Fig. 3. Specially constructed burial boxes. Sides of 3/4-inch plywood reinforced to withstand burial in concrete.

Fig. 4. Exterior of plastic containment hut with airlock portion in foreground.
Fig. 5. Interior of plastic containment hut. Wrapped and partially removed vessel in background.

Fig. 6. Plutonium-239 recovery room at conclusion of equipment removal project.
DEMONITION OF BUILDING 12, AN OLD PLUTONIUM FILTER FACILITY

by

E. L. Christensen, R. Garde, and A. M. Valentine

ABSTRACT

This report discusses the decommissioning and disposal of a plutonium-contaminated air filter facility that provided ventilation for the main plutonium processing plant at Los Alamos from 1945 until 1973. The health physics, waste management, and environmental aspects of the demolition are also discussed.

I. HISTORY

A plutonium processing facility was built in Los Alamos in 1944, on what is now known as DP Mesa. The urgency at that time dictated that the facility be built as rapidly as possible, incorporating all the best construction ideas but using only those materials that were readily available.

The process buildings were constructed with sheet metal on 1.22-m-high concrete wainscoting. Plaster, on metal laths over metal studs, was used to give a smooth interior surface.

The buildings were ventilated with a 60 000-m³/min-capacity central air exhaust system. This system handled air from rooms and fume hoods, sparging of solvents, and venting of solution tanks. At that time exhausting air from the glove boxes was not believed necessary. Several years later the decision was made to vent these work enclosures. The air was exhausted, without being filtered, through the room air exhaust system. Particulates were removed from the exhaust air by electrostatic precipitron units backed up by a single bank of American Air Filter Company Type PL-24 filters. This system was considered the best available for air clean-up at that time.

The filter building, designated Building 12, was completed and put into service in May 1945. It continued in service for room and process air until July 1, 1959. That year another system was installed for the process air, and afterward only room air was handled in Building 12. Building 12 continued in service until February 1973, when new room air filtration systems were completed, one for each of the process buildings.

II. DESCRIPTION OF FACILITY

The site plan (Fig. 1) shows the relationship of the process buildings to the filter building. The finished site is shown in Fig. 2. The filter building is on the left. Air from the rooms was exhausted from floor level, up vertical ducts through the roof, then to ducts mounted parallel to the roof, to the collector duct on the peak of the roof. All the ductwork was galvanized steel. In those ducts that handled chemical fumes, corrosion began immediately, and small holes formed within a few years. Corrosion products and dirt drawn through the holes in the ductwork were deposited in the plenum of the filter building.
The floor plan of Building 12 is shown in Fig. 3. The floor area for that portion housing the filters and precip­trion units was 30.8 m by 19.5 m. The intake plenum was a trapezoidal area 23.5 m wide at its longest base, 7.6 m wide where the air entered the building, and 18.9 m from that point to the rectangular portion of the building.

The preciptrion units and filter banks were built in five sections. Each section had two large doors that could be lowered to isolate the area while filters were being changed or while work was being done on the preciptrion unit. Access to the isolated section was by ladder from the second story of the building. The second story housed the doors when they were in the raised position.

Figure 4 shows a side view of the building; and Fig. 5, a side view of the filter and blower area, shows the positions of the electrostatic preciptrion units, the PL-24 filter bank, the common blower plenum, the exhaust blowers, and the doors used to isolate the sections. A front view of the building is shown in Fig. 6.

The construction of Building 12 was constrained by the materials available at that time. The concrete foundation was made deeper and thicker because reinforcing steel was in short supply. The wall studs and floor and roof beams were wood. They were covered with two layers of gypsum board to give a smooth interior surface. This construction actually helped prevent the spread of contamination during demolition. Construction details will be discussed in Sec. IV.

III. DECONTAMINATION OF FACILITY

In 1960 the interior of the plenum and the largest portion of the air ducts were cleaned. About 3000 kg of dirt were removed from the building during this first cleaning operation, including several hundred pounds of sand that had been used in sandblasting plutonium parts. Samples of dirt removed were analyzed and showed a plutonium content ranging from 0.001 to 0.05 wt%.

The data indicated that this dirt, which was packed in two 0.3-mm-thick plastic bags and placed in steel drums for burial, contained about 600 g of plutonium (93.5% $^{239}$Pu, 6% $^{240}$Pu, and 0.5% $^{241}$Pu). The preciptrion units were disassembled, removed from the building, wrapped in several layers of plastic, and packed in plywood crates for burial.

Over the next few years the building was cleaned several times. Each time the final operation was to wipe down the entire floor with wet rags. Immediately after this cleaning, the floor would have a swipe count of only a few hundred disintegrations per minute, but the direct count was still > 100 000 dis/min per 60 cm$^2$. All the cracks, such as expansion joints, had a swipe count of > 100 000 dis/min.

IV. DEMOLITION OF BUILDING 12

A proposed procedure for the demolition of the building was prepared by a member of the Engineering group and a member of the Plutonium Processing group. Their report was submitted for approval to the Demolition Committee, which was composed of representatives from the Los Alamos Scientific Laboratory (LASL) and from the contractor that would do the demolition. The names of the groups represented are shown in Table I. Demolition work was started using this approved procedure; but as work progressed, conditions were sometimes encountered that necessitated a change in procedure. Therefore, the Committee met every week to hear progress reports on the demolition and to review proposals for any change in the procedure.

<table>
<thead>
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<td>Plutonium Processing</td>
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<td>Environmental Studies</td>
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<td>Fire Safety</td>
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<td>Contractor for Demolition</td>
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304
The first step in the demolition was removal of the ductwork leading to Building 12. This work was started in June 1972 and was completed in February 1973. As ductwork was removed and air supply was reduced, blowers in Building 12 were shut down. When the third blower was shut down, a partition was built in the blower plenum so that blower No. 4 and filter No. 5 could provide ventilation for the building. The position of the partition is shown in Fig. 3 at point No. 8.

A change room was built on the east side of the building, adjacent to the air lock and access door shown in Fig. 3. Here, the workers were suited up, including a fitting and testing of full face masks.

An initial cleaning was done by chemical technicians assisted by janitors, and the final cleaning just before painting was done by janitors and laborers. The painter was kept on duty during the entire period of demolition to paint freshly exposed surfaces. After the walls, ceilings, and partitions had been cleaned with water spray, the floors were wiped with wet rags. Again, the contamination could be reduced only to the levels discussed earlier. Then, water-base paint was applied with a spray gun. After several applications, nearly all exposed areas in the building no longer had any swipe or direct count. However, if any paint peeled off the surface, the direct count would reappear and the area had to be wiped with wet rags and repainted. As expected, all expansion joints still had large amounts of solids that soaked in with water from previous cleaning operations.

At this stage blowers Nos. 1, 2, and 3, were idle. Air was being drawn down the stacks, through the filters in bays 1 through 4 in reverse flow, through the filters in bay 5 in the normal manner, and exhausted through blower No. 4. With this air flow helping to control contamination, removal of stacks 1, 2, and 3 was begun. The roof and walls around the blowers for these three stacks were removed by lifting on a cable wrapped around ceiling beams. The roof was constructed with the beams ending at the middle of the brick wall separating the blower room from the blower plenum. Thus, the beams could be lifted off this dividing wall without exposing the contaminated blower plenum.

After the blower room roof (except for a section over blower No. 4 and another section over the electrical panels) was removed, work was started on removing the stacks. Figure 7 shows a rigger being raised to the top of the first 15.2-m (50-ft) stack to attach a lifting collar. The stacks had a square base that was slipped over a slightly smaller male fitting on the blower to provide the air seal. This joint had been taped and painted to make it air tight. The stack was removed by cutting the tape, cutting some external supports (which were not contaminated), and lifting the stack off the blower with a crane. The bottom of the stack and the opening of the blower were immediately covered with preassembled sheets of plywood. The stack was then placed on a lowboy, the ends were sealed with metal plates, and the stack was wrapped in plastic for hauling to the burial site. Figure 8 shows the blower room after the first three stacks were removed.

The next step was to remove all the filters in banks 1 through 4. As shown in Fig. 9, each bank contained 63 filters, each 0.67 by 0.67 m by 0.22 m (2 ft by 2 ft by 8 in.). The filters were lifted out of the frame and put in plastic bags, carried to the access door of the change room, and slipped into another bag held by two laborers. This outer bag was checked for external contamination so that the package could either be rebagged or could be safely carried through the change room to plywood boxes for burial.

Next, the filter frames were cleaned and painted. Disassembling the filter rack, which had been made by rivetting open-end metal boxes together, required either sawing the frames into pieces or driving a wedge between them so that the rivets would pop loose. The latter method was found to be faster and was used to remove the 252 frames in filter bays 1 through 4. The frames were taken from the building and crated, using the same method that was used for the filters.

The laborers then began disassembling the preciptron frames. These frames were 1.22 m wide, 0.61 m deep, 4.27 m high, and weighed 275 kg. As soon as a frame was unbolted, it was lowered to the floor with a chain hoist, then cleaned, painted, and placed on rollers.
to be moved to an access door of the exhaust blower plenum area (Fig. 3). There, a final coat of paint was applied before the frame was rolled through the door onto a large plastic sheeting. The frame was wrapped in plastic, loaded onto a truck, and hauled to the burial site. Figures 10, 11, and 12 give views of various stages of this operation.

Sprinkler pipes and electrical conduit and process lines leading to the oil baths on the precipitron units were removed, cut with hacksaws into 2.5-m lengths, painted, wrapped in plastic, and passed through access doors to be crated for burial.

Similar techniques were used for the large doors that isolated the filter sections. The doors were 1.6-cm (5/8-in.) plywood mounted on a 10-cm channel iron frame. Each bay had two doors 5.2 m wide, one 3.1 m high and the other 4.3 m high.

Except for the filters in bay 5, the building was empty and was considered ready for removal of the interior surfaces of the walls, floor, and ceiling.

The construction details indicated that the contamination of walls and ceiling might be restricted to the first layer of material. As shown in Fig. 13, the roof was made of two layers of wood beams, 5 cm by 20 cm (2 in. by 8 in.), supported by metal I beams. The beams were covered with two layers of gypsum board and a 0.3-cm layer of transite. The final layer was a hot tar and roofing paper application. The ceiling was two layers of gypsum board covered by a fabric called "Walltex." A 1.6-mm-thick metal nailing strip was used to prevent the nails from pulling through the gypsum board when the plenum was operating at its lower air pressure. After the metal strips were pulled from the ceiling, the surface fabric layer, covered with several coats of paint, was easily pulled off leaving a nearly contamination-free surface.

Figure 14 shows construction of the walls and floor. The walls were made of two layers of gypsum board nailed to the inside of the 5-cm by 20-cm studs. Here, too, the gypsum board could be pulled off without contaminating the studs. All exposed surfaces were immediately covered with a coat of paint to seal porous surfaces.

The wall and floor junction consisted of overlapping layers of gypsum board, expansion joint material, and gunnite. This construction had prevented the sill from becoming contaminated; and by removing the expansion joint material along with a strip of the gunnite, the sill was exposed free of contamination. The remaining gunnite was coated with paint until all of the contamination was covered. It remained on the floor for removal with the foundation.

At this time samples of the soil under the floor were taken and analyzed for gross alpha activity. The results, discussed in Sec. VIII., showed that the soil was contaminated in certain areas and would have to be removed to leave a clean site.

Demolition of the plenum could now be completed using power equipment to tear down the roof and walls in a normal manner. The appearance of the intake plenum's interior is shown in Fig. 15, and the appearance of the area that housed the precipitrons and filters is shown in Fig. 16.

In the penthouse area the interior wall covering was removed without spreading contamination to the wall studs. The floor, however, was built of 5-cm by 10-cm tongue and groove boards, and the cracks between the boards were filled with contaminated dirt, which could not be fixed, even with several coats of paint. Therefore, all the floor boards were pried loose and painted individually to fix the contamination. These interior floor boards and the gypsum wallboard were packed in plywood boxes, then banded and sealed and hauled to the burial site. The interior, after removal of floor and interior surface of the walls of the penthouse, is shown in Fig. 17.

The external siding was made of paperboard nailed to the 5-cm by 20-cm studs covered with corrugated asbestos siding. The asbestos siding was removed, monitored for alpha contamination, and hauled to the LASL waste disposal site. Figure 18 shows the building after the siding was removed. Because no alpha contamination was found on the siding, it was hauled to the disposal site in an open truck.

After the exhaust plenum, blower plenum, precipitron area, and the penthouse area had been stripped,
cleaned, and painted as discussed earlier, a survey for alpha contamination showed that all contamination was fixed, except for the soil under the floor and in the expansion joints in the concrete floor.

The steel columns that held the ten large doors could not be dismantled without cutting torches. Because of the fire danger from wooden construction in the area it was decided to leave the steel standing and tear down the building around the steel. After all combustible material was removed, the steel was cut up and hauled to the disposal site. The removal of the steel is discussed later in this section.

The interior was stripped and cleaned as much as possible. The next step was to shut down the last blower and to remove the last bank of filters. Because this would leave the building without any ventilation, a 300-m^3/min blower and HEPA filter were installed.

While blower No. 4 was still running, and before the new blower was started, the filters were coated with water-base spray paint to fix the dust and contamination. Just as the filters began to plug, the large blower was shut off and the 300-m^3/min blower was started.

The filters and frames were then removed, using the same technique as for the others. After bay 5 was stripped and cleaned, the building was surveyed again for alpha contamination. When all loose contamination and detachable items were removed and all areas were painted at least three times to cover impregnated contamination, the decision was made that the remainder of the building could be safely torn down and loaded onto trucks with equipment working from the outside.

Because no contamination could be detected on the remaining portions of the walls, it was decided to pull the penthouse over with a cable as if it were a normal building being razed. This was done, exposing the steel beam door supports. Figures 19 and 20 show the building with most of the penthouse gone. As portions were pulled down, the long boards were cut into 2,5-m sections with chain saws. The pieces were checked for contamination and then loaded into a dump truck fitted with plywood sides, canvas top, and rear flap. Only rarely was any contamination found, and when it was the area was immediately painted.

The remainder of the walls and ceiling of the blower room, which never had been contaminated, were broken apart and loaded onto a truck with a payloader. The concrete foundations were broken loose with a bulldozer and loaded onto the dump truck.

After the work on the penthouse and blower room was completed, work was started on the intake plenum. The roof was pulled down with cables, and the debris was hand-loaded into the covered truck. Then the walls were pushed over, dismantled, and loaded. Figure 21 shows this area after one of the walls was pushed over. When this work was completed, the building was reduced to the brick and steel remaining in the precipitron area and the floor of the intake plenum area.

The next stage was to tear out the intake plenum floor with a payloader. The foundation was extensive, as shown in Fig. 22. The concrete at the point where the external foundation intersects with the internal foundations was often 46 cm thick. The foundation was 1.52 m deep, and because some of the soil inside was contaminated, the decision was made to have the equipment dig deep enough to go beneath the foundation and to load foundation, soil, and floor at the same time. Figure 23 shows the equipment in the process of removing the plenum floor area. When that was completed the building was reduced to the steel, brick and concrete shown in Fig. 24.

An attempt was made to pull some of the steel down with a cable and in the process to break some bolts and rivets so that the individual beams could be loaded onto the truck. Unfortunately, the construction was such that when the bulldozer pulled on a piece of steel at the end of the building, the whole steel assembly toppled over and became the tangled mess shown in Fig. 25. The steel then had to be cut apart with cutting torches and loaded onto an open dump truck with a crane. Figures 26, 27, and 28 show various stages of this operation.

After the steel was cleared away, only the concrete floor and foundations in the precipitron and filter remained (Fig. 28). The only contaminated areas on the floor
slabs were the edges that had been in contact with the ex-
pan°°on joints, and these areas were immediately paint-
ed. A bulldozer (Fig. 29) was used to lift the floor slabs
and push them to an area where the payloader could load
them onto a dump truck. Then the bulldozer was used
to loosen and break the foundation into pieces small
enough to load. Most of the foundation was 15 to 20 cm
thick and 1.5 m deep. However, one piece of the foun-
dation was nearly 75 cm wide, 1.5 m deep, and 30 m
long. Efforts to break this foundation into small chunks
with the bulldozer proved fruitless. Therefore, this
30-m piece of foundation had to be weakened by drilling
a series of holes as a perforation line. Part of this
perforation line is shown in Fig. 30. The bulldozer was
then able to break this foundation into pieces small enough
to be lifted onto the truck. Figure 31 shows the removal
of the last concrete and dirt from the site.

The final task was to remove the drain pipe that led
from the precipitron and filter area to a tile field. The
tile field had been removed several years earlier, but
the plugged drain line remained in place. Workers en-
gaged in removing the drain line are shown in Fig. 32.
Although this cast iron drain line had been embedded in
the soil for nearly 30 yr, corrosion had penetrated less
than 0.16 cm (< 1/16 in.).

After the drain line was removed, the trench and
the area that had been occupied by the building were
surveyed for alpha contamination. When no alpha con-
tamination was detected, soil samples were taken for
analysis, the area was backfilled with dirt until the
original ground contour was restored, and native grasses
were planted as a ground cover. Figure 33 shows the
area after completion of the backfilling operation.

The demolition work was started in February and
completed in July 1973, at a total cost of approximately
$160 000. Craftsmen employed on this project were rig-
gers, painters, laborers, equipment operators, truck
drivers, carpenters, and electricians.

V. HEALTH PHYSICS

Personnel assigned to do the demolition were inex-
perienced in dealing with plutonium contamination. How-
ever, they were provided with formal health physics
instruction and with day-to-day instructions from the plu-
tonium plant supervisor and from health physics techni-
cians who were present during all phases of the project.
All workers also participated in a full face respirator
fitting and testing program. Full face respirators
equipped with high-efficiency particulate filters were
the standard respiratory protection during all phases of
demolition involving loose contamination. During prior
decontamination work in 1960, supplied air suits were
used.

Demolition workers were provided protective (anti-
contamination) clothing for work in the area. For work
inside the building, workers were double-suited with
coveralls, booties, a cap and hood, gloves, and under-
wear (Fig. 34). Disposable paper coveralls, hoods,
and plastic booties were used for outerwear. The outer
garments were overlapped and taped together, and open-
ings in the coveralls were taped shut. This clothing
provided adequate protection against worker contamina-
tion during the demolition, and no personnel decontamina-
tion beyond normal showering and washing procedures
was required.

