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NUCLEAR MATERIALS DEVELOPMENT FACILITY DECOMMISSIONING FINAL REPORT

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REMEDIAL ACTION AND
DECOMMISSIONING PROGRAMS

NUCLEAR MATERIALS DEVELOPMENT FACILITY DECOMMISSIONING FINAL REPORT

BY

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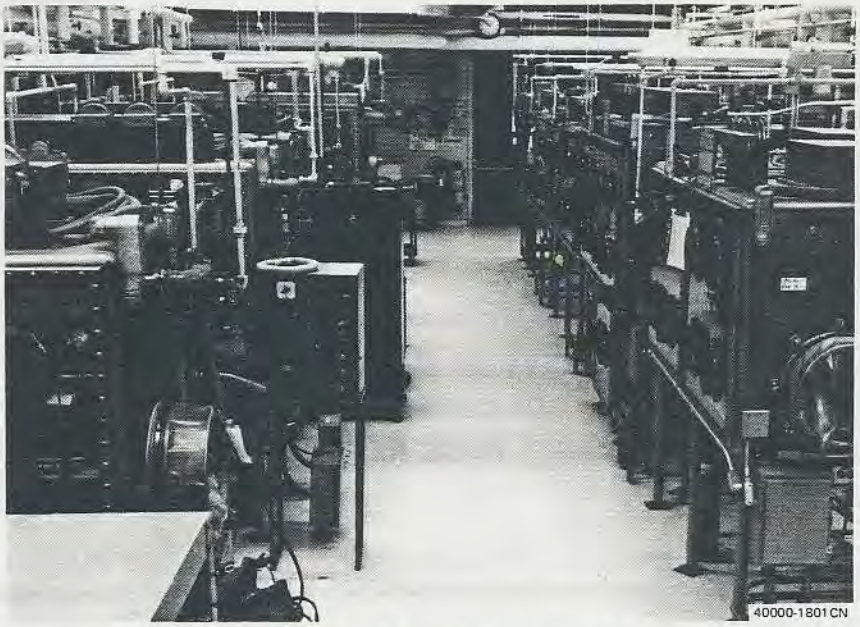

(a) Prior to Decommissioning

(b) After Final Decontamination and Decommissioning

Frontispiece. Glove Box Room

SUMMARY

The Nuclear Materials Development Facility (NMDF), building 055, was utilized for research, development, and production work on radiotoxic nuclear fuels, primarily ^{239}Pu. The decision was made in FY 1982 to decommission the facility as part of the Department of Energy's (DOE's) Surplus Facilities Management Program. The intent was to decontaminate and decommission (D&D) the NMDF to the extent it would be suitable for unrestricted use.

A project plan was prepared to describe the scope of the work, the techniques used, and the equipment needed for D&D. Activity requirements and detailed work procedures were prepared to define the work required on each major segment of the decommissioning.

A facility description, history, and the special techniques used during D&D are given in this report. The more significant D&D activities, which include glovebox decontamination, support area contamination, and HVAC decontamination, are summarized in this document. The NMDF was decontaminated to levels that were as low as reasonably achievable (ALARA), but in all cases to levels below the limits prescribed for unrestricted use. The disposal of potentially contaminated NaK, contained in 10 bubblers that were used to purify the inert atmosphere of the glove boxes, also is discussed.

The decommissioning of Rockwell's NMDF began in October 1982 and was completed in October 1986. Final surveys, waste shipments, and the final report were completed by March 1987. The final schedule for the project is shown in Section 5.0 (Figure 46).

ACRONYMS

ACR	activity requirement
AEC	Atomic Energy Commission
AFS	advanced fuel systems
AI	Atomics International
ALARA	as low as reasonably achievable
ANL	Argonne National Laboratory
D&D	decontamination and decommissioning
DOE-RL	Department of Energy—Richland
DOE-SAN	Department of Energy—San Francisco
DWP	detailed work procedure
EBR-II	Experimental Breeder Reactor-II
FFTF	Fast Flux Test Facility
FY	fiscal year
HAD	heat-activated device
HEPA	high-efficiency particulate air
HP	health physics
LANL	Los Alamos National Laboratory
LASL	Los Alamos Scientific Laboratory
LMFBR	liquid metal fast breeder reactor
LSA	low specific activity
MSA	Mine Safety Appliances
NMDF	Nuclear Materials Development Facility
NTS	Nevada Test Site
PCS	performance control system
PROVE	plutonium recovery option verification exercise
R/A	radioactive
RFP	Rocky Flats Plant
RHO	Rockwell Hanford Operations
RIHL	Rockwell International Hot Laboratory
RMDF	Radioactive Materials Disposal Facility
RRD	Reactor Research Division

SFMPO	Surplus Facilities Management Program Office
SNM	special nuclear materials
SSFL	Santa Susana Field Laboratory
TLD	thermoluminescent dosimeter
TRU	transuranic

CONTENTS

CONTENTS

TABLES

FIGURES

FIGURES

1.0 BACKGROUND

1.1 FACILITY HISTORY

The Nuclear Materials Development Facility (NMDF) (building 055) was completed in 1967 and was pressed into service in 1968 for two programs in support of the government's Fast Flux Test Facility (FFTF). The first program was an analytical chemistry round-robin, which was used to verify analytical techniques for the analyses of mixed uranium-plutonium oxide fuel pellets. The purpose of the second program was to develop a technique to directly recycle scrap mixed uranium-plutonium oxide pellets back into the fuel fabrication cycle. Both of these programs were conducted during the period of April 1968 through June 1969.

A new government program was introduced to the facility in July 1968. This program was to develop a technique to introduce microquantities of tungsten into mixed uranium-plutonium carbide. The purpose of the microscopic dispersion of tungsten was to act as nucleating sites for fission gas. This program ran until June 1970.

In April 1970, a fabrication effort was initiated for Argonne National Laboratory (ANL). This effort produced mixed uranium-plutonium oxide pellets that were used by ANL for irradiation tests. The effort lasted until September 1970, at which time the facility was put on a standby maintenance and surveillance mode.

The facility was removed from standby in March 1974 and made operational for participation in the government's Advanced Fuel Systems (AFS) Program for liquid metal fast breeder reactors (LMFBRs). Concurrently, another AEC program was conducted during the 1974 to 1975 period when the facility was being upgraded and outfitted for the AIR-I fuel pin program. This program demonstrated the use of a molten salt combustor to reduce the volume of transuranic (TRU) solid waste.

Development of the process to reduce the volume and weight of TRU waste began in 1974 when bench-scale combustion tests on uncontaminated waste were carried out. Subsequently, combustion tests of plutonium-contaminated waste in a bench-scale combustion unit were made at the NMDF.

A total of three molten salt combustion tests were completed using the bench-scale equipment setup shown in Figure 1.

Volume reduction factors of 45 for the molten salt combustion process without plutonium recovery and a factor of 57 with plutonium recovery were realized. An economic analysis indicated the entire cost of a molten salt combustion plant for TRU waste would be recovered during the first year of operation.

Concurrent with the molten salt combustor project completion, the facility preparatory tasks for the AFS pin fabrication program also were nearly finished. The initial phase of the program included process development of the synthesis of mixed plutonium-uranium carbide into high-density fuel pellets. This process development had required equipment procurement and facility modifications for the following operations:

- Receival, sampling, analysis, and storage of raw feed materials, including ceramic-grade PuO_2 powder
- Batch weighing, blending, and agglomeration of PuO_2 powder, UO_2 powder, and graphite
- Carbothermic reduction of oxide powders and graphite to plutonium-uranium carbide
- Conversion of plutonium-uranium carbide to nitride
- Chemical analysis of carbide or nitride sample
- Crushing and milling of carbide or nitride
- Pressing of carbide or nitride pellets
- Sintering of carbide or nitride pellets
- Product analysis
  - Chemical analysis of selected pellets
  - Metallographic examination of selected pellets
  - Preparation and packaging of scrap materials for shipment to recovery vendor.

