A TECHNIQUE FOR THE DISPOSAL OF HIGHLY CONTAMINATED GLOVE BOXES

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I. Introduction

The NUMEC Plutonium-238 facility consisted of six glove boxes in a room approximately 20 feet x 40 feet. Each glove box was approximately 6 feet long, 3 feet wide and 3 feet high. Boxes were stainless steel with Homalite windows. Plutonium-238 in both solution and powder form had been processed in the boxes. The facility had been idle for more than four years. Although gamma and neutron radiation levels were low, alpha contamination was very high. We can only estimate contamination levels in the boxes by extrapolating from measurements made in Plutonium-239 glove boxes. Allowing for the higher specific activity of Plutonium-238 (250 times the specific activity of Plutonium-239), alpha contamination levels probably ranged from 2×10^6 dpm/cm^2 on less contaminated surfaces (ceiling, vertical surfaces, etc.) to higher than 1×10^9 dpm/cm^2 on highly contaminated surfaces such as glove box floors, and glove forearms and hands. The glove boxes were arranged in a train and were interconnected by poly-vinyl chloride bag tunnels. Boxes could be separated by sealing the bags with dielectric sealer and cutting the bag on one of the seals. The ventilation system was based on once-through air sweep of about 20 cfm per box. Box inlet air passed through an absolute filter before entering the box. Exhaust air passed through a pre-filter and two absolute filters before emission from plant stacks. Filters were bagged in line to facilitate change. All ductwork was poly-vinyl chloride.

The design of the facility and the condition of the boxes were inadequate for future work so it was decided to dispose of the boxes.

The most serious hazard was a Plutonium-238 release which could have been caused by a serious fire or by mechanical damage during manupulation of the glove box.

II. Disposal Techniques

A number of disposal techniques were considered. Complete decontamination of the glove boxes was not feasible. Partial decontamination and use of the boxes for other work was also considered not feasible because of box design and expense. For a time, we planned to remove all loose equipment, package it and ship it for burial, strap down other equipment in boxes, crate the boxes and ship them for burial. There were a number of problems with this approach.

1. Extensive handling of equipment was required.

2. A serious contamination hazard existed during operations in the aged boxes.

3. The technique provided no protection against fire during shipment.

4. The adequacy of protection against mechanical damage to boxes during shipment was questionable.

These problems caused us to seek other solutions to the problem.

We finally chose a technique in which boxes would be filled with a rigid polyurethane foam and placed in a steel drainage culvert. The remaining space within the culvert would then be filled with the same foam. The culverts would be closed, shipped, and buried. The technique promised to be economical and safe. It provided excellent mechanical protection for the glove boxes. The foam would fill all glove box space and would hold loose equipment in place. The rigid foam has a 25 psi compression strength at yield point. A man can walk on sheets of this foam without any noticeable compression of the foam. In addition, the foam has a "gripping" property which tends to give added support to windows. (A spot of foam the size of a dime formed on a dirty floor grips so well that a screw driver is required to remove it.) Tests of various types of foam under compression for periods up to two years in the Plutonium-238 glove boxes indicated that the foam and the foam components were compatible with the box atmosphere and structural materials.

An additional benefit was derived from the fire retardant properties of the polyurethyne foam we decided to use. Tests on cut surfaces of the foam indicated that a blow torch would char the foam but the foam would not support combustion when the torch was removed. The foam met ASTM Designation; D1692-59T, "Tentative Method of Test for Flammability of Plastics, Foams, and Sheeting." This consideration became especially important in our evaluation of the technique when we received word of a polyurethane foam fire at Peach Bottom. The fire started deep within the foam and could not be extinguished easily.

III. Foaming Technique

After we decided to use the foaming technique and after the New York Operations Office of the AEC approved, we began testing to establish which of several methods of foam generation would be the most satisfactory for our purposes. We constructed a plywood mock-up box for a series of tests. We determined that in place generation of foam was not practical because of a volume expansion factor of approximately 40. The high volume expansion factor made control of foam generation difficult. We instead chose a froth technique in which the two foam components, prepolymer and cross-linker, are combined in a mixing chamber and then are carried to the delivery point by a stream of Freon gas before the polymerization reaction has been completed. By using this froth technique, the volume expansion factor can be reduced from approximately 40 to approximately 8.

Our glove box test demonstrated that foaming could be performed while the box was still connected to the ventilation system. This would maintain the pressure differential across the face of the box even though some gas was being pumped into the box. We estimated the flow of free Freon to be approximately 1 cfm during the foaming operation. Most of the Freon remains trapped in the cellular structure of the foam. Air displacement rate was approximately 6 cfm.