Air in the working area was sampled by drawing
it through HV-70 filter paper at the nominal rate of
0.56 m³/min. The paper was removed and counted daily
for alpha activity to provide a record of the workers'1
exposure to air contamination. On four occasions the
air-borne plutonium concentration exceeded 2000 x 10⁻¹²
µCi/mL, but during most of the remaining work days the
concentration generally ranged from 50 to 150 x 10⁻¹²
µCi/mL with some as low as 2 x 10⁻¹² µCi/mL.

All personnel working on the project were provided
with monthly beta-gamma and neutron film badges to
record external radiation exposures. The highest monthly
recorded exposure was 40 mrem. All workers were sur-
veyed for alpha contamination before leaving the area,
and nose swipes were collected after work requiring
respiratory protective equipment. The frequency of these monitoring practices varied somewhat with the assigned task and level of contamination involved. A few cases of hand contamination occurred; however, all were decontaminated by normal showering and washing methods. Of 1195 nose swipes collected only four were > 10 dis/min alpha; of these 85 dis/min was the highest single result. Workers submitted urine samples for plutonium analysis at the beginning and completion of the job. Most workers were given plutonium chest counts at job completion. No measurable plutonium body or lung burdens were indicated by the results of the urinalysis and chest counting programs. One minor injury occurred during the job. The wound, caused by a nail puncture, was monitored by alpha and x-ray monitoring techniques and found to be free of plutonium contamination.

VI. WASTE MANAGEMENT

Waste materials were packaged in different ways depending on size and contamination level to make transport and disposal safe. Small items and highly contaminated larger items that could be reduced in size were placed in plastic-lined 0.56-m³ cardboard boxes. The bags were sealed with tape to prevent leaks during disposal. Approximately 1320 cardboard boxes were filled with waste and buried at LASL's solid radioactive waste disposal site, about 9 km from the demolition site. The location of this site is shown in Fig. 33. Larger items, such as filters, filter frames, gypsum board pieces, and metal trim, were wrapped in plastic and placed in 69 plastic-lined plywood crates (1.2 by 1.2 by 2.4 m) for burial at the disposal site. In addition to the boxed and crated waste, approximately 1200 m³ of contaminated transite, doors, lumber, pipes, roofing materials, and metals were taken to the disposal site in covered dump trucks. Fixing the contamination on large items with several coats of paint allowed for handling, transport, and disposal without vehicle or personnel contamination problems. In addition to the waste already mentioned, approximately 400 m³ of concrete, dirt, and large metal items were buried in a disposal site located at TA-21, 300 m from the building site.

All waste packages and unpackaged items were monitored for plutonium contamination with portable alpha survey instruments. The waste was buried as nonretrievable, < 10 nCi/g plutonium waste. The wastes that contained > 10 nCi/g plutonium had been placed in retrievable storage during decontamination, before actual demolition.

Trucks, loaders, and bulldozers used to load or transport contaminated materials were monitored during the job and decontaminated as necessary. The equipment did not become highly contaminated, and washing with cold water was sufficient to reduce contamination levels to less than 100 dis/min per 60 cm².

During the 169 days required for the demolition work and site clean-up, a total of 235 man-days of health physics technician effort were required for personnel and miscellaneous monitoring.

VII. ENVIRONMENTAL AIR MONITORING

The Los Alamos Scientific Laboratory Environmental Studies Group monitored the environmental impact of the demolition operation with its routine air sampling network and a special on-site sampling program. The routine air sampling network, consisting of 36 sampling stations was supplemented with two additional stations to more adequately encircle the demolition site. The positioning of the supplemental samplers was limited somewhat by availability of electrical power and access to the equipment. The location of these sampling stations (with the exception of the Santa Fe, Espanola, and Pojoaque stations) and of the demolition site are shown in Fig. 35.

The samples drew air through a 78-mm Microsorban filter with an efficiency of about 99.8% for 0.3-µm dioctyl phthalate (DOP) particles (a standard test aerosol for determining filter efficiency) at either 70 l/min or 200 l/min. The two different rates were due to replacing the 70-l/min pumps with higher capacity pumps that require less maintenance.

The 38 samples were collected weekly. This schedule was not intended to provide an early detection of a plutonium release but to help document the magnitude of an accidental release. Meteorological data were available.
for TA-21 during the entire operation and could have been used if a high gross alpha concentration had been detected at any of the sampling stations. Because no concentration of any significance was detected, it was not necessary to use the data to determine the pollution source.

The samples were handled routinely; they were counted after a 1-day decay period and then recounted after approximately a 10-day decay period to allow for the decay of natural radon and thoron daughters. During the demolition both measurements were observed and compared to background levels to detect any abnormal concentrations. An attempt was made to compare these 10-day measurement data to the corresponding data for 17 weeks of 1972 to eliminate seasonal background variations. However, the data for those weeks in 1972 were influenced by fallout from a Chinese Nuclear Test and no meaningful comparison was possible. Instead, the data were compared to the 1972 averages. These data are presented in Table II and indicate that if plutonium was released to the environment during demolition, it was minimal and had no detectable impact on the overall gross alpha background levels in the area.

Air monitoring in the immediate vicinity of the structure was added to provide an early detection of a release of radioactivity. If such a release had been detected the operation would have been curtailed until more protective demolition measures could be used. These samples (location of samplers shown in Fig. 36) were collected daily. Because of mechanical failures, a variety of sampling devices and rates were used. On April 4, 1973, at the start of the sampling operation, the network consisted of four Staplex "Hi-Volume" samplers. They sampled through 76-mm-diam Microsorb paper (similar to the filter media for the weekly samples) at a rate of approximately 0.37 m/min. Two of the samplers were located near buildings and used line power; the other two were driven by gasoline-powered generators.

By the end of April three of the samplers had been changed to use 100-mm Microsorb filters to increase the flow rate and reduce pump heating. The flow increased to approximately 0.52 m/min. These samplers were located, as shown in Fig. 36, so that they could be operated on line power and were used throughout the remainder of the sampling period. The fourth sampling station was abandoned because the others would give adequate coverage. The samplers were not centered around the building but instead, around the center of the demolition activity, where releases of contamination were more likely to occur.

The filters were first counted by Health Physics personnel within an hour after collection for early detection of a release. Two weeks later, after allowing for decay, they were counted by Environmental Studies personnel. The average and maximum gross alpha concentration values for the second measurement are compared in Table III to AEC Manual Chapter 0524, Concentration Guides for Uncontrolled Areas. All of the gross alpha activity was assumed to be insoluble 239Pu for comparison to applicable concentration guides. The highest 24-h concentration at any on-site sampler (8.7 x 10^-13 µCi/m²)

### Table II

**Average Gross Alpha Concentrations**

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<td>14</td>
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<td>3.0 ± 2.2</td>
<td>2.1 ± 1.0</td>
</tr>
<tr>
<td>15</td>
<td>-</td>
<td>-</td>
<td>3.2 ± 3.2</td>
</tr>
<tr>
<td>16</td>
<td>-</td>
<td>3.2 ± 2.2</td>
<td>2.0 ± 0.8</td>
</tr>
<tr>
<td>Perimeter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>N110 E300</td>
<td>2.7 ± 3.2</td>
<td>1.9 ± 0.8</td>
</tr>
<tr>
<td>18</td>
<td>N110 E250</td>
<td>1.3 ± 2.0</td>
<td>1.6 ± 0.8</td>
</tr>
<tr>
<td>19</td>
<td>N100 E20</td>
<td>1.3 ± 2.4</td>
<td>1.5 ± 0.4</td>
</tr>
<tr>
<td>20</td>
<td>N100 E150</td>
<td>1.8 ± 2.8</td>
<td>1.5 ± 0.6</td>
</tr>
<tr>
<td>21</td>
<td>N80 E10</td>
<td>1.7 ± 2.8</td>
<td>1.5 ± 0.6</td>
</tr>
<tr>
<td>22</td>
<td>N50 E250</td>
<td>1.8 ± 2.8</td>
<td>1.5 ± 0.6</td>
</tr>
<tr>
<td>23</td>
<td>S100 E300</td>
<td>2.2 ± 2.4</td>
<td>1.5 ± 0.6</td>
</tr>
<tr>
<td>24</td>
<td>S100 E50</td>
<td>1.6 ± 2.0</td>
<td>1.5 ± 0.6</td>
</tr>
<tr>
<td>25</td>
<td>S100 E70</td>
<td>2.1 ± 2.1</td>
<td>1.6 ± 0.6</td>
</tr>
<tr>
<td>26</td>
<td>S210 E250</td>
<td>1.9 ± 2.0</td>
<td>-</td>
</tr>
</tbody>
</table>

**On-Site**

| 27             | N90 E70    | 1.8 ± 1.8 | 1.3 ± 0.4 | 0.8 ± 0.4 |
| 28             | N90 E70    | 2.6 ± 4.0 | 2.2 ± 0.8 | 1.0 ± 0.4 |
| 29             | N100 E150  | 1.5 ± 2.2 | 1.5 ± 0.6 | 1.0 ± 0.6 |
| 30             | N20 E170   | 2.6 ± 4.2 | 1.6 ± 0.4 | 1.0 ± 0.6 |
| 31             | S50 E110   | 1.3 ± 1.8 | 1.1 ± 0.6 | 1.1 ± 0.8 |
| 32             | S40 E150   | 1.8 ± 2.0 | 1.5 ± 0.4 | 1.3 ± 1.2 |
| 33             | S50 E160   | 1.3 ± 1.8 | 1.1 ± 0.4 | 0.8 ± 0.4 |
| 34             | S60 E10    | 3.1 ± 1.4 | 2.2 ± 0.4 | 1.4 ± 1.3 |
| 35             | S70 E80    | 1.5 ± 1.8 | 1.3 ± 0.4 | 0.8 ± 0.6 |
| 36             | S250 E250  | 2.3 ± 5.4 | 1.0 ± 1.2 | 1.1 ± 1.0 |
| 37             | N90 E70    | -        | -      | 1.1 ± 1.0 |
| 38             | N70 E150   | -        | -      | 1.1 ± 1.0 |

* Average (±2 standard deviations)
TABLE III
ON-SITE (TA-21) GROSS ALPHA CONCENTRATIONS IN AIR

<table>
<thead>
<tr>
<th>Sampling Period</th>
<th>Average(^a)(± 2 S.D.) for Average</th>
<th>Percent of (2 \times 10^{-12}) μCi/ml</th>
<th>Maximum(^b)(± 2 S.D.) for Maximum</th>
<th>Percent of (2 \times 10^{-12}) μCi/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/4 - 4/9/73</td>
<td>(4(± 1))</td>
<td>0.4</td>
<td>(8(± 1))</td>
<td>0.8</td>
</tr>
<tr>
<td>4/10 - 4/16/73</td>
<td>(11(± 49))</td>
<td>1.1</td>
<td>(114(± 5))</td>
<td>11.4</td>
</tr>
<tr>
<td>4/17 - 4/23/73</td>
<td>(2(± 3))</td>
<td>0.2</td>
<td>(6(± 1))</td>
<td>0.6</td>
</tr>
<tr>
<td>4/24 - 5/30/73</td>
<td>(11(± 4))</td>
<td>1.1</td>
<td>(78(± 9))</td>
<td>7.8</td>
</tr>
<tr>
<td>5/1 - 5/7/73</td>
<td>(3(± 0))</td>
<td>0.3</td>
<td>(17(± 8))</td>
<td>1.7</td>
</tr>
<tr>
<td>5/8 - 5/14/73</td>
<td>(8(± 24))</td>
<td>0.8</td>
<td>(42(± 15))</td>
<td>4.2</td>
</tr>
<tr>
<td>5/15 - 5/21/73</td>
<td>(73(± 418))</td>
<td>7.3</td>
<td>(632(± 213))</td>
<td>63.2</td>
</tr>
<tr>
<td>5/22 - 5/28/73</td>
<td>(4(± 15))</td>
<td>0.4</td>
<td>(20(± 16))</td>
<td>2.8</td>
</tr>
<tr>
<td>5/29 - 6/4/73</td>
<td>(2(± 4))</td>
<td>0.2</td>
<td>(6(± 3))</td>
<td>0.6</td>
</tr>
<tr>
<td>6/5 - 6/11/73</td>
<td>(3(± 7))</td>
<td>0.3</td>
<td>(15(± 8))</td>
<td>1.5</td>
</tr>
<tr>
<td>6/12 - 6/18/73</td>
<td>(2(± 9))</td>
<td>2.4</td>
<td>(112(± 55))</td>
<td>11.2</td>
</tr>
<tr>
<td>6/19 - 6/25/73</td>
<td>(39(± 33))</td>
<td>3.9</td>
<td>(166(± 80))</td>
<td>16.6</td>
</tr>
<tr>
<td>6/26 - 7/2/73</td>
<td>(98(± 108))</td>
<td>9.8</td>
<td>(278(± 111))</td>
<td>27.8</td>
</tr>
<tr>
<td>7/3 - 7/9/73</td>
<td>(110(± 490))</td>
<td>11.0</td>
<td>(869(± 347))</td>
<td>86.9</td>
</tr>
<tr>
<td>7/10 - 7/16/73</td>
<td>(10(± 23))</td>
<td>1.0</td>
<td>(30(± 15))</td>
<td>3.0</td>
</tr>
<tr>
<td>7/17 - 7/23/73</td>
<td>(2(± 4))</td>
<td>0.2</td>
<td>(7(± 3))</td>
<td>0.7</td>
</tr>
<tr>
<td>7/24 - 7/30/73</td>
<td>(1(± 1))</td>
<td>0.1</td>
<td>(6(± 1))</td>
<td>0.6</td>
</tr>
<tr>
<td>7/30 - 8/2/73</td>
<td>(1(± 1))</td>
<td>0.1</td>
<td>(2(± 1))</td>
<td>0.2</td>
</tr>
</tbody>
</table>

\(\text{Average}^a\) for all 24-h samples for particular sampling period (± 2 Standard Deviations),

\(\text{Maximum}^c\) for any single 24-h sample during the sampling period (± 2 Standard Dev.).

\(\text{Concentration Guide for insoluble }^{239}\text{Pu for uncontrolled areas, AEC Manual Chapter 0524.}\)

\(\text{Maximum concentration of any single 24-h sample during the sampling period (± 2 Standard Dev.)}\)

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on July 5) was 87% of the \((1 \times 10^{-12})\) μCi/ml concentration guide for insoluble \(^{239}\text{Pu}\) in controlled areas.

Air exhausted by the ventilation blower was sampled by drawing it through HV-70 filter paper at the nominal rate of 0.56 m³/min. The filter papers were measured daily for gross alpha activity. Data indicated that 1371 μCi of plutonium were released through the blower between February and May 1973.

VIII. SOIL SAMPLING

As was mentioned in Sec. IV., water from clean-up operations escaped the building through expansion joints in the concrete floor. For this reason, the concrete was broken and surface and core samples of dirt were collected at suspect locations to determine the magnitude and depth of contamination. The surface samples were collected with a spoon from the top centimeter of soil, and the core samples were collected by driving a 2.54-cm-diameter polyvinyl chloride (PVC) pipe into the soil with a hammer. The sample locations and the gross alpha concentrations at those locations are shown in Fig. 37 and Table IV, respectively. The data confirmed expectations that some soil underneath the building would be contaminated.

After the building and approximately 30 cm of soil were removed, an attempt was made to survey the remaining 2-m depression with a low-energy x-ray detector. The results of the survey were meaningless, however, because the instrument readings were influenced by radioactive materials stored in a nearby building. Therefore, soil core samples were collected at the locations shown in Fig. 38. Samples collected at points 4, 5, and 6 near the centerline of the building were divided into the listed segments to determine variation in
contamination with depth. Samples from the other locations were analyzed as single samples. Runoff from a rainshower the previous night that had formed a puddle at the northeast side of the depression was also sampled; its gross alpha concentration was less than the minimum detection limit of 4 x 10^-8 μCi/g.

To arrive at a quick estimate of contamination levels and also minimize the number of plutonium analyses, gross alpha measurements were made on all the samples by leaching the samples with acid and analyzing the leachate. The gross alpha concentrations were used to select samples for plutonium analyses that would include the maximum and minimum gross alpha concentrations and several concentrations within the range. The plutonium data are shown in Table V.
FIGURES

1. General layout of DP Site West
2. View of plutonium processing facility
3. Floor plan of building DP-12
4. Side view of building 12
5. Side view of blower and filter area
6. Front view of Building 12
7. Preparing to remove stack No. 1
8. Blower room after removal of stacks Nos. 1, 2 and 3
9. View of filter banks in 1945
10. Precipitron frame being rolled onto plastic sheeting
11. Precipitron frame being wrapped in plastic, ready for loading
12. Precipitron frame ready for hauling to disposal site
13. Details of roof construction
14. Details of floor and wall construction
15. Intake plenum after stripping and painting
16. Precipitron and filter area after stripping and painting
17. Interior of penthouse area after stripping and painting
18. Building 12 after corrugated siding had been removed from intake plenum wall
19. Ground-level view of penthouse area after removal of most of the walls and roof
20. Roof-level view of penthouse area, after removal of most of the walls and roof
21. Intake plenum after east wall was pulled down
22. Foundation for intake plenum
23. Removal of intake plenum floor
24. Precipitron and filter area after blower room and intake plenum were removed
25. Appearance of structural steel after attempt to pull down individual pieces
26. Cutting steel beams with welding torch
27. Loading steel beams onto truck for disposal
28. Precipitron area after most of the steel had been removed
29. Bulldozer removing concrete floor in precipitron area
30. Part of concrete foundation
31. Removing the last concrete and dirt
FIGURES (Cont.)

32. Removing drain line
33. View of site after completion of demolition
34. Worker suited for demolition work
35. Location of demolition site and air sampling stations
36. On-site (TA-21) air sampler locations
37. Locations of soil samples taken underneath intake plenum
38. Locations of soil samples taken from cleared site
BUILDINGS
1. OFFICES & CHANGE ROOMS
2. ETHER EXTRACTION
3. OXALATE PRECIPITATION
4. FLUORINATION OF OXALATE
5. METAL PREPARATION & FABRICATION
6-11. PLANT SERVICES
12. FILTER BUILDING
13-22. PLANT SERVICES

Fig. 1. General layout of DP Site West.

Fig. 2. View of plutonium processing facility.

Fig. 3. Floor Plan of Building DP-12.