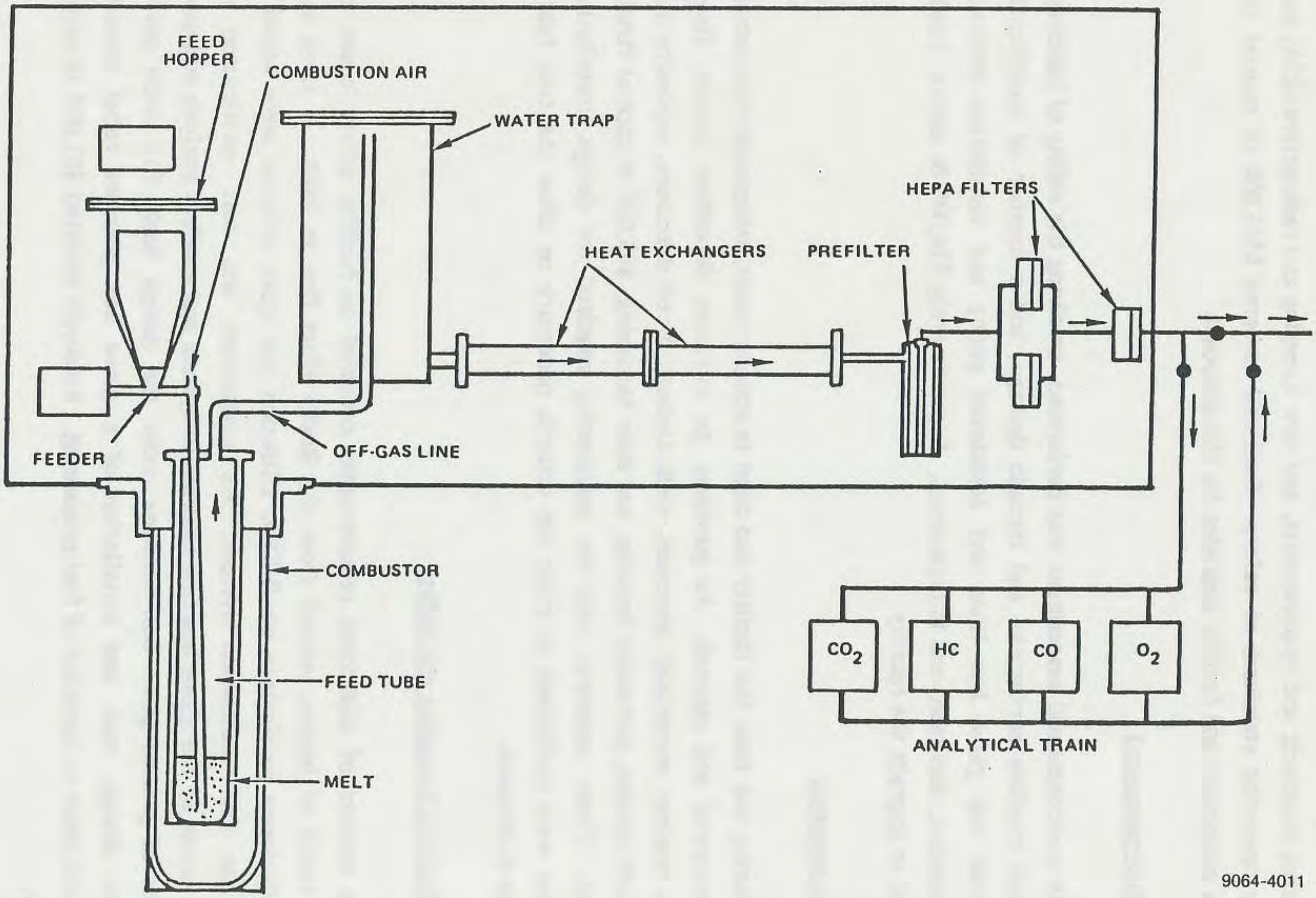

Figure 1. Bench–Scale Radwaste Combustor Flow Diagram

Facility modifications were required for new environmental standards, new safeguards standards and requirements, and new licensing and radioactive (R/A) materials facility operating standards of safety. Rockwell invested $355,000 of capital funds in process equipment and facility upgrades for this proposal.

1.1.1 Environmental

An environmental assessment was performed, involving the ability of building 055 to withstand credible earthquake and tornado damage, and a number of modifications to strengthen the glove box lines and associated piping and ventilation systems were recommended, designed, and implemented. Approximately $24,000 in capital funds were invested to upgrade the facility.

1.1.2 Safeguards

During the time the facility had been in standby mode, safeguards requirements had been reviewed and updated. To purchase an intrusion detection system, fixed–SNM (special nuclear materials) detectors, walk–through metal detectors, explosive detector, entry–exit station, perimeter lighting, and door hardening, $65,000 in capital funding was required. These measures and the engineering required for design, installation, and checkout were performed to meet the criteria necessary to allow the fuel fabrication program to proceed.

1.1.3 Facility Licensing and Safety

A number of additional requirements centered on facility safety issues, many a direct result of lessons learned from the Rocky Flats fire in 1969. A third stage of high–efficiency particulate air (HEPA) filtration and spark arrester were added to the glove box line ventilation system. An assessment and test verification of the effectiveness of the glove box fire suppression system and a safety analysis addressing the behavior of plastic glove box windows under the design basis fire were performed. Analysis, design, test, and installation of a glove box pressure relief system were completed prior to initiation of fuel processing. Rockwell invested $81,000 to modify the facility.

1.1.4 Fuel Processing Equipment

Approximately $185,000 of capital funding was invested in new equipment to increase throughput capacity by a factor of 10 over existing national laboratory fuel fabrication capabilities. The major cost items to support the schedules were the carbothermic reduction furnace and the sintering furnace (Figure 2), each with a 5-kg load capacity. Other equipment required included recorder-controllers, liquid solids twin shell blender, hydraulic pellet press (Figure 3), ball mills and accessories, analytical chemistry equipment, glove box atmosphere hygrometers, and oxygen monitors.

All of this equipment was purchased, installed, checked out, connected to facility alarm systems prior to actual production fuel batches being processed in 1975–1976 after certification by Los Alamos Scientific Laboratory (now LANL—Los Alamos National Laboratory) and RRD (Reactor Research Division).

Atomics International was the responsible contractor for the AIR-1 experiment designed X276 when irradiated in the Experimental Breeder Reactor-II (EBR-II). The mixed carbide fuel had the composition shown in Table 1. The 316 stainless steel-clad fuel pins were sodium bonded and had both shrouded and unshrouded pins. Figure 4 shows the pellet loading station and Figure 5 the component parts of the fuel pin.

Flow diagrams for the fuel pellet fabrication and fuel element fabrication are shown in Figures 6 through 9.

The 1977 RRD funding levels were in a state of flux with the new administration's position on nuclear energy. Because of budget constraints, RRD notified AI to close out the Mixed Carbide Fuel Fabrication Program in May 1977. Funding levels were maintained to keep the facility operational and perform some decommissioning work on excess glove boxes. Carbide fuel was oxidized and glove box lines were cleaned. Four glove boxes were cleaned to non-TRU levels by a combination of foam cleaning and acid wash. They were packaged and shipped to land burial.

Figure 2. Fuel Pellet Sintering Furnace

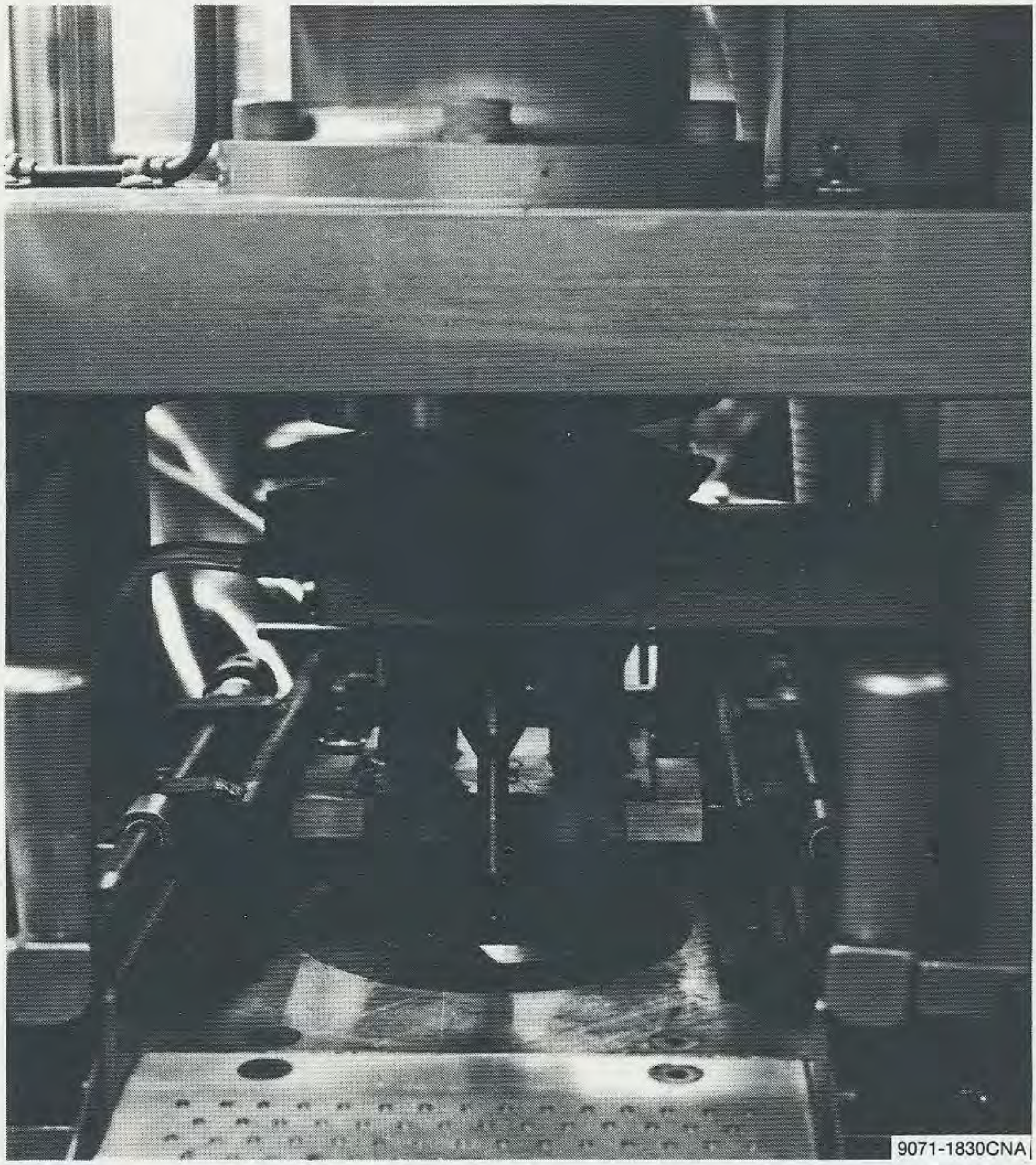

Figure 3. Automatic Pellet Press

TABLE 1
CHEMICAL ANALYSIS OF (Pu, U) CARBIDE FUEL

Fuel Composition	Specification	Batch Number E-0190		Batch Number E-0100	
		AI	LASL	AI	LASL
Uranium (wt. %)		75.84	Approved by LASL and RDD (see last column)	76.29	Approved by LASL and RDD per (1) TWX dated 3 June 1976, Cunningham to Thorne (6686AT); (2) Letter dated 4 August 1976, Waterbury to Jones (10095AT); and (3) Letter dated 14 September 1976, Lee to Jones (12304 AT)
Plutonium (wt. %)		18.68		18.49	
Pu/(Pu + U)	0.200 ± 0.005	0.198			
$C + N_2 + O_2$	5.00 ± 0.10	5.08		5.02	
Carbon (wt. %)		5.01		4.92	
	Limit ppm				
Nitrogen	1000	790		790	
Oxygen	1000	260		472	
Aluminum	300	35		35	
Boron	20	<1 D[a]		<1 D	
Beryllium	20	<0.5 ND[b]		<0.5 ND	
Cadmium	20	<1 D		<1 D	
Calcium	300	25		25	
Chlorine	20	<1		2	
Chromium	250	50		150	
Cobalt	20	<5 D		<5 D	
Copper	200	15		10	
Fluorine	10	<1		<1	
Iron	500	100		150	
Lead	200	10		8	
Lithium	10	3		2	
Magnesium	200	<10 D		<10 D	
Molybdenum	200	50		10	
Nickel		1500		1500	
Potassium	300	5		<5 D	
Silicon	100	25		25	
Sodium	300	3		3	
Tantalum	300	<200 ND		<200 ND	
Tungsten	500	<250 D		<250	
Vanadium	300	2		5	
Zinc	200	<50 D		<50 ND	
Zirconium	200	<200 ND		<200 ND	

[a] D = Detected
ND = Not detected.

