; and, there should be a cost-benefit analysis made to determine whether it is necessary to have leakage from the pool water purification system drain back to the pool or some facility sump.

4.1.5 Miscellaneous Systems

There were two events that involved miscellaneous systems. The first event involved problems with timers. It was reported not only to an Ageement State by its licensee, but also to the NRC as a Part 21 report by the manufacturer. The second event involved malfunction of pistons used to engage clutches in the product conveyor system.

4.2 Management Deficiencies

There were ten events ascribed to management deficiencies of one type or another. In one event, a dose distribution study that involved the stationary irradiation of cardboard, a fire resulted from gamma heating of the cardboard. This was the only event with demonstrable consequences in this group of ten events.

The most common management deficiency was operating an irradiator without operational interlocks required by 10 CFR 20.403 (c), with several events reoccurring at the same facility.

4.3 Natural Phenomena and Other Site Problems

There were three events in this category, none of which had any known impact on the irradiator at which the event occurred. One irradiator site was struck by a tornado. The storage pool was unaffected. A second irradiator was about 120 km from the epicenter of a series of six earthquakes of from 3.6 - 4.8 magnitude. The irradiator itself was inspected by state licensing personnel and found to be undamaged.

In a third event, there was a fire at an irradiator facility in a building that was separate from the irradiator. The building was used to store sawdust, a combustible material. The irradiator suffered no damage.

These three events do not contribute much knowledge about external events affecting operational events at irradiators. In the two events involving natural phenomena, the irradiators were unaffected. The event involving a fire in an auxiliary building of an irradiator facility demonstrates that there may be unrelated site problems that could have some impact on the irradiator itself.

5.0 FINDINGS

The review of events at large pool irradiators showed that there were 45 events reported during the approximately 360 irradiator years of operating experience, a freqency of about 0.12 events/irradiator year. Of the 45 events, only about 10 - 20 percent had significant consequences. Hence, the frequency of significant events appears to be on the order of 0.01 - 0.02 events/irradiator

year. Since there are few specific reporting requirements for irradiator events, the overall frequency may be greater than predicted by this report. The events in the report show that there have been failures in several safety-important systems: access control, source movement and suspension, encapsulation, and pool leakage and purification system. It is suggested that the requirements for the operability of these systems be assessed, together with an assessment of the need for licensees to define action levels if system function falls below some predetermined value.

Current requirements for the reporting of events at irradiators are not adequate to identify potential problems at a facility, nor to identify possible generic problems. For example, if a source is stuck in an unshielded position, or there is an uncontrolled drop of the source assembly, there is no requirement that this be reported, unless it is reportable for some other reason, for example, the facility must shut down operations for more than 24 hours.

6.0 CONCLUSIONS AND RECOMMENDATIONS

It is suggested that during the development of a regulation for large pool-type irradiators consideration be given to:

- requirements for reporting breakdowns in access control systems;
- requirements for periodically inspecting the source movement and suspension system;
- requirements for licensees to have effective means of accurately detecting source leakage and subsequent potential product contamination;
- requirements that licensees specify allowable pool leakage, as well as requirements for automatic shutdown of the pool purification system in case of system failures; and,
- specifying reporting requirements that assure that there is feedback of information on operational events involving safety-important systems.

7.0 REFERENCES

1. "Radiation Accidents: A Conference Review," L.A. Sagan and S.A. Fry; Nuclear Safety, Vol. 21, No. 5, September-October 1980.

2. "A Dosimetric Study of the Belgian (1965) and Italian (1975) Accidents," N.C. Parmentier, J.C. Nenot, and H.J. Jammet; The Medical Basis for Radiation Accident Preparedness, K.F. Hubner and S.A. Frys, Eds., Elsevier, 1980.

3. "The Radiation Accident at Institute for Energy Technology, Sept. 1982, Some Technical Considerations," Leiv Berteig and Jon Flatby, National Institute of Radiation Hygiene, Norway; J. of Indust. Irradiation Tech., 2(3&4), 309-319 (1984).

4. NRC Region I Investigation Report No. 74-01, dated August 8, 1974; License #29-15364-01.

5. "The New Jersey Radiation Accidents of 1974 and 1977," Barlotta, Flora M.; The Medical Basis fo Radiation Accident Preparedness, K.F. Hubner and S.A. Frys, eds Elsevier, 1980.

6. Licensee report, dated July 6, 1982, from Isomedix, Inc., to NRC, Region I; NRER #82-069

7. Letter, dated January 20, 1978, from Converters to the Texas Department of Health Resources.

8. 10CFR21 Notification Report, dated April 19, 1985, from AECL to the NRC.

9. Licensee report, dated September 25, 1987, from Ethicon, Inc., to NRC, Region I.

10. NRC Region I Inspection Report 30-06990/87-01, dated April 19, 1988.

11. NRC Region I Combined Inspection Report Nos. 30-07022/84-01 and 30-19146/84-01, dated December 29, 1986.

12. NRC Inspection Report Nos. 30-07022/86-01 and 30-19146/86-01, dated April 4, 1986.

13. NRC PNO-I-87-81, dated August 19, 1987.

14. Licensee report, dated September 15, 1981, from Radiation Technology, Inc., to NRC Region I.

15. Letter, dated August 10, 1982, from AECL to Texas Department of Health, Bureau of Radiation Control.

16. NRC Region I Combined Inspection Report Nos. 30-07022/87-01 and 30-19146/87-01, dated May 28, 1987.

17. Licensee report, dated June 16, 1981, from the Defense Nuclear Agency to the NRC Region I.

18. Letter, dated October 27, 1987, from the Texas Department of Health to the NRC, GPA.

19. State of California Department of Health, Radiological Health Section Report, dated March 11, 1985.

20. NRC Region I Combined Inspection Report Nos. 30-07022/86-18 and 30-19146/86-18, dated January 6, 1987.

21. Letter, dated April 10, 1987, from Radiation Technology, Inc., to NRC Region I.

22. AECL notes, dated November 16, 1986.

23. NRC Confirmatory Action Letter 82-25, dated October 29, 1982.

24. Licensee report, dated December 23, 1982, from International Nutronics, Inc., to NRC Region I.

25. NRC Inspection Nos. 30-07022/86-14 and 30-19146/86-14, dated October 10, 1986.

26. Letter, dated September 15, 1987, from NRC Region I to Radiation Technology, Inc.

27. Licensee report, dated August 28, 1980, from Ethicon, Inc., to NRC Region I.

28. Supplementary information on the fire at the Ethicon Sommerville facility was provided to the NRC in a memorandum dated April 15, 1988.

29. Letter, dated December 5, 1980, from State of Nebraska, Department of Health to the NRC Office of State Programs.

30. Letter, dated June 16, 1981, from AECL to Becton-Dickinson

31. Licensee report, dated June 23, 1981, from Becton-Dickinson to NRC Region I.

32. Letter, dated February 19, 1982, from P.T. Giri Kencana Jaya to AECL.

33. AECL memorandum, dated November 25, 1982.

34. Ethicon, Inc., memorandum, dated February 16, 1983.

35. NRC Region I Preliminary Notice of Occurrence PNO-I-87-112, dated December 2, 1987.

36. NRC Region I Request for Investigation of International Nutronics, Inc., dated October 6, 1983.

37. NRC PNO-I-86-89A, dated December 5, 1986.

38. Amendment 19 to NRC License #29-13848-01, dated November 10, 1986.

39a. NRC Region I Inspection Report and Notice of Violation, dated January 5, 1977, License #29-13613-02.

39b. NUREG-0940, Vol.6, No.1, Enforcement Actions: Significant Actions Resolved; p.II.A-73.

40. License No. 29-13613-02 Renewal, dated August 22, 1986.

41. New York Times, March 20, 1988; p.38.

42. NRC Region III Inspection Report No. 030-19025/87-01, dated March 17, 1987.

43. Abnormal Occurrence 87-5, NUREG-0090, Vol.10, No.1.

44. NRC Region I Order Modifying License 29-20777-01, dated September 4, 1987.

45. NRC Order Revoking License 29-20777-01, dated February 10, 1988.

46. NRC Inspection Report No. 030-13537/85-01, dated September 16, 1985.

47. Letter, dated October 26, 1987, from Utah Department of Health, Bureau of Radiation Control to NRC, Office of State Programs.

48. Internal Memorandum, Radiation Technology, Inc., dated March 11, 1988.

49. NRC PNO-II-88-40, -40A, and -40B dated June 7, 8, and 9, 1988.

50. Region V to AEOD communication, dated May 25, 1988.

51. NRC Region II letter to U.S. F.D.A. dated June 21, 1988.

APPENDIX A

NOTES ON LARGE POOL-TYPE IRRADIATORS LOCATED IN THE UNITED STATES [1/]

LICENSEE	CITY	ST	LIC. NO.	LIC.DATE	NOTES
PROCESS TECHNOLOGY	WEST MEMPHIS	AR	SL	06/01/81	FACILITY IS THE SAME AS THE PROCESS TECHNOLOGY FACILITIES IN SALEM, NJ, AND HAW RIVER, NC, BUT ON A SMALLER SCALE THAN AT THOSE FACILITIES. PROCESSING CAN BE EITHER AUTOMATIC OR MANUAL, BUT IS USUALLY AUTOMATIC. PRODUCT ON PALLETS IS LOADED ONTO CARTS THAT ARE MOVED INTO THE IRRADIATION CHAMBER ON TRACKS. OCTOBER 12, 1987, ARKANSAS LETTER NOTED: - LICENSED FOR 2.25 MCI, BUT CURRENTLY POSSESS 900,000 CI. - CUSTOM DESIGN OF RTI OF NEW JERSEY. - ON AT LEAST TWO OCCASIONS, EMPLOYEES ACCIDENTLY DROPPED FILM BADGES INTO THE IRRADIATOR POOL. THERE WERE NO OTHER REPORTABLE OCCURRENNCES. - AN OLD PIECE OF AIR FILTER WAS BROUGHT BACK FOR ANALYSIS FOLLOWING AN INSPECTION AND WAS FOUND TO BE CONTAMINATED WITH CO-60. HOWEVER, AN EXTENSIVE SURVEY FOUND NO CONTAMINATION OTHER THAN THAT ON THE OLD AIR FILTER. IT WAS ASSUMED THAT THE LOW LEVEL OF CONTAMINATION ON THE FILTER DID NOT RESULT IN ANY INTERNAL EXPOSURES. IT WAS ULTIMATELY DETERMINED THAT THE CONTAMINATION CAME FROM A CONTAMINATED SHIPPING CASK.

[1/] Data from Agreement States on events (or absence of events) at irradiators in the States has been included in this Appendix.