1. Forced Air Opening
2. Function Room Area
3. Ventury Change Room
4. Dust Free Isolation Area
5. Ceramic Membranes, Spring
6. Filter and Filter Housing
7. Exhaust Stair Flue, Area
8. New Temporary Mat
9. Exhaust Exhaust Fan and Snaps
10. Tower Room Area
11. Area of Physical Change
12. Rondhouse Area (Miss Structure)
13. Section Support Dunny
14. Evapor Dew Water
Fig. 4. Side view of Building 12.

Fig. 5. Side view of blower and filter area.
Fig. 12. Precipitron frame ready for hauling to disposal site.

Fig. 13. Details of roof construction.

Fig. 14. Details of floor and wall construction.

Fig. 15. Intake plenum after stripping and painting.

Fig. 16. Precipitron and filter area after stripping and painting.
Fig. 17. Interior of penthouse area after stripping and painting.

Fig. 19. Ground-level view of penthouse area after removal of most of the walls and roof.

Fig. 18. Building 12 after corrugated siding had been removed from intake plenum wall.

Fig. 20. Roof-level view of penthouse area, after removal of most of the walls and roof.

Fig. 21. Intake plenum after east wall was pulled down.
Fig. 22. Foundation for intake plenum.

Fig. 23. Removal of intake plenum floor.

Fig. 24. Precipitron and filter area after blower room and intake plenum were removed.

Fig. 25. Appearance of structural steel after attempt to pull down individual pieces.
Fig. 26. Cutting steel beams with welding torch.

Fig. 27. Loading steel beams onto truck for disposal.

Fig. 28. Precipitron area after most of the steel had been removed.
Fig. 29. Bulldozer removing concrete floor in precipitron area.

Fig. 30. Part of concrete foundation.

Fig. 31. Removing the last concrete and dirt.

Fig. 32. Removing drain line.
Fig. 33. View of site after completion of demolition.

Fig. 34. Worker suited for demolition work.

Fig. 35. Location of demolition site and air sampling stations.
APPROXIMATE LOCATION OF INITIAL SAMPLING NETWORK

APPROXIMATE LOCATION OF FINAL SAMPLING NETWORK

BUILDINGS
1. OFFICES AND CHANGE ROOMS
2. ETHER EXTRACTION
3. OXALATE PRECIPITATION
4. FLUORINATION OF OXALATE
5. METAL PREPARATION AND FABRICATION
6-21. PLANT SERVICES
22. RESEARCH AND DEVELOPMENT

Fig. 36. On-site (TA-21) air sampler locations.

Fig. 37. Locations of soil samples taken underneath intake plenum.

Fig. 38. Locations of soil samples taken from cleared site.
PROGRAM PLAN
FOR
DECONTAMINATION AND DECOMMISSIONING
THE
MATERIALS TESTING REACTOR
AT THE INEL

ABSTRACT

This paper discusses a program plan developed for the dismantling of the Materials Testing Reactor located in the Testing Reactor Area (TRA) of the Idaho National Engineering Laboratory. Included in the discussion are: The scope of work, dismantling problems resulting from the nature of construction of the MTR and a program plan for physically dismantling the reactor.

Thomas F. Jones
Aerojet Nuclear Corporation
Idaho Falls, Idaho 83401
SUMMARY OF PROGRAM STATUS

Program plans for the overall dismantling of the Materials Testing Reactor Complex are still in the development stage. A general program plan has been prepared but will have to be expanded upon following the final decisions on all demolition techniques to be utilized. Cost, practicality, and radiation exposure potential will have to be considered prior to selecting the D&D methods to be utilized. Preliminary cost estimates have been prepared but will have to be expanded upon to reflect the complications inherent in a contaminated and irradiated facility. Basic tooling designs are being developed, but exotic tool selection and procurement is precluded until decisions on demolition techniques have been finalized.
INTRODUCTION

The Materials Testing Reactor (MTR) is included on the list of facilities to be decontaminated and decommissioned (D&D) at the Idaho National Engineering Laboratory (INEL). The Materials Testing Reactor actually consists of a number of interrelated facilities such as the MTR structure, the process water facility, the air discharge system including the stack, the two plug storage enclosures, and all interrelated primary and secondary reactor utility supply and discharge systems. This report deals only with the main reactor structure contained within the MTR 603 reactor building.

The MTR was a high flux, light water cooled reactor having the primary function of advancing reactor development for military and peace-time applications. It was designed to gain more information about radiation effects on construction materials, graphite fission product cross sections as related to the problem of breeding gain in power reactor work, and isotope production by second and third order neutron capture. This basic research was used to obtain physical, chemical, biological and engineering data.

The MTR achieved initial criticality in March of 1952 and reached full power in May, 1952. The power was increased to 40 mega watts in 1955 and operated primarily at that level until its final shutdown in 1970. Prior to the final shutdown, the reactor had accumulated 178,810 MWD of operating output.
SCOPE OF WORK

The main Materials Testing Reactor structure considered in this report is a 34 foot square facility centrally located in the MTR 603 reactor building. The main biological structure extends 24 feet above the main floor and 16 feet below it. The outer portion of the structure is high density concrete enclosed by a steel liner. In-bedded in this concrete are the structural supports, air ducting, water systems, reactor vessels and numerous experiment penetrations. Directly around the reactor core area is a graphite ball zone which in turn is surrounded by a solid graphite section approximately 14 foot square by 9 foot high. Enclosing the graphite on all sides are two 4 inch thick carbon steel plates which serve as thermal shields.

The entire reactor main structure including all of the aforementioned components will have to be dismantled and removed to appropriate storage areas. All precautions must be taken to insure that the MTR D&D work does not adversely affect the existing operating facilities at the Test Reactor area. Every effort will be made to retain the integrity of the MTR 603 building so that it can be remodeled for future use.
D&D PROBLEMS

The MTR has many dismantling problems not present in most conventional power reactors. Of major consideration is the proximity and interrelated nature of the two operating test reactors at TRA. Total isolation of all MTR Systems that might adversely affect the operation of ETR or ATR must be insured. Any use of explosives will require studies to limit ground shock and air blast problems.

The presence of graphite both in solid form and balls near the core lattice poses some interesting problems. In the dismantling process, the carbon dust must be contained both to insure that nuisance dust levels do not exceed industrial hygiene limits and that carbon fourteen ($^{14}$C) emissions stay within the AECM 0524 guide concentrations. Although $^{14}$C is not anticipated to be a problem according to calculations, an analysis of the graphite balls will be required to substantiate the actual maximum levels of $^{14}$C that will be received.

Combustibility of the graphite balls and dust in either dismantling with plasma cutters or explosives must be considered. This problem is complicated by the Wigner Effect, the increase in stored energy in crystalline lattices due to neutron bombardment, which in effect lowered the combustion temperature of the graphite balls for self-sustained combustion from 820 °C to 750 °C. Removal of the graphite balls and spraying the resultant cavity with a non-flammable fixative prior to the addition of an external heat source will eliminate this problem to a great extent.

Other problems of limited scope are the numerous experiment penetrations into the biological structure, the interlacing of utility systems through the concrete, the remote location of the canal, and the contamination problems resulting from numerous past fission breaks. Many of these problems are counter balanced by the location of a contaminated storage site at the INEL and by the number of trained personnel available to call upon if the need arises.
PROGRAM PLAN

For planning purposes, the dismantling of the Materials Testing Reactor structure has been divided into two major tasks, each having a number of work packages under them. Task I consists of preliminary preparation work including the removal of some easily retrievable components. Task II deals primarily with the general demolition. Final decontamination and building renovation will not be dealt with in this report. The following listing shows the various work packages in their task groupings:

TASK I:
- W.P. 1. Remove In-Tank components
- W.P. 2. Remove Graphite Pebble Shielding
- W.P. 3. Remove Reactor Vessel Tanks Band C
- W.P. 4. General Preparation and Isolation

TASK II:
- W.P. 1. Prepare Sub-Pile Room
- W.P. 2. Remove Vessel Tank D and Top Section of E Tank
- W.P. 3. Remove Reactor Vessel Tanks A and the Remainder of E
- W.P. 4. Removal of Experiment Penetration Inserts
- W.P. 5. Stage Demolition of the Biological Shielding

Prior to the physical removal of any portion of the MTR, a program plan must be developed and approved for the specific task being considered. Included in this plan will be the technical planning, health and safety requirements, equipment requirements, schedules, and cost estimates. Detailed sequencing procedures will have to be developed to insure that the D&D problems are limited to the greatest extent possible.

The over-all planning of work can be diminished by removing various reactor components in stages. After removing the core components and retrievable in-tank items, an exact radiation mapping can be obtained to determine what methods are to be ultimately utilized to remove the imbedded tanks. Samples taken during the removal of the graphite pebbles will indicate whether or not carbon fourteen is going to pose a problem.
The removal of the in-tank components can be accomplished in approximately four months at a current operating cost of $100,000. The work involves tool fabrication and removal of the following:

- A-Tank Extension
- Existing Experiment Tubes
- Thermocouple Ring
- Inner Shielding Ring
- Spider Support Ring
- Loose Components Adjacent to Core
- Upper Support Casting
- Skirt Plates
- Beryllium Reflector Components
- Lower Assembly Grid
- Lower Guide Grid
- Shock Absorbers
- Monitor Tubes

Components having cross sectional dimensions three inches by three inches or less can be discharged to the canal through the discharge chute. Larger items will have to be removed over the top of the reactor in transfer casks. Personnel shielding during removal operations will be provided by maintaining a maximum practical water level in the reactor vessel.

Work package two of Task I covers the removal of the graphite pebble shielding. These balls will be dumped into plastic lined steel barrels through the two pebble discharge chutes in the reactor basement. Dust emissions during discharge will be controlled by utilizing a double containment bag out system and by providing a negative pressure at the discharge nozzle with the existing reactor air system.

Following the in-tank component removal and the graphite pebble discharge, the reactor vessel water level can be lowered for the removal of the B-Tank and the C-Tank. The B-Tank is a 2' 2" high 345 stainless steel vessel having an outside diameter smaller than the inside diameter of the A-Tank. After unbolting it from both the A-Tank and the C-Tank, the entire B-Tank section can be removed through the top of the reactor vessel. The B-Tank will have a reading of about 400 millirem per hour, thus allowing
it to be sealed at both ends and then transported as its own shipping container.

The C-Tank is an aluminum-25 structure having a height of 4' 3½" and an outside diameter equal to that of the B-Tank. After unbolting it from the D-Tank, it can also be removed through the A-Tank as one unit. Radiation should be insignificant but contamination on the outer portion of the tank may pose a problem because of the tanks interface with the graphite balls. Again the vessel could serve as its own shipping container by placing it in a Nucon sleeve.

General preparation consists of terminating existing electrical, instrumentation and mechanical service systems to the reactor and biological shield. Temporary services as required for the D&D activities will be installed. Components adjacent to the reactor structure but not vital to reactor dismantling will be removed. All contaminated and irradiated trash items stored in the canal will be hauled to the RWMC for disposal. Filtering systems will be installed in the air exhaust system as required to minimize the spread of contamination.

Existing accesses to MTR-603 will be sealed and a manway access installed to provide isolation of the work area. The reactor structure may be siemsically isolated from the ground floor to minimize interference with adjacent operations as a result of blasting.

By modifying the sub-pile room, the rubble of demolition can be dropped through the reactor vessel cavity into containers at the MTR basement floor level. The filled containers can then be sealed, wheeled out of the sub-pile room to the north, lifted through a hatchway in the floor, placed on a truck, and hauled to the Radioactive Waste Management Complex for disposal. Sub-pile room modification consists of filling in the canal under the reactor structure after decontamination, removing the canal parapet walls, repairing the sub-pile room floor, and making a new equipment access door in the north wall to permit transfer of the debris containers.

Numerous experiment liner attachments were built into the D-Tank. The six horizontal beam penetrations consist of 6" diameter thimbles made out of
extruded aluminum. The tank is also pierced by two bars containing the pneumatic rabbit holes (HR-1 and HR-2) and by the horizontal through hole facility (HT-1). Horizontal rabbit tubes (HR-3 and HR-4), horizontal graphite facilities (HG-5, HG-6, and HG-9), and six down beam liners are also attached to sockets on the outside of the tank. A remotely operated plasma-arc torch or explosive internal pipe cutters will be used to separate these attachments from the D-Tank.

The D-Tank constructed out of aluminum-25 and the upper portion of E-Tank, a stainless steel 304L vessel, will be removed down to a horizontal plane just above the top of the upper thermal shield. Explosive shape charges or a plasma-arc torch will be used to section the tanks.

The A-Tank, a 304-L stainless steel vessel, is firmly imbedded in the biological shield. In addition to being entirely surrounded by high density concrete, it has four large fins protruding into the biological structure on the NE, NW, SE and SW sides. There is also a large imbedded steel shielding ring surrounding the top of the A-Tank. Two 24" process water lines enter the A-Tank from the north and the south.

The lower two-thirds of the E-Tank is also firmly imbedded in the biological shield. It is penetrated by the two 24" process water lines on its south and north sides. Attached to it are four 2" thick imbedded ribs on its NE, NW, SE and SW sides. The 4" thick lower thermal shield ring and a 4" thick lower flange are welded to the outside of the E-Tank wall. The E-Tank proper is a 2" thick 304-L stainless steel vessel.

The exact method to be utilized in removing the imbedded portions of these tanks has not been determined at this time. Possible considerations are as follows:

1. Explosive Cutting
2. Milling Exposed Portions of Tank
3. Plasma-Arc Sectioning
4. Removal of Tank Sections following Removal of Surrounding Biological shield
The bottom plug will have been removed prior to the removal of the A and E Tanks. For removal, it can be attached to the overhead crane by two existing eyebolts, unbolted from the bottom, and then lowered.

The MTR Reactor biological structure is interlaced with 105 various experiment penetrations. Of these, 30 are horizontal penetrations, 69 are vertical and 6 are downbeam penetrations on a 30 degree slant. The bulk of these penetrations have inserts in them in the form of imbedded chambers. Prior to dismantling the biological shielding around the reactor vessels, it would be advisable to remove as many of the chambers as is economically and physically feasible. By removing these chambers, a great deal of the contamination build-up in the penetrations can be removed, thus limiting the contamination control problems inherent in the demolition of a reactor structure.

The demolition of the biological shielding includes sectioning and removing of all imbedded structural supports, piping, conduit, thermal shields, experiment liners, air ducting, permanent graphite blocks, and the high density barytes concrete shield. The stage demolition will progress from the top downward and from the reactor vessel center line outward.

Stage I:
Top of structure at 120' 6" elevation to 115' 0" elevation
except outer steel shell to be removed at Stage V.

Stage II:
115' 0" elevation to 107' 0" elevation
Top Thermal shield plates
Permanent graphite blocks

Stage III
107' 0" elevation to 95' 0" elevation
Remaining thermal shield plates

Stage IV:
95' 0" elevation to sub-pile room ceiling

Stage V:
Sub-pile room ceiling to floor (el. 79' 10"
Outer steel shell
LIST OF FIGURES

1. Idaho National Engineering Laboratory
2. Test Reactor Area
3. MTR Reactor Structure
4. MTR Reactor Vertical Cross Section
5. Reactor Structure N-S Center
6. Reactor Structure E-W Center
7. Reactor Structure Horizontal Cross Section at Reactor Center Line
9. Reactor Air Flow Schematic
FIGURE 3  MTR REACTOR STRUCTURE
Figure 4

MTR Reactor Structure
Vertical Cross Section

MTR Reactor Vertical Cross Section
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PNL STUDIES OF D&D AT HANFORD

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INTRODUCTION

The Hanford Reservation in the State of Washington was selected in 1943 by the United States Army Corps of Engineers as the location for reactor and chemical separation facilities for the production and purification of plutonium. The years since 1943 have seen the construction, use and retirement of graphite-moderated reactors, several generations of chemical processing plants, facilities ancillary to the production plants, laboratories, and a large number of ground sites used for the disposal or storage of contaminated equipment and solid or liquid wastes. In consequence, the decontamination and decommissioning (D&D) of retired, contaminated facilities at Hanford offers a great engineering and economic challenge.

HANFORD RESERVATION

The Hanford site (Figure 1) measures 570 square miles or 365,000 acres. The reactor facilities are located along the Columbia River in what is known as the 100 Areas. The reactor fuel processing and waste management facilities are in the 200 Areas which are on a plateau about 7 miles from
the river and about 200 feet higher in elevation than the 100 Areas. The 300 Area, just north of Richland, contains the reactor fuel manufacturing facilities and the research and development laboratories. A few miles north of the 300 Area, the FFTF and WPPSS Hanford No. 2 reactors are under construction.

A representative section of a typical Hanford reactor area, 100 B-C, is shown in Figure 2. Of major concern in the D&D program are 1) the reactor building with its ancillary recirculating gas and ventilation systems and 2) the retention basin system used for return of reactor coolant water to the river.

Major features of the chemical processing areas are diagrammed in Figure 3. These areas include five chemical processing plants and one semi-works, a plutonium purification and fabrication plant, extensive facilities for the storage and handling of high-level liquid and solid wastes, laboratories, and many contaminated burial grounds, cribs, ditches and ponds. The semi-works and some of the plants and laboratories have been retired. Others are held on stand-by or have been converted to uses supporting the waste management program. Many of the contaminated soil sites have been retired.
D&D AT HANFORD

For a number of years, Hanford has been the site of varied D&D-related activities. Some idea of the scope may be gained from Figure 4. The UNI characterization of the retired 100 Areas involves taking and analyzing samples from many locations (soils, filters, reactor cores, etc.) to improve the knowledge of radionuclide inventories. AEC/ERDA, ARHCO, PNL and UNI have long been concerned with the migration of contamination through soil and with development of techniques for stabilizing soils against wind erosion, plant and animal incursion, and downward movement of radionuclides to the water table. PNL maintains an active investigation of the part that plant and animal life and non-biological environmental forces play in the transport of radioactivity into the Hanford environs. PNL is studying safety and cost factors in decommissioning fuel cycle facilities for NRC and has started a study of methods for characterizing solid waste burial grounds. ARHCO has active programs to demonstrate the recovery of plutonium from ground disposal sites and to study techniques for dismantling and consolidating contaminated equipment and facilities. Consideration is also being given to the possible recovery and disposal of fission products from cribs, burial grounds, etc.

The PNL study, D&D at Hanford, was started in June, 1974, with the objectives stated in Figure 5.
Task 1.

The first task, to establish methods, costs and priorities for D&D at Hanford, has been approached in the following manner:

1. An annotated bibliography of over 400 D&D references has been prepared and issued as a formal BNWL report.*

2. The contaminated facilities at Hanford have been categorized into the eleven groupings shown in Figure 6. The following comments about some of these classes might help provide an idea of the magnitude of the D&D problem at Hanford.

