DECONTAMINATION EFFORTS AT THE RADIATION STERILIZERS, INC. (RSI) FACILITY IN DECATUR GEORGIA

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ABSTRACT

Through 1988, Radiation Sterilizers, Inc. (RSI), a commercial irradiation Facility in Decatur, Georgia, stored 252 identical cesium (^{137}Cs) sources. RSI stored these sources in a series of racks submersed in a pool of demineralized water. By periodically withdrawing the racks from the pool, RSI generated a high gamma radiation field within a shielded cell. The radiation field was used to sterilize packaged pharmaceutical products. The sterilization process involved cycling the products through the irradiation cell on a remotely operated conveyor system. In June of 1988, one of the ^{137}Cs sources leaked radioactive cesium chloride (CsCl).

The radioactive site remediation division of Chem-Nuclear Systems, Inc. (later called Chemical Waste Management, Nuclear Remediation Services, Inc.) was a member of the Emergency Response team mobilized to assess the radiological situation and establish the necessary controls and containment in and around the RSI facility. The response evolved into a complex, four and one half (4 1/2) year remediation project involving the removal of all of the cesium sources and the decontamination and radiological survey of the affected areas of the RSI facility. The CsCl that escaped from the leaking source was estimated to have an activity level of 8 to 10 curies. The high curie content coupled with the soluble characteristic of the CsCl resulted in widespread radioactive contamination of the packaged product, the RSI warehouse facilities, the irradiation cell structures, and the storage pool water. The subsequent decontamination effort required the implementation of a variety of decontamination techniques and resulted in the creation of three different radioactive material waste streams. The entire remediation project was subjected to public, political, and regulatory scrutiny throughout.

OVERALL APPROACH

In order to conduct the decontamination process in a logical and controlled fashion, the facility was initially divided into three zones. These zones were defined as a result of surveys that identified and quantified the spread of contamination.

Zone 1 comprised approximately two-fifths of the warehouse and included the aerosol production line, mezzanine, clean room, laboratory, rest rooms, lunch rooms, and office spaces. The majority of the contamination was physically located on the product packages that had been irradiated and then placed on pallets for shipment. Small amounts of contamination were detected in the office spaces, primarily the RSO's office, and on carpet, desks, and chairs. Approximately 80% of the product was surveyed and released with Georgia DNR/DHR concurrence. The remainder of the product that could not be released was packaged and sent for burial as low level radioactive waste. Zone 1 was decontaminated first in order to permit access by RSI employees as soon as possible.

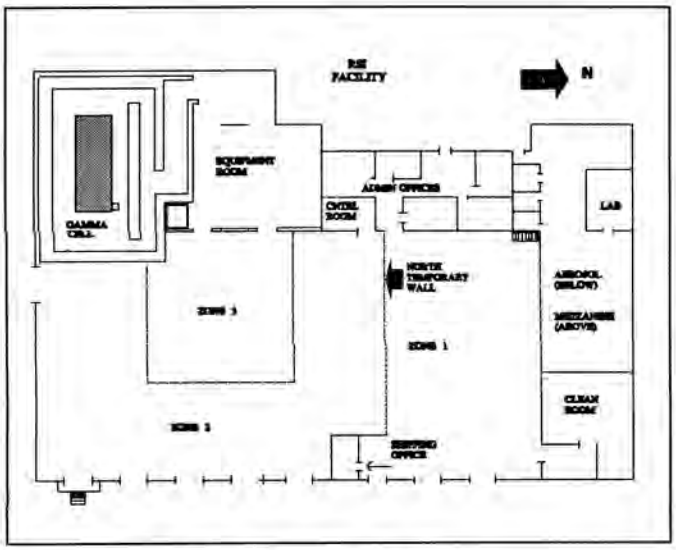

Fig. 1. RSI facility diagram.

Re-entry authorization to Zone 1 was granted by Georgia DHR/DNR on July 22, 1988 to allow RSI to restart the aerosol production line. This re-entry authorization was dependent upon the construction of a temporary wall that physically divided the facility. The wall provided a radiological controls boundary by preventing access to the controlled areas of Zones 2 and 3.