LICENSEE	CITY	ST	LIC. NO.	LIC.DATE	NOTES
BECTON-DICKINSON	OXNARD	CA	SL#3332-56	11/29/79	J8500 TOTE TYPE DESIGN WAS SIMILAR TO THAT OF THE B-D FACILITY IN SUMTER, SC. FALCON LABWARE DIVISION OPERATIONS WERE TERMINATED 05/15/86. SOURCES WERE RETURNED TO CANADA (PER CALIFORNIA). ACTIVITIES MOVED TO THE SC B-D PLANT.
INTERNATIONAL NUTRONICS, INC.	IRVINE	CA	SL#3911-30	02/22/83	VOLUNTARY SHUTDOWN. SOURCES REMAINED IN POOL UNTIL THEY WERE REMOVED IN MARCH 1988.
INTERNATIONAL NUTRONICS, INC.	PALO ALTO	CA	SL#1822-43	02/20/69	VOLUNTARY SHUTDOWN. SOURCES REMAINED IN POOL UNTIL THEY WERE REMOVED IN MARCH 1988.
RADIATION STERILIZERS, INC.	TUSTIN	CA	SL#3390-30	06/15/79	THE IRRADIATOR HAS THE RSI PRODUCT OVERLAP DESIGN (3-LEVEL SHUFFLE DWELL) IN WHICH PRODUCT IN METAL TOTES IS EXPOSED FOR PERIGDS OF TIME AT EACH OF THREE VERTICAL POSITIONS IN THE CARRIER. FACILITY WAS COMPLETELY REDESIGNED AND REBUILT IN 1985-86.
COBE LABS	LAKEWOOD	CO	SL#CO494-01	01/09/82	5 MCI POSSESSED
IOTECH, INC.	NORTH GLEN	CO	SL#CO613-01	01/14/85	15 MCI POSSESSED
BECTON-DICKINSON	NORTH CANAAN	CT	06-13514-01	11/21/69	AECL TYPE J6500 SER. NO. IR21 (FOR STERILIZATION OF MEDICAL/SURGICAL PRODS) TOTES ON CONVEYOR.
SHERWOOD MEDICAL	DELAND	FL	SL	05/05/82	ORIGINAL FACILITY DESIGN (SOURCE OVERLAP) WAS IDENTICAL TO THAT OF THE FACILITY IN COMMERCE, TX. PER OCTOBER 21, 1987 FLORIDA LETTER: - 1,524,535 CI AS OF 10/01/87. - AECL CO-60 MODEL C-188 PENCILS - NO EVENTS WERE REPORTED. - LICENSE VIOLATIONS NOTED DURING INSPECTIONS HAD TO DO WITH TRAINING ADMINISTRATIVE REQUIREMENTS.
RADIATION STERILIZERS, INC.	DECATUR	GA	SL	01/01/85	RSI PRODUCT OVERLAP DESIGN; 3-LEVEL SHUFFLE-DWELL USES BOTH COBALT-60 AND CESIUM-137 SOURCES IN A (PROPRIETARY) RATIO. OCTOBER 1, 1987 GEORGIA LETTER NOTED: - RADIATION STERILIZERS DESIGN - 12 MCI CS-137 POSSESSED AS OF 04/01/86. - NO EVENTS REPORTED - OBSERVED DURING INSPECTIONS: - 02/07/85: RESTRICTED AREA COULD BE ENTERED WITHOUT ACTIVATING A DEVICE TO AUTOMATICALLY LOWER THE SOURCES.

LICENSEE	CITY	ST	LIC. NO.	LIC.DATE	NOTES
					- 10/23/85: FAILURE TO REPORT WHEN EMPLOYEE'S FILM BADGE EXPOSURE EXCEEDED 1.25 REM/QUARTER. (THE BADGE WAS THOUGHT TO HAVE BEEN EXPOSED BY A CHECK SOURCE.) - "NO ENTRY" LIGHT AT ENTRANCE TO MAZE AREA NOT FUNCTIONAL.
ISOMEDIX, INC.	LIBERTYVILLE	IL	SL	11/01/85	FORMER NRC LIC #29-19769-03 WAS TRANSFERRED TO THE STATE IN 1987. IN THIS SOURCE OVERLAP DESIGN, PRODUCT (ABOUT 75% DISPOSABLE MEDICAL) IS TRANSPORTED IN CARRIERS. THE FACILITY IS CURRENTLY OPERATED IN A BATCH MODE BUT IT CAN BE MODIFIED TO BE OPERATED IN AN AUTOMATIC MODE (THIS WAS CONSIDERED IN THE INITIAL DESIGN)
ISOMEDIX, INC.	MORTON GROVE	IL	SL	01/29/74	J6300 TOTE TYPE FORMER NRC LICENSE #29-15364-02 WAS TRANSFERRED TO ILLINOIS ON 06/30/87. USED AS AN R&D FACILITY AT THIS TIME. 500,000 CI CO-60 POSSESSED AS OF EARLY 1988.
RADIATION STERILIZERS, INC.	SCHAUMBERG	IL	SL	07/02/81	PRODUCT OVERLAP DESIGN; 3-LEVEL SHUFFLE-DWELL. DUAL SOURCE RACKS. ALTHOUGH THIS IS THE OLDEST OF THE RSI DESIGN FACILITIES, IT DIFFERS FROM THE OTHER FOUR ONLY IN THE ELEVATOR DESIGN. LICENSE FOR POSSESSION AT THIS FACILITY WAS FORMERLY PART OF LIC #04-19644-01 (MANAGED BY REGION III) AND WAS TRANSFERRED TO IL ON 6/30/1987 CS-137 LIMIT IS 30 MCI AND CO-06 IS 5 MCI.
ISOMEDIX, INC.	NORTHBORO	MA	29-19769-02	08/31/82	AECL MODEL C-188, TYPE 1,2,3, OR 4, FOR USE IN AECL MODEL IR-126 IRRADIATOR. PRODUCT (MEDICAL DISPOSABLES) IS MANUALLY MOVED INTO AND OUT OF THE IRRADIATION AREA AND AUTOMATICALLY MOVED DURING IRRADIATION.
DEFENSE NUCLEAR AGENCY	BETHESDA	MD	19-08330-03	09/21/70	LICENSE FOR THE ARMED FORCES RAD-BIO RESEARCH INST.
NEUTRON PRODUCTS	DICKERSON	MD	SLMD3102503	09/02/83	0.75 MCI POSSESSED MANUAL BATCH PROCESS.
NEUTRON PRODUCTS	DICKERSON	MD	SLMD3102504	01/04/80	1.5 MCI POSSESSED CONTINUOUS AUTOMATIC PROCESS.

LICENSEE	CITY	ST	LIC. NO.	LIC.DATE	NOTES
TUREMO	ELKTON	MD	SL	/ /	FACILITY PROPOSED FOR THE IRRADIATION OF SURGICAL/ MEDICAL PRODUCT.
DOW CORNING CORP.	MIDLAND	MI	21-08362-13	03/28/77	BNL MODEL MK-1, OR NEUTRON PRODUCTS, INC., CAT. NO. NPI-12005, OR NRRP-330-14-I, SOURCES. FACILITY USES GAMMA RADIATION TO CATALYZE A CHEMICAL REACTION(S). BULK PRODUCT MOVES WITHIN A PIPE THAT IS HOUSED WITHIN THE IRRADIATION CHAMBER.
GAMMA-MED, INC.	COLUMBUS	MS	SLMS-661-01	04/12/76	J6500 TOTE TYPE; ADJACENT PRODUCT BOXES MOVE ON CONVEYOR ROLLERS BY GRAVITY. ISOMEDIX WAS FORMER LICENSEE. CURRENTLY HAVE 0.866 MCI IN POOL. NON-REPORTABLE EVENT: DURING AECL SOURCE CHANGE TECHS NOTICED A FRAYED CABLE; CABLE WAS REPLACED.
PROCESS TECHNOLOGY	HAW RIVER	NC	SL	06/01/83	LIKE THE PROCESS TECHNOLOGY FACILITIES AT WEST MEMPHIS, AND SALEM, NJ. PRODUCT ON PALLETS IS LOADED ONTO CARTS THAT ARE MOVED INTO THE IRRADIATION CHAMBER. PROCESSING CAN BE EITHER AUTOMATIC OR MANUAL, BUT IS USUALLY AUTOMATIC. AN OCTOBER 27, 1987, NORTH CAROLINA LETTER NOTED: - RADIATION TECHNOLOGY DESIGN MODEL 4101 - RADIOISOTOPE LIMITS AND AMT POSSESSED 01/87: - LIMIT OF 1.2 MCI 720,000 CI POSSESSED. - LIMIT OF 71,600 CI AND 71,000 CI POSSESSED. - NO EVENTS REPORTED - NO INSPECTIONS FINDINGS.
BECTON-DICKINSON	BROKEN BOW	NE	SL#410101	05/09/78	J7500 TOTE TYPE; 2.73 MCI POSSESSED. ALUMINUM TOTES ARE MOVED ON A CONVEYOR.
SHERWOOD MEDICAL	NORFOLK	NE	SL#070201	11/27/78	J7500 TOTE TYPE; 2.84 MCI POSSESSED
ETHICON, INC.	SOMERVILLE	NJ	29-02786-03	05/18/64	THIS PRODUCT OVERLAP DESIGN IS SIMILAR TO THAT OF THE FACILITY IN SAN ANGELO, TX. PRODUCT IS CONTAINED IN FOUR METAL BOXES PER CARRIER. THE LOCATIONS AND ORIENTATIONS OF THE BOXES ARE REVERSED DURING THE IRRADIATION CIRCUIT.
INTERNATIONAL NUTRONICS, INC.	DOVER	NJ	29-13848-01	11/13/70	FACILITY OPS BEGAN IN 1970 AND ENDED IN 1986. SURVEY IN JAN. 1986 INDICATED THE FACILITY HAD BEEN DECONNED AND THE LICENSE WAS TERMINATED BY AMENDMENT 19 ON NOVEMBER 10, 1986. LEXINGTON INSURANCE CO. PAID CLEANUP COSTS OF ABOUT $2 MILLION.