   • Contaminated Liquid Disposal Sites.
     These include surface ponds or ditches and underground structures called cribs. As of September, 1974, a total of 177 cribs had been provided in the 200 Areas for disposal of intermediate-level liquid waste. Of these, 144 are now deactivated, eight were not used, ten are in standby, and 15 are in current use. There are also 30 surface ponds or ditches in the 200 Areas used for disposal of cooling water.

been discharged to 30 surface ponds or ditches. About 360 acres of land have been used for these disposal operations, with about 180 acres currently in use. Cribs, ditches, and ponds are located in the 100 and 200 Areas in large numbers.

- **Contaminated Solids Storage and Burial Sites.**

As of September, 1974, more than five million cubic feet of contaminated dry solids had been buried in the 100 Areas, 200 Areas and near the 300 Area. Initially, transuranic waste received special packaging for containment, but was not buried for 20 year recovery. Since May 1970, transuranic waste is packaged in sealed metal containers, segregated from other waste, and placed in special burial trenches to permit recovery in the original packaged condition.

- **Fuel Storage Basins.**

Each reactor has its fuel storage basin, and three additional basins were constructed on the 200 Areas plateau. Most of them were left with water in them on retirement. Some were filled with clean soil to prevent spread of contamination.
- Reactors

Nine reactors were built for plutonium production. Only N-Reactor, designed also for power production, is still operating. The other eight are retired or on stand-by.

- Reactor Retention Basin Systems.

Each single-purpose reactor was cooled by once-through flow of water from the Columbia River. Effluent water passed through large-diameter steel or concrete pipe to a retention basin and thence back to the river. Some of the basins are concrete, some are mild steel. The concrete basins leaked and contaminated adjacent soil. All have had at least a foot or two of clean soil added to prevent spread of contamination. The systems include several linear miles of contaminated buried pipe-line.

3. As many as five possible alternatives were identified for treatment of each category of facilities. The alternatives under consideration are shown in Figure 7.
Procedures considered applicable to each alternative were described, and consideration was given to the volumes of contaminated waste that would be generated and to methods of waste disposition.

4. The following cases were selected for evaluation of over-all D&D strategy at Hanford:
   - Complete cleanup of retired ERDA facilities
   - Cleanup of the areas near the Columbia River and dedication of the 200 Areas for long-term nuclear use including storage or burial of radioactive wastes. Wastes removed from the 100 and 300 Areas would be relocated to the 200 Areas.
   - Dedication of the entire reservation for nuclear uses.

5. Preliminary cost estimates will be made for several scenarios based on the above cases, safety implications will be reviewed, and priorities will be established for the various scenarios. We anticipate that selected scenarios will then be subjected to more extensive evaluations of hazards and costs.
Task 2.

Under the second task, to provide the detailed planning for a specific D&D demonstration, we have selected a relatively small building which is highly contaminated. This facility, the 233-S Building, is adjacent to the Redox Plant and was used for concentration of the plutonium product from Redox. Some of the principal features of the 233-S Building are outlined in Figure 8. Our best estimate of the plutonium inventory in the hood is that it does not exceed 1.5kg. This value was arrived at by placing metal discs at various places on the outside of the hood and determining the induced activity in the discs. The activity appears to be localized in or near one of the process vessels.

Much of the interior of the building was contaminated as a result of a violent chemical reaction in one of the process vessels, which breached the hood and caused a fire. The facility was cleaned of gross contamination, painted and returned to service for a few years. The facility was retired from production service in 1967. Continued surveillance and maintenance of the ventilation system are necessary, and entry to the building is made only under carefully monitored and controlled conditions.
In early planning, we identified the disposition alternatives listed in Figure 9. Because a major objective of the program is to learn as much as we can about D&D technology for this type of facility, we are basing our detailed procedures on the fifth alternative--to strip the facility, decontaminate it as far as practical, and dismantle the structure. The operations will be phased, however, to permit stopping with the building structure intact should that be desirable. The six phases, or activities, of the demonstration are listed in Figure 10. Activity IV, to be conducted after the process hood is cleaned out, provides for in-hood testing on actual plant equipment and structures of a variety of decontamination and size reduction procedures. We plan to conduct at least limited testing of advanced technology also in Activities II, III, and V. We also expect to document the various activities thoroughly, to provide a complete record of events and results.

SUMMARY

In summary, the PNL D&D at-Hanford program involves 1) the preparation of a long-term plan for a systematic approach to the extensive and varied problems of decommissioning retired facilities at Hanford; and 2) a D&D demonstration project, the decommissioning of a grossly-contaminated plutonium processing facility.
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2. TRANSPORT OF RADIONUCLIDES THROUGH SOIL, AIR, GROUNDWATER & BIOTA (ARHCO, PNL, UNI)

3. STABILIZATION OF CONTAMINATED SOILS (ARHCO, PNL, UNI)

4. DEVELOPMENT OF SAFETY AND COST OF DECOMMISSIONING FUEL CYCLE FACILITIES (REGS—PNL)

5. EQUIPMENT AND FACILITIES DECOMMISSIONING (ARHCO)

6. CHARACTERIZATION OF 300-WYE AND NORTH BURIAL GROUND (PNL)

7. DISPOSITION (D&D) OF RETIRED CONTAMINATED FACILITIES AT HANFORD (PNL)
DISPOSITION (D&D) OF RETIRED CONTAMINATED FACILITIES AT HANFORD

OBJECTIVES FOR FY1975-76

- ESTABLISH METHODS, COSTS, PRIORITIES FOR D&D OF RETIRED, CONTAMINATED FACILITIES AT HANFORD (TASK 1)

- FORMULATE PLANS FOR A SPECIFIC D&D PROJECT TARGETED TO START IN FY1976 (TASK 2)

- IDENTIFY R AND D NEEDED FOR D&D PROJECTS.
CATEGORIES OF CONTAMINATED FACILITIES AND SOIL SITES

1. CONTAMINATED LIQUID DISPOSAL SITES
2. CONTAMINATED SOLIDS STORAGE AND BURIAL SITES
3. FUEL PROCESSING FACILITIES
4. FUEL STORAGE BASINS
5. GAS & EXHAUST AIR SYSTEMS (REACTORS)
6. LABORATORIES
7. REACTORS
8. RETENTION BASIN SYSTEMS
9. TRANSURANIC FACILITIES
10. URANIUM FACILITIES
11. WASTE MANAGEMENT FACILITIES

FIGURE 6
DISPOSITION ALTERNATIVES

1. SHORT-TERM MAINTENANCE AND SURVEILLANCE (PENDING FUTURE DEVELOPMENTS)

2. PREPARATION FOR LONG-TERM MAINTENANCE AND SURVEILLANCE (PENDING DECAY OF SHORT-LIVED NUCLIDES)

3. STABILIZATION IN PLACE (ENTOMBMENT)

4. DECONTAMINATION TO LOWEST PRACTICAL LEVEL

5. DISMANTLING AND REMOVAL

FIGURE 7
TASK 2: D&D DEMONSTRATION PROJECT (233-S, PLUTONIUM CONCENTRATION BLDG.)

- STRUCTURE: 85'x37'x32'; CONCRETE & METAL WALLS
- EQUIPMENT: PLEXIGLASS PROCESS HOOD CRITICALLY-SAFE VESSELS & PIPING
- CONTAMINATION:
  - BETWEEN 1 AND 3 Kg PLUTONIUM IN HOOD
  - AS HIGH AS 800,000 D/M SMEARABLE CONTAMINATION OUTSIDE HOOD.

FIGURE 8
FIGURE 9

TASK 2: D&D OF 233-S

DISPOSITION ALTERNATIVES

MAINTAIN AS IS
ENCLOSE IN CONCRETE SHELL
ENTOMB (ENCASE & FILL)
STRIP INTERIOR & DECONTAM.*
DISMANTLE FACILITY *

*PREFERRED ALTERNATIVES
MAJOR ACTIVITIES: D&D OF 233-S BUILDING

ACTIVITY I. DETAILED CHARACTERIZATION OF THE FACILITY

ACTIVITY II. SITE PREPARATION

ACTIVITY III. DISMANTLING AND REMOVAL OF PROCESS EQUIPMENT

ACTIVITY IV. IN-CELL TEST PROGRAM

ACTIVITY V. FINAL DECONTAMINATION

ACTIVITY VI. DEMOLITION
DESIGN FEATURES FOR DECONTAMINATION
IN NEW PLUTONIUM FACILITIES

by
Kenneth J. Freiberg
&
Charles G. Haynes

August 1975

RFP - 2428

Because radioactive contamination can not only make a place unfit for its intended use, but also can expose operating personnel and the public to significant health hazards, design criteria have been established for preventing and controlling contamination, and methods have been developed for removing contamination if necessary.

ERDA has developed design criteria intended to assure that contamination can be prevented or controlled in its facilities, and that the facilities ultimately can be decommissioned to a safe status. ERDA's "General Design Criteria" (ERDA Manual Appendix 6301, Part II) was utilized in developing the design of the new Plutonium Recovery and Waste Treatment Facility at Rocky Flats Plant, Golden, Colorado.

Specifically, the General Design Criteria directs that:

1. Design of critical areas shall incorporate measures to simplify decontamination.

2. The building shall be designed to facilitate decontamination for decommissioning.

3. Ancillary equipment shall be located in areas that are least likely to become contaminated.

A primary design goal for the new Facility is to confine radioactive materials during normal operations and design-basis accident conditions. Hence, in the new Facility, the primary goal with respect to contamination is designing the structure and equipment to keep the radioactive
materials confined within the areas where they are supposed to be. This is where the most effective decontamination savings are realized.

However, since it is impossible, from a practical point of view, to prevent some contamination, design features are incorporated that make it easier to remove the contamination during useful life of the Facility, and when it is decommissioned.

Specific features for preventing, containing, controlling, and removing contamination in the Plutonium Recovery and Waste Treatment Facility are outlined below.

Design Features For Contamination Containment

I. Structure

The building is constructed from reinforced concrete and designed with tornado and seismic considerations. As the expected structure life will exceed the process life, the ability to decommission the facility becomes apparent.

A. Compartmentalization

Compartmentalization provides for physical separation of various production and support processes. Each compartment is also isolated by ventilation design.
B. Air Locks

Air locks isolate areas both physically and by ventilation. Air lock doors are separated so that it is impossible for one person to open both doors simultaneously.

C. Sealed Penetrations

All penetrations, such as process piping, ductwork, conduit, etc., through any walls, floors, and ceilings are sealed to prevent contamination movement from one area to another. Conduit is internally sealed to further limit spread of radioactive materials.

D. Pneumatic Stack Closure Valves

These valves are on each ventilation discharge point to provide protection against the high negative pressures of tornadic winds. They also provide the capability of complete shutdown and isolation of the facility in case of a major incident.

E. Canyons

The canyons remove process equipment from a glovebox-type operation. As most contamination incidents in our present
facility are glove failures, this will reduce the number of incidents as well as lessen the exposure potential. The canyons isolate the process equipment physically and by ventilation and operated remotely. Access into the canyons for maintenance purposes is through air locks with submarine-type doors.

F. Remote and Shielded Storage

All in-process material is stored and most solid material transfer is through a computer controlled stacker-retriever that is glovebox accessible from most process areas. This vault eliminates glovebox storage and reduces material handling thereby minimizing contamination incidents.

G. Curbs

The curbs are two-inch high concrete dams located at critical points in and around the process area. They are for the purpose of restricting liquid movements, primarily fire sprinkler water, from one area to another. The two-inch height is dictated by criticality considerations.
II. Ventilation

A primary function of the ventilation system is to assist in the containment of contaminates and to control the spread of contamination if it escapes from its confines. This is accomplished by some of the following.

A. Four Separate Zones

The ventilation system is designed to direct the flow of air from the area of least contamination to the area of greatest contamination. The areas are broken down into four separate zones, each separated physically as well as by pressure differentials created by the ventilation system.

B. Adequate Air Flow

The rates of air changes are dictated by the need to control contamination, to control dust in certain operations and to prevent the buildup of radioactive material within gloveboxes. The air change or flow rates are:

<table>
<thead>
<tr>
<th>Area</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gloveboxes</td>
<td>30 changes/hour</td>
</tr>
<tr>
<td>Hoods</td>
<td>150 feet/minute</td>
</tr>
<tr>
<td>Downdraft Tables</td>
<td>200 feet/minute</td>
</tr>
<tr>
<td>Submarine Doors</td>
<td>75 feet/minute</td>
</tr>
<tr>
<td>Work Areas</td>
<td>15 changes/hour</td>
</tr>
</tbody>
</table>
The work area change-rate has evolved from experience and from testing performed at Rocky Flats using various air change rates. The fewer air changes per hour, the larger the area of contamination spread.

Proper location of work area exhaust ducts also minimizes contamination spread. Ducts located floor level draw air away from breathing zones as well as reducing spread. The ducts are placed under the gloveboxes and around the perimeter of the room.

C. HEPA Filtration and Scrubbers

The filter plenums are designed such that, in case of an accident and loss of one stage of filtration, contamination will be contained within the building. The room air plenums have two stages of filtration and the process plenums have four. The plenums have a separate air lock to each stage with submarine doors. The scrubbers, primarily for removal of chemical pollutants, are also quite effective for removal and containment of particulate contamination.

III. Gloveboxes

Design advancements in gloveboxes have been minimal for many years. Some new thoughts incorporated into the gloveboxes for the new facility are:
A. Remote Operations

Many operations are remotely controlled even though they are in gloveboxes. This reduces man-hours in the gloves and lessens the number of incidents due to glove failures.

B. Spacing and Location

Each glovebox is designed around its particular piece of equipment; therefore, the glovebox is neither too small and cramped nor too large as to make areas inaccessible. This feature reduces excessive stress on the glovebox and helps prevent glove failures.

C. Inline HEPA Filtration

The inline filters consisting of a HEPA filter and a roughing filter at the exhaust point in the glovebox prevents buildup of residual contamination in the HVAC ductwork. This is a nuclear safety consideration as well as contamination control.

D. Elimination of Air Locks on Gloveboxes

Air locks were eliminated as they presented contamination control problems. Most equipment enters or leaves the glovebox
over a downdraft table. The downdrafts are contained within separate metal rooms in the work area.

E. Elimination of Bag-Ports

Chemical recovery of Plutonium created many problems for the common bagging method. To eliminate this procedure, pneumatic transfer, gravity feed, the stacker-retriever and a double-port transfer device are being utilized. The double-port device is a device where a container can be easily attached to or removed from special glovebox ports located throughout the building.

F. Enclosure of Criticality Drains

The existing criticality drains overflow from the glovebox to the floor and are a constant source of contamination. The new design has each drain piped to critically safe holding tanks. There are separate drain systems because of chemical incompatibility of some processes. This entire system is continuously monitored by level alarms.

G. Dust Control

Dust-generating equipment will be enclosed and ventilated within the glovebox to minimize buildup of material.
Cyclone separators are also utilized. The lesser amounts of loose material decreases the scope of any incident.

H. Pneumatic Transfer

The transfer of liquids and fines by pneumatic methods within double contained piping minimizes other methods of material handling, thereby decreasing the potential for an incident.

I. Double Containment and Welded Pipe

The most common problem with process piping systems is leakage at the flanges. Most flanges external to gloveboxes and canyons were eliminated. In addition, most process piping is double contained utilizing cryogenic type piping in process areas. Cryogenic piping is sloped so that plutonium solutions drain back to the glovebox.

IV. Fire Protection

Quickly extinguishing a fire involving contaminated materials will not only reduce fire damage but decrease the area of contamination. Overheat detectors with remote alarms and fire sprinklers are required for rapid response and control. Most sprinklers are heat activated, both on and off, to prevent accumulation of
excessive amounts of fire water. Water from sprinkler systems protecting the filter plenums is collected in a critically safe holding tank. Holding ponds have been provided in case of a massive incident that requires volumes of water greater than the capacity of the tanks.

V. Health Physics Selective Air Monitor System

The primary function of the continuous air monitors is to warn personnel of airborne contamination. As the air monitors are remotely alarmed to the guard shack as well as the Health Physics Office, contamination surveillance is provided during off hours, and in unmanned areas. They have been known to detect a smoldering fire before the overheat detection system.

Design Features For Decontamination

I. Structures

Several features were incorporated in the basic structure to facilitate decontamination. Some of those are listed below.

A. Smooth Clean Surfaces

The concrete finish is specified so that all pits, protrusions, cracks, etc., are minimized. Any cracks in the walls are sealed by epoxy injection.
B. Accessible Surfaces

All surfaces are designed so that they are accessible for decontamination. Concrete inserts for hanger support are replaced by steel plates.

C. Water Proofing

The exterior of the structure is waterproofed to prevent out-leakage of contaminated liquids or in-leakage of sub-surface water.

II. Surface Finishes

The finish on all surfaces, including equipment, was evaluated so that a good decontaminatable finish would be available.

A. Floors

Additional water proofing is applied to the concrete floors to prevent liquid movement from one level to another. Over the water proofing a re-inforced 4-inch thick concrete cover is poured. All edges and corners are coved to make them accessible. All seams are filled. Several coats of an epoxy and aggregate finish is applied. The epoxy is 90 mils thick and is resistant to most process chemicals.
B. Walls and Ceilings

The concrete is finished to a smooth surface, then given a treatment to fill small pits and voids. A primer coat is then applied followed by 3 coats of epoxy with a total thickness of 8 mils. Experience has shown that light colors are easier to decontaminate, therefore, they are applied to all surfaces.

C. Metal & Equipment Surfaces

A high gloss epoxy or enamel is applied to all equipment in the process area to assure decontaminatibility. Electrical equipment that must be in the area is sealed, supply air ducted to them with HEPA filtered outlets. This is to pressurize the cabinet to prevent internal contamination to equipment that is uncleanable. The supply air also cools the equipment.

III. Gloveboxes

Several additional features were incorporated in the glovebox design to facilitate contamination removal.

A. All corners and edges are rounded for accessibility and to prevent material buildup. All seams are welded, flanges are
held to minimum. The gloveboxes are spaced so that all surfaces are accessible. Epoxy is applied to all lead shielded gloveboxes. All seams in the lead are epoxy filled to assist decontamination and to prevent contaminates from getting behind the shielding. Neutron shielded gloveboxes are double walled and water filled. This eliminates the contamination traps associated with external shielding.