Zone 2 comprised approximately one-fifth of the warehouse and included the irradiation cell control room. The contamination in this zone was primarily located on product packages and floor surfaces. Decontamination was relatively easy to perform by wipe down. Meanwhile, a complicated search and isolation process for the leaking source took place. Once the leaking source was isolated and removed from the pool, the remaining sources were removed, and decontamination of the highly contaminated third zone commenced. Since constant passage through Zone 2 was required to perform activities in Zone 3, Zone 2 was not immediately surveyed for release; rather, it was merged with Zone 3 for the duration of the project.

Zone 3 comprised approximately two-fifths of the warehouse area and included the equipment room, chiller sump area, access to the cell ceiling (also called "mezzanine"), maze, and irradiation cell. Radiation associated with the

contamination on the product packages, conveyor track, carrier/tote units, irradiation cell structures, pool water, and sources remaining in the storage pool made the initial radiological characterization of Zone 3 extremely difficult. Original surveys indicated that fixed and loose $\beta\gamma$ contamination levels ranged from 2,000 to 10,000,000 dpm/100 cm^2. As expected, Zone 3 was the one most affected by the leaking source and quickly became the center of attention for all subsequent project activities.

UNIQUE SOURCE AND CIRCUMSTANCES OF THE RADIOACTIVE CONTAMINATION

The radioactive contamination discovered at the RSI facility was extensive and worthy of discussion based on the following unique circumstances:

- A dual path existed for the introduction and subsequent migration of the ^{137}Cs contamination to the facility's surroundings. The operation of periodically removing the leaking source from and returning it to the storage pool established a direct path for the ^{137}Cs to contaminate objects within the atmosphere of the irradiation cell as well as the water in the source storage pool. The extreme solubility of the radioactive CsCl and the immediate abundant supply of water made the contamination readily mobile.
- The CsCl most likely escaped from the source while it was exposed to the cell's atmosphere in the form of steam. The escaping steam was propelled from the source by internal pressure then dispersed by forced air circulation inside the cell before it condensed on the various surfaces and objects within the cell.
- A large amount of radioactivity escaped from the leaking source. Approximately 8 to 10 curies of activity in the form of CsCl was unleashed and readily available for dispersion.

These factors are considered to be the major causes of the wide spread contamination experienced at RSI. The contamination was concentrated in the vicinity of the leaking source and surrounding pool/cell structures; however, extensive surface contamination existed throughout the building. The following conclusions regarding the nature of the radioactive contamination can be made after a detailed review of the survey data obtained throughout the course of the project:

- Exposed structure surfaces, primarily non-painted, porous concrete, showed a high affinity for the cesium chloride contamination. Penetration was dependent upon the level and duration of exposure to the contaminant.
- The contamination levels found on exposed metal were dependent upon the amount of oxide layer (rust) present and the mode of exposure either direct contact with liquid (water) or airborne (steam) contamination.
- Soil contamination was primarily localized in the vicinity of the weir sump. This sump was the primary avenue of escape for the ^{137}Cs contaminated pool water. The expansion joint material proved to be an accessible pathway for the cesium contaminated water to reach the underlying soil.

DECONTAMINATION EFFORTS

A variety of decontamination techniques were employed throughout of the site remediation. A brief description of the major structures/materials affected by contamination and the associated decontamination techniques is provided below.

Source Storage Pool Water

A pool water sample taken immediately following the discovery of the incident was analyzed by the Georgia Institute of Technology. Analysis indicated that approximately 4 curies of ^{137}Cs had dissolved in the pool water, resulting in pool water specific activity of 4.58 E-2 μCi/ml. The original pool water treatment/filtration system was highly contaminated, and the on-contact radiation levels of the filter units exceeded 90 mR/hr.

A demineralizer system was installed and continuously operated by CNSI/CWM personnel to remove the ^{137}Cs contaminate. The new system removed the ^{137}Cs contaminant by ion exchange using resin filled vessels and a pump/piping system which circulated the pool water through the resin. (Refer to Fig. 2.)

The resin was a unique product of CNSI and protected as a proprietary asset. To avoid damage to the resin due to the large amount of decay heat generated by the sources stored in the pool water, it was necessary to operate the existing chiller system to maintain the water temperature below 54 degrees C. Frequent resin bed change outs took place until a consistent specific activity of less than the MDA of 5.6×10^{-7} μCi/ml was obtained. The first waste shipment from RSI consisted of solidified, spent resin containing 6.9 curies of ^{137}Cs activity.