LICENSEE	CITY	ST	LIC. NO.	LIC.DATE	NOTES
ISOMEDIX, INC.	PARSIPPANY	NJ	29-15364-01	08/13/73	ORIGINAL DESIGN WAS THAT OF A HOT CELL WITH NON-AECL EQUIPMENT. THE OPERATION WAS CHANGED TO A BATCH OPERATION USING CARRIERS. OPERATIONS WERE RECENTLY TERMINATED. THE SOURCES HAVE BEEN REMOVED AND THE FACILITY IS BEING DISMANTLED.
ISOMEDIX, INC.	WHIPPANY	NJ	29-19769-03	07/19/83	AECL MODEL C-188, TYPE 1,2,3, OR 4, FOR USE IN AECL MODEL IR-131 IRRADIATOR FOR IRRADIATION OF MATERIALS. LICENSEE REPORTED AN ACTUAL INVENTORY OF 2.367 MCI AS OF 3/14/86. PRODUCT (MEDICAL DISPOSABLES) IN CARRIERS IS MANUALLY MOVED INTO AND OUT OF THE IRRADIATION AREA AND AUTOMATICALLY DURING IRRADIATION.
PRECISION MATERIALS CORP.	MINE HILL	NJ	29-20777-01	03/29/85	PRODUCT WAS TRANSPORTED ON DOLLIES. THE FACILITY WAS SHUTDOWN ON 09/04/87, SOURCES WERE REMOVED.
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	29-13613-02	11/18/70	ABNORMAL OCCURRENCE #77-10. ABNORMAL OCCURRENCE #86-6. THE ORIGINAL PRODUCT OVERLAP DESIGN (SOURCE IS SURROUNDED BY PRODUCT) WAS A SHUFFLE DWELL WITH TWO POSITIONS, I.E., TWO STACKED 3-FOOT HIGH ALUMINUM TOTES MOVED AROUND THE SOURCE, THE TOTES WERE REPOSITIONED, AND THE EXPOSURE CIRCUIT WAS COMPLETED. IN THE SUMMER OF 1988, THE FACILITY WAS MODIFIED TO A SOURCE OVERLAP DESIGN. IN THAT BATCH OPERATION, 7-FOOT TALL CARRIERS ARE INDEXED AUTOMATICALLY.
SOUTH JERSEY PROCESS TECH,INC	SALEM	NJ	29-20900-01	03/14/86	LIKE THE PROCESS TECHNOLOGY FACILITIES AT WEST MEMPHIS, AR, AND HAW RIVER, NC. PRODUCT ON PALLETS IS LOADED ONTO CARTS THAT ARE MOVED INTO THE IRRADIATION CHAMBER. PROCESSING CAN BE AUTOMATIC OR MANUAL, BUT IS USUALLY AUTOMATIC.
ISOMEDIX, INC.	GROVEPORT	OH	29-19769-04	01/12/84	AECL MODEL C-188, TYPE 1, 2, 3, OR 4. IN THIS SOURCE OVERLAP DESIGN, PRODUCT IN CARRIERS IS MOVED THROUGH 29 POSITIONS IN A TWO PASS SHUFFLE DWELL (TWO PASSES ON EACH SIDE).
RADIATION STERILIZERS, INC.	WESTERVILLE	OH	04-19644-01	12/08/83	PRODUCT OVERLAP DESIGN, 3-LEVEL SHUFFLE-DWELL. DUAL SOURCE RACK. LICENSE FORMERLY INCLUDED THE RADIATION STERILIZERS FACILITY AT SCHAUMBERG, IL.

LICENSEE	CITY	ST LIC. NO.	LIC.DATE	NOTES
				THAT PORTION OF THE LICENSE WAS TRANSFERRED TO ILLINOIS.
PERMAGRAIN PRODUCTS, INC.	KARTHAUS	PA 37-17860-01	12/21/77	CS-136 LIMIT IS 30.0 MCI, BUT ACTUALLY POSSESSED ABOUT 8 MCI 10/02/87. CO-60 LIMIT 5.0 MCI THIS UNDERWATER CO-60 IRRADIATOR FACILITY IS LOCATED NEAR CLEARFIELD, PA. THE IRRADIATOR IS INSTALLED IN A POOL FORMERLY OCCUPPIED BY A POOL-TYPE REACTOR. THE SAME BUILDING HAS HOT CELLS AND A VENTILATION SYSTEM CONTAMINATED WITH SMALL AMOUNTS OF STRONTIUM-90. NOTE: THE DATE ON INITIAL LIC IS NOT CLEAR, HOWEVER, A. WITT STATED HE HEADED FACILITY FROM 11/69 TO 02/78. FIRST INSPECTION WAS 08/79. SECOND WAS IN 04/84 AND YEARLY SINCE. NEUTRON PRODUCTS USED THE FACILITY TO LOAD RADIOGRAPHY SOURCES. CURRENT LIMIT: 1.2 MCI CS-137 (WESF CAPSULES), AND 400 KCI CO-60
ISOMEDIX, INC.	VEGA ALTA	PR 52-23041-01	09/14/84	ISOMEDIX IS CURRENTLY OPERATING THE FACILITY FOR ABBOT, THE CURRENT OWNER.
TRAVENOL LABS., INC.	AIBONITO	PR 52-21175-01	07/31/83	OWNED BY BAXTER, BUT STILL LICENSED BY TRAVENOL LABS, INC.
BECTON-DICKINSON	SUMTER	SC SL#0315	07/20/81	AECL MODEL C-188, TYPE 1,2,3, OR 4. 1.68 MCI POSSESSED. THERE ARE FOUR ROWS OF CARRIERS ON EACH SIDE OF THE SOURCE.
ISOMEDIX, INC.	SPARTANBURG	SC SL#0267	06/15/78	2.48 MCI IS POSSESSED. THERE ARE THREE ROWS OF CARRIERS ON EACH SIDE OF THE SOURCE.
MINNESOTA MINING & MFG., CO.	BROOKINGS	SD 22-00057-61	02/02/79	J7500 TOTE TYPE; FULLY AUTOMATED MOVEMENT OF PRODUCT (SURGICAL/MEDICAL). ACTUALLY POSSESSED ABOUT 1 MCI IN 10/87.
AMERICAN CONVERTERS	EL PASO	TX SL	/ /	PROPOSED FACILITY #IR13 OPERATIONS BEGAN IN AUGUST 1988. A SECOND POOL (PROPOSED FACILITY #IR145) WITH A CAPACITY OF 15.0 MCI IS ALSO PROPOSED FOR THE SITE (PROJECTED STARTUP IN 01/91).
AMERICAN CONVERTORS	EL PASO	TX SL#L2407	10/01/77	NO INFORMATION.
ETHICON, INC.	SAN ANGELO	TX SL#L0720	09/01/64	DESIGN SIMILAR TO THAT OF ETHICON FACILITY IN SOMERVILLE, NJ.

LICENSEE	CITY	ST	LIC. NO.	LIC.DATE	NOTES
JOHNSON & JOHNSON	SHERMAN	TX	SL#L1870	12/04/73	J6700 CARRIER TYPE. PRODUCT IN BOXES IS MOVED BY CONVEYOR TO THE LOWEST POSITION IN A 4-LEVEL CARRIER. DURING THE IRRADIATION PROCESS THE BOXES ARE MOVED UPWARD TO HIGHER LEVELS (SHUFFLE DWELL; DOUBLE SHUFFLE). FACILITY IS OPERATED AROUND THE CLOCK.
RADIATION STERILIZERS, INC.	FORT WORTH	TX	SL#L3851	01/01/86	RSI PRODUCT OVERLAP DESIGN; 3-LEVEL SHUFFLE-DWELL. AS WITH OTHER RSI FACILITIES, THE SHIELDING IS DESIGNED FOR 10 MCI CO-60.
SHERWOOD MEDICAL	COMMERCE	TX	SL#L3314	10/26/82	ORIGINAL FACILITY DESIGN WAS IDENTICAL TO THAT OF FACILITY IN DELAND, FL.
SURGIKOSE	ARLINGTON	TX	SL#L2435	01/01/78	J7500 TOTE TYPE
SURGIKOSE	ARLINGTON	TX	SL	/ /	FACILITY IS UNDER CONSTRUCTION. ANTICIPATED STARTUP OF OPERATIONS BETWEEN JAN. AND MAR. 1989.
ISOMEDIX, INC.	SANDY CITY	UT	SL	01/03/85	NO INFORMATION.
APPLIED RADIANT ENERGY CORP.	LYNCHBURG	VA	45-11496-01	01/24/66	THERE IS A LIMIT OF 1,250,000 CI ON CS-137 (WESF CAPSULES) AND A LIMIT OF 400,000 CI ON CO-60. RADIATION PROCESSING IS PERFORMED ENTIRELY UNDERWATER.

APPENDIX B

OPERATING EVENTS REPORTED AT LARGE POOL-TYPE IRRADIATORS

FACILITY/LICENSEE	CITY	ST	DATE	PROBLEM	NOTES
ISOMEDIX, INC.	PARSIPPANY	NJ	06/13/74	RAD OVEREXPOSURE	AT APPROXIMATELY 5:30 PM, A 61-YEAR-OLD MALE EMPLOYEE RECEIVED A 185-400 REM DOSE FROM A 3-10 SECOND EXPOSURE TO 120,000 CURIES OF CO-60. THE RADIATION DOSE RECEIVED WAS NEARLY LETHAL. THE EMPLOYEE WAS LISTED IN CRITICAL CONDITION OVER MOST OF HIS 6 WEEKS IN HOSPITALIZATION. HIS BLOOD COUNT RETURNED TO NORMAL BY THE END OF OCTOBER. HOWEVER, A LIVER BIOPSY IN JANUARY 1975 INDICATED THE WORKER HAD VIRAL HEPATITIS. THE WORKER MOVED FROM NJ AND FURTHER INFORMATION ON HIS HEALTH WAS NOT AVAILABLE. THERE WERE A NUMBER OF FACTORS THAT CONTRIBUTED TO THIS EVENT, INCLUDING DESIGN DEFICIENCIES AND A FAILURE TO FOLLOW PROCEDURES. IN ADDITION, THE OPERATOR MADE THE ERROR ON THE TWELFTH HOUR OF THE FOURTH STRAIGHT DAY ON WHICH HE HAD WORKED 10 TO 12 HOURS. TO PREVENT RECURRENCE THE LICENSEE ADDED SAFETY SYSTEMS AND EQUIPMENT TO THIS HOT CELL FACILITY AND PUT IN PLACE ADDITIONAL SAFETY PROCEDURES. (SOURCES: RI INVESTIGATION RPT 74-01, DATED 08/08/74, AND FOIA REPORT #82-75 DATED 02/09/82; ALSO "THE NEW JERSEY RADIATION ACCIDENTS OF 1974 AND 1977" BY FLORA M. BARLOTTA) THE LICENSE WAS SUSPENDED BY ORDER DATED JUNE 14, 1974, AND THAT ORDER WAS RESCINDED JULY 8, 1974. A NOTICE OF VIOLATION WAS ISSUED SEPTEMBER 22, 1974.