IV. General

A. Piping Held to a Minimum

Remote chemical operations generally dictate large quantities of conduit as well as process piping. By relocating that which does not have to pass thru a process area, some of the more difficult decontamination work is reduced.

B. Pre-Filtration

Pre-filtration is utilized on room air ductwork as well as the glovebox exhaust. Roughing filters reduce contamination levels within the ductwork. They also lessen the accumulation of lint which can be a fire hazard.
C. Control Rooms

Control rooms remove people and equipment from the process area. They isolate delicate equipment that cannot be effectively decontaminated.

D. No Threaded Rod

Threaded rod, unistrut and concrete inserts are standard items in the construction industry, but they are difficult to decontaminate and present safety hazards when decontamination is attempted. Fully threaded rod and unistrut have been replaced by square tubing and angle iron welded to steel plates in the concrete, which replaces the standard concrete inserts.

E. Spacing

All equipment should be spaced so that all surfaces are available for decontamination. HVAC duct work will be separated to provide access. If space is not available the inaccessible area will be enclosed. All piping and conduit will be separated so that it can be wiped down. Large equipment is located so that it is accessible from all sides.
F. Ventilation and Compartmentalization

A primary function of a ventilation system is to decontaminate building air. Proper location of ductwork aids in surface decontamination efforts. Room air exhaust ducts are located away from entry doors to prevent direct entrance into areas of highest contamination levels. Supply air ducting is located in the attic area with sealed penetrations thru the ceiling. A HEPA filter acts as a diffuser for the supply air and prevents possible entry of contamination into the ductwork. Generally each compartment has its own ventilation system to further isolate them.

Decommissioning of a facility can only be accomplished by decontamination of that facility. Any aids to decontamination that can be incorporated into the design of the building and equipment will facilitate that goal. Probably the most important aids are proper spacing and accessibility associated with good surface finishes.
WASTE MANAGEMENT AND SAFETY
CONSIDERATIONS FOR FUTURE LASL D & D PROJECTS

ABSTRACT

Currently excess contaminated facilities at the Los Alamos Scientific Laboratory are described along with associated Decontamination and Decommissioning waste management and safety considerations. Waste management and safety considerations are also briefly described for the removal and disposal of plutonium contaminated gloveboxes and equipment items in the LASL plutonium facility since the facility will be decontaminated when current operations are transferred to a new facility and for both past and future upgrading of the exhaust air filter system in a chemistry metallurgy research facility.

by

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*Work done under the auspices of The Energy Research and Development Administration

July, 1975
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WASTE MANAGEMENT AND SAFETY CONSIDERATIONS
FOR FUTURE LASL D & D PROJECTS

1. Introduction

Several excess facilities at the LASL are contaminated with radioactive materials to an extent they cannot be occupied without health physics control and cannot be beneficially used in their present condition. Similarly, facilities, equipment items and numerous miscellaneous tanks, pits and pipe lines have been or are expected to be declared excess due to reorientation of research programs, the termination of certain projects, and/or construction of new facilities. In many instances, these excess facilities have accumulated over the past years because of a continuing need to commit operating funds to more direct support of vital research programs.

Safety considerations always have been paramount both in identifying a need for and in the accomplishment of Decontamination and Decommissioning (D & D) type projects at the LASL. Waste management considerations and planning, although important to the overall project completion, have been handled with relative ease of accomplishment owing to the rather basic approach of burial of the resulting debris in an approved onsite solid radioactive waste burial site. More recently as a consequence of the nature of pending projects, and the issuance of ERDA-MC-0511, considerably more complicated waste handling and disposal concerns related to these projected D & D activities
are being identified. Specific problem areas include:

1. providing packaging, handling, and storage for large bulky items
2. providing the means for decontamination and/or size reduction of large bulky items of waste for both burial and storage
3. safety of personnel during accomplishment of these more extensive required waste management activities
4. means of assay to determine quantity of TRU-contamination present
5. containment of tritium contamination

Presently the LASL is in the early planning stages on D & D projects involving several contaminated facilities. These facilities and related waste management and safety concerns are discussed.

2. Excess Contaminated Facilities and Equipment Items

Listed in Table 1 are the major excess contaminated facilities and equipment items that have been identified at LASL. Some of these excess contaminated facilities and equipment items represent significant potential sources of radioactive material which may be accidentally dispersed in the event of a fire or other destructive occurrence. One facility which was abandoned in 1974, releases a few thousand curies of tritium per year to the atmosphere because the exhaust ventilation system must continue in operation to protect
## TABLE I

**LISTING OF EXCESS CONTAMINATED FACILITIES AND MAJOR EQUIPMENT ITEMS AT LASL**

<table>
<thead>
<tr>
<th>NOMENCLATURE</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment</td>
<td></td>
</tr>
<tr>
<td>2. Filter Building and Equipment</td>
<td>TA-21, Bldg. 153</td>
</tr>
<tr>
<td>3. Incinerator Facility</td>
<td>TA-42</td>
</tr>
<tr>
<td>4. UHTREX Reactor Facility</td>
<td>TA-52</td>
</tr>
<tr>
<td>5. Tritium Gloveboxes</td>
<td>TA-35, Bldg. 2, Rm A-12, A-12A and A-12B</td>
</tr>
<tr>
<td>6. Air Washer and Equipment Ra-La Liquid Waste Tanks</td>
<td>TA-35, Bldgs. 6, 7, and 10</td>
</tr>
<tr>
<td>7. LAMPRE Reactor Vessel</td>
<td>TA-35, Bldg. 2, Rm L</td>
</tr>
<tr>
<td>8. LAPRE II Reactor Vessel</td>
<td>TA-35, Under TA-0-585 Trailer</td>
</tr>
<tr>
<td>9. Liquid Waste Tanks</td>
<td>TA-35, Bldg. 37, 38, 39 and 40</td>
</tr>
<tr>
<td>10. Sodium Storage Tanks</td>
<td>TA-35-43</td>
</tr>
<tr>
<td>11. Misc. Abandoned Pits, Tanks and Lines</td>
<td></td>
</tr>
</tbody>
</table>
personnel working in the adjacent laboratory facilities. The presence of these contaminated facilities also hamper and in some cases prevent beneficial use of other associated building and land spaces.

The Water Boiler Reactor was a low power homogeneous reactor fueled with enriched uranyl nitrate solution. The fuel was contained in a stainless steel sphere with volume of approximately 13 liters. The uranyl nitrate fuel was removed in 1974. The reactor vessel with its associated recombiner and plumbing is contained in a concrete, graphite-lined biological shield structure that has an approximate volume of 73 m$^3$. The reactor and its biological shield structure and control room is housed in a frame building approximately 18 m x 18 m x 8 m. Gaseous effluents from the reactor were released via a small double encased stainless steel line which exited the reactor enclosure underground and proceeded to an underground concrete chamber. This chamber contains several pumps and tanks. The line passed through this chamber and on to an aboveground concrete valve house. From the valve house, the effluent line entered a condensing trap and two delay tanks before terminating at a stack. The delay tanks are stainless steel and have volumes of approximately 3 m$^3$.

Radiation surveys indicate radiation levels in excess of 50 R/h at the reactor vessel surface primarily from induced $^{60}$Co activity. The stack line, underground chamber, valve house and delay tanks have contact radiation levels as high as
The primary concern with this disposal will be personnel exposure control during removal, packaging and transport to LASL radioactive solid waste disposal site. Because of the presence of high gamma radiation levels from the reactor components, any significant size reduction will be extremely difficult without special shielded and/or remote facilities.

Not connected with the reactor, but in the same general area, and no longer being used, is a septic tank. This tank is contaminated with fission products and has an approximate volume of 8 m$^3$.

The Filter Building and Equipment items are located at the DP-East site and about 15 m from an operating facility. This filter building is a two story frame and masonry structure with 300 square meters of floor area on the ground floor and 84 square meters on the second story. The building was used for cleaning the exhaust air from buildings at DP-East from the late forties until March, 1970. The building contains several lineal meters of metal ducts, and associated plenums, filter housings, two blowers, and two stacks. Dismantling this facility to effect size reduction particularly of the plenums, ducts and other bulky pieces is needed to minimize the volume of contaminated waste that must be disposed of on site.

The primary radioactive contaminant in this facility is $^{227}$Ac and its daughters. Precleaning after shutdown removed most of the contamination in those parts of the building which
could be decontaminated without dismantling. However, unmeasured quantities of radioactive contamination remain on inaccessible surfaces in the duct work, plenums, blowers and stacks. TRU-retrievable packaging is not of concern in this project, and a similar facility was decommissioned in 1973 by LASL.

The **Incinerator Facility** is located approximately 120 m west of Pecos Drive immediately north of TA-55, the new LASL plutonium facility which is under construction. The incinerator is adjacent to a control office building which contains about 185 square meters of floor space. This building houses the office, change room, sorting area, and entrance ports to the incinerator. Associated equipment items include blowers, cyclones, separators and other air cleaning devices, two large storage tanks plus drain lines, a septic tank and drain field. Preliminary decommissioning work accomplished in 1975 resulted in the removal of walls inside the control office building and removal of most equipment items except the incinerator and its associated liquid tanks.

Internal surfaces of the incinerator, liquid waste tanks, drain lines, and air cleaning devices are contaminated with plutonium. While levels are thought to be sufficiently low to allow disposal as nonretrievable waste, accurate assay of the major contaminated areas of many of these items will be almost impossible. Many of the removable equipment and facility components are bulky by nature and will lend themselves to considerable size reduction if facilities to effect this were
available. Additional handling associated with size reduction efforts would pose an increased worker exposure risk, however.

The **Tritium Glovebox Line** is located in the basement of an operating facility. This glovebox line is a combination of gloveboxes and hoods interconnected directly or by transitions. The gloveboxes and hoods have a combined length of approximately 25 meters and are constructed of steel frame with glass or plastic windows. Some of the glovebox and hood sections were assembled in place because movement after final assembly was not possible. The line was constructed in a walled-off portion of an existing basement. It was necessary to excavate and remove a portion of the exterior basement wall to get some of the associated large equipment items into the basement. The wall was then rebuilt and area back-filled with soil. At present, in and around the gloveboxes and hoods, there are numerous vacuum pumps, utility lines and exhaust ducts. Also in the main room there are conventional laboratory cabinets and benches. An adjacent room houses the electrodryer and its associated pumps and lines. Exhaust room ventilation, the glovebox and the hood ventilation is provided by an exhaust blower and stack system separate from the main building exhaust system. This system is not equipped with effluent treatment systems for tritium removal; hence a few thousand curies of tritium is released per annum.

It is estimated that there are some $10^4 - 10^5$ Ci of residual tritium contamination in the electrodryer system, and between
2000 and 10 000 Ci of tritium in the glovebox line itself. Spraying the walls of the gloveboxes and hoods with asphalt followed by sectioning and packaging the systems for burial has been suggested as one possible disposal and containment means. However, recent investigations of tritium waste disposal at the primary LASL burial site indicate that the past use of asphalt has been almost, if not totally, ineffective in containing the tritium in the waste. In an object as large as this glovebox chain, the capability of applying an effective asphalt coating also must be questioned. Additional study of means of application, adherence, and effectiveness of such a coating should be carried out prior to initiation of this project. Means of assuring safe handling and containment of the tritiated water in the dryer system are not expected to pose as great a problem, since these systems are contained in heavy metal tanks.

The Exhaust Air Washers and several Ra-La Liquid Waste Tanks are located east of the main laboratory office building at Ten Site, an occupied area. These large systems received contaminated exhaust air and liquid wastes from the main facility at Ten Site and are contaminated with fission products, primarily $^{90}\text{Sr}$ and $^{137}\text{Co}$, and low levels of TRU materials.

The components of these systems are large metal and/or concrete structures and it will be extremely difficult to effect size reduction prior to disposal without significant additional worker risk.
There are several other equipment items in and around these facilities that could be eliminated such as the old pumphouse and several smaller liquid waste tanks.

The UHTREX Reactor Facility is located south of Puye Road approximately 300 m east of Pajarito Road. This reactor was a gas cooled research reactor which was operated at high temperatures. It utilized enriched uranium impregnated in graphite rods for fuel elements. In addition to the reactor are numerous large equipment items such as heat exchangers, gas clean-up systems, pumps, filters and stack. The irradiated fuel elements have been removed, however, and undetermined quantity of fuel fragments remain in the graphite liner of the reactor vessel along with a $^{238}$Pu neutron source.

Both waste management and safety considerations regarding the future disposition of this facility indicate that it may be best to leave the reactor vessel in place, removing only the associated contaminated reactor hardware from the facility. Other possible uses for the UHTREX facility are being proposed, some of which (e.g. LASL High-Temperature Helium Test Loop Facility) make use of much of the existing facility equipment while leaving the reactor vessel in place. Obviously such future applications of these facilities is most advantageous from the waste management standpoint when compared to complete facility decommissioning.

The LAMPRE Reactor Vessel is located in the main labora-
tory office building at Ten Site. The LAMPRE reactor was defueled in the mid-1960's leaving a vessel which has approximate dimensions of 6 m long and 0.6 m diameter. The vessel is steel and most of the associated cooling pipes and control apparatus have been removed. The vessel is setting upright in a basement room which opens into a high bag ground level room. The top of the vessel is shielded by graphite and lead bricks. Radiation surveys indicate radiation levels of ~5 R/h at the top support yoke and ~200 R/h immediately above the vessel surface.

It is estimated that 50-100 gms of $^{239}$Pu remain in the vessel cooling coils; consequently removal of the Pu or packaging for 20-year storage must be considered. The size, gamma radiation levels, and present locations of the LAMPRE reactor and associated contaminated hardware will make handling and packaging most difficult. If at all possible a cutting of the 6 m long core vessel into three (or more) smaller sections followed by packaging into shielded containers, or removal of the Pu, should be effected.

The LAMPRE II Reactor Vessel is located below ground level at Ten Site. The LAMPRE II reactor was an experimental reactor used for early liquid metal reactor experiments. The reactor was defueled in 1959 and all associated equipment except the vessel and fuel storage tank were removed later in 1959. The vessel is covered with dirt and a layer of black top and a trailer is positioned on the black top directly above the

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vessel location.

The vessel is approximately 1.8 m in diameter and 3 m long and is constructed of stainless steel and with a gold lining. Radiation levels are not significantly above background in the area adjacent to where the vessel is located. Justification for removal of the vessel would be to facilitate a general area clean-up and to consolidate the location of all buried radioactive residues. However, in the present location, little of any direct hazard is present, and perhaps leaving the LAPRE II reactor vessel in place is the most desirable from both the waste management and safety standpoint.

The four (4) Liquid Waste Treatment Tanks located at Ten Site are about 1.8 m in diameter and 3 m deep. The tops of these tanks are at ground level and two of the tanks house ion exchange columns. The other two tanks provide regenerator and flocculator storage capacities. The drain lines, ion exchange columns, pumps, and various liquid piping systems associated with these tanks would be removed. Undetermined levels of fission products including $^{90}$Sr exist on the inside surface of these tanks, ion exchange columns and pipes. The penetrating radiation associated with these tanks and systems will make handling and packaging difficult. Since the systems do not contain plutonium there will be no need to package and treat the resulting waste as TRU-waste.

Two Sodium Storage Tanks are located several hundred yards south of the main laboratory office building at Ten Site.
and on the edge of a small canyon. These underground double walled stainless steel tanks are 12-15 cm ID and about 40 m long. The tanks are approximately 0.6 m apart and the tops are near ground level. They each contain approximately 115-150 liters of sodium which is contaminated with some fission and activation product activities, and probably some $^{239}$Pu. The pumps, lines and exposed tops of the tanks are housed in a small shed. The sodium transfer pipes leading to the tanks have been removed. Radiation levels at surface of the tank range from 5-10 m$^2$/hr.

Concern has been raised regarding the presence of these tanks. However, removal and the associated handling to dispose of elsewhere likely may not be worth the associated risks and costs. Chemical treatment or controlled reaction of sodium need investigation. Also, the possibility of leaving the tanks in place while significantly modifying the surface cover and facilities is a viable alternative.

Miscellaneous Contaminated Waste Disposal Pits, Tanks and Lines have been abandoned in place on and around LASL site. These items are listed in Table II and disposition will for the most part consist of removal and on-site disposal of contaminated items followed by restoration of land area. No major waste management concerns are foreseen in such cleanup operations except for the large volumes of waste generated.
### TABLE II

MISCELLANEOUS CONTAMINATED PITS, TANKS, AND LINES

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Principle Radionuclides</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Underground pits used for liquid disposal:</strong></td>
<td></td>
<td>Ro, Ac, Ra</td>
</tr>
<tr>
<td>1. Near TA-21-164</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Unmarked: Between TA-21-2 and TA-21-3, liquids from Hanford container washing operation</td>
<td>Pu</td>
<td></td>
</tr>
<tr>
<td>3. Unmarked: TA-21-0 (dismantled laundry) between TA-21-14 and Waste Disposal Area B</td>
<td>Pu, U</td>
<td></td>
</tr>
<tr>
<td>4. At TA-49</td>
<td>Pu</td>
<td></td>
</tr>
<tr>
<td><strong>B. Septic Tanks and Sumps:</strong> TA-2, TA-21, TA-33, TA-41, TA-42, TA-46 (WA-61, 69, &amp; 70)</td>
<td>Pu, U, T</td>
<td></td>
</tr>
<tr>
<td><strong>C. Underground contaminated drain lines:</strong></td>
<td></td>
<td>Pu, U, FP</td>
</tr>
<tr>
<td>1. TA-3-700 to ULR-33 manhole</td>
<td>Pu, U, FP</td>
<td></td>
</tr>
<tr>
<td>2. ULR-33 to ULR-35 manhole</td>
<td>Pu, U, FP</td>
<td></td>
</tr>
<tr>
<td>3. HRL to ULR-35</td>
<td>Pu, FP</td>
<td></td>
</tr>
<tr>
<td>4. ULR-35 to N side Trinity Drive</td>
<td>Pu, U, FP</td>
<td></td>
</tr>
<tr>
<td>5. Under Canyon Rd. near Diamond Drive</td>
<td>Pu, U, FP</td>
<td></td>
</tr>
<tr>
<td>6. ULR-2 to N side Central Avenue</td>
<td>Pu, U</td>
<td></td>
</tr>
<tr>
<td>7. Under Rose St. near Central Ave.</td>
<td>Pu, U</td>
<td></td>
</tr>
<tr>
<td>8. Under Canyon Rd. near Central Ave.</td>
<td>Pu, U</td>
<td></td>
</tr>
<tr>
<td>9. TA-48-1 to ULR-149</td>
<td>Pu, U, FP</td>
<td></td>
</tr>
<tr>
<td>10. Miscellaneous lines at TA-21</td>
<td>Pu, Am, U</td>
<td></td>
</tr>
<tr>
<td>11. Dirt bunkers (4) at TA-15-44, 45, e, and I-J firing points</td>
<td>U</td>
<td></td>
</tr>
<tr>
<td>12. Underground chamber TA-33-29</td>
<td>Po</td>
<td></td>
</tr>
</tbody>
</table>
3. Contaminated Facilities and Equipment Items Expected to Become Excess

Construction of new facilities and effluent treatment systems upgrading projects are expected to cause several major equipment items to become excess in the next 2-3 years. Since these items are contaminated with TRU materials special planning is needed. These items and associated waste management and safety considerations are described in the following paragraphs.