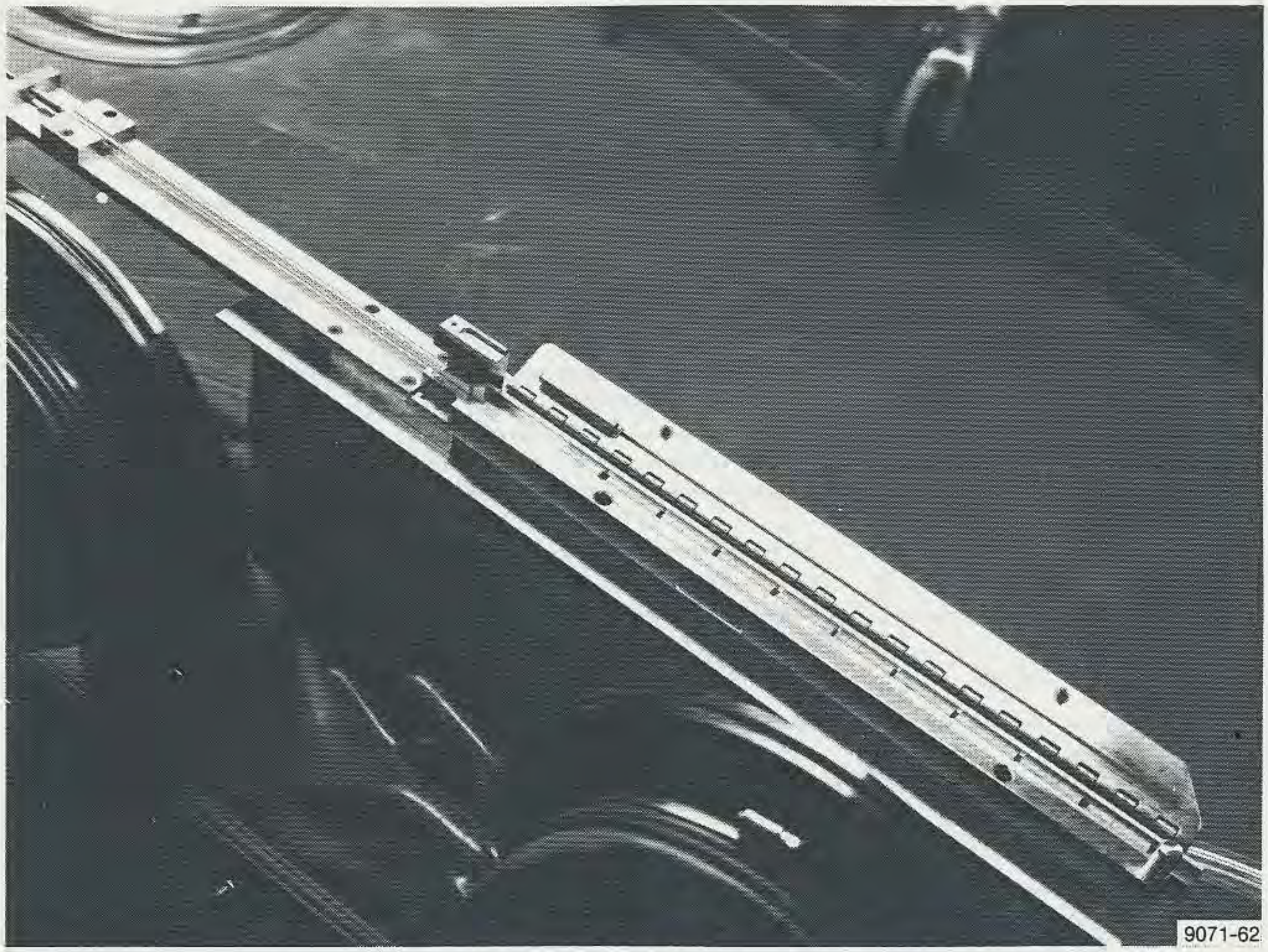

Figure 4. Loading of (U, Pu) Cx Pellets Into the Shroud

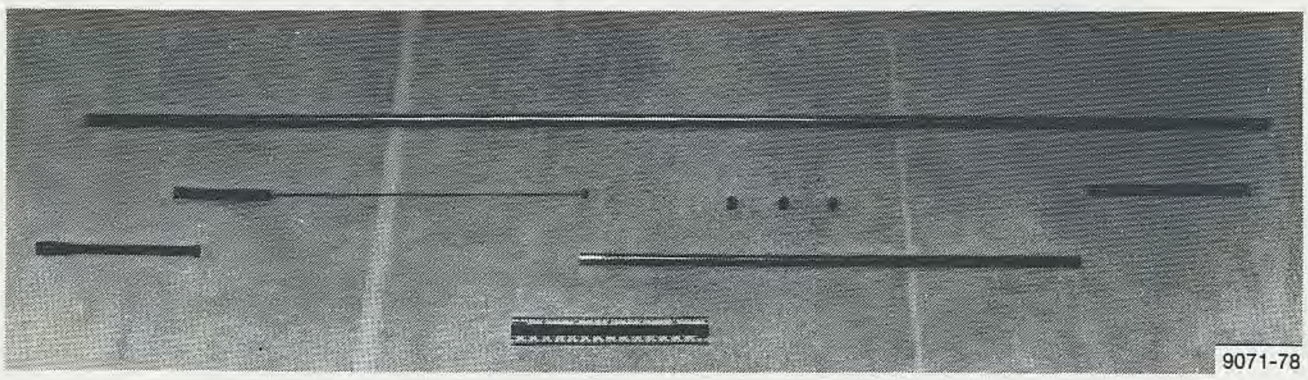

Figure 5. Advanced Fuel Systems Component Parts and Subassemblies

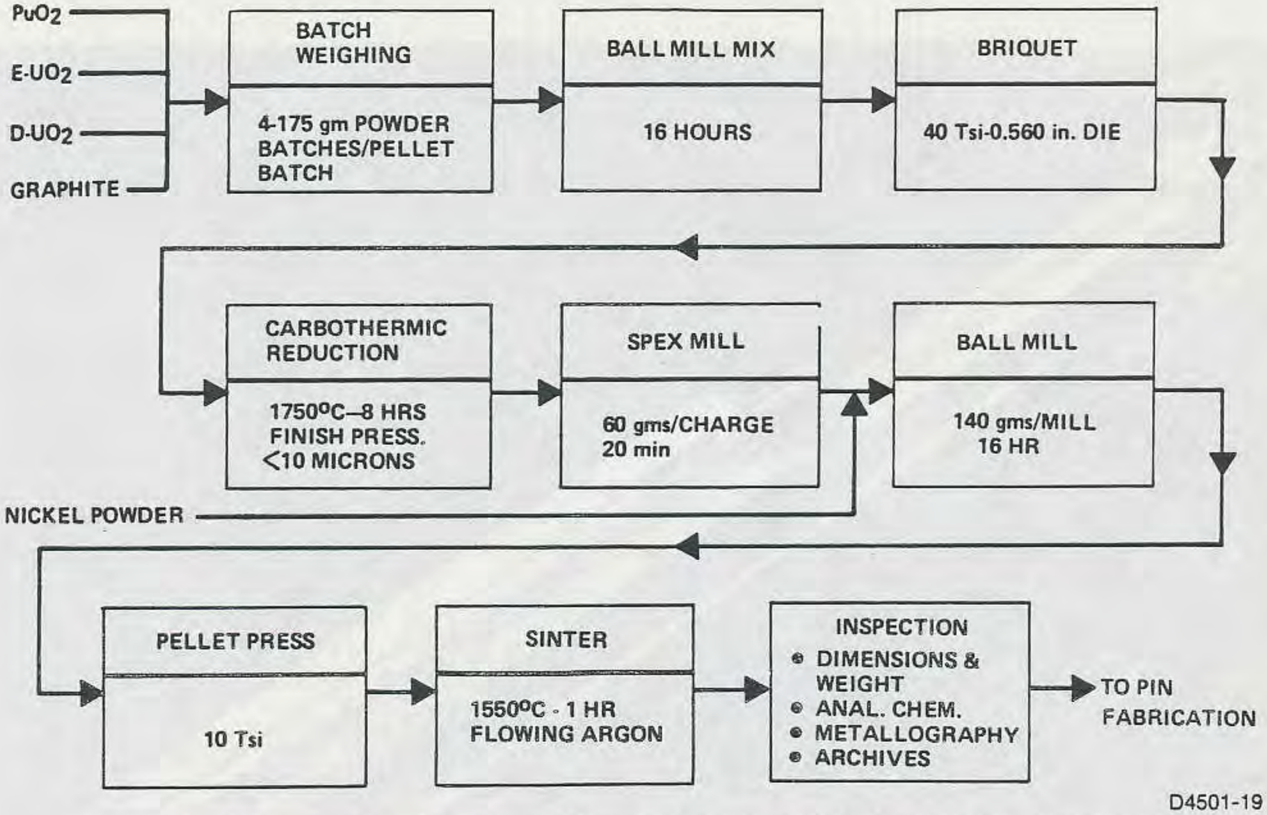

Figure 6. Advanced Fuel Systems Mixed Carbide Pellet Production, Process Flow

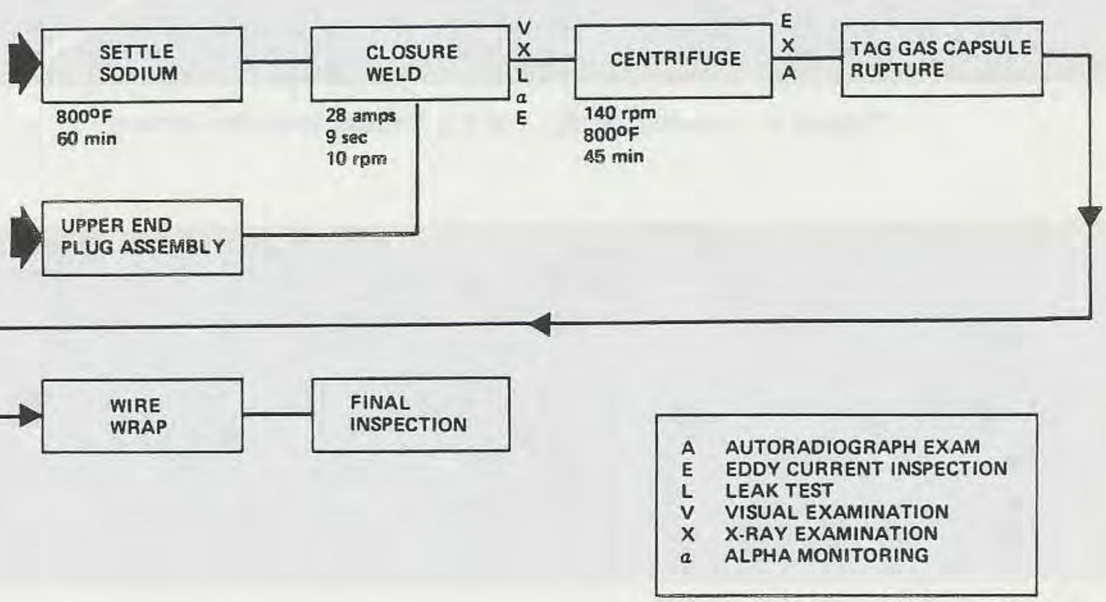

Figure 7. Advanced Fuel Systems Fuel Element Fabrication Flow Diagram

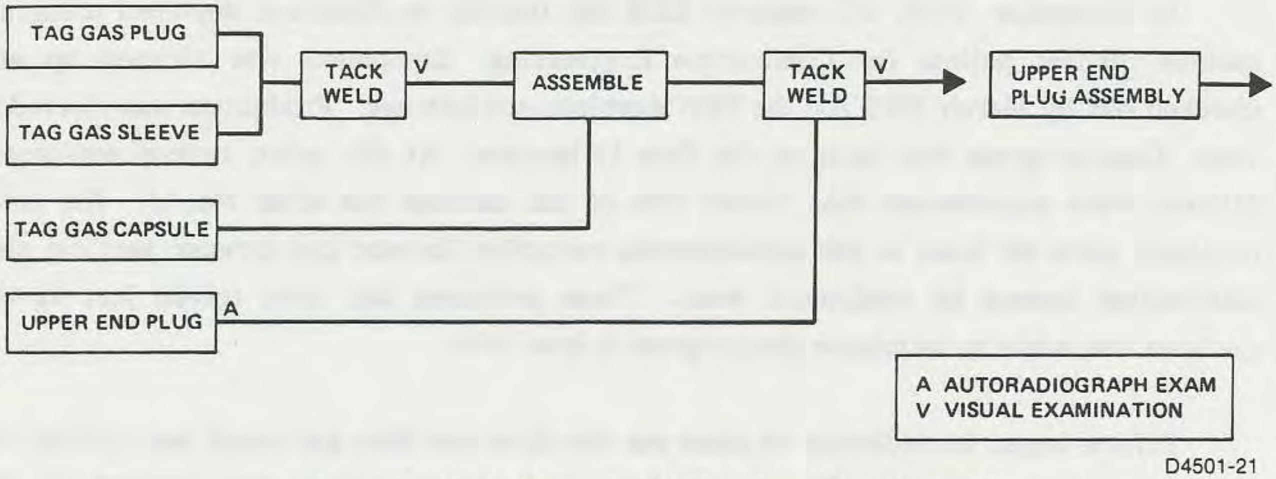

Figure 8. Fuel Element Fabrication Flow Diagram

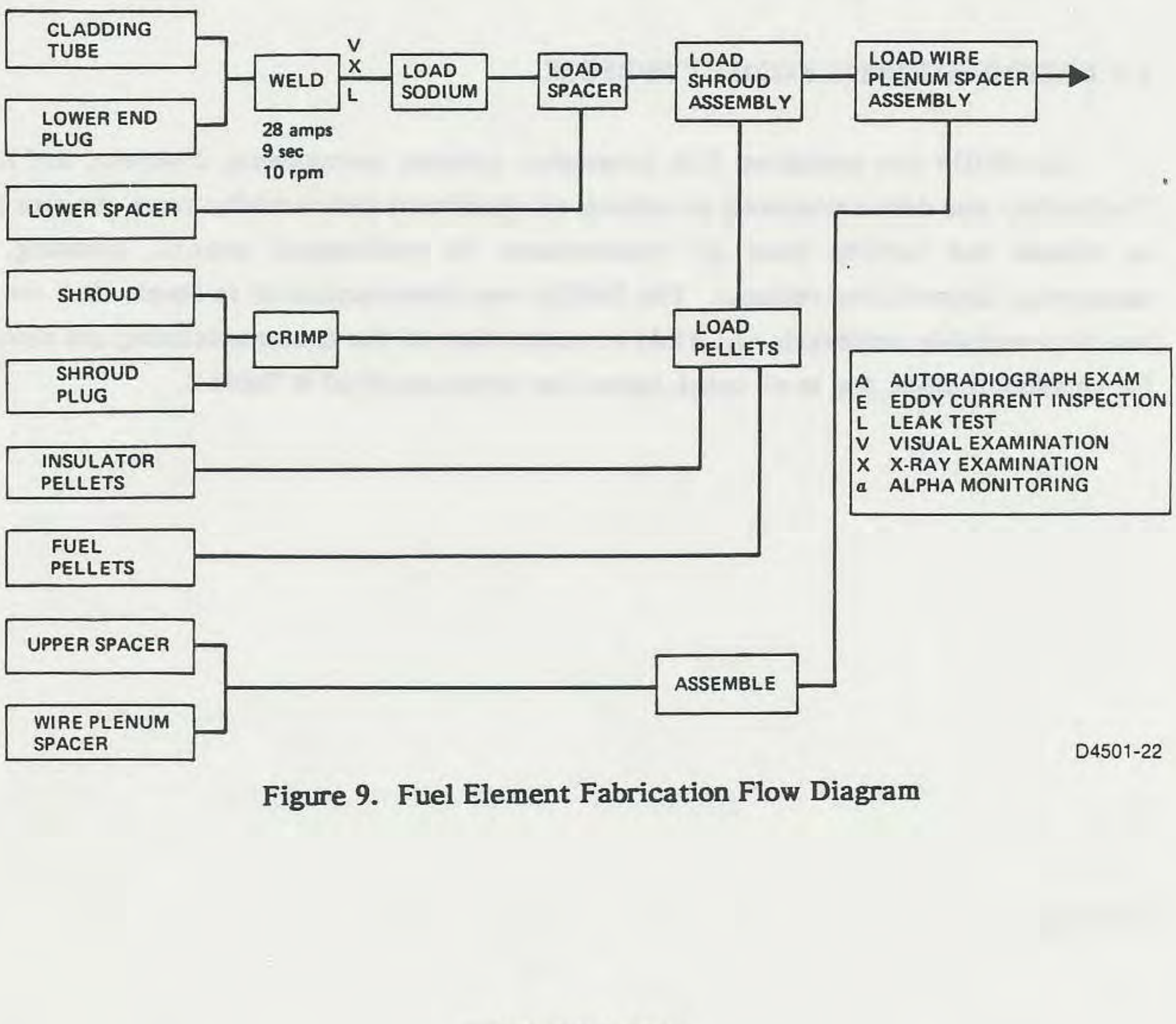

Figure 9. Fuel Element Fabrication Flow Diagram

In November 1978, AI received $538,000 funding to fabricate depleted uranium-carbide blanket pellets for Combustion Engineering. Equipment was cleaned up and checked out by March 1979 for the first development batches. Production was started in June. Good progress was made on the first 15 batches. At this point, several equipment failures were experienced that ruined 75% of the batches run after No. 15. The main problems were air leaks in the carbothermic reduction furnace and powder particle size distribution caused by equipment wear. These problems had been solved just as the decision was made to terminate the program in late 1979.

Efforts began immediately to clean out the glove box lines and crush and oxidize the uranium carbide. Good pellets were inspected, encapsulated, and shipped to the customer. Negotiations for the decommissioning of Atomics International's plutonium fuel fabrication facility were then initiated with the Department of Energy (DOE).