FACILITY/LICENSEE	CITY	ST	DATE	PROBLEM	NOTES
STIMOS	ITALY	NA	05/13/75	RAD OE, FATALITY	THE INCIDENT OCCURRED AT A FACILITY FOR CORN IRRADIATION WITH A 30,000 CI COBALT 60 SOURCE, THAT HAD BEEN IN OPERATION SINCE FEBRUARY 1975. THE OPERATOR HAD CLIMBED ONTO THE CONVEYOR BELT TO MAKE AN ADJUSTMENT AND WAS MOVED UNDER THE UNIT WHILE THE SOURCE WAS EXPOSED (IN SPITE OF SAFETY DEVICES). WHEN THE OPERATOR COMPLAINED OF SEVERE PAIN IN HIS HEAD, HIS PARTNER ATTEMPTED TO REMOVE HIM FROM BENEATH THE UNIT. HOWEVER, HE RAN THE CONVEYOR FORWARD RATHER THAN IN REVERSE AND EXPOSED THE VICTIM'S ENTIRE BODY TO THE UNSHIELDED SOURCE. THE VICTIM DIED 12 DAYS LATER. THE ABSORBED DOSE WAS LATER ESTIMATED TO HAVE BEEN ABOUT 1000 RADS. (SOURCE: "RADIATION ACCIDENTS: A CONFERENCE REVIEW," L.A. SAGAN AND S.A. FRY; NUCLEAR SAFETY VOL. 21, NO. 5, SEPTEMBER-OCTOBER 1980. ALSO, "A DOSIMETRIC STUDY OF THE BELGIAN (1965) AND ITALIAN (1975) ACCIDENTS," N.C. PARMENTIER, J.C. NENOT, AND H.J. JAMMET; THE MEDICAL BASIS FOR RADIATION ACCIDENT PREPAREDNESS, K.F. HUBNER AND S.A. FRY, EDS., ELSEVIER, 1980.)
ISOMEDIX, INC.	MORTON GROVE	IL	03/06/76	STUCK SOURCE RAC	(NO DETAILS)
ISOMEDIX, INC.	MORTON GROVE	IL	05/21/76	STUCK SOURCE RAC	(NO DETAILS)
ISOMEDIX, INC.	PARSIPPANY	NJ	06/09/76	CONTAMIN, PIPING	IN 1976, DURING WELDING OPERATIONS ON THE HOT CELL DOOR, SPARKS IGNITED A PLASTIC TARPAULIN THAT WAS BEING USED TO COVER THE STORAGE POOL, AND THE WELDER USED A CHEMICAL EXTINGUISHER TO PUT OUT THE FIRE. OVER TIME THE CHEMICALS CAUSED CORROSION OF THE CO-60 SOURCES. WHEN ANALYSIS OF THE POOL WATER INDICATED THE PRESENCE OF CO-60, THE WATER WAS TREATED TO PERMIT DISPOSAL TO A SANITARY SEWER SYSTEM. FOLLOWING ION-EXCHANGE FILTRATION THE POOL POOL WATER WAS DISPOSED OF IN THE PLANT'S TOILET. IN A SUBSEQUENT EFFORT TO RETURN THE AREA AND HOT CELLS TO UNRESTRICTED USE IT WAS NECESSARY TO DISPOSE OF THE TOILET AND SOME CAST IRON PIPING AS CONTAMINATED MATERIAL.

FACILITY/LICENSEE	CITY	ST	DATE	PROBLEM	NOTES
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	03/14/77	LIC. VIOLATIONS	LICENSE VIOLATIONS IDENTIFIED DURING OCTOBER 1976 INSPECTION INCLUDED - FAILURE TO REPORT LEAKING SOURCE - FAILURE TO ADEQUATELY EVALUATE RADIATION DOSES TO EMPLOYEES - DISPOSING OF RAD MATERIAL AS ORDINARY TRASH
RAD. TECHNOLOGY, INC.	ROCKAWAY	NJ	09/23/77	RAD OVEREXPOSURE	ABNORMAL OCCURRENCE 0#77-10. A 32-YEAR-OLD EMPLOYEE RECEIVED A 150-300 REM DOSE ON ENTERING THE IRRADIATION ROOM, BECAUSE SAFETY INTERLOCKS HAD BEEN BYPASSED. AFTER AN ESTIMATED TEN SECONDS OF EXPOSURE TO A 500,000 CURIE SOURCE, HE FELT A TINGLING SENSATION ON HIS ARMS AS HE BEGAN WORK ON A CONVEYOR BELT ABOUT NINE FEET FROM THE SOURCE. THE LICENSE WAS TEMPORILY SUSPENDED.
AMERICAN CONVERTORS	EL PASO	TX	01/19/78	INTERLOC DEFECT	IDENTIFIED CONDITION IN WHICH THE SOURCE RACK COULD MOVE FROM THE SAFE TO THE FULLY UNSHIELDED POSITION WITH THE FAILURE OF TWO DOOR INTER-LOCK SWITCHES. THE CORRECTIVE ACTION CONSISTED OF A WIRING MODIFICATION.
RAD. TECHNOLOGY, INC.	ROCKAWAY	NJ	03/18/79	MALF,SOURCE MECH	SOURCE MECHANISM MALFUCNTION (ACEL RECORDS)
ETHICON, INC.	SOMERVILLE	NJ	07/30/80	FIRE	STATIONARY IRRADIATION OF PRODUCT RESULTED IN A FIRE. THIS OCCURRED PLACE WHILE THE PLANT WAS SHUTDOWN FOR ROUTINE MAINTENANCE AND WAS THE RESULT OF A DOSE-MAPPING STUDY THAT CONSISTED OF STATIC IRRADIATION OF CORRUGATED BOXES FILLED WITH CORRUGATED MATERIAL. THE SOURCES HAD BEEN LOWERED INTO AND SECURED AT THE BOTTOM OF THE POOL (20 FEET DEEP) ONE-HALF HOUR EARLIER. SPONTANEOUS COMBUSTION OCCURRED BECAUSE THE ENERGY ABSORBED IN THE FILLER COULD NOT BE DISSIPATED. THE PRESENCE OF OXYGEN AND OZONE MAY HAVE PROMOTED THE REACTION. FURTHER EVALUATION BY THE LICENSEE FOUND THAT SEVERAL CARDBOARD TOTES HAD RECEIVED OVER 50 MRADS OVER 7 HOURS, AND THAT THIS MAY HAVE BEEN ENOUGH TO RAISE THE TEMPERATURE TO ITS IGNITION POINT (~450°F.).

FACILITY/LICENSEE	CITY	ST	DATE	PROBLEM	NOTES
BECTON-DICKINSON	BROKEN BOW	NE	10/24/80	FIRE	ON FRIDAY, 10/24/80, AT ABOUT 2:00 PM THE SOURCE RACK WOULD NOT RETURN TO THE STORAGE POSITION. A NUMBER OF UNSUCCESSFUL ATTEMPTS WERE MADE TO FREE THE SOURCE. A FIRE BROKE OUT AT ABOUT 9:00 PM. AECL REPRESENTATIVES ARRIVED ON THE SITE AT ABOUT 1:10 PM ON 10/25/80 AND WERE SUCCESSFUL IN FREEING THE SOURCE BY 1:30 PM. IT WAS DETERMINED THAT DAMAGED PRODUCT TOTES HAD INTERFERED WITH SOURCE MOVEMENT. THERE WAS NO DAMAGE TO THE SOURCE RACK OR PENCILS.
DEFENSE NUCLEAR AGENCY	BETHESDA	MD	04/22/81	STUCK SOURCE RAC	AT 11:58 HOURS ON 04/22/81, SOURCE #2 AT THE ARMED FORCES RADIOBIOLOGICAL RESEARCH INSTITUTE (AFRRI) JAMMED ON THE SUPPORT STRUCTURE OF AN EXPERIMENTAL OPERATIONS FRAME USED FOR IRRADIATIONS. WITH THE ASSISTANCE OF ORNL PERSONNEL A ROBOT WAS USED TO RETURN THE SOURCE RACK TO THE POOL. CORRECTIVE ACTIONS INCLUDED A NUMBER OF CHANGES IN DESIGN AND PROCEDURES.
JOHNSON & JOHNSON	SHERMAN	TX	05/14/81	STUCK SOURCE RAC	SOURCE RACK WAS STUCK BECAUSE OF FRAYED HOIST CABLE.
BECTON-DICKINSON	NORTH CANAAN	CT	05/14/81	FIRE	AT ABOUT 5:07 PM, 05/14/81, ALUMINUM PRODUCT TOTES BECAME JAMMED INTO THE SOURCE RACK. WHEN THE UNIT SHUT DOWN FOR A REASON UNRELATED TO THE JAM, THE SOURCE RACK WOULD NOT RETURN TO THE STORAGE LOCATION. SEVERAL ATTEMPTS WERE MADE TO FREE THE SOURCE RACK BY MANUALLY LIFTING ON THE HOIST CABLE FROM OUTSIDE THE CELL. ALTHOUGH THE PANEL LIGHTS EVENTUALLY INDICATED THE SOURCE WAS DOWN, THE RAD MONITOR STILL INDICATED A HIGH LEVEL OF RADIATION IN THE CELL. AECL WAS CONTACTED AT THAT POINT. ACCORDING TO A JUNE 16, 1981, REPORT ON THIS EVENT, A B-D EMPLOYEE CALLED ON FRIDAY MORNING, MAY 22, 1981, TO SAY THAT THE WATER SPRINKLERS IN THE CELL HAD ACTUATED AND THAT THERE WAS SMOKE COMING FROM THE CELL. AECL PERSONNEL CHARTERED A FLIGHT AND LEFT FOR CANAAN AT ABOUT

FACILITY/LICENSEE	CITY	ST	DATE	PROBLEM	NOTES
					10:30 AM. THE RACK WAS RAISED AND LOWERED UNTIL IT COULD BE LOWERED INTO THE POOL. A TV CAMERA INDICATED THAT THE TOP CENTER MODULE WAS MISSING AND THE LOWER CENTER MODULE WAS IN POSITION, BUT MOST OF THE PENCILS WERE MISSING. THE MODULE AND PENCILS WERE LOCATED AND RETURNED TO THE POOL USING MIRRORS AND TOOLS THROUGH HOLES IN THE ROOF. THE ALUMINUM TOTES WERE RE-DESIGNED USING A THICKER MATERIAL AND A SHROUD WAS INSTALLED AROUND THE SOURCE RACK.
STERITEX CO.	DENMARK	NA	06/01/81	MALFUNC,SOURCE R	SOURCE RACK LOWER MODULE FAILED BECAUSE OF AN ACCUMULATION OF FOREIGN MATERIAL ON THE SOURCE RACK GUIDE CABLES. THIS ACCUMULATION WAS THOUGHT TO HAVE OCCURRED BECAUSE POOL WATER HAD A HIGH CONDUCTIVITY RELATIVE TO THAT SPECIFIED IN THE OPERATING MANUAL).
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	09/15/81	CABLE FAILURE	DURING STARTUP, THE SOURCE CABLE BROKE WITHIN THE SOURCE HOIST CASING. THE CABLE FAILURE WAS DETERMINED TO BE A RESULT OF CONTINUED ABRASION AGAINST THE CABLE HOUSING (RATHER THAN CABLE FATIGUE) BECAUSE THE CABLE WAS SLIGHTLY OUT OF PLUMB. ACTION TO PREVENT RECURRENCE CONSISTED OF CHECKING THE CABLE WAS PLUMB (USING A LEVEL) AND PERIODIC INSPECTION OF THE CABLE WITHIN THE SOURCE HOIST ASSEMBLY. (THE REPORT NOTES THAT THE CABLE HAD BEEN IN CONTINUOUS USE SINCE JULY 1970, THAT A COMPLETE INSPECTION OF THE HOIST MECHANISM EXTERIOR HAD BEEN MADE IN DECEMBER 1978, AND THAT A VISUAL INSPECTION HAD BEEN MADE THREE WEEKS EARLIER. THE HOIST MECHANISM HAD NEVER BEEN INSPECTED SINCE ITS INITIAL INSTALLATION.) NOTE: ON DECEMBER 8, 1981, NRC DISTRIBUTED AN INFORMATION LETTER ON THIS EVENT TO ALL LARGE IRRADIATOR LICENSEES.