The presently operational LASL Plutonium Facility commonly referred to as DP-West, has been operational since 1945. Operations at this facility will be relocated in a new plutonium facility which is currently under construction. Once operations have moved to the new site, extensive cleanup, decontamination and quite possibly some complete facility decommissioning is planned at the abandoned facility. Although the primary decision has not yet been made regarding the extent to which the LASL DP-West Pu-facility will be decommissioned, very large volumes of solid TRU waste are anticipated. These cleanup efforts likely will begin in late FY77 or FY78.

Much of this waste will be TRU-retrievable. Presently it is acknowledge that all gloveboxes and associated equipment in the recovery area will require removal. This amounts to approximately 100 lineal meters of glovebox line measuring approximately 2.5 m high by 1.5 m wide. In other Pu-processing areas, additional gloveboxes will require removal as
TRU-waste while some can be cleaned and moved into the new facility. Additional waste to be generated includes ductwork, wall plaster, contaminated soil from utility tunnels, equipment and possibly the process air filter building. A total waste volume is expected to range from 2000-3000 m$^3$ in this project.

Means to decontaminate and/or prepare the highly contaminated glovebox lines for 20-year storage are a major concern in the planning for this operation. Three alternatives have, thus far, been identified, these being:

1) providing a size reduction and decontamination facility to facilitate packaging of gloveboxes into standard sized crates.

2) package glovebox lines into oversized boxes, as is required for individual components.

3) seal all openings in glovebox lines and use the glovebox itself as the containment.

In light of current accepted ERDA-contractor practices, the first option is the most desirable; however, it is also the most costly. In the long term, assuming eventual removal of all TRU-wastes from the LASL to a centralized repository, the accomplishment of this option would be the most economical as well as the safest approach in light of the future handling, decontamination size reduction, and packaging efforts that may be required. Many other large-sized components in the
facility will require eventual size reduction, while not at this time being suitable for the other options because of their construction, contamination, etc. Overall, the option 1 indicated likely is the most desirable from the waste management standpoint. As such, funding, planning, and implementation are required.

In 1973, major modification to the air filter system in three wings of a chemistry metallurgy research facility was initiated. This facility houses varied fission product, TRU and U research and development activities in a total of 6 independent but interconnected wings. A total of 48 sections of filter plenum were generated as waste, the largest section measuring approximately 5.5 m x 5.5 m x 3.5 m (6 pieces this size). The approximate total waste volume was 1700 m³ (60 000 ft³). Assay of several sections of the plenum indicated that the two pieces at the "head end" were likely in excess of 10 nCi/g for ²³⁹Pu (also 100 nCi/g for ²³⁸Pu) and required retrievable storage. Several other pieces "down stream" were measured at or about the retrievable limits; however, the error in measurement being ± 100% or more made this determination very questionable, and it was subsequently decided to bury these pieces. Nevertheless, there are at the LASL waste disposal/storage area eight (8) pieces of this plenum which are felt to require 20-year storage for which there is no presently acceptable means of handling or storage. Furthermore, the possibility of easy decontamination at this time has been removed
because of treatment each piece received at the time of removal from the building; to facilitate the safe handling of each piece and transport to the interior surface to "fix" the contamination. Decontamination at the time of removal was not accomplished because of the difficulty and cost of the operation.

Presently anticipated air filter system modifications will result in the removal of four additional plenum systems from 2 wings, a few sections of which could be retrievable under the current 10 nCi/g standard. Total volume of waste anticipated is approximately 1130 m$^3$ (40 000 ft$^3$). This volume, as with the earlier sections, is about 75% void space. While current LASL programs attempt to reduce current operational waste volumes by a few to 10s of cubic meters per month, the existing program can have little if any impact on this large waste volume. Providing necessary means of waste size reduction is a major waste management problem to this future project.

4. Summary

Major D & D type projects currently identified at the Los Alamos Scientific Laboratory will have major impacts on volumes of radioactive solid wastes generated in coming years. Means of effecting volume reduction and decontamination of much of this waste will be essential to the proper execution of waste management programs. In particular, 50% or more of the anticipated TRU-retrievable waste to be generated in the next 4-5 years
may result from D & D operations. Most of this will be comprised of highly contaminated equipment, glovebox lines, and components of air cleaning systems. Size reduction and/or decontamination will be required to effect the proper and safe handling, packaging, and disposal or storage of retrievable TRU wastes.

Several other identified D & D type projects at the LASL will require considerable additional study to determine safe means of accomplishment. On the other hand, such study may identify modifications to D & D planning which indicate alternative uses for all or portions of existing facilities, or that the facility is best entombed at its present location, with or without some modifications.
THE HOT FUEL EXAMINATION FACILITY/SOUTH

REFURBISHMENT PROGRAM

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ABSTRACT

The Hot Fuel Examination Facility/South has been in continuous service since 1964. With the exception of a two-month air cell shutdown in 1969, all maintenance and repair has been done either remotely or by the removal of components from the cells for repair or replacement. The point has now been reached where extensive overhaul is required, and a major shutdown of the facility is planned.

During the facility shutdown, the in-cell equipment will be removed from the cells. The cells will be decontaminated, cell windows and lighting will be modified, and remote-handling equipment will be improved. When the cells and cell equipment have been cleaned and modified, the facility will be returned to service in support of the LMFBR program.
Argonne National Laboratory-West is located 36 miles west of Idaho Falls at the Idaho National Engineering Laboratory. There are four major facilities at ANL-West; these are the Transient Reactor Test Facility (TREAT), the Zero Power Plutonium Reactor (ZPPR), Experimental Breeder Reactor (EBR-II), and the Hot Fuel Examination Facility (HFEF).

The TREAT reactor is used for experimental verification of fuel failure thresholds and failure mechanism resulting from accidents. Reactor transient overpower and loss-of-coolant experiments are carried out within self-contained loops in TREAT to provide the basis for modeling the course of such events.

The major component of the Laboratory's reactor physics program is ZPPR, which provides valuable information about the behavior of proposed fast reactor designs. ZPPR is the nation's largest fast reactor critical assembly and the only zero-power reactor in the world large enough to permit plutonium-fueled mockups of the large breeder reactors that are envisioned as central power stations in the 1990s and beyond.

The major experimental facility in the LMFBR Program is EBR-II, which was designed by Argonne and built at ANL-W. As the nation's only operating fast breeder reactor, EBR-II is the primary irradiation test facility for fuels, materials, and components in the LMFBR safety program.

The HFEF complex consists of two hot cell facilities. HFEF/South, originally called the Fuel Cycle Facility (FCF), was placed in operation in 1962 and HFEF/North was placed in operation in April, 1975. These
two facilities provide a heavily-shielded, highly-automated system for examining and analyzing irradiated fuels and materials experiments and tests. HFEF also provides major support for the LMFBR safety program.

Two general types of examinations are currently performed at the HFEF complex; these are interim nondestructive examinations of irradiated fuels and structural specimens that may later return to the reactor, and nondestructive and destructive examinations after final irradiation. These examinations furnish valuable information on the performance of candidate LMFBR fuels and materials in an environment of intense fast neutron radiation, heat, and flowing sodium in the core of a fast breeder reactor.

The completion and activation of HFEF/N in April, 1975 has made it possible to implement a program to shut down and refurbish the HFEF/S facility. Work now being performed at HFEF/S will be temporarily transferred to HFEF/N for the time required to perform the refurbishment work in HFEF/S.

This paper presents the features of a refurbishment program for HFEF/S; these features can be described in four categories: deactivation, decontamination, equipment and facility repair, and reactivation. We are currently in the early stages of the deactivation program.

HFEF/S is made up of two connected shielded cells and support facilities housed in a 22,500-ft² building. The building is attached to the EBR-II containment shell on the eastern quadrant of its circumference. The cells are constructed of 5-ft-thick, high-density concrete walls and a 4-ft-thick concrete roof.
The rectangular-shaped air cell has nine lead-glass windows. Interior lighting is furnished by mercury-vapor lamps that provide an intensity of approximately 150 foot-candles of in-cell illumination at the work level. One 5-ton bridge crane, two electro mechanical (E-M) manipulators and 18 master-slave manipulators constitute the remote-handling equipment for operations and maintenance within the air cell. The floor, walls, and ceiling of the cell are concrete with an epoxy enamel surface finish.

The argon cell, which has the shape of a 16-sided regular polygon, has 14 lead-glass shielding windows at its outer perimeter. Interior lighting is also furnished by mercury-vapor lamps with the same lighting intensity as those in the air cell. There are two 5-ton bridge cranes, six E-M manipulators, and 18 master-slave manipulators in the argon cell. In addition to the work stations outside the outer perimeter of the polygon, there is a viewing and operating room inside the polygon with 5-ft-thick concrete walls which has eight shielding-window locations. The interior surface of the cell is lined with a steel liner to provide a fully sealed cell for the containment of inert argon gas. The surface of the steel liner has been zinc coated and then shot peened to provide a diffused light reflecting surface.

EBR-II and HFEF/S were designed and built by Argonne National Laboratory and placed in operation in 1963 to develop and demonstrate an LMFBR Pilot Plant, including production of electricity and pyro-chemical fuel reprocessing system for uranium-fission EBR-II driver fuel. From 1964 to 1968 approximately 40,000 fuel pins were processed.
The source of spent fuel for this reprocessing program was EBR-II, which operated (and continues to operate) as a power-producing (2.0MW electrical) fast breeder reactor. Irradiated fuel subassemblies were transferred from the reactor to the HTEF/S air cell in an interbuilding cask. In the air cell, the fuel elements were removed from the subassemblies in preparation for transferring to the argon cell. The fuel elements were then transferred to the argon cell where the remote fuel reprocessing activity was performed. The reprocessing operation consisted of removing the fuel cladding, chopping the fuel pins to short lengths, and melt-refining these pieces to remove the fission products. The slag from the refining process was then treated to remove the small amount of trapped uranium.

This latter process caused much of the contamination that is presently distributed throughout the argon cell. The major part of this contamination is $^{137}\text{Cs}$, $^{144}\text{Ce}$, $^{235}\text{U}$, and $^{239}\text{Pu}$. The fission products $^{137}\text{Cs}$ and $^{144}\text{Ce}$, which are present in very low mass, account for most of the beta and gamma radiation. Also contributing to the beta and gamma radiation are very small amounts of other long-lived fission products such as $^{106}\text{Ru}$ and $^{90}\text{Sr}$ and some very small amounts of long-lived activation products such as $^{58}\text{Co}$, $^{60}\text{Co}$, and $^{54}\text{Mn}$. The $^{239}\text{Pu}$ in the cell comprises only $\sim0.5\%$ of the fissile material believed to be present in the cell. However, because it is very active, $^{239}\text{Pu}$ contributes over 90\% of the alpha activity.
From 1968 until the present, the cells have been used as a conventional hot cell facility for the examination of irradiated specimens and materials from EBR-II, TREAT, and other reactors.

Except for a two-month shutdown of the air cell in 1969, HFEF/S has been in continuous service. With the exception of this one shutdown, which was required to repair the overhead in-cell handling equipment, all maintenance and repair has been done remotely or by the removal of components from the cell for repair or replacement. Although this maintenance has kept the cells in operation, a point has now been reached where extensive overhaul is required, and the facility must be shut down to accomplish this refurbishment work. During the shutdown of the facility, the in-cell equipment will be removed from the cells. The cells will be entered and decontaminated, the cell windows and lighting will be modified, and the remote-handling equipment will be improved. When the cells and cell equipment have been cleaned and modified, the facility will be returned to service to support the LMFBR Program by providing a backup for and supplement to the new HFEF/N facility.

The major unknowns in the refurbishment plan at this time are (1) the level of radiation expected in the argon cell after all fuel and equipment have been removed, and (2) how effectively these levels can be reduced by the use of remote decontamination methods prior to actual personnel entry into the cell for contact decontamination and refurbishment operations.
PRE-SHUTDOWN TEST PROGRAM

A program for remote decontamination tests has been established to provide information on these unknowns. The goal of the remote decontamination tests is to determine the amount and types of contamination present, the radiation levels associated with each type, and the best method for the removal of the contamination.

As a basis for the test program, we have separated the contamination present into three general types: free, adherent, and fixed.

1. Free Contamination: that which is easily removed by vacuuming, flowing water, or dry wiping with cloth.

2. Adherent Contamination: that which can be removed only by vigorous wiping and scrubbing using detergent or complexing solutions.

3. Fixed Contamination: that which is mechanically or chemically bonded into the surface and can be removed only by removing the surface.

In order to obtain this information as quickly as possible, the decontamination test program is to be accomplished while the HFEF/S cells are still in operation. Obtaining this information prior to the shutdown will provide time to work out the details of the actual remote decontamination. To evaluate the effectiveness of the remote decontamination tests, a method for taking radiation readings on selected cell surface areas must be used.
Remote radiation readings will be accomplished using a Jordan "Rad Gun." The Jordan "Rad Gun" was chosen because it has a very wide range. In three separate scales it covers from 0.01 millirems/hr to 10,000 rems/hr. A wide range was deemed necessary because we expect that there will be a great variation in intensities of radiation. We will want to measure not only high-level radiation, but will also want to measure moderate and low-level radiation from partially decontaminated surfaces in the presence of high background radiation. To do this we have built a shield around the "Rad Gun" which attenuates gamma radiation by a factor of $\sim 10^6$ from all directions except one.

The shielded "Rad Gun" assembly weighs about 2,000 lb and therefore must be transported and positioned by means of one of the 5-ton capacity in-cell bridge cranes. A lifting bale has been provided to lock the shield for obtaining readings on either a horizontal or vertical surface. Placing the instrument against the cell surfaces will give directional radiation readings and will give us an indication of the amount and location of contamination in the cells. By the use of these data, selected areas in the cell will be decontaminated and resurveyed to obtain information on the effectiveness of the decontamination methods.

Using a remotely operated vacuum cleaner with a special attachment for collecting the free contamination on a filter paper, test areas will be vacuumed. The filter paper will then be transferred to the chemistry laboratory and analyzed for uranium and other radioisotopes. After being vacuumed, each test area will be resurveyed to measure the reduction of
radiation and hence obtain a decontamination factor for each vacuum treatment. This decontamination factor will thus be tied to a definite amount and kind of material.

Using cloth pads soaked in a cleaning solution, the test location will be remotely cleaned. After this wiping operation, the test pads will be analyzed for the type and quantity of radioisotopes, and the test patch area will again be surveyed with the Jordan "Rad Gun." This will establish the decontamination factor for wiping or scrubbing off adherent contamination and will tie it to a definite amount and kind of material removed.

If radiation levels indicate that contamination still exists in the test areas, a controlled acid etching process will be used to remove the fixed contamination. The solution selected for the initial work is a sulfamic acid solution which will lift the zinc plating and the fixed contamination embedded in the zinc. The solution will be collected and analyzed as before for type and quantity of radioisotopes.

In summary, the results of the quantitative and qualitative analysis and the gamma surveys made on each test location after each test will tie the material removed to the radiation measured and establish a decontamination factor for each process. These data will also allow us to make a proper estimate of the amount of uranium we can expect to collect in the overall decontamination to insure criticality safety during the waste collection and disposal.
REMOTE DECONTAMINATION TEST PROGRAM

The remote decontamination procedure for the argon cell will rely heavily upon the results of the decontamination tests. Also, data on contamination levels in the argon cell are now being gathered from the equipment currently being removed and will supplement data collected during our remote decontamination tests.

Planning for the air cell can confidently be based on similar work carried out in 1969. During a two-month period in 1969, the HFEF/S air cell was shut down for remote cleanup, direct cleanup, crane repair, manipulator repair, and miscellaneous work. Upon completion of remote cleanup of the cell, radiation levels at window locations ranged from 150 mR/hr to 280 mR/hr. After contact cleanup was completed, personnel exposures produced by in-cell radiation sources were between 12 mR/hr and 50 mR/hr. Because the argon cell has never been entered, no comparable data are available.

After the facility is shut down, the remaining equipment will be removed, decontaminated, boxed and stored for maintenance or disposal. To reduce the time required for equipment removal from the argon cell, the argon atmosphere will be released from the cell as early as possible. This argon gas (which contains a small quantity of Krypton-85) will be discharged to the atmosphere under carefully controlled and monitored conditions in order to maintain safe environmental-release conditions.

The goal of the remote decontamination is to reduce the in-cell general radiation levels to ~100 mR/hr before cell entry. Provided that the remote testing indicates the method to be useful, the first step will
be to vacuum all cell interior surfaces using remotely operated vacuum cleaners while periodically measuring the radiation with the shielded "Rad Gun." This will be followed by a wash-down with damp or wet cloths and cleaning solutions. We expect that these two operations will be quite successful in decontaminating the walls, ceiling, and other exposed surfaces.

We also expect substantial success in decontaminating most of the floor areas using these two methods. However, on the floor and perhaps on some vertical surfaces, we probably will find localized hot spots, and perhaps general areas where the contamination has been ground in and is mechanically bonded to the cell structure. At that time a decision will be made whether to pursue additional remote cleaning techniques or to remotely install shielding over those areas which would prevent cell entry by personnel.

CONTACT DECONTAMINATION

When we have met our goal of reducing the general radiation background, the cells will be entered and direct contact decontamination will begin. Personnel entry into the air cell will be through an existing cell access door; entry into the argon cell will be made through one window location, which is now set up as a periscope viewing station. Anti-contamination change rooms will be constructed adjacent to the transfer station.

The initial entries into the cells will be made by ANL personnel, especially trained in health physics operations, to perform direct
radiation and air-monitor surveys and to establish other cell conditions relating to safety in subsequent operations.