1.2 DECOMMISSIONING PROJECT PURPOSE

The NMDF site contained R/A structures, systems, components, concrete, and soil. The facility was decommissioned to remove all significant radioactivity from the site and to release the facility from all requirements for radiological control, licensing, or monitoring (unrestricted release). The facility was decontaminated to levels that are as low as reasonably achievable (ALARA) at completion of the decommissioning and release for unrestricted use, and in all cases, below the levels specified in Table 2.

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TABLE 2

ACCEPTABLE LIMITS FOR RESIDUAL RADIOACTIVITY (ROCKWELL INTERNATIONAL/ROCKETDYNE)

	Total Average[a]	Total Maximum[b]	Removable
Surface contamination			
Beta-gamma emitters	5,000 dpm/100 cm^2	15,000 dpm/100 cm^2	1,000 dpm/100 cm^2
Alpha emitters	100 dpm/100 cm^2	300 dpm/100 cm^2	20 dpm/100 cm^2
Surface dose rate At 1 cm through 7-mg/cm^2 absorber	0.1 mrad/h	0.5 mrad/h	
Ambient exposure rate At 1 m from surfaces	5 mR/h above background		
Soil contamination ^{239}Pu		25 pCi/gm[c]	
Water Released to unrestricted areas		<110% of local water supply	

[a]Average over a 1-m^2 area
[b]Maximum value measured in 1-m^2 area, averaged over 100 cm^2
[c]NRC requirement for building 055 only.

2.0 FACILITY DESCRIPTION

The NMDF building enclosure is a tilt-up concrete structure 200 ft long, 60 ft wide, and 16 ft high (Figures 10 and 11). The building is divided into an administration area, change rooms, chemistry and other service laboratories, a glove box room, a vault, and facility equipment rooms. The design permits outward expansion of the building from either side. The facility layout is described in Section 2.1.1.

Primary plutonium containment was provided by the glove box system. Secondary containment was provided by the pressure-controlled zones in the building, which include the glove box room, chemical support room, general support room, counting room, electronics shop, darkroom, R/A exhaust equipment room, and the vault. Air locks were provided at the main and rear entrances to the posted zones. The facility ventilation system was designed to force airflow from clean areas toward areas of highest R/A material contamination potential.

The normal entrance way to the administration area and posted zone is through the main entrance at the front of the building. Except in emergency situations, Protective Services and the facility supervisor must be informed prior to opening any of the other external doors. These doors are normally secured with keyed locks and quick-release devices to facilitate emergency evacuation.

2.1 BUILDING AND SYSTEMS

The NMDF building is constructed of noncombustible materials, including windowless, precast, tilt-up concrete slab walls of 6-in. thickness and a concrete slab floor. The roof (consisting of lightweight, tarred felt and gravel) is supported on steel deck panels and girders.

The portion of the building surrounding the pressure-controlled zone is constructed and maintained by Thiokol (joint filler and crack sealer, filled concrete joints, painted concrete surfaces, weatherproofed doors, and suitable partitions).

The floors of the glove box room and chemical support laboratory had a polyvinyl linoleum covering for the concrete floor with a minimum of seams for easy contamination control.

The building is provided with the following systems:

- Air conditioning systems, including temperature and humidity control
- An R/A exhaust system for the facility posted zones
- A separate R/A exhaust system for glove boxes
- Glove box lines
- Radioactive liquid waste holdup system
- Electrical power distribution, including an emergency power generation system
- Annunciator and control panels
- Alarms and instrumentation
- Fire and control systems
- Plumbing system
- Storage vault.

2.1.1 Facility Layout

Figure 12 shows the layout of the building 055 enclosure.

2.1.2 Office Area

The office area consisted of a reception lobby, secretarial office, five offices suitable for management and engineering, a design engineering office, a conference room, a Health Physics (HP) office, two restrooms, a clothing change room, and a shower room.