FACILITY/LICENSEE	CITY	ST	DATE	PROBLEM	NOTES
ISOMEDIX, INC.	SPARTANBURG	SC	09/27/81	STUCK SOURCE RAC	SOURCE RACK BECAME STUCK BECAUSE A GATE WAS LEFT OPEN ON THE CARRIER.
P.T. GIRI KENCANA JAYA	INDONESIA	NA	01/31/82	FIRE	A SOURC JAM OCCURRED JANUARY 20, 1982, AT 11:50 PM LOCAL TIME WITH THE SOURCE RACK IN THE IRRADIATE POSITION. AFTER ATTEMPTS TO LOWER THE SOURCE, IT WAS DECIDED TO WAIT UNTIL THE PRODUCT DETERIORATED SUFFICIENTLY TO FREE THE SOURCE. A FIRE BROKE OUT ON JANUARY 31, 1982. THE MAZE DOOR WAS OPENED AND THE FIRE EXTINGUISHED AFTER ABOUT 45 MINUTES. THE IRRADIATOR WAS TOTALLY DESTROYED AND A REPLACEMENT FACILITY WAS ORDERED THAT WAS TO INCLUDE A SOURCE SHROUD.
BECTON DICKINSON	OXNARD	CA	05/07/82	CABLE FAILURE	SOURCE MECHANISM MALFUNCTION BECAUSE OF BROKEN HOIST CABLE. (NO DETAILS) AECL #IR104.
ISOMEDIX, INC.	PARSIPPANY	NJ	06/18/82	RAD OE, BADGE	FILM BADGE OF MAINTENANCE HELPER EMPLOYEE INDICATED A DOSE OF 48 REM. THIS WAS NOT SUPPORTED BY THE WORKER'S ACTIVITIES (DOSIMETERY OF COWORKERS) NOR BY MEDICAL EXAMINATION RESULTS. CAUSE UNKNOWN BUT LICENSEE FELT THERE WAS REASON TO SUSPECT THE BADGE HAD BEEN EXPOSED BY PERSON(S) UNKNOWN.
INST FOR ENERGY TECHNOLOGY	NORWAY	NA	09/02/82	RAD OE, FATALITY	SERVICE TECHNICIAN WAS EXPOSED TO A 64,000 CURIE CO-60 SOURCE AND RECEIVED A DOSE OF ABOUT 1,000 REMS. THE TECHNICIAN DIED ON 09/15/82. THE ACCIDENT OCCURRED AT A DRY-STORAGE IRRADIATOR IN NORWAY. THE IRRADIATOR WAS A CONVEYOR BELT, CONTINUOUS-MODE TYPE, OPERATING 24 HOURS A DAY, UNATTENDED AT NIGHT. THE CONVEYOR BELT JAMMED AT NIGHT AND THE SOURCES FAILED TO AUTOMATICALLY RETRACT TO THE SHIELDED POSITION. THE TECHNICIAN ARRIVED AT WORK IN THE MORNING TO FIND A GREEN INDICATOR LIGHT AND AN UNLOCKED DOOR INTERLOCK, AND ENTERED THE MAZE AND EXPOSURE ROOM WHILE

FACILITY/LICENSEE	CITY	ST	DATE	PROBLEM	NOTES
					WHICH A 115V RELAY WAS USED TO REPLACE A 12V RELAY. THE REPLACEMENT RELAY DID NOT FUNCTION PROPERLY AND THE INTERLOCK FAILED TO SHUTDOWN THE UNIT. THE ENSUING FIRE COULD STILL HAVE BEEN PREVENTED IF THE CONSOLE TIMER SYSTEM HAD BEEN OF THE PROPER DESIGN (PULSE TIMER) OR THE IN-CELL TEMPERATURE SENSOR HAD BEEN CORRECTLY INSTALLED (AT THE TIME OF THE FIRE, THE SENSOR WAS LOCATED IN A POSITION SUCH THAT IT DID NOT REACH ITS THRESHOLD TEMPERATURE UNTIL AFTER THE FIRE HAD ALREADY BEGUN).
INTERNATIONAL NUTRONICS, INC.	DOVER	NJ	12/31/82	SPILL	INI WAS PROCESSING IRRADIATOR POOL WATER TO REDUCE THE CO-60 CONCENTRATION THAT RESULTED FROM A LEAKING SOURCE (SEE INI ENTRY FOR 10/25/82), WHEN A SPILL OCCURRED. DURING UNATTENDED CLEANUP OPERATIONS A LINE BECAME DETACHED AND POOL WATER SPILLED ONTO THE FACITITY FLOORS. SMALL QUANTITIES OF CO-60 WERE FOUND IN SOIL SAMPLES TAKEN FROM AREAS ADJACENT TO THE PLANT. CONCENTRATIONS IN THE SOIL WERE BELOW THE LIMITS OF 10 CFR PART 20 FOR LIQUID EFFLUENT RELEASES TO UNRESTRICTED AREAS. (PNO-I-83-101,101A) AN INSPECTION WAS CONDUCTED BECAUSE OF ALLEGATIONS THAT THE FACILITY HAD HELD BACK INFORMATION. THE FACILITY WAS ORDERED TO SHUT DOWN ON OCTOBER 4, 1983. ON 06/24/86 A FEDERAL GRAND JURY INDICTED TWO INI EMPLOYEES AND THE EMPLOYEES WERE CHARGED WITH CRIMES COMMITTED WHILE ATTEMPTING TO CONCEAL THE SPILL. THE INVESTIGATION HAD FOUND THAT FOLLOWING THE SPILL INI EMPLOYEES WERE INSTRUCTED TO DISPOSE OF THE WATER IN THE PUBLIC SEWER SYSTEM AND TO CONCEAL THE FACT FROM NRC INSPECTORS. A CONVICTION RESULTED IN A $35,000 FINE FOR THE COMPANY AND TWO YEARS PROBATION FOR A MANAGEMENT EMPLOYEE. (NRC INFORMATION NOTICE #87-29, ITEM 1)

FACILITY/LICENSEE	CITY	ST	DATE	PROBLEM	NOTES
INTERNATIONAL NUTRONICS, INC.	DOVER	NJ	11/22/83	LIC. VIOLATION	LICENSEE REPORT THAT SMALL AREA OF ROOF HAD DOSE RATES OF 11-13 MR/HR, I.E., RADIATION IN AN UNRESTRICTED AREA WAS GREATER THAN 10 TIMES ANY APPLICABLE LIMIT SET FORTH IN 10 CFR PART 20. THIS RESULTED FROM IMPROPERLY SHIELDED MATERIALS WITHIN THE LABYRINTH IN THE BUILDING. RESTRICTIONS THAT WERE THEN IN PLACE ON ENTRY TO THE LABYRINTH PRECLUDED CORRECTIVE ACTION (A THREE-SIDED WARNING PLACARD WAS PLACED IN THE AREA.) THE WALLS WERE 17 FEET HIGH AND THE AREA WAS INACCESSIBLE WITHOUT PORTABLE EQUIPMENT.
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	09/21/84	INTERLK,BYPASSED	DURING AN INSPECTION ON SEPTEMBER 21, 1984, AN NRC INSPECTOR DISCOVERED THAT THE LICENSEE HAD BEEN OPERATING THE IRRADIATOR WITH AN INOPERABLE SAFETY INTERLOCK ON ONE OF THE TWO CONVEYOR OPENINGS USED TO TRANSFER PRODUCT INTO THE IRRADIATION ROOM. THE LICENSEE HAD EXPERIENCED A PROBLEM WITH SWITCHES THAT SENSED THE MOVEMENT OF A TOTE THROUGH THE CONVEYOR DOOR. THE SWITCHES HAD BECOME BENT DUE TO CONTACT WITH THE TOTES, SO THAT THE SOURCE WAS BEING DROPPED, CAUSING DELAYS IN PRODUCTION. ON APRIL 4, 1984, THE LICENSEE POSTED A MEMO REQUIRING THAT THE CONVEYOR DOORS BE WIRED OPEN DURING THE AUTOMATIC MODE OF OPERATION. ON SEPTEMBER 26, 1984, REGION I ISSUED A CONFIRMATORY ACTION LETTER THAT DOCUMENTED THE LICENSEE'S COMMITMENT TO OPERATE THE FACILITY ONLY IF ALL SAFETY INTERLOCKS WERE OPERABLE AND TO CEASE OPERATIONS IF ANY SAFETY INTERLOCK FAILED TO FUNCTION AS REQUIRED. IN NOVEMBER 1985, THE INTERLOCK WAS REPLACED WITH A NEW DESIGN, BUT WITHOUT THE REQUIRED NRC APPROVAL.

FACILITY/LICENSEE	CITY	ST	DATE	PROBLEM	NOTES
JOHNSON & JOHNSON	SHERMAN	TX	11/01/84	STUCK SOURCE RAC	ON NOVEMBER 1, 1984, THE SOURCE RACK BECAME JAMMED. THE LICENSEE WAS ABLE TO MANUALLY CYCLE THE TRANSFER CYLINDERS AND WHEN THE CARRIER WAS RELEASED THE SOURCE RACK WENT TO THE SHIELDED POSITION. THERE WAS NO DAMAGE EXCEPT TO THE CARRIER. THE CARRIER WAS REPLACED AND UNIT RETURNED TO SERVICE. (#4399)
JOHNSON & JOHNSON	SHERMAN	TX	12/08/84	STUCK SOURCE RAC	ON DECEMBER 8, 1984, THE SOURCE RACK WOULD NOT MOVE TO THE STORED POSITION AFTER A SHUTDOWN, BECAUSE THE SOURCE WAS JAMMED BY A PRODUCT CARRIER. THE JAM WAS CLEARED FROM CONTROLS OUTSIDE THE ROOM. SINCE THIS PROBLEM HAS BEEN A RECURRING ONE, THE LICENSEE HAD CONTRACTED TO HAVE A BACK-UP SAFETY DEVICE INSTALLED. (#4408)
INTERNATIONAL NUTRONICS, INC.	IRVINE	CA	03/08/85	STUCK SOURCE RAC	NRC INFORMATION NOTICE 87-29, ITEM 6. THE SOURCE PLAQUE BECAME STUCK WHILE EXPOSED. CONVEYORS STOPPED, THE SOURCE DOWN LIGHT CAME ON, BUT CELL RADIATION LEVELS REMAINED HIGH. CABLE SLACK DATA INDICATED PLAQUE WAS STUCK ABOUT FIVE AND A HALF FEET DOWN FROM THE FULL-UP POSITION. THE PLAQUE WAS RAISED AND LOWERED IN ATTEMPTS TO FREE THE SOURCE, BUT IT BECAME STUCK IN THE FULL-UP POSITION. WHEN THE PRODUCT CONTAINERS WERE RUN OUT OF THE CELL, SOME WERE FOUND TO BE MISALIGNED ON THE CARRIERS. IT WAS DETERMINED THAT THE CABLE WAS OFF ITS PULLEY. AFTER THE CABLE WAS SET ON ITS PULLEY, THE CABLE WAS GUIDED THROUGH, AND THE PLAQUE WAS LOWERED, UNTIL IT CAUGHT AGAIN. A CAMERA WAS USED TO VIEW THE PLAQUE. APPARENTLY THE STATIONARY ALUMINUM SHROUD BETWEEN THE PRODUCT CONTAINERS AND PLAQUE HAD BEEN DEFLECTED AND CAUGHT ON THE PLAQUE FRAME. THE PLAQUE WAS RAISED AND LOWERED UNTIL IT BROKE FREE AND DROPPED INTO THE POOL.