Our Plutonium-239 experience indicated that contamination would be lowest if we injected the foam through penetrations in the tops of the glove boxes. Tests on the mock-up box indicated that foam introduced through Tygon tubing through holes in the box top worked as well as foam injected from the bottom of the box. Our Plutonium-239 experience indicated that we could perform this activity without serious release risk.

Tests proved that foaming in layers helped to overcome control difficulties caused by the three minute rise time of the polyurethane foam. Tests on the mock-up indicated that more than 95% of the free box volume could be filled with foam. The last part of the box to be foamed was at the top near the air exhaust. The unfoamed volume (less than 5% of free box volume) was near the top of the box where there was no danger of mechanical damage from shifting equipment. The foamed boxes were placed in steel culverts. The culverts were foamed as the boxes, except that side penetrations were used in addition to top penetrations. (No alpha contamination hazard existed at this point.)

IV. Operational Experiences

The foaming of the boxes went as smoothly as mock-up tests indicated it would. The froth technique using multiple penetrations in the box top proved successful. Greater than 95% of the free box volume was filled with rigid foam. No pressurizations or other difficulties were experienced during or after foaming. The boxes and culverts were buried without incident.

The operation was totally satisfactory from the Health Physics standpoint. Only one small contamination incident occurred. During movement of one of the boxes a piece of PVC duct work was chipped. The operators found approximately 10,000 cpm alpha (PAC-1SA) in one small spot. The break was patched and decontaminated immediately. No airborne release was detected. Thereafter, we covered the PVC duct work with aluminum. With the exception of this incident, contamination levels were less than 100 dpm/100 cm^2 removable alpha at all times. Although MSA Clearvue full-face respirators were worn during high exposure potential operations (glove changes, separation boxes, drilling of box penetrations, foaming of boxes, etc.) airborne Plutonium-238 concentrations never exceeded MPCa. Airborne plutonium concentrations were determined by counting samples collected by fixed-station samplers, lapel samplers, and high volume samplers. Internal exposure, determined by urine and fecal samples, was negligible.

The technique also proved to be as economical as first thought.

Cost of Foam	$1/ft^3
Froth Gun Rental	$2,000/15 wk
Cost of Culverts	$2280/culvert
Labor	90 man-weeks

Table I -- Cost Data for Glove Box Foaming

V. Transportation

The United States Atomic Energy Commission, New York Operations Office (NY), reviewed the culvert-type container and packaging procedures for the shipment of Plutonium-238 contaminated equipment, in accordance with the provisions of paragraph 73.393 (m) (2) of the Interstate Commerce Commission Regulations and AEC Manual Chapter 0529. It was determined that the shipping containers might possibly withstand the hypothetical accident conditions of AEC Manual Chapter 0529 without releasing radioactive material. However, since the containers were to be used on a "one time only" basis and then buried, rather than attempting a detailed thermal and impact analysis, it was deemed more practical to provide an AEC escort. AECMC 0529 allows for such deviations from packaging standards provided a determination is made that the shipment will not endanger life or property or the common defense and security.

The eight culvert-type containers were transported on three flat bed trailer trucks, exclusive use basis, by an ICC authorized truck carrier from the NUMEC facility to the Nuclear Fuel Service, West Valley, N. Y., burial site. The loaded weight of individual containers varied from 5000 to 6000 pounds and totaled 43,000 pounds. The loading of the trucks was observed by a United States Atomic Energy Commission, New York representative and measurements were taken to assure there was no significant radioactive surface contamination. Surface radiation levels for each container were less than 0.5 mr/hr.

The shipment was escorted by United States Atomic Energy Commission, New York representatives in a separate Radiological Emergency Assistance Team radio equipped vehicle. Radio communications between the escort vehicle and the New York Radiological Emergency Assistance Team radio control room were used throughout the shipment. However, it should be pointed out that the use of radio communication was never construed to be a safety requirement but merely afforded the New York Radiological Emergency Assistance Team an excellent opportunity to test the capability and reliability of the Radiological Emergency Assistance Team communications system in the event of a radiological incident.

The shipment arrived at Nuclear Fuels Services, West Valley, approximately seven hours after departure without incident. Radio communications between the escort vehicle and the New York Radiological Emergency Assistance Team control proved to be effective as well as comforting since driving conditions for most of the trip were hazardous due to packed road snow and snow storms.

VI. Recommendations

The foam technique is a safe, easy economical technique to minimize contamination hazards due to fire or mechanical damage during the shipment and burial of contaminated glove boxes. It might be made more economical by using wooden crates rather than steel culverts. Because of the fire retardant properties of the foam, the use of wooden crates would not compromise safety.