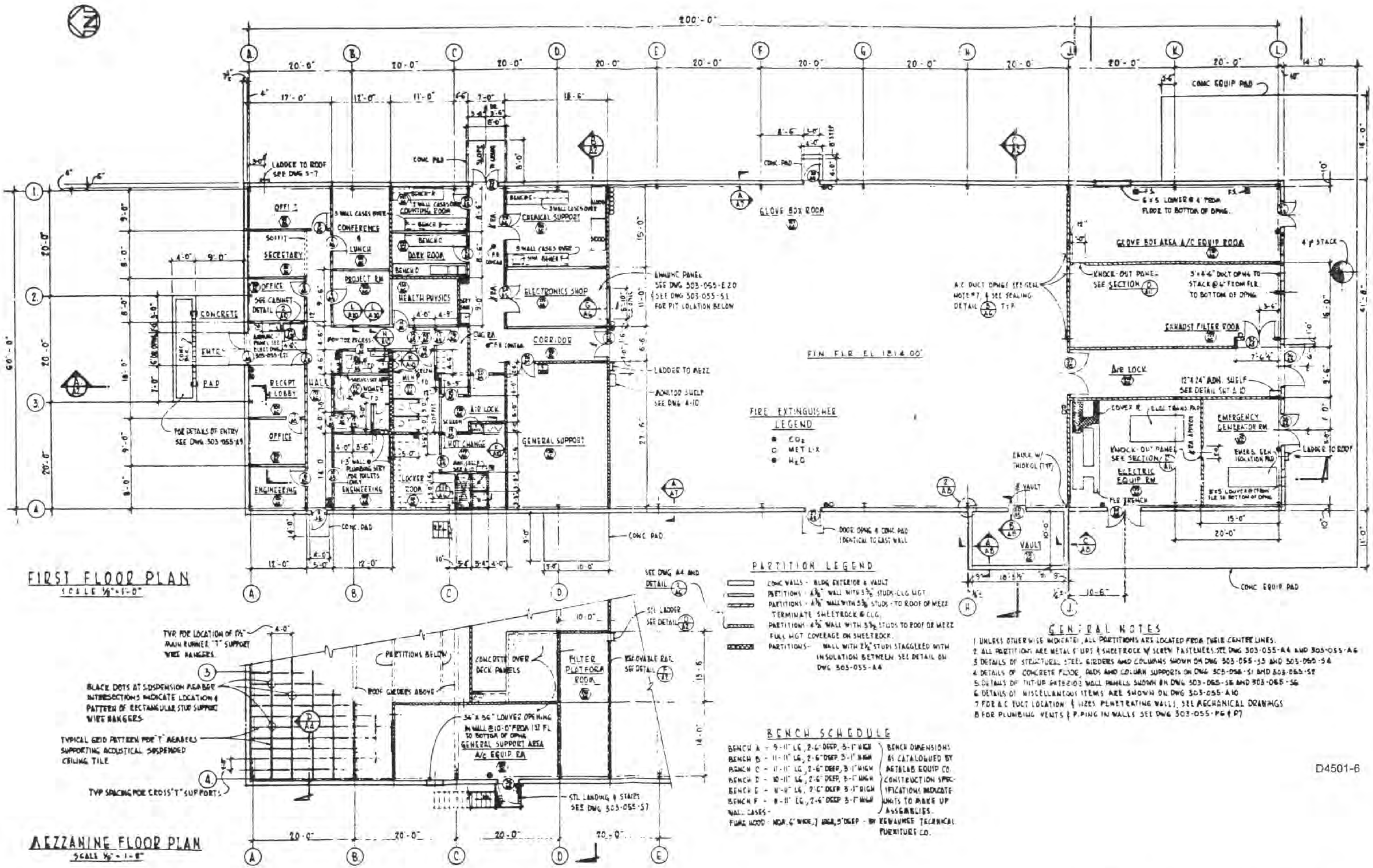

Figure 10. Architectural Plan, NMDF

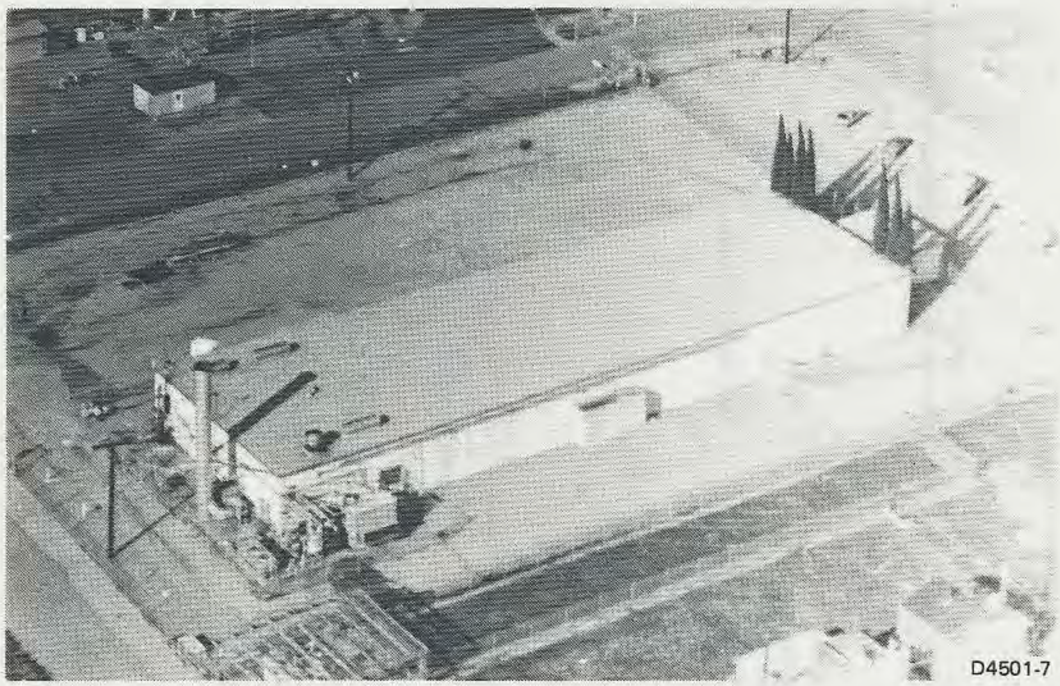

Figure 11. Aerial View—NMDF, Building 055

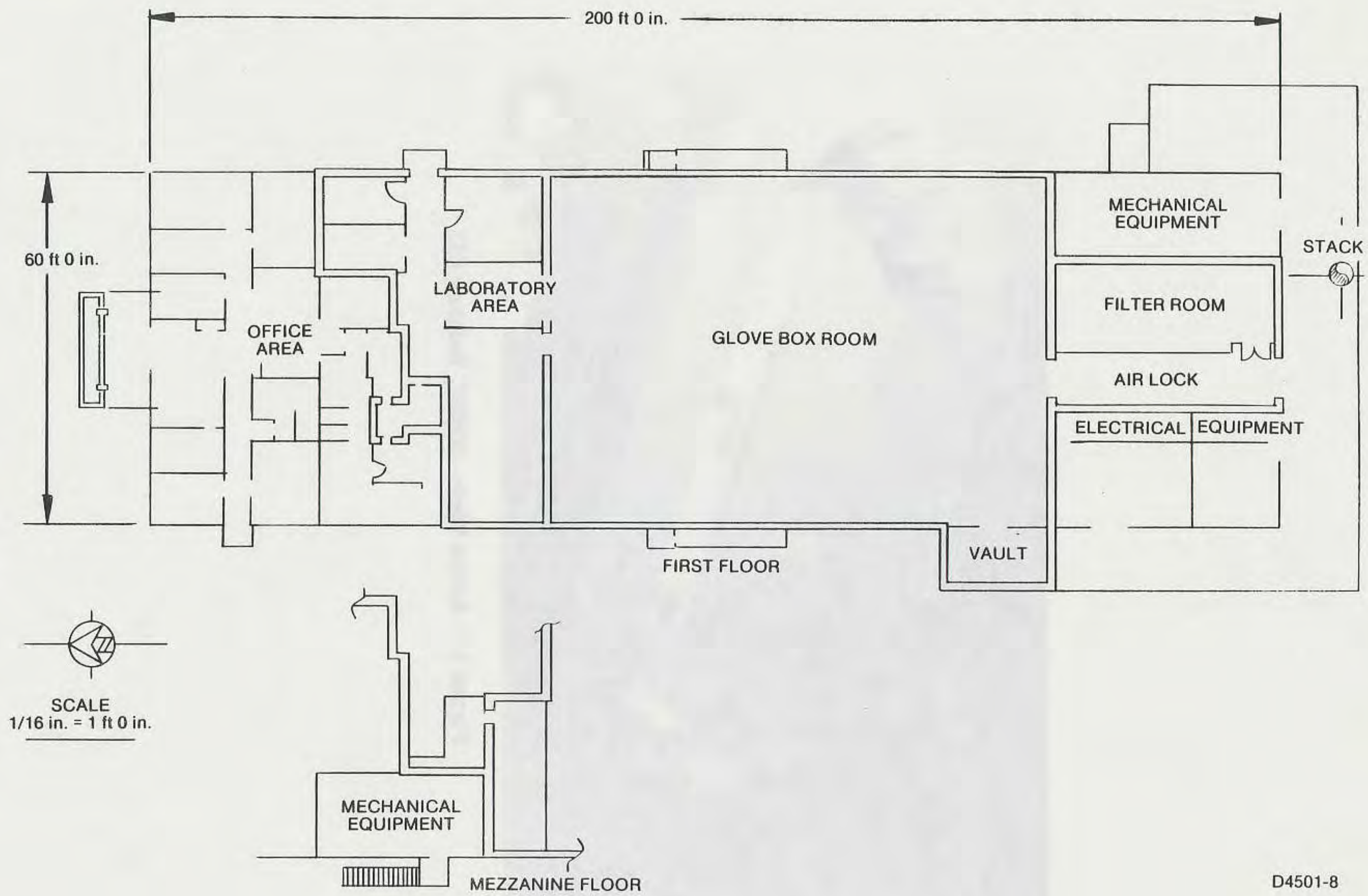

Figure 12. Building Enclosure—NMDF, Building 055

2.1.3 Support Area

The support area contained a darkroom for the processing of film and negatives taken of metallurgical samples. An HP counting room was located next to the darkroom. Three laboratories were provided. In the first laboratory, chemical sampling and experimentation were conducted. In the second laboratory, electronic setups and process equipment repairs were made and the third laboratory was utilized for metallographic work associated with the production line.

2.1.4 Glove Box Room

The glove box room was 81 ft 6 in. long by 61 ft 6 in. wide by 16 ft high. Construction is the same as described in Section 2.1. The room contained two glove box lines as shown in Figure 13. The fuel fabrication line had 14 glove boxes connected to a transfer tunnel and the analytical line had 15 glove boxes that were connected to a separate transfer tunnel. Figure 14 displays the work station and the auxiliary equipment locations within the glove box room. Design details of the boxes are shown in Figures 15 and 16, respectively.

2.1.5 Stainless Steel Materials Storage Vault

The fuel storage vault was constructed of 9-in.-thick, reinforced-concrete walls, ceiling, and floor. It had a combination lock, vault-type door that opened to the glove box room. The vault was connected into the building exhaust and was equipped for inert gas and fire extinguishing. Refer to Figure 10 for dimensions and location.

2.1.6 Radioactive Exhaust System

All air being exhausted from the building had to pass through the main bank of high-efficiency filters, which were located in the R/A exhaust filter room (Figure 12). Twenty-seven filters were arranged in nine isolatable units of three filters each (Figure 17). Filters could be replaced by isolating one unit at a time, changing the filters, and putting the unit back in service.

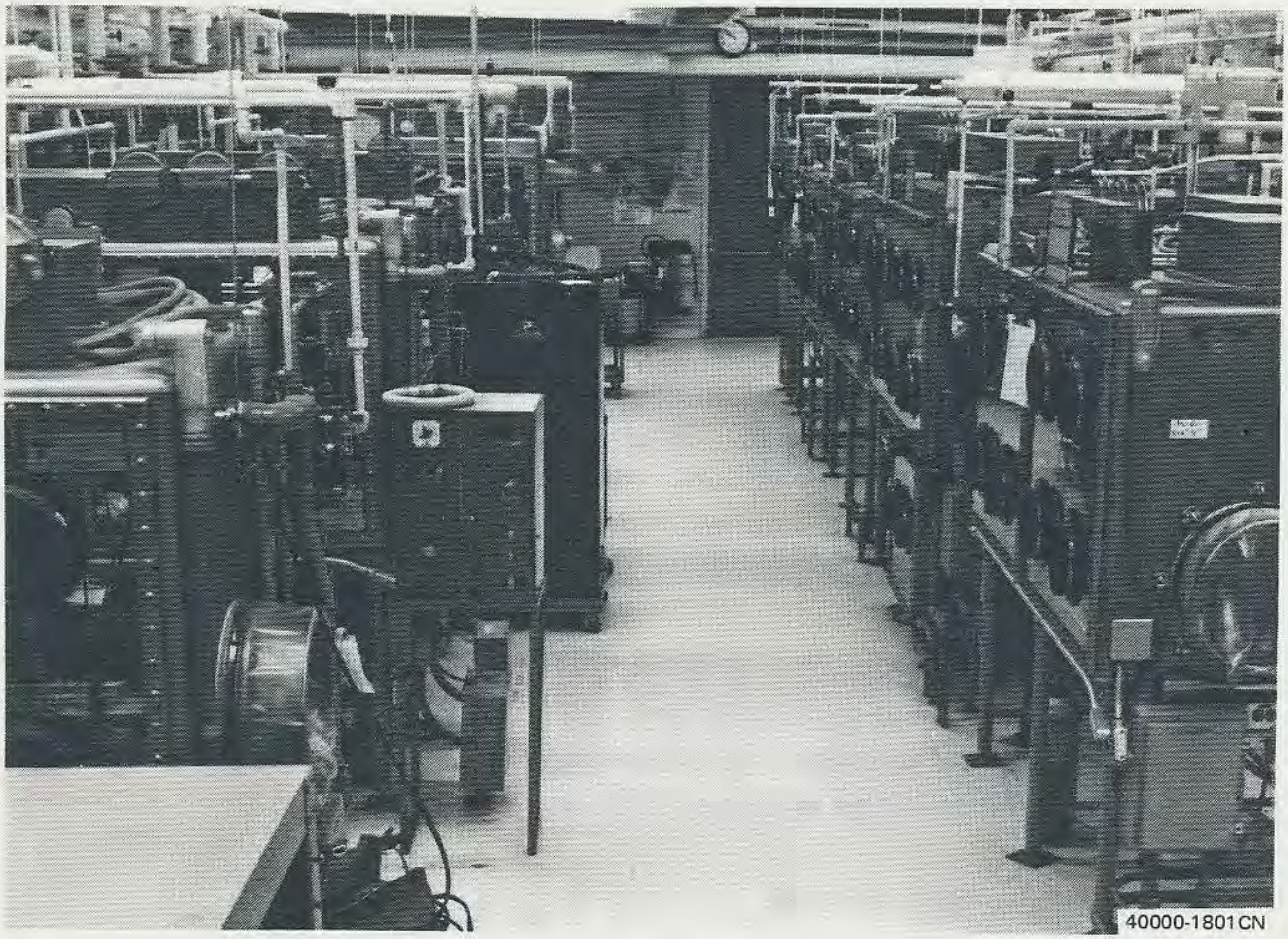

Figure 13. Glove Box Room Prior to Decommissioning

Item Number	Work Station Number	Auxiliary Equipment Number	Fuel Fabrication Line
1	1		Air Entrance
2	2		Inert Gas Entrance
3	3		Dry Blending and Agglomeration
3A	3		PuO_2 Receiving and Weighting
4	4		Carbothermic Reduction
5	5		Crush, Ball Mill and Sieve – Agglomerates and Granules
6	6		Sintering
7			Mechanical Pellet Press[b]
8	8		Press and Measure Green Density
9			Powder Granulating[b]
11			RAD Waste Combustion[b]
12	2		Balance Box
13	13		Pellet Dimensioning and Weighing
14	14		Pin Loading, Sodium Settling and in Process Storage
30	30		Final End Plug Welding
10		10	Powder Granulating and Crushing and Milling
			Analytical and Development Line
1A	1A		Air Entrance
2A	2A		Inert Gas Entrance
15A	2A		Weighing
19	19		Metallography Sample Preparation
20	20		Metallography Sample Etching, Final Polishing, Autoradiography & View Port for Metallograph
M	20		Metallograph
204		204	X-Ray Diffraction Power Supply & Source
16	16	204	X-Ray Fluorescence Analysis
C		C	X-Ray Fluorescence Console and Readout
18	18		Inert Gas Fusion Analysis
17	17		Emission Spectrograph Sample Preparation
17A	17		Arc Spark Chamber for Emission Spectrograph
22	22		Thermo-Gravimetric Analysis
201		201	Emission Spectrograph
24	24		(U-Pu)C Powder Processing[a]
28	28		Transfer[a]
27	27		(U-Pu)C Compact Pressing[a]
H	H		Fume Hood