FACILITY/LICENSEE	CITY	ST	DATE	PROBLEM	NOTES
					IT WAS DETERMINED THIS INCIDENT OCCURRED BECAUSE THE SHROUD WAS INADEQUATELY DESIGNED. THIS LED TO THE SHROUD DEFORMING, WHICH INTERFERED WITH PLAQUE MOTION. INADEQUATE MAINTENANCE WAS A CONTRIBUTING FACTOR. THE CABLE SHOULD HAVE BEEN REPLACED INSTEAD OF SPLICED. AS A RESULT OF THIS EVENT IT WAS RECOMMENDED THAT THE DESIGNS OF THE SHROUD, UPPER PLAQUE GUIDES, AND SOURCE HOIST SYSTEM BE MODIFIED. ON SEPTEMBER 10, 1986, THE ENTIRE SOURCE HOIST MECHANISM FAILED WHILE THE SOURCE WAS SUBMERGED. AS A RESULT THE HOIST WAS REPLACED WITH ONE THAT HAD AN INCREASED LIFTING CAPACITY (UPGRADED FROM 1000 TO 2000 LBS.) AND AN INCREASED DRUM DIAMETER (TO INCREASE CABLE LIFE).
AMERICAN CONVERTORS	EL PASO	TX	03/20/85	INTERLOCK DEFECT	ON MARCH 20, 1985, A RELAY CONTACT FAILURE CAUSED THE SOURCE TO REMAIN IN THE UNSHIELDED POSITION WHILE PRODUCT CARRIERS WERE NOT BEING CYCLED THROUGH THE UNIT. THE UNIT WAS SHUT DOWN WITHOUT THE EXPOSURE OF PERSONNEL. LICENSEE INVESTIGATION FOUND THAT A RELAY OR THE RECEPTACLE PLUG ASSOCIATED WITH IT HAD DENIED PRIMARY POWER TO THE MASTER TIMER AND OVERDOSE TIMER. BOTH RELAY AND PLUG WERE CHANGED AND THIS WAS REPORTED TO THE MANUFACTURER, WHO MODIFIED THE CIRCUITRY TO THIS SHOULD RESULT IN THE SOURCE BEING RETURNED TO THE SHIELDED POSITION IF EITHER TIMER GOES OUT. (#4502) ON 04/19/85, AECL SUBMITTED A 10 CFR PART 21 REPORT OF A DESIGN DEFECT IDENTIFIED ON MARCH 18, 1985, BY AN IRRADIATOR IN EL PASO. THE AFFECTED EQUIPMENT WAS THE CIRCUITRY OF THE POWER SUPPLY TO THE MASTER AND OVERDOSE TIMERS THAT CONTROL PRODUCT INDEXING AND OVERDOSE TIME SHUT DOWN. THE REPORT INDICATED A STATIC RADIATION CONDITION COULD EXIST (PERHAPS LEADING TO FIRE IN THE TIMERS NOT TIMING DOWN DUE TO A POOR CONNECTION IN A RELAY/SOCKET SUB-SYSTEM.

FACILITY/LICENSEE	CITY	ST	DATE	PROBLEM	NOTES
PERMAGRAIN PRODUCTS, INC.	KARTHAUS	PA	05/31/85	TORNADO DAMAGE	TORNADO OCCURRED ABOUT 8 PM ON 05/31/85. TWO LICENSEE PERSONNEL WERE PRESENT AT THE TIME. THE STORAGE POOL WAS UNAFFECTED BY THE TORNADO. THERE WAS NO INJURY OR RELEASE OF RADIOACTIVITY.
RADIATION TECHNOLOGY, INC:	ROCKAWAY	NJ	02/26/86	INTERLK,BYPASSED	ABNORMAL OCCURRENCE #86-6. ON FEBRUARY 26, 1986, AN NRC INSPECTOR DISCOVERED THE LICENSEE HAD OPERATED THE FACILITY IN SPITE OF A MALFUNCTION OF A RADIATION MONITOR. THE SERIOUSNESS WAS COMPOUNDED, BECAUSE RTI HAD BYPASSED INTERLOCKS ON EARLIER OCCASIONS ON MARCH 3, 1986, REGION I ISSUED AN ORDER SUSPENDING THE LICENSE. ON MARCH 13, 1986, THE NRC ISSUED A CONDITIONAL RESCISSION OF ORDER SUSPENDING LICENSE, BECAUSE THE LICENSEE AGREED TO THIRD AND FOURTH PARTY OVERSIGHT OF FACILITY OPERATIONS WITH UNCENSORED PERFORMANCE REPORTING DIRECTLY TO THE NRC. ON MARCH 20, 1986, DURING A SPECIAL, UNANNOUNCED INSPECTION TO DETERMINE COMPLIANCE WITH THE MARCH 13, 1986, CONDITIONAL RECISSION OF ORDER SUSPENDING LICENSE, ANOTHER VIOLATION WAS IDENTIFIED. ON MARCH 13, 1986 THE LICENSEE HAD USED LICENSED MATERIAL PRIOR TO NRC RECEIPT AND VERIFICATION OF THE LICENSEE'S CONTRACT WITH ITS CONSULTANT. THE NRC DETERMINED THAT THESE AND EARLIER RTI PROBLEMS COMPRISED AN ABNORMAL OCCURRENCE, BECAUSE THEY WERE DUE TO A BREAKDOWN IN LICENSEE MANAGEMENT CONTROLS. (SEE EVENTS OF 06/23/86 AND 03/19/88, BELOW)
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	06/23/86	LIC. SUSPENDED	ON JUNE 23, 1986, NRC REGION I ISSUED AN ORDER SUSPENDING LICENSES BASED ON THE RESULTS OF AN OI INVESTIGATION OF RTI ACTIVITIES. THE INVESTIGATION HAD BEEN CONDUCTED IN RESPONSE TO CONCERNS EXPRESSED BY THE THIRD PARTY OVERSIGHT ORGANIZATION AND OTHER INDIVIDUALS ASSOCIATED WITH RTI. THE INVESTIGATION FOUND THAT THE THIRD PARTY WAS NOT INFORMED OF ALL EQUIPMENT MALFUNCTIONS. FURTHER, SEVEN EMPLOYEES,

FACILITY/LICENSEE	CITY	ST	DATE	PROBLEM	NOTES
					INCLUDING OPERATORS AND MANAGERS, CONSPIRED TO LIE TO INVESTIGATORS REGARDING THE SAFETY INTERLOCK PROBLEM. THEY ALSO MADE FALSE STATEMENTS RELATIVE TO THE "COACHING" RECEIVED PRIOR TO THE OI INTERVIEWS. IN ADDITION, THE PRESIDENT OF THE COMPANY INTIMIDATED EMPLOYEES AND PREPARED THEM WITH THE COMPANIES POSITION PRIOR TO INTERVIEWS. (NRC INFORMATION NOTICE #86-29, ITEM 2) IN ADDITION TO SUSPENDING THE LICENSE AT THE ROCKAWAY FACILITY, THE ORDER PROHIBITED THE TRANSFER OF ANY EMPLOYEE OR OFFICER INVOLVED WITH THE FACILITY FROM APRIL 3, 1984, TO FEBRUARY 26, 1986, TO ANY OF RTI'S OTHER FACILITIES WITHOUT APPROVAL FROM THE REGION I REGIONAL ADMINISTRATOR. RTI ADMITTED THE VIOLATIONS HAD TAKEN PLACE AND PROPOSED A CORRECTIVE ACTION PROGRAM THAT INCLUDED CHANGES IN MANAGEMENT. ON AUGUST 22, 1986, BASED ON THESE SUBMITTALS THE NRC LIFTED THE SUSPENSION FOR A SIX-MONTH PROBATIONARY PERIOD.
RADIATION STERILIZERS, INC	SCHAUMBERG	IL	07/17/86	STUCK SOURCE RAC	(NRC INFORMATION NOTICE #87-29, ITEM 5.) LICENSEE HAD IDENTIFIED A FRAYED LIFT CABLE, BUT INSTEAD OF IMMEDIATELY REPLACING THE CABLE, DECIDED TO WAIT FOR SCHEDULED MAINTENANCE. THE CABLE JAMMED AND FROZE THE SOURCE PLAQUE IN A LESS THAN FULLY SHIELDED POSITION. EMPLOYEES CUT THE CABLE AND LET THE SOURCE PLAQUE FALL INTO THE POOL. THE INCIDENT COULD HAVE BEEN PREVENTED BY REPLACING THE FRAYED CABLE IMMEDIATELY, AND SELECTING CABLE MATERIAL WITH FRAY-RESISTANT QUALITIES.

FACILITY/LICENSEE	CITY	ST	DATE	PROBLEM	NOTES
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	09/22/86	SPILL	NRC INFORMATION NOTICE 87-29, ITEM 3. AT ABOUT 6:00 AM AN OPERATOR ENTERING THE FACILITY NOTICED A LOW WATER LEVEL ALARM HAD BEEN ACTIVATED INDICATING A LOW WATER LEVEL IN BOTH THE MAIN AND R&D IRRADIATOR POOLS. THE POOLS CONTAINED OVER 650,000 CURIES OF CO-60 AT THE TIME. IT WAS DISCOVERED THAT A PVC PIPE ON THE DISCHARGE SIDE OF THE POOL WATER PURIFICATION SYSTEM HAD CRACKED OR PARTED, CAUSING WATER FROM THE POOL TO BE DISCHARGED IN THE PURIFICATION PUMP ROOM AND SUBSEQUENTLY DRAINED TO SITE'S SANITARY SEWER SYSTEM. THE FACILITY HAD BEEN SHUTDOWN FOR THE WEEKEND, SINCE ABOUT MIDNIGHT, SEPTEMBER 22,1986. AN INSPECTION IDENTIFIED A NUMBER OF FACTORS THAT MAY HAVE CONTRIBUTED TO THIS EVENT. THESE INCLUDED: THE PVC PIPE WAS SUITABLE FOR COLD WATER WHILE THE POOL TEMPERATURE WAS NORMALLY 110-120°F., AND RECENT MAINTENANCE WORK TO ELIMINATE LEAKS HAD INCLUDED TORQUING OF JOINTS AND CONNECTORS. ACTIONS TO PREVENT RECURRENCE INCLUDED CHANGES IN PROCEDURES (LICENSEE DEVELOPED ENGINEERING AND DESIGN CONTROL PROCEDURES AND OPERATING PROCEDURES, SUCH AS A REQUIREMENT THAT THE PUMP BE TURNED OFF WHEN OPERATING PERSONNEL ARE NOT PRESENT IN THE FACILITY) AND IN EQUIPMENT DESIGN (THE PVC PIPING WAS CHANGED TO POLYPROPYLENE AND THE PURIFICATION PUMP WAS SET TO SHUT DOWN ON A LOW LEVEL ALARM).