While the demineralizer system removed the ^{137}Cs from the pool water, a complicated search and isolation process for the leaking source took place. Eventually, the leaking source was located, packaged, removed, and shipped for examination at a DOE facility in Hanford, Washington. By November, 1990, the last of the 252 identical sources were packaged and removed from the pool for shipment to Hanford.

Initial decontamination efforts in Zone 3 began in December, 1990 and proceeded until March, 1991. Removal of the decontaminated pool water and subsequent decontamination efforts of the pool structure were delayed by a regulatory decision on how to best handle the massive quantity (approximately 83,275 liters) of water in the pool from March through

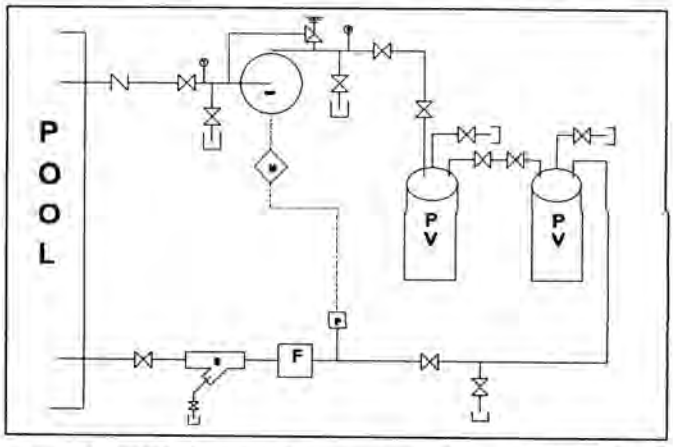

Fig. 2. CWM demineralizer system schematic (typical).

September of 1991. In October, 1991, a closely monitored, controlled evaporation process began to remove the water, leaving the ^{137}Cs contamination on the stainless steel pool liner. The demineralizer system continued to operate until the water level dropped below that required to maintain sufficient net positive suction head to the system's pump.

In March, 1992, the pool level had decreased to approximately 12,870 liters. The evaporation heaters were secured and the remaining water was pumped from the source storage pool into two holding tanks located in the warehouse. This water was subsequently solidified and added to boxes containing dry activated decontamination waste (DAW) and personnel protective equipment (PPE) waste for shipment to *Barnwell, SC.*

Irradiation Cell and Storage Pool Structure

Contamination on the source storage pool's stainless steel liner varied in magnitude and was dispersed in a random fashion. The physical integrity of the liner had been breached, and water had collected between the liner and its concrete support structure in several locations. Therefore, the liner was removed from the pool and packaged as radioactive waste. Although it is probable that an abrasive form of surface layer removal would have been effective at decontaminating the stainless steel liner, it was readily determined that the cost of such an effort, not to mention the detailed radiological release survey required, would have far exceeded the cost of directly disposing of the entire liner as radioactive waste.

Upon removal of the pool's liner, contamination was discovered fixed to the pool's concrete floor and walls, which provided the structural support to the liner. The contamination varied in both magnitude and depth of penetration. Destructive decontamination techniques such as needle gunning and jack hammering were the most cost effective and efficient means to remove the contaminated layers of concrete. Extensive personnel protective measures and constant air monitoring was performed throughout the decontamination process. In some areas of the pool walls, the depth of contamination, measured from the original surface, exceeded twelve inches.

Coreboring samples taken at various depths and locations indicated that CsCl had managed to migrate and seep into the sub-grade structures and soils of the irradiation cell, most likely dissolved in contaminated water that escaped the pool confines. Eventually, it became necessary to remove the cell's entire four inch thick concrete floor slab.

The clay soil adjacent to the pool and beneath the concrete cell floor was contaminated to various levels up to a maximum of 2,000 pCi/gm. Remediation required the excavation and removal of all soil with ^{137}Cs concentrations above the GA DNR established unrestricted release limit of 5.5 pci/gm. The soil excavation process was extremely man power intensive since access to the irradiation cell through the maze was severely restricted. As a result, heavy machinery could not be used, and the entire excavation process was performed manually. Pneumatic hand held spades were used to dislodge the highly compressed clay soil, which was then shoveled into drums and carted out of the cell into the warehouse for packaging in appropriate strong tight containers. The pool retainer collar, which resides three feet beneath a clay subgrade, was also contaminated in several areas. Destructive decontamination techniques were utilized on the concrete collar, resulting in complete removal of some areas of the 610 cm thick collar. The high compressive strength of the concrete and its dense steel reinforcement required the use of heavy pneumatic tools (hammers, chisels, etc.) and cutting torches. In some locations, the clay soil beneath the collar was also contaminated and required removal.