[a] Pilot line for development covered by a separate NSA (6)
[b] Not covered by this NSA

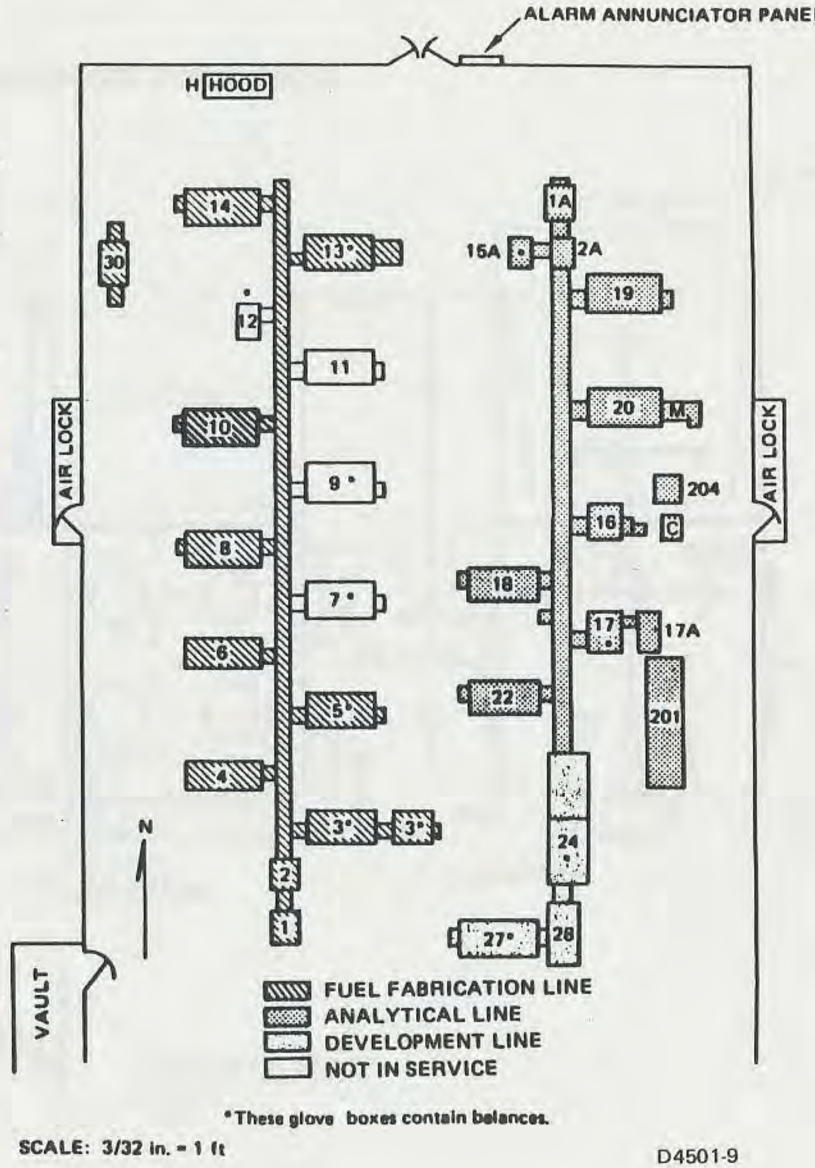

Figure 14. Work Station and Auxiliary Equipment Locations, Glove Box Room

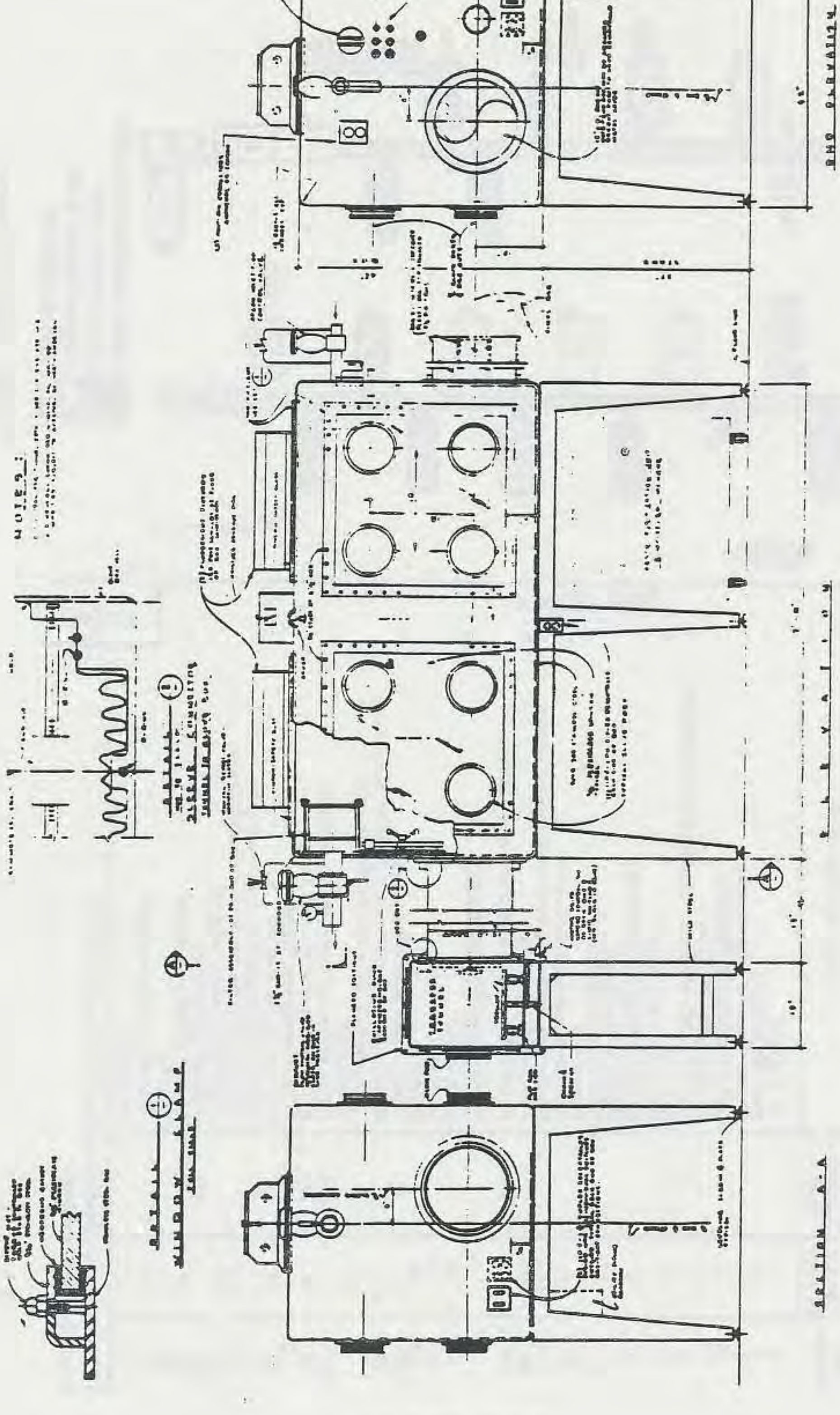

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Figure 15. Glove Box Design Detail, NMDF