FACILITY/LICENSEE	CITY	ST	DATE	PROBLEM	NOTES
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	11/13/86	LIC. VIOLA.	INFORMATION NOTICE 87-29, ITEM 4. ON THE EARLY PART OF THE NIGHT SHIFT (7-11) ON NOVEMBER 13-14, 1986, THE OPERATOR NOTICES THE TRAVEL TIME TO THE FULLY UNSHIELDED POSITION WAS SLOW. THE SOURCE WAS RAISED BUT COULD NOT BE LOWERED BY NORMAL OR EMERGENCY MEANS. THE OPERATOR VENTED AIR FROM THE AIR SYSTEM, BUT BELIEVED THAT THE SOLENOID VALVE (THAT CONTROLLED AIR FLOW TO RAISE OR LOWER THE SOURCE RACK) WAS FROZEN. THE OPERATOR BEGAN HEATING THE SOLENOID VALVE WITH A PORTABLE HEATER AT 0.45 AM. WAS ABLE TO COMPLETE A SAFETY INTERLOCK TEST BY 02:34 AM. THE INSPECTION REPORT NOTED THAT THIS INVOLVED TWO VIOLATIONS: FAILURE TO IMMEDIATELY NOTIFY THE RSO WHEN THE SOURCE FAILED TO RETURN TO THE SHIELDED POSITION, AND FAILURE TO OBTAIN AUTHORIZATION AND APPROVAL OF REPAIRS TO A SAFETY-RELATED COMPONENT OF THE IRRADIATOR. NOTE: LICENSEE LATER INSTALLED HEAT TRACING AND INSULATION TO INHIBIT THE FREEZING OF CONDENSATE IN THE AIR LINES.
RADIATION TECHNOLOGY [illegible]C.	ROCKAWAY	NJ	01/08/87	MALFUNC,CONVEY.	INSPECTION REPORT NOTED THAT LICENSEE WAS EXPERIENCING DIFFICULTIES MOVING TOTE BOXES THROUGH THE MAZE INTO THE CELL. THE PISTONS USED TO ENGAGE THE CLUTCHES AND DRIVE THE CONVEYOR WERE NOT FUNCTIONING PROPERLY. THE OPERATOR CLIMBED ONTO THE CONVEYOR ENDS OUTSIDE THE MAZE ENTRANCE TO PHYSICALLY SHAKE THE UPPER CONVEYOR VIGOROUSLY TO CAUSE THE TOTE BOXES TO MOVE INTO POSITION AROUND THE MAZE. NEW PARTS WERE ON ORDER.
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	01/08/87	DAMAGE, SOURCE	INSPECTION REPORT NOTED THAT SINCE NOVEMBER 1986 LICENSEE HAD BEEN TAKING AN INVENTORY OF CO-60 IN THE IRRADIATOR. THEY HAD ENCOUNTERED DIFFICULTY TRYING TO IDENTIFY THE SERIAL NUMBERS OF PENCILS THAT HAD BEEN TRANSFERRED TO THE R&D POOL FOLLOWING DAMAGE TO THE SOURCE ASSEMBLY THAT HAD OCCURRED EARLIER. THEY HAD TRIED UNSUCCESSFULLY TO REMOVE PENCILS FROM THE BENT AND DAMAGED RODS IN WHICH THEY WERE LOADED AS PART OF THE SOURCE MODULES.

FACILITY/LICENSEE	CITY	ST	DATE	PROBLEM	NOTES
RADIATION STERILIZERS, INC.	WESTERVILLE	OH	01/14/87	LIC. VIOLATIONS	ABNORMAL OCCURRENCE #87-5. ON 01/14/87 AND 01/27/87 THE NRC PERFORMED UNANNOUNCED, ROUTINE SAFETY INSPECTIONS AT THE LICENSEE'S SCHAUMBERG AND WESTERVILLE FACILITIES. AT THAT TIME THE SCHAUMBERG FACILITY POSSESSED ABOUT 2.5 MCi OF CO-60 AND THE WESTERVILLE IRRADIATOR WAS LOADED WITH ABOUT 8.5 MCI CS-137. DURING THE INSPECTIONS A NUMBER OF VIOLATIONS WERE IDENTIFIED, INCLUDING: (1) FAILURE TO TEST SMOKE AND TEMPERATURE ALARMS, (2) FAILURE TO MAINTAIN AN OPERABLE WARNING BEACON IN THE MAZE ENTERANCE, (3) FAILURE TO MAINTAIN OPERABLE CONTROL PANEL WATER LEVEL INDICATION AND AN OPERABLE SYSTEM TO DETECT AND SHUT DOWN THE IRRADIATOR IN THE EVENT OF EXCESSIVE WATER LOSS FROM THE STORAGE POOL, (4) FAILURE TO MAKE A THOROUGH VISUAL CHECK OF THE GAMMA CELL BEFORE EXPOSING THE SOURCE, ETC. THE NRC DETERMINED THAT THESE PROBLEMS COMPRISED AN ABNORMAL OCCURRENCE (#87-5), BECAUSE THEY WERE THE RESULT OF A BREAKDOWN IN THE MANAGEMENT

FACILITY/LICENSEE	CITY	ST	DATE	PROBLEM	NOTES
					OVERSIGHT AND CONTROL OF THE RADIATION SAFETY PROGRAMS AT TWO OF THE LICENSEE'S FACILITIES.
JOHNSON & JOHNSON	SHERMAN	TX	05/14/87	STUCK SOURCE RAC	ON MAY 14, 1987, AN IRRADIATOR SOURCE BECAME JAMMED BY A PRODUCT CARRIER. THE CARRIER WAS MANUALLY CLEARED AND THE SOURCE RETURNED TO THE SHIELDED POSITION. THE CARRIERS INVOLVED WERE REPAIRED OR REPLACED AND THE SOURCE RACK AND CABLE WERE INSPECTED WITH NO DAMAGE FOUND. NO EXPOSURE WAS RECEIVED BY ANY PERSONNEL.
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	05/28/87	CONTAMIN, BURIED	ON MAY 28, 1987, THE LICENSEE, IN COOPERATION WITH NRC REGION I, INITIATED EFFORTS TO DO EXPLORATORY EXCAVATIONS OF PORTIONS OF THE ROCKAWAY SITE WHERE IT WAS SUSPECTED THAT RADIOACTIVE MATERIAL MAY HAVE BEEN BURIED PREVIOUSLY. A CRUSHED METAL CONTAINER THAT WAS UNEARTHED (PRESUMED TO BE A 1 OR 5 GALLON CAN) HAD A DOSE RATE OF 200 MILLIREM PER HOUR ON CONTACT. SUBSEQUENT DIGGING IN THE SAME APPROXIMATE AREA THROUGH JUNE 12 UNEARTHED OTHER OBJECTS: 7 55-GALLON DRUMS; 2-30-GALLON DRUMS; 3 DIATOMACEOUS EARTH FILTER PUMP UNITS, ETC., FROM WHICH RADIATION LEVELS BETWEEN 0.05 AND 50 MILLIREM-PER-HOUR WERE MEASURED. (PNO-I87-54) A SEPTEMBER 15, 1987, LETTER FROM REGION I TO RTI CLARIFIED RTI'S ROLE AND RESPONSIBILITIES IN THE CLEAN UP.
ISOMEDIX, INC.	PARSIPPANY	NJ	08/19/87	INTERLK,BYPASSED	DURING A ROUTINE INSPECTION ON THE MORNING OF 08/19/87, INSPECTORS LEARNED THAT THE LICENSEE HAD BEEN OPERATING A WALK-IN IRRADIATOR SINCE MAY 1987 WITHOUT THE RADIATION DETECTOR THAT SENSES ELEVATED RADIATION LEVELS WHEN THE SOURCE IS EXPOSED. THE DETECTOR OPERATED A DOOR INTERLOCK THAT PREVENTS PERSONNEL FROM ENTERING A HIGH RADIATION AREA. THE DETECTOR HAD BEEN REMOVED FOR REPAIRS AND HAD BEEN REMOVED ON OTHER EARLIER OCCASIONS FOR CALIBRATION. (PNO-I-87-81, DTD. 08/19/87)

FACILITY/LICENSEE	CITY	ST	DATE	PROBLEM	NOTES
ETHICON, INC.	SOMERVILLE	NJ	08/27/87	INTERLOCK DEFECT	AS THE PNEUMATIC RAM ATTEMPTED TO PUSH A TOTE FROM FROM THE CONVEYOR INTO THE TOTE CARRIER, IT BECAME JAMMED. THE JAMMED TOTE FLEXED AND CAUSED A MICROSWITCH BETWEEN THE RAM AND OUTER SHROUD TO MAKE CONTACT AND SHORT OUT. THIS CAUSED THE MAIN CIRCUIT BREAKER OF THE 24 VOLT AC CONTROL CIRCUIT TO TRIP, AND THE SOURCE BEGAN TO MOVE TO THE SHIELDED POSITION. HOWEVER, SINCE THE CONTROLLER WAS OUT, THE SYSTEM DID NOT RECOGNIZE WHEN THE SOURCE REACHED THE SAFE POSITION (LOSS OF THE 24 VAC POWER CIRCUIT RESULTED IN A MALFUNCTION OF ALL SAFETY SENSORS ON THAT CIRCUIT INCLUDING THE SOURCE PLAQUE ASSEMBLY SHIELDED POSITION SENSOR), AND THE SOURCE CABLE DRUM CONTINUED TO ROTATE RAISING THE SOURCE BY WINDING THE CABLES ON THE DRUM IN REVERSE. THE MOTOR STALLED WHEN THE SOURCE PLAQUE REACHED THE FULL-UP POSITION. AFTER CONSULTATION WITH THE IRRADIATOR MANUFACTURER, THE LICENSEE HAND CRANKED THE SOURCE PLAQUE INTO THE SHIELDED POSITION.
ISOMEDIX, INC.	SANDY CITY	UT	09/17/87	EARTHQUAKES	FROM SEPTEMBER 17 THROUGH 28, 1987, THERE WERE SIX SEPARATE EARTHQUAKES OF MAGNITUDE 3.6 AND GREATER CENTERED APPROXIMATELY 120 KM NORTHWEST OF THE IRRADIATION FACILITY. THE LARGEST WAS CATEGORIZED AS RESULTING IN A PEAK HORIZONTAL ACCELERATION OF LESS THAN 0.01 G AND HAVING AN INTENSITY OF II, BUT NOT GREATER THAN III, ON THE MODIFIED MERCALLI INDEX. A STATE INSPECTION ON OCTOBER 7, 1987, VERIFIED THE FACILITY HAD SUSTAINED NO DAMAGES AS A RESULT OF THE EARTHQUAKES. A REVIEW OF STORAGE POOL WATER VOLUME INDICATED THERE HAD BEEN NO INCREASE IN THE RATE OF MAKEUP WATER ADDITIONS. (SOURCE: OCTOBER 26, 1987, REPORT BY THE UTAH DEPT. OF HEALTH, BUREAU OF RAD. CONTROL)