Once safe working conditions have been established, the initial cleanup work will be performed by ANL personnel to remove hot areas in an attempt to quickly reduce the general cell radiation levels. Reducing radiation levels in this manner will permit the general contact decontamination, which it is planned will be done by a subcontractor using a minimum of personnel. The decontamination goal will be to reduce the radiation levels for safe entry of personnel for extended work periods without the necessity for breathing protection.

The direct decontamination techniques will be generally the same as those used for remote decontamination; other methods, if found useful and more practical when having direct access to the contaminated surfaces, will also be used. Once the decontamination goal has been reached, repair of the cells and replacement and repair of the cell equipment will begin.

WASTE MANAGEMENT

During the course of the Refurbishment Program, large quantities of solid radioactive waste and obsolete contaminated equipment will be removed from the cells. Much of this material will be buried in the INEL nuclear burial ground. The equipment will be partially decontaminated, wrapped, boxed, and buried according to provisions for disposal of such material as defined in the Argonne-West Health and Safety Manual and ERDA-ID requirements.
The radioactive liquid wastes generated during the shutdown will be processed through the ANL-W Liquid Suspect Waste Processing System. The quantity of liquid to be processed is not expected to be greater than the capacity of the existing process equipment. The total quantity of radioactive waste to be disposed of has been estimated and factored into the overall ANL-West disposal program for 1975 and 1976.

PERSONNEL TRAINING AND SAFETY

There is obviously a potential for industrial safety hazards during a project of this nature; personnel will work at heights up to 20 feet, work in confined spaces, hoist heavy equipment, and perform abrasive and chemical cleaning. The hazards of this type of work are clearly recognized, and appropriate controls will be established as covered in the Argonne-West Health and Safety Manual.

Personnel safety will be of utmost concern during the HFEF/S Refurbishment Project. All work will be done under safety controls which insure that personnel are not subjected to unsafe working conditions from either industrial or radiological hazards.

All personnel working in radiation fields and with radioactively contaminated materials shall be properly trained for this work. Many of the technicians and craft personnel who are to accomplish the decontamination and equipment repair are now qualified radiation workers who have been trained in accordance with the ANL-W Radiation Worker Training Program. Other personnel who have not received this training will be trained before working with radioactive materials. Detailed work
procedures and radiation work permits will be issued and approved by Radiological Engineering prior to the start of any work.

REACTIVATION

Following the completion of the HFEF/S refurbishment and after all equipment has been requalified, the facility will be returned to service in support of the LMFBR program. The mission of the refurbished facility will be to back up and complement HFEF/N for interim nondestructive examinations of LMFBR experimental irradiations. Included in this mission will be the provisions for interim storage of experimental capsules and elements in an inert-gas environment.
The Atomics International (AI) Decontamination and Disposition (D&D) of Facilities Program for the Sodium Reactor Experiment (SRE) and other ERDA-owned, AI-operated, radioactive facilities is described. The program objective along with a description of each of the subject facilities is presented. A description of the organizational structure within AI supporting the D&D program is given. The elements of planning required to prepare for the D&D task are detailed, including the requirements for cost and schedule control. The D&D progress to date and the future plans are presented. The available technology utilized in the program is described.
A. PROGRAM OBJECTIVE

There are eight inactive, ERDA-owned nuclear facilities at the Atomics International (AI) Santa Susana Nuclear Development Laboratory included in the Decontamination & Disposition of Facilities (D&D) Program. These facilities include completed reactor experiments, hot cave facilities, and waste disposal facilities which contain extensive amounts of radioactive materials in the form of activated or contaminated structures and components. These facilities are: Sodium Reactor Experiment (SRE), Building 003 Hot Cave, Kinetic Experiments Water Boiler (KEWB), Shield Test Irradiation Reactor (STIR), SNAP Experimental Reactor (SER) Facility, SNAP Experimental Test Facility (SETF), SNAP 8 Ground Prototype Facility (SGPTF), and the Radioactive Materials Disposal Facility (RMDF).

The principal objective of the AI D&D Program is the decontamination and dismantling of the above facilities, with funding from ERDA Division of Waste Management and Transportation, culminating in the release of the facilities from all requirements for radiological control, licensing or monitoring, and the placing of the facilities into a condition acceptable for unrestricted use. The D&D effort will take five years to accomplish, beginning with GFY 1975.

An additional program objective requires that the SRE Cores I and II fuel, presently stored at the RMDF, be declad, cleaned of NaK bonding in the AI Hot Laboratory, and shipped to Savannah River for reprocessing.
B. FACILITIES BACKGROUND DATA

SRE--The SRE is a 20-Mwt sodium-cooled, graphite moderated thermal reactor. The core, moderator, reflector, and support structures are contained in a \( \frac{3}{4} \)-in.-thick, stainless-steel vessel liner within a 1\( \frac{1}{2} \)-in.-thick, stainless-steel reactor vessel, which is surrounded concentrically by 5\( \frac{1}{2} \)-in.-thick steel thermal shielding, \( \frac{1}{5} \)-in.-thick steel outer vessel, 1-ft-thick insulation, \( \frac{3}{4} \)-in.-thick steel cavity liner, and 4-ft-thick high density concrete biological shielding. Primary sodium heat transfer circuits carried the heat generated in the reactor to a secondary circuit through sodium-to-sodium heat exchangers. The secondary sodium carried the heat to airblast heat exchangers or to a steam generator.

The SRE and associated auxiliary facilities have been "stored in place" since the SRE-PEP program was terminated in GFY 1968. The facility was maintained in this condition pending approval of funding and plans for complete dismantling.

SRE Fuel Decladding--The irradiated fuel from SRE Cores I and II has been stored in the irradiated fuel storage vault at the RMDF since it was removed from the SRE reactor (1959 for Core I and 1964 for Core II). Because the fuel is bonded to the cladding with liquid metal (NaK), it cannot be reprocessed without special head-end, pre-reprocessing treatment which is currently not available at the Division of Production Savannah River reprocessing plant. The decladding of the fuel and removal of the NaK bonding, which is being performed at the AI Hot Laboratory, will place the fuel in an acceptable condition for reprocessing at the Savannah River Reprocessing Plant.
**Hot Cave**--The Building 003 hot cave was a high-density concrete, steel, and lead shielded remote handling facility containing two hot cells, complete with manipulator systems, and a transfer tunnel. The hot cave had been inactive since the close out of the SNAP Program in GFY 1973. Prior to that time, it had been used for the analysis of SNAP fuel burnup samples. The inner surfaces were grossly contaminated with mixed fission products. Dismantling of this facility was completed by Atomics International during GFY 1975.

**KEWB**--The KEWB reactor was a homogeneous-fueled, graphite-reflected reactor used for power transient studies. The reactor facility had been "stored in place" since the KEWB program was terminated in GFY 1967. The fuel was removed from the fuel storage tank and shipped to a recovery plant in GFY 1969. Radioactive components remaining in the facility were the reactor core vessel, the fuel handling system, the reflector assembly, all waste handling systems, and a number of other contaminated or activated components. Dismantling of this facility was also completed by Atomics International in GFY 1975.

**STIR**--The Shield Test Irradiation Reactor was a 1-Mwt, pool-type reactor which operated with a highly enriched core consisting of 20 MTR-type fuel elements. The reactor was used throughout the SNAP Program to test shielding materials for SNAP power systems, and was defueled and partially dismantled during the closeout of the SNAP Program in GFY 1973. There remain at the facility a number of activated and contaminated structures, including: (1) the core structure, (2) the reactor pool tank, (3) the concrete biological shielding, (4) the thermal column, and (5) the fuel storage cells.
SER--Two SNAP reactors, S2ER and S8ER, were operated over several years in a below-grade reactor containment vessel in the SER facility. Following completion of respective operating tests, the reactors were removed intact and transferred to the AI Hot Laboratory for disassembly and examination. There remain at the facility, extensive high level activated and contaminated materials, including steel containment vessels and concrete biological shielding, most of which are below grade.

SETF--The SETF was used as a facility for the operating endurance test of the SNAP 10FS3 reactor. The reactor was operated in a vacuum vessel contained in a below-grade test vault, and was subsequently removed intact and transferred to the AI Hot Laboratory for disassembly and examination. Activated components and structures remaining in the facility include the SNAP 10FS3 vacuum vessel, the test vault liners, and the concrete biological shielding.

SGPTF--The SGPTF was designed for endurance testing of the SNAP 8 Development Reactor. The reactor was operated for more than a year at power levels of up to 1 Mwt. Following completion of the test in GFY 1970, the reactor was removed intact and transferred to the AI Hot Laboratory for disassembly and examination. There remain at the facility extensive below-grade activated structures, including steel containment vessels and vacuum ducts, high density concrete biological shielding, and sand fill.

RMDF--The Radioactive Material Disposal Facility (RMDF) is a facility devoted to radioactive waste process and storage. It includes an irradiated fuel and high-level waste storage vault, a waste compaction and packaging building, a component decontamination building, and liquid waste storage tanks. Extensive fission product and activation product contamination exists in the waste handling systems.
C. PROGRAM ORGANIZATION

AI has placed sufficient emphasis on the decommissioning activities to establish a full Program Office with a Program Manager directing the activities of a staff of Project Managers and Project Engineers. The decommissioning activities are recognized by AI as an integral phase in the overall development of nuclear energy, and AI intends to provide this service to the industry. The overall divisional management organization at Atomics International is shown in Figure 1.

The D&D Program Manager, who reports to the Director, Fuel and Test Facility Programs (Figure 2), has overall programmatic responsibility for all efforts associated with the decontamination and disposition of ERDA facilities at the Santa Susana Field Test Laboratory.

An Engineering Project Manager reports directly to the Program Manager. This project manager is responsible for the engineering efforts associated with the D&D Program, including the development of Activity Requirements, Test Plans, and Operating Procedures associated with the design and development of special tooling and containers. The development and coordination of the program documentation and Activity Network Schedules are also the responsibility of this Project Manager. Project engineers assist the Engineering Project Manager within specific areas of the D&D engineering.

A Dismantling Activities Project Manager reports directly to the Program Manager. This Project Manager is responsible for the development of Dismantling Plans, Activity Requirements, Detailed Working Procedures, and the physical dismantling activities being performed by AI, Rocketdyne, and subcontractor personnel. Project engineers established for major dismantling tasks within this project, will also report to this Project Manager.
D. PROGRAM PLANNING

The overall schedule for the D&D Program, Figure 3, was established by determining the optimum sequence for dismantling the various facilities according to degree of hazard potential, program utilization of existing facilities, cost effectiveness, funding limitations, and special planning and tooling development requirements. Several general activity categories were identified to provide sufficient detail for the overall program activity schedule and to establish a common base for developing the more detailed individual facility Activity Network Schedules and Dismantling Plans. The general categories were identified as: (1) program management, (2) planning, (3) tooling and equipment, (4) decontamination and dismantling, (5) waste disposal, (6) radiological survey, and (7) documentation. All of the efforts involved in the D&D Program fall into one of these categories.

A Dismantling Plan is prepared and approved for each of the facilities prior to commencing the dismantling efforts. The plan defines the scope of the dismantling effort, provides a brief description of the facility and background data, expands upon the specific applications of the general activity categories listed above, and identifies the major tasks which require the preparation of separate Activity Requirements documentation.

Activity Requirements are written for each of the major tasks involved in each of the facilities. The Activity Requirements define the scope, proposed methods and sequence for accomplishing the task, tooling requirements, overall health and safety requirements, and technical guidelines for the preparation of the Detailed Working Procedures.
Detailed Working Procedures are written where required to supplement existing approved in-house working procedures. These procedures describe the details of the decontamination and dismantling operations, the associated radiation safety and industrial hygiene requirements, the use of special tooling, and any special handling requirements.

The following paragraphs describe the details of the general activity categories listed above which are used in developing the activity network schedules for the overall D&D Program; in preparing the detailed schedules and manpower estimates for the individual facilities; and in preparing the specific Dismantling Plans.

Program Management--The program management activity includes the efforts involved in directing the overall performance of the program objectives; interfacing with the appropriate offices of ERDA, internal AI management, and outside suppliers and contractors; obtaining the services of the internal functional organizations, and monitoring the subsequent performance; and performing administration support functions such as reproductions, data management, cost monitoring, schedule monitoring, and purchasing activities.

Planning--The planning activity includes the efforts required to develop and prepare the overall D&D Program Plan, the Quality Assurance Plan, the Operational Safety Plan (including occupational and radiological safety requirements), and a Training Plan; establish schedules and projected costs for each facility; and prepare the Dismantling Plans, Activity Requirements, and Detailed Working Procedures for each facility. Figure 4 presents the document tree for the D&D Program.
Tooling and Equipment Design and Fabrication--The tooling activities involve the establishment of the functional and operational requirements for tooling and equipment to support the decontamination and dismantling operations; the preparation of detailed designs for tooling and equipment not available off-the-shelf; the fabrication and/or procurement of the identified tooling and equipment; the design, fabrication, and operation of a mockup facility, where required for remote operational checkout; checkout operations; and development of operational parameters for remote tooling and equipment in the mockup facility. The SRE will require the greatest tooling effort. A remote manipulator system will be utilized to cut up the reactor vessels. The manipulator system will be submerged under water as necessitated by the requirements for radiation shielding. A vessel mockup will be used to develop and check out the remote manipulator operating parameters prior to installation in the SRE. The ORNL manipulator design used for the Elk River dismantling program has been modified by AI Engineering to meet the SRE geometry requirements and material requirements; e.g., the system will be fabricated from stainless steel rather than carbon steel for ease of decontamination. The vessel mockup facility was designed by AI and was constructed by an outside contractor in an existing building at AI. An existing manipulator control console was obtained from ORNL and modified for added versatility of operation. The remaining facilities in the D&D Program will require less extensive tooling. The two SNAP 8 test facilities (SER and SGPTF) will require some remote tooling for dismantling the vessels, which will be an adaptation of the SRE tooling.

Decontamination and Dismantling--This activity involves all the effort associated with the actual decontamination and dismantling of equipment, hardware, systems, and facilities. This activity does not include the processing, packaging, shipping, or
burial of the radioactive waste, which is a separate activity category. Each of the facilities require substantial decontamination prior to and in conjunction with the dismantling operations. The Detailed Working Procedures for each facility identify the extent of required decontamination operations expected for those activities involving activated or contaminated materials and/or equipment. AI personnel trained in radioactive material handling perform all tasks involving high-level radioactive material. AI personnel, or specially qualified contractor personnel supervised by AI personnel, are used to handle low-level radioactive material and other hazardous materials. Contractor personnel are utilized as much as possible to remove nonradioactive materials, especially where the salvage value of the material partially defrays the removal costs. Demolition contractors will be used extensively in the concrete removal activities.

Waste Disposal--This activity involves efforts associated with the preparing, packaging, and shipping for burial of radioactive waste generated in the D&D Program. Special shipping containers meeting NRC and Department of Transportation requirements will be fabricated, obtained on loan, or rented from commercial sources. The overall D&D Program radioactive waste disposal effort is coordinated by the RMDF to minimize the overall shipping and burial costs. ERDA equipment that is not contaminated or has been decontaminated is processed through the equipment utilization system. Salvage material is made available to the outside contractors in fair consideration for operating costs on a bid basis. Noncontaminated scrap is disposed of in landfill sites.
Radiological Survey--Initial radiological surveys are made in each facility to provide input to the planning efforts. Continuous radiological surveillance is performed at each facility for personnel and environmental safety, to determine the extent of decontamination required and to segregate waste. A final radiological survey will be made at each facility at the conclusion of the dismantling activity to certify that the site meets the established limits for unrestricted access.

Documentation--All documents generated in support of the planning and engineering activities will have release and revision control according to the requirements of an Engineering Release Plan of Action. The Quality Assurance, Health, Safety, and Radiation Services records for the Program will be maintained for permanent traceability. Photographic documentation will be used for tracing progress, recording pertinent developments, future informational or training aids, and for historical purposes. A final report will be written for each facility to document: the effort, schedule, and costs expended as compared to the original estimates; any special problems encountered and the methods used for resolution; any tooling or process developments that would be useful to future programs; and the final radiological status of the site. The levels of radioactivity remaining after the D&D process will be certified, and approval for release for unrestricted use will be obtained from ERDA, with concurrence by AI and California Bureau of Radiological Health. These approvals will be included in the final report.

E. PROGRAM COST AND SCHEDULE CONTROL

Budgetary cost estimates were developed by the preparation of detailed manloaded activity networks. Equipment, material, subcontract, consultant, and other direct expenses associated with an activity were also estimated to determine the total
forecast activity costs. An internal monthly cost report and cost analysis is prepared utilizing AI's computerized cost reporting system as a means of monitoring actual costs vs forecast at each of the general activity levels. These expenditures, along with the physical progress of the activities, are compared to the forecasts and the results of the comparison are transmitted to ERDA in the monthly progress report for the D&D Program.

F. PROGRESS AND PLANS TO DATE

SRE--Tasks completed during GFY 1975 included the preparation of the SRE Dismantling Plan; drumming of the primary sodium; removal of the airblast heat exchangers, kerosene cooling system, and gallery cooling system; removal of some secondary sodium components and piping external to the reactor building; design completion and fabrication initiation of the rotating mast manipulator for vessel cutup and the SRE vessel mockup facility; and initial operation of the plasma arc cutting system in a small scale underwater cutting tank for cutting parameter development. The schematic representation of the plasma arc cutting development system is shown in Figure 5.

Activity Requirements and Detailed Working Procedures will be prepared as required for the duration of the D&D task on the SRE. Mockup operations for the vessel cutup remote tooling will be accomplished during GFY 1976. Operating parameters for the cutup and removal of the vessel internals, core tank liner, core tank, thermal rings, outer tank, insulation, and cavity liner will be developed. Also during GFY 1976, the residual sodium in the reactor and primary piping will be reacted, the primary system piping and the secondary system sodium piping inside the building will be dismantled, the portable hot cell will be dis- mantled, work will begin on removing the storage and wash cells,
and special one-way shipping and burial containers will be designed and procured. The storage and wash cells, the reactor vessel internals, and the waste tanks and lines will be removed during GFY 1977.

The remote removal of the reactor vessels, the cavity liner, and biological concrete shielding will be completed during GFY 1978. Also, during this period the moderator handling machine will be dismantled, the retention pond will be removed, the building structures will be razed or repaired, and the site will be backfilled as required.