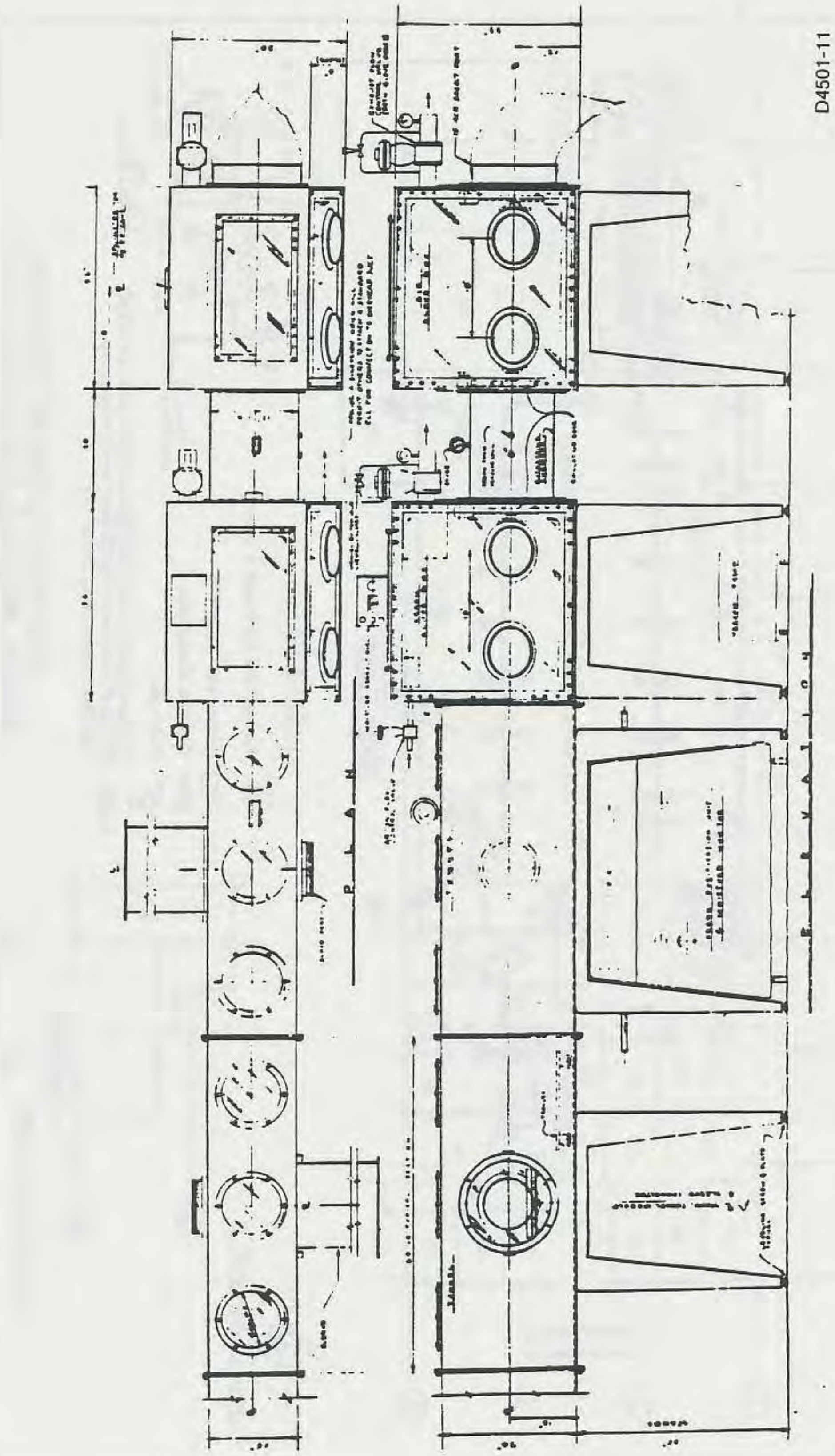

Figure 16. Glove Box Transfer Tunnel Design Detail, NMDF

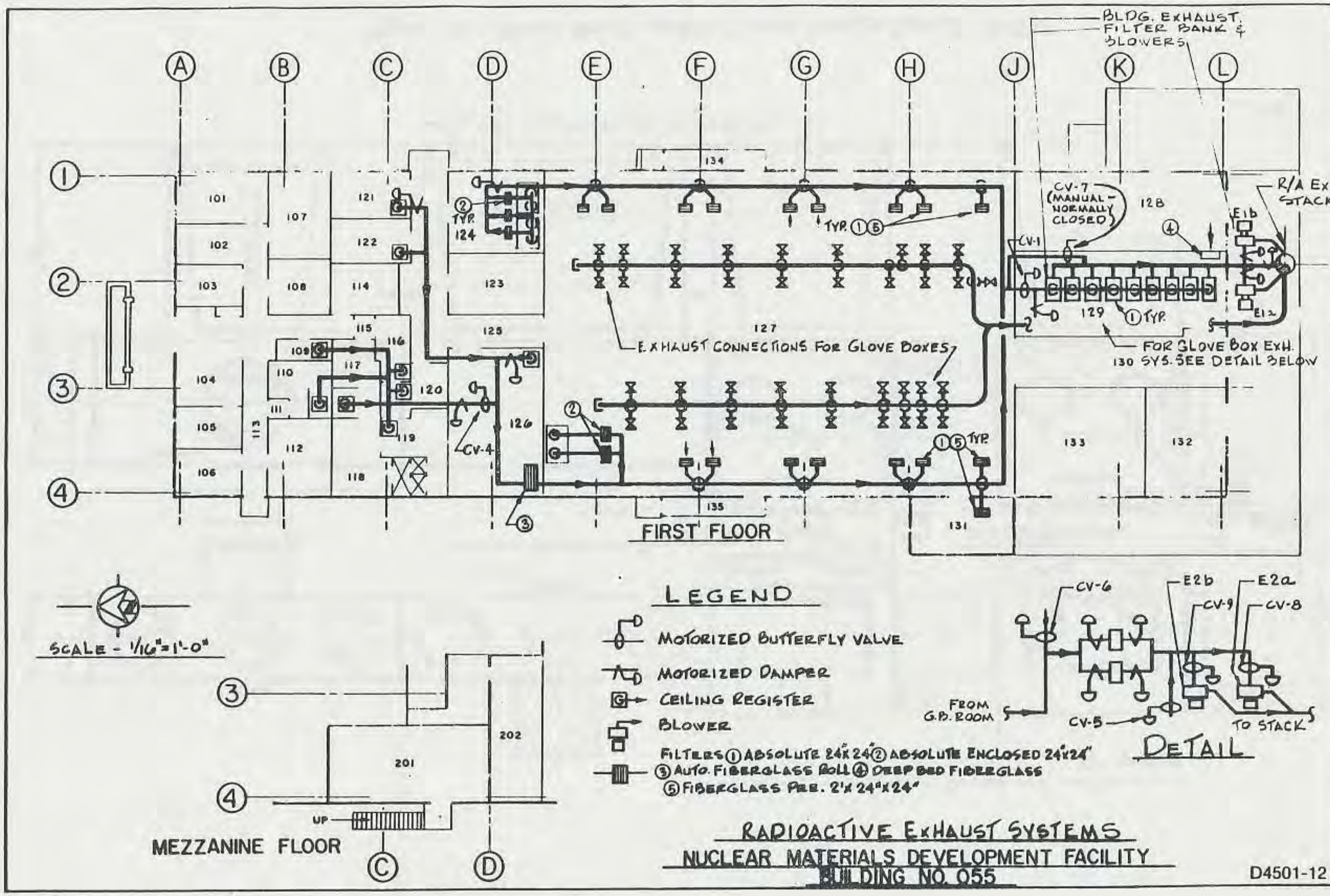

Figure 17. Radioactive Exhaust Systems

All air that was exhausted from the glove box room and the Chemistry laboratory was prefiltered through high-efficiency filters before it reached the main filter bank, thereby providing double high-efficiency filtration for those areas having primary involvement with radiological hazards.

All air that was exhausted from other containment support areas was prefiltered through low-efficiency filters ahead of the main filter bank.

The glove box exhaust system, which was separate from the building exhaust system (Figure 17), incorporated a series of three high-efficiency filters. Gas or air being released from a box passed through a high-efficiency filter located inside the glove box before entering the exhaust piping. At the end of the main piping run, a metal filter served as a fire-stop for burning material that may be passing through the system. Beyond the fire-stop were parallel double high-efficiency filters in series with automatic isolating valves that allowed only one filter system to be active, with the second double in-series filter system serving as a backup to the active filter system.

If a large quantity of particulate matter could get past the glove box filters and loaded up the active final filter system, the system would first start the standby blower, and if this did not provide sufficient air movement, the system would switch to the clean standby filter system.

The above supposition of particulate matter getting past the glove box filter was based primarily on the probability of an incident in a glove box that damaged or burned out the glove box filter. To avoid the possibility of hot gases going past the fire-stop and burning the final filter, a vent valve (CV-6) opened on high temperature in the duct to allow room air to enter and cool the hot gases by dilution.

Blowers E2a and E2b served the glove box exhaust systems shown in Figure 17. Under normal operating conditions, blower E2b was in service and blower E2a was on standby. The glove box exhaust system normally functioned as a static system with the small quantities of argon and air being released from the boxes amounting to only 1 ft^3/h.

Because each blower had a capacity of 700 cfm at 8 in. of water, the exhaust headers were maintained at a negative 8 in. of water by bleeding outside air into the system just ahead of the blowers.

If a glove failure occurred, the dump valve opened to provide sufficient airflow through the glove to ensure containment of R/A material. If pressure in the exhaust system increased to a negative 4 in. of water, the standby blower E2a automatically came on to support the operating blower if fan E2b was running and SW 302 was in the auto position.

2.1.7 Liquid Radioactive Waste Holdup System

All floor drains, service sinks, and laboratory sinks potentially capable of receiving R/A liquid waste were directly connected to the R/A liquid waste system (Figure 18). No fluids known to be contaminated were allowed to be introduced to the system. Known contaminated fluids were solidified as R/A waste.

A manually operated, three-way valve permitted selective discharge of the change room shower drains to either the R/A liquid waste system, or to the sanitary sewer system. Normal position of the valve was to the R/A system, to accommodate emergency situations. If nonemergency showering was required, that did not involve R/A particulate matter, the showers were drained to the sanitary sewer system. To eliminate the possibility of R/A contamination entering the sanitary sewer system, the showers were restricted and used only for emergency purposes.

Potentially contaminated liquid wastes flowed through underground soil piping to the control tank installation at the southeast corner of the building 055 yard area. Wastes first entered the hot waste clarifier tank (T-1) for removal of suspended solids. A float-controlled pump (P-5) then automatically transferred the clarified liquid to the 230-gal receiver tank (T-2). When this tank was full, a sample was analyzed to determine if radioactivity were present, and the contents were then manually discharged to one of the 1000-gal holdup tanks (T-3 and T-4) for future disposal.