FACILITY/LICENSEE	CITY	ST	DATE	PROBLEM	NOTES
PERMAGRAIN PRODUCTS, INC.	KARTHAUS	PA	12/01/87	FIRE	ON TUESDAY, DECEMBER 1, 1987, AT 8:00 PM, A FIRE DEVELOPED IN AN AUXILIARY BUILDING SEPARATE FROM THE IRRADIATOR BUILDING. THE BUILDING IN WHICH THE FIRE OCCURRED WAS USED TO STORE SAWDUST THAT THE LICENSEE GENERATES WHILE MANUFACTURING FLOORING. NO LICENSED MATERIAL WAS INVOLVED. THE FIRE WAS CONTROLLED BY AN INSTALLED SPRINKLER SYSTEM AND LOCAL FIRE COMPANIES. (PNO-I-87-112)
PRECISION MATERIALS CORP.	MINE HILL	NJ	02/11/88	LIC. REVOKED	DURING AN INSPECTION JULY 23-24, 1987, REGION I BECAME AWARE OF HIGH RATE OF WATER LOSS FROM THE IRRADIATOR POOL. AS A RESULT THE LICENSEE AGREED TO MONITOR THE RATE OF MAKEUP (LEAKAGE) AND TO MEASURE THE CO-60 MORE FREQUENTLY. IN A MEETING WITH REGION ON AUGUST 31, 1987, THE LICENSEE NOTED THAT THE POOL WAS LEAKING AT ABOUT 20 GALLONS PER HOUR. IT WAS ALSO NOTED THAT BECAUSE OF FINANCIAL DIFFICULTIES THE COMPANY WAS EXPERIENCING, OFFICERS OF THE COMPANY INCLUDING THE RSO PLANNED TO RESIGN. AS A RESULT OF THESE PROBLEMS, THE LICENSEE WAS ORDERED ON SEPTEMBER 4, 1987, TO SUSPEND OPERATION OF THE IRRADIATOR, TO MONITOR THE POOL TO MAINTAIN LEVEL, AND TO DETECT RADIOACTIVE CONTAMINANTS UNTIL THE SOURCES WERE PLACED IN STORAGE CASKS, AND EITHER (1) PROVIDE A BASIS FOR THE RESUMPTION OF LICENSED ACTIVITIES, OR (2) TRANSFER THE SOURCES TO ANOTHER AUTHORIZED LICENSEE. AFTER THE SOURCES WERE TRANSFERRED AND THE FACILITY DECONTAMINATED FOR RELEASE FOR UNRESTRICTED USE, THE LICENSE WAS REVOKED ON FEBRUARY 11, 1988. (EN-87-74A)

FACILITY/LICENSEE	CITY	ST	DATE	PROBLEM	NOTES
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	03/19/88	LIC. VIOLATIONS	ON MARCH 19, 1988, A FEDERAL GRAND JURY INDICTED THE FORMER CEO AND ANOTHER EMPLOYEE OF RTI ON CHARGES OF CONSPIRACY, OBSTRUCTION OF JUSTICE, AND VIOLATIONS OF THE ATOMIC ENERGY ACT. THE INDICTMENT CHARGED THAT A FORMER RTI EXECUTIVE SUBMITTED FALSE STATEMENTS TO THE NRC ABOUT SAFETY PROCEDURES, CONSPIRED TO COVER UP SAFETY DEFICIENCIES, AND URGED EMPLOYEES TO LIE TO INVESTIGATORS. (SEE EVENTS DATED FEBRUARY 26, 1986 AND JUNE 23, 1986.)
RADIATION TECHNOLOGY, INC.	ROCKAWAY	NJ	03/07/88	CABLE FAILURE	AT ABOUT 2:00 AM THE SOURCE CABLE BROKE. THE RSO WAS NOTIFIED AND WORK BEGAN AT 4:30 TO CHANGE THE CABLE. WHILE ATTEMPTING TO REMOVE MODULE 'B' FROM THE MODULE HOLDER, IT WAS FOUND THAT SOME PENCILS LEANED TO THE OUTSIDE AND THE MODULE COULD NOT BE REMOVED. WHEN THE RSO ARRIVED, THE PENCILS WERE REMOVED WITH DIFFICULTY. THE MODULES WERE SQUARED, RELOADED, AND REINSTALLED IN THE SOURCE ASSEMBLY. A NEW CABLE WAS INSTALLED AND THE EQUIPMENT WAS MADE READY FOR OPERATION BY 9:00 PM
INTERNATIONAL NUTRONICS, INC.	PALO ALTO	CA	05/31/88	LOSS OF CONTROL	AS A RESULT OF BANKRUPTCY, THE INVENTORY OF SOURCES WAS REMOVED FROM THE STORAGE POOL. HOWEVER, RADIATION LEVELS INCREASED WHILE THE POOL WAS BEING DRAINED. AFTER IT WAS FOUND THAT THE POOL WATER WAS NOT CONTAMINATED, SOME PREVIOUSLY UNNOTICED PENCILS WERE DISCOVERED ON THE FLOOR OF THE POOL. THE SOURCES WERE NOT IN THE INVENTORY RECORDS FOR THE FACILITY.
RADIATION STERILIZERS, INC.	DECATUR	GA	06/03/88	CONTAMIN, POOL	ON JUNE 7, 1988, DOE REPORTED POSSIBLE LEAKAGE OF CS-137 FROM WESF CAPSULES IN THE STORAGE POOL AT THE RSI DECATUR FACILITY. THE LEAKAGE WAS DISCOVERED SOMETIME AFTER JUNE 3, 1988, BUT THE THE NRC WAS NOT INFORMED OF THIS UNTIL JUNE 7. IT WAS DISCOVERED THAT EMPLOYEES WORKING IN THE FACILITY RECEIVED CLOTHING AND MINOR SKIN CONTAMINATION, AND THAT PRODUCT BOXES WITH MINOR SURFACE CONTAMINATION HAD BEEN SHIPPED FROM THE FACILITY AFTER APRIL 29, 1988. (PNO-II-88-40B)

Appendix C

REPORTING REQUIREMENTS FOR 10 CFR 20.403

§ 20.403 Notifications of incidents.

(a) *Immediate notification.* Each licensee shall immediately report any events involving byproduct, source, or special nuclear material possessed by the licensee that may have caused or threatens to cause:

(1) Exposure of the whole body of any individual to 25 rems or more of radiation; exposure of the skin of the whole body of any individual of 150 rems or more or radiation; or exposure of the feet, ankles, hands or forearms of any individual to 375 rems or more of radiation; or

(2) The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 5,000 times the limits specified for such materials in Appendix B, Table II of this part; or

(3) A loss of one working week or more of the operation of any facilities affected; or

(4) Damage to property in excess of $200,000.

(b) *Twenty-four hour notification.* Each licensee shall within 24 hours of discovery of the event, report any event involving licensed material possessed by the licensee that may have caused or threatens to cause:

(1) Exposure of the whole body of any individual to 5 rems or more of radiation; exposure of the skin of the whole body of any individual to 30 rems or more of radiation; or exposure of the feet, ankles, hands, or forearms to 75 rems or more of radiation; or

(2) The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 500 times the limits specified for such materials in Appendix B, Table II of this part; or

(3) A loss of one day or more of the operation of any facilities affected; or

(4) Damage to property in excess of $2,000.

(c) Any report filed with the Commission pursuant to this section shall be prepared so that names of individuals who have received exposure to radiation will be stated in a separate part of the report.

(d) Reports made by licensees in response to the requirements of this section must be made as follows:

(1) Licensees that have an installed Emergency Notification System shall make the reports required by paragraphs (a) and (b) of this section to the NRC Operations Center in accordance with § 50.72 of this chapter.

(2) All other licensees shall make the reports required by paragraphs (a) and (b) of this section by telephone to the NRC Operations Center [1] and by telegram, mailgram, or facsimile to the Administrator of the appropriate NRC Regional Office listed in Appendix D of this part.

[27 FR 5906, June 22, 1962, as amended at 28 FR 6323, July 3, 1963; 42 FR 43965, Sept. 1, 1977; 43 FR 2719, Jan. 19, 1978; 48 FR 33859, July 26, 1983; 52 FR 33917, Sept. 8, 1987]

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SEE INSTRUCTIONS ON THE REVERSE

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NUREG-1345

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11a. TYPE OF REPORT

Special Case Study Report

b. PERIOD COVERED (Inclusive dates)

1964 - June 1988

12. SUPPLEMENTARY NOTES

13. ABSTRACT (200 words or less)

Large pool-type gamma irradiators are used in applications such as the "cold" sterilization of medical and pharmaceutical supplies, and recent changes in federal regulations make it possible they will be used extensively in the preservation of foodstuffs. Because of this possible large increase in the use of irradiators, the Office of Nuclear Materials Safety and Safeguards was interested in knowing what events had occurred at irradiators. The event data would be used as background in developing new regulations on irradiators. Therefore, AEOD began a study of the operating experience at large, wet-source storage gamma irradiators. The scope of the study was to assess all available operating information on large (more than 250,000 curie), pool-type irradiators licensed by both the NRC and the Agreement States, and events at foreign facilities.

The study found that about 0.12 events have been reported per irradiator-year. Most of these events were precursor events, in that there was no evidence of damage to the radioactive sources or degradation in the level of safety of the facility. Events with more significant impacts had a reported frequency of about 0.01 event per irradiator-year. However, the actual rate of occurrence of events of concern to the staff may be higher because there are few specific reporting requirements for events at irradiators.

14. DOCUMENT ANALYSIS - a. KEYWORDS/DESCRIPTORS

Cesium-137 Cobalt-60; Contamination; Food preservation; Irradiators Radiation overexposure; Radiation sterilization; Radioactive; Source encapsulation; Source leakage; Wet-source storage.

b. IDENTIFIERS/OPEN-ENDED TERMS

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