SRE Fuel Decladding--Preparations and initial operations for decladding and cleaning the NaK from SRE Cores I and II fuel were accomplished in GFY 1975. The preparations included safety studies; planning; tooling design, fabrication, and testing; intrasite transfer cask selection and preparation; setup of hot cell operations, tooling, and processing arrangements in the AI Hot Laboratory; design of shipping canisters for fuel slugs; design of waste containers; and arrangements for shipping casks and inserts. Following completion of the preparations, the first three Core I fuel storage containers were transferred from the RMDF to the AI Hot Laboratory where the actual decladding, cleaning, and repackaging was performed. During GFY 1976, the cleaned and repackaged Core I and II fuel will be returned to the RMDF in shipping canisters, from where it will be shipped to the Savannah River Reprocessing Plant.

Building 003 Hot Cave--The Dismantling Plan and Detailed Working Procedures were prepared for the Hot Cave, and, subsequent to the approval of the Plan by ERDA, decontamination and dismantling was completed during GFY 1975. The dismantling included removal of the Hot Cave, the integral cave and the building exhaust and liquid radioactive waste systems, and extensive floor excavation.
KEWB--The Dismantling Plan and Detailed Working Procedures were prepared for the KEWB facility, and, subsequent to approval of the Plan by ERDA, the decontamination and dismantling was completed during GFY 1975. The KEWB dismantling included removal of the core vessel and all contaminated components, dismantling of the reactor and support buildings, excavation of the waste tanks, and backfilling and regrading of the area.

STIR--Preparation of the Dismantling Plan was completed in GFY 1975. Preparation of the Activity Requirements for the STIR will be accomplished during the first half of GFY 1976. Subject to the approval of the Plan, dismantling the fuel storage wells, heat exchanger, cooling system, shield carriage system, core structure, thermal column, activated vessel, activated concrete, exhaust system, and liquid waste systems will be completed during GFY 1976.

SER--The SER Dismantling Plan, Activity Requirements, and Detailed Working Procedures will be written and approved during GFY 1977. The tooling design, fabrication, development, and checkout will occur during GFY 1978. The actual dismantling operations will extend through the first quarter of GFY 1979.

The major effort in the SER dismantling activity will be the removal of the activated steel reactor containment vessel and the biological shielding, all located below grade. The concrete was poured around the vessel and attached cooling coils, leaving a steel-lined, activated, concrete monolith below grade. Tooling will be required to excavate the structure with some shielding required. The choice of entry from the inside or outside of the structure remains to be determined. The metal building enclosing the facility will be demolished.
SETF--The SETF Dismantling Plans, Activity Requirements, and Detailed Working Procedures will be written during early GFY 1978. A minimal tooling effort will be required, and the tooling and dismantling operations will be accomplished during the second half of the year.

The effort in SETF will consist mainly of removing and disposing of the activated SNAP 10FS3 vacuum vessel located in one of the vaults, removing the test vault aluminum liners, excavating some of the adjacent concrete biological shielding, and possibly removing portions of the exhaust and liquid waste holdup systems.

SGPTF--The SGPTF Dismantling Plan, Activity Requirements, and Detailed Working Procedures will be prepared during GFY 1978. The tooling effort and dismantling operations will extend through GFY 1979.

Extensive below-grade activated structures remain in the SGPTF, including steel containment vessels and vacuum lines, concrete biological shielding, and sand fill.

RMDF--The RMDF Dismantling Plan, Activity Requirements, and Detailed Working Procedures will be written during GFY 1978. The tooling effort and dismantling operations will extend through GFY 1979.

G. AVAILABLE TECHNOLOGY

A modification of the remote manipulator-plasma arc system design, developed by Oak Ridge National Laboratory (ORNL) for the Elk River Reactor dismantling, is being used by AI for the SRE vessel cutup. The design was modified by AI Engineering as required to fit the SRE Requirements. Fabrication of the system
is now underway in the AI manufacturing shops. Following completion of the manufacturing, the AI Remote Technology Unit will check out the system in the SRE vessel mockup facility and establish parameters for the actual cutting of the SRE vessels. Extensive remote tooling expertise exists at Atomics International from experience gained on the SRE, Hallam, Piqua, and SNAP reactor programs.

Explosive demolition techniques similar to those used for the Elk River Reactor Dismantling Program will also be utilized on this program to remove concrete structures. Additionally, commercially available remote techniques for piping and component removal will be utilized wherever possible; e.g., underwater explosive pipe cutting used in offshore drilling operations.
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Figure 2. Fuel and Test Facility Program Organization Chart.

Figure 3. Overall Schedule for D&D Program.

Figure 4. A.I. D&D Document Tree.

Figure 5. SRE Vessel Mockup Facility.
Rockwell International
Atomics International Division

FUEL & TEST FACILITY PROGRAMS

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435 JUNE 25, 1976

Figure 2
QUALITY ASSURANCE PLAN

OPERATIONAL SAFETY PLAN

TRAINING PLAN

ENGINEERING RELEASE PLAN OF ACTION

PROCUREMENT PLAN

PROGRAM ADMINISTRATION PLAN

PROGRAM DATA MANAGEMENT PLAN

DISMANTLING PLANS

ACTIVITY REQUIREMENTS

DETAILED WORKING PROCEDURES
Figure 5

SRE Vessel Mock-Up Facility

SRE Core Cavity Liner Mock-Up

Vessel Wall Mock-Up

Grid Plate Mock-Up

Torch Devl'nt Tank

Console

Manipulator

Water Fill

Water Drain

3 TON
A DECOMMISSIONING PLAN
FOR THE HEAVY WATER COMPONENTS TEST REACTOR

by

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A DECOMMISSIONING PLAN
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ABSTRACT

Three alternatives to decommission the Heavy Water Components Test Reactor (HWCTR) have been analyzed. The major elements of the alternatives are shown in Table 1. No final choice has been made between alternatives, and all are feasible. The Protective Confinement approach is advantageous as long as current activities onsite require limited access by the general public, and because excellent confinement of the residual activity (2.3 × 10⁴ curies) is provided by in situ dry storage as the radiation from ⁶⁰Co diminishes. Entombment provides the most-secure confinement of the activity at some increased cost; in 35 years, the activity will decay to 2 × 10³ curies and consist primarily of ⁶³Ni. Dismantling HWCTR has no apparent advantages, other than a demonstration at the Savannah River site, because of the long-term commitment to safeguarding radioactive material; the relative cost is high.

Selection of a plan for decommissioning will depend on criteria that are presently being formulated within ERDA and other regulatory bodies.

The information contained in this article was developed during the course of work under Contract No. AT(07-2)-1 with the U. S. Energy Research and Development Administration.
HWCTR HISTORY

Before discussing the alternatives used to develop decommissioning plans for HWCTR, some background information on the purpose for building the reactor will be given.

The Heavy Water Components Test Reactor (HWCTR) was a test reactor used to develop candidate fuel designs for heavy water power reactors. The nominal reactor power of 50 MWt was dissipated to the atmosphere; the total HWCTR exposure was 13,900 MWD. The general plan of the site is shown in Figure 1, and the appearance of the site during operation is shown in Figure 2.

The reactor hydraulic system operated at 1200 psig and 250°C. The reactor vessel was made of 3- to 5-inch-thick carbon steel clad with stainless steel; the external hydraulic system was carbon steel only. Two test loops isolated from the primary hydraulic system were provided for special test conditions. Arrangement of the equipment within the containment building is shown by models in Figures 3, 4, and 5. These models were used in building construction and also during the decommissioning studies.

After HWCTR was shut down in December 1964, the fuel assemblies and the startup source were removed from the site. Safety rods and control rods were delatched from their drives and fully inserted into the reactor vessel. Heavy water was drained from the reactor, and the system was dried. The reactor was maintained in a standby status for about one year and then retired in place. Since that time, surveillance has been provided
by personnel from an adjacent site. Access to HWCTR is controlled by the locked fences surrounding the site.

PREPARATION OF A DECOMMISSIONING PLAN

A six-step procedure was followed to prepare a decommissioning plan for HWCTR:

- Assemble a task force to develop alternatives.
- Study guidelines and precedents in comparable efforts and propose criteria for the current effort.
- Define the residual activity.
- Define alternatives; characterize feasibility, cost, and residual risk to public.
- Assess the alternatives using the criteria.
- Determine a course to be followed considering constraints and plans for the site.

TASK FORCE PERSONNEL

To assemble the information needed to evaluate alternatives for decommissioning HWCTR, seven senior employees with varied backgrounds were assigned to the effort (Table 2). The services of Du Pont Engineering Department, which designed and built HWCTR, were used to estimate capital costs for the decommissioning options. Laboratory services onsite were used for more-extensive radiological analyses of HWCTR samples than could be attained by field surveys. Three members of the task force, who had been assigned at the HWCTR site during operations recovered records, reviewed
construction techniques, and outlined special operating occurrences relevant to decommissioning modes.

OBJECTIVES AND CRITERIA

The three alternatives identified for decommissioning the HWCTR facility and the objective to be achieved through each alternative are listed in Table 3.

The criteria used to evaluate the merits of the alternatives are:

Radiation Impact. Acceptably low probability of release of the HWCTR activity to the environment for normal and unlikely occurrences.

Land Area Commitment. The acreage committed both to confine the activity and to monitor and control water runoff.

Cost. Decommissioning capital cost and operating cost for surveillance after decommissioning.

Certainty and Finality. The resolution of current decommissioning steps must take into account radioactive decay, retrievability, and site equipment reactivation.

Aesthetics. Appearance of the site.

RESIDUAL ACTIVITY

The definition of the residual activity at the HWCTR site was divided into three tasks: defining the activity in the reactor system (exclusive of the reactor vessel), defining the induced
activity in the reactor vessel and shield, and determining the radiation emitted by the equipment so that working conditions could be estimated for removal operations.

Reactor System Activity

The current inventory of activity was defined inside the reactor vessel and in the exterior circulating system. In HWCTR, the logical point of division between these two systems is where stainless-steel-lined pipe stubs are welded to the carbon steel piping system (primarily 10-inch-diameter pipes, steam generators, and pumps). The carbon steel portion of the system was coated with an adherent magnetite film; a sidestream from the major system was circulated through a purification system (filters and deionizers) made of stainless steel. Corrosion product deposits and small amounts of adsorbed activity from fuel failures cause the residual radiation in the carbon steel, or external, portion of the system. Activity levels and distribution in the system are shown in Table 4. The amount of activity in the external system is less than 0.01% of the total and, therefore, is not a controlling factor in design of a method to provide long-term confinement of the residual activity at the HWCTR site.

The transuranium (TRU) activity in the main system is from failure of two experimental fuel assemblies; the calculated total release was 5 g of uranium and 4 mg of plutonium. One failure also occurred in the liquid loop and released an additional 5 g of uranium that was confined to the loop. The other test loop (boiling loop)
never contained a test assembly. Further studies are being made on small samples of pipe that were cut from the piping systems so that laboratory analysis techniques (rather than field surveys) could be used to characterize the small amounts of activity in the carbon steel portion of the system.

Induced Activity in Reactor Vessel and Shields

The major source of residual activity is induced activity in the HWCTR vessel (the stainless-steel-lined portion of the reactor system inside the biological shield). The calculated activities of the reactor components within the vessel boundary are listed in Table 5. The principal activities are $^{55}\text{Fe}$, $^{60}\text{Co}$, and $^{63}\text{Ni}$. However, as shown in Figure 6, after 30 to 50 years, the only induced activity remaining will be $^{63}\text{Ni}$, and radiation levels in the reactor components will be minimal.

The concrete biological shields surrounding the reactor vessel contain trace amounts of $^{59}\text{Co}$ (100 ppm); reinforcing rods and steel shot (assumed to contain 1000 ppm of $^{59}\text{Co}$) were also used in the shield structures. All shielding and rods within 3 ft of the reactor vessel would have to be removed to reduce site activity to the level applied in the Elk River dismantlement if the assumption of 100 ppm $^{59}\text{Co}$ in the concrete is correct. Three separate types of shield would be involved in the HWCTR case. The quantity of concrete shielding to be removed is uncertain because impurity levels of $^{59}\text{Co}$ vary over a wide range.
External Radiation

Radiation levels near the HWCTR system are generally less than 3 mR/hr. The residual radiation is attributed to small deposits of corrosion products with induced activity (chiefly $^{60}\text{Co}$). Work on the reactor system equipment (excluding the reactor vessel) will only involve breathing protection for tritium if lines are opened, or for particulates if cutting or welding is done. Radiation emitted by the reactor vessel is not extremely high (1-2 R/hr at a distance of 2 ft) because of the shielding provided by the vessel walls; radiation intensities inside the vessel in the range of 100-200 R/hr from the thermal shield would be encountered if parts of the vessel exterior were removed (reactor top or main coolant nozzle).

ALTERNATIVES

The steps taken with the major equipment are compared in Table 6 for the three options for decommissioning HWCTR: Dismantlement, Entombment, and Protective Confinement.

SAFETY ASSESSMENT

With HWCTR shutdown and the nuclear fuel removed, only two mechanisms for public sector dose are postulated: direct exposure onsite and transport offsite via water. Direct exposure is currently prevented by physical security of both the HWCTR site and SRP site. Water transport of corrosion products from the thermal shield to the plant streams and then offsite is a long-term risk.
The risk analysis is made with many conservatisms. The dose criteria are based on 30-mrem bone dose associated with drinking water ingestion of $^{63}\text{Ni}$ (the major isotope remaining after 50 years). Even postulating highly improbable events that cause failure of protective vaults in the next 20 years, more than 100 years would be required for water first to reach the reactor vessel and then to seep to the site creeks. The analyses are summarized in Table 7.

The probability estimates for immersion of the vessel reflect the higher water table in the burial ground (10 to 20 ft below the bottom of a trench). At the HWCTR site, the water table is 30 ft below the bottom of the building and therefore more than 50 ft below the reactor vessel. In addition, the barriers to water penetration differ. In the Protective Confinement case, water must corrode through the carbon steel piping before the vessel internals will start to corrode. In the Entombment case, water must penetrate at least one-quarter inch of stainless steel before reaching the vessel internals. A mechanism for transport of the corrosion products into the ground water is assumed to be similar in all cases, but no credit for soil removal effects are included. Thus the concentration of activity in the creek largely reflects the differences in dilution and decay of $^{63}\text{Ni}$.

SITE CONSIDERATIONS

The Savannah River site is shown in Figure 7. If HWCTR is dismantled, the activity is relocated from U area to the site
burial ground. Rainwater runoff and ground water flow in the vicinity of the burial ground reaches either Upper Three Runs Creek or Four Mile Creek. Therefore, if the HWCTR vessel were transferred to the burial ground, long-term surveillance of the nearest creek would be involved. However, as shown in Figure 7, with the activity remaining at the present site, Upper Three Runs Creek would still be the first creek to be affected by the postulated activity transport if activity somehow escaped the confinement provided by the HWCTR system. Long-term plans for the SRP burial grounds will probably involve commitment of a caretaker crew for perhaps 100 years. Such a crew might easily provide surveillance for the nearby HWCTR site if the alternatives of either Entombment or Protective Confinement were chosen.

PROGRAM

Alternatives for decommissioning HWCTR are described in a plan document that has been forwarded to ERDA for appropriate review. Each alternative has been assessed using the criteria (Table 1); major conclusions are shown in Table 8.

When funding is provided to decommission HWCTR, a final design and analysis will be required. The decommissioning plan for the HWCTR site will be integrated into longer-range planning for other radioactive sites on the Savannah River Plant.
<table>
<thead>
<tr>
<th>Radiation Exposure</th>
<th>Dismantlement</th>
<th>Entombment</th>
<th>Protective Confinement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accidental to Public</td>
<td>Remove all radioactive equipment to burial ground</td>
<td>Relocate above-grade equipment to burial ground, and fill building with concrete</td>
<td>Repair dome, seal building, and seal piping system</td>
</tr>
<tr>
<td>Planned Occupational(^a)</td>
<td>Unlikely</td>
<td>Extremely unlikely</td>
<td>Very unlikely</td>
</tr>
<tr>
<td></td>
<td>Some</td>
<td>Less</td>
<td>Least</td>
</tr>
<tr>
<td>Land Area, acres</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HWCTR</td>
<td>0</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Burial Ground</td>
<td>2</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>Water Rights, acres</td>
<td>Burial site to creeks (already needed)</td>
<td>From 0 to 90 (HWCTR to creek)</td>
<td>90 (HWCTR to creek)</td>
</tr>
<tr>
<td>Capital Cost, $ millions(^b)</td>
<td>5</td>
<td>1</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>Annual Cost, $</td>
<td>&lt;100</td>
<td>1500</td>
<td>3000</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Best</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>Best</td>
<td>Good</td>
<td>Least attractive</td>
</tr>
</tbody>
</table>

\(^a\) An estimate of the man-rem involved will be given when the paper is presented.

\(^b\) Costs given are approximations; better cost estimates will be given when the paper is presented. Burial costs are included where incurred but no cost for land or water rights is included.
TABLE 2

HWCTR Decommissioning Task Force

<table>
<thead>
<tr>
<th>No.</th>
<th>Education</th>
<th>Site Experience</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Physics</td>
<td>Nuclear Physics</td>
<td>Flux, exposure, and induced activities</td>
</tr>
<tr>
<td>1</td>
<td>Math</td>
<td>Health Physics</td>
<td>Surveys of HWCTR facilities, decontamination requirements</td>
</tr>
<tr>
<td>1</td>
<td>Chemical Engineer</td>
<td>Long-Range Planning</td>
<td>Coordinate planning and analyses</td>
</tr>
<tr>
<td>1</td>
<td>Chemical Engineer</td>
<td>Reactor Engineering</td>
<td>Develop engineering steps for alternatives, make safety studies</td>
</tr>
<tr>
<td>1</td>
<td>Nuclear Engineer</td>
<td>Reactor Engineering</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Chemist</td>
<td>Environmental Studies</td>
<td>Apply environmental and site guidelines</td>
</tr>
<tr>
<td>1</td>
<td>Nuclear Engineer</td>
<td>Separations Engineering</td>
<td>Plant liaison</td>
</tr>
</tbody>
</table>

a. Assigned to HWCTR during period of reactor operation.

b. Part-time members of the task force.

TABLE 3

Objectives

Alternative

Dismantlement

Objective

Restore the U site to a condition suitable for release to the general public. Relocate HWCTR radioactivity to the burial ground.

Entombment

Objective

Secure the activity remaining in the HWCTR facility so that release to the environment is extremely improbable until decay renders it harmless.

Protective Confinement

Objective

Confine activity at the HWCTR site in dry storage while decay proceeds for the foreseeable future.

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