Wall, Ceiling, and Floor Surfaces throughout the Facility

Contamination remote from the irradiation cell was limited to exposed surfaces. In many cases, simple dry and/or wet wiping removed loose contamination and rendered the location/item suitable for release. In some instances, the danger of spreading loose contamination necessitated the use of HEPA ventilated vacuums. Most concrete surfaces, and some steel surfaces, required removal of a 0.16 cm to 0.32 cm thick layer in order to remove fixed contamination. The surface layers were removed by the use of pneumatic needle guns attached to HEPA ventilated vacuum lines, which collected and contained all chips/dust generated by the abrasive process. After wall and floor surfaces were decontaminated to below release criteria, the surfaces were coated with removable latex to prevent cross contamination from adjacent areas/activities. Upon the completion of all decontamination activities, the latex was removed so the surfaces could be surveyed for final unrestricted release.

Two other types of decontamination technologies were investigated and tested for possible use on concrete and metal surfaces during the course of the RSI project.

- A chemical application/removal process was found to be effective at removing fixed contamination from flat, fairly non-porous surfaces, but the cost of the chemical and treatment of the secondary waste stream proved prohibitive.
- CO_2 pellet blasting was also tested. However, for this particular application, its relative cost effectiveness was limited.

RADIOACTIVE WASTE DESCRIPTION AND DISPOSAL SUMMARY

Low level radioactive waste generated as result of decontamination efforts at the RSI facility was packaged on site and shipped to the CNSI Barnwell Waste Management Facility located in Barnwell, SC. A summary of yearly totals and types of waste generated at the RSI project are shown in Table I.

Minimizing the generation of radioactive waste was a prime concern during the RSI recovery project. Various techniques employed during the course of the project greatly reduced the volume of waste requiring burial as low level radioactive waste.

- Equipment was strictly controlled as it was introduced to the radiologically controlled area (RCA). Equipment was taken into the RCA only when necessary; items not required to support operations in the RCA were not permitted access. The vast majority of equipment/supplies were stored outside of the warehouse facility.
- Items and equipment needed inside the RCA were taken into the RCA only after sound radiological work practices were employed to ensure protection against contamination of the item/equipment. Items introduced into the warehouse facility were controlled as "potentially contaminated" pending a "release survey" performed by CWM personnel. Once these surveys were satisfactorily performed, a

second, confirmatory survey was performed by GA DNR personnel. Items were placed in a "hold" status pending results of the confirmatory survey. Once GA DNR concurred with the release survey, the items were tagged as "released" and removed from the warehouse.

The free release criteria enforced throughout the course of the RSI Project were as follows:

Removable Beta/Gamma	1,000 dpm/100cm^2
Average Beta/Gamma (1 m^2)	5,000 dpm/100cm^2
Maximum Beta/Gamma (1 m^2)	15,000 dpm/100cm^2

TABLE I
Waste Disposal Summary

Year	Soil		DAW		Resin	
	m^3	Act.	m^3	Act.	m^3	Act.
1988	0	0	185.4	28.825	6.3	7,740.388
1989	0	0	97.7	27.405	5.7	401.485
1990	0	0	0	0	0	0
1991	0	0	70.8	38.513	1.4	1.925
1992	42.5	28.120	135.0	265.642	0.9	0.972
	42.5	28.120	488.9	360.385	14.3	8,144.770

Total Activity (mCi)	Total Volume (m^3)
8,533.275	545.7
% Activity/Waste Type	% Volume/Waste Type
Soil - 0.3 %	Soil -7.8 %
DAW - 4.2 %	DAW - 89.6 %
Resin - 95.5 %	Resin - 2.6 %

Notes:

1. All volumes listed are disposal volumes.
2. Material shipped to subcontractor for decontamination accounted for 2.214 mCi.
3. All activity calculations are based on ^{137}Cs being the sole isotope.
4. One (1) solidified drum of ^{137}Cs contaminated oil was shipped to Hanford, WA for burial (0.64 m^3, 0.300 mCi). These totals are not included in Table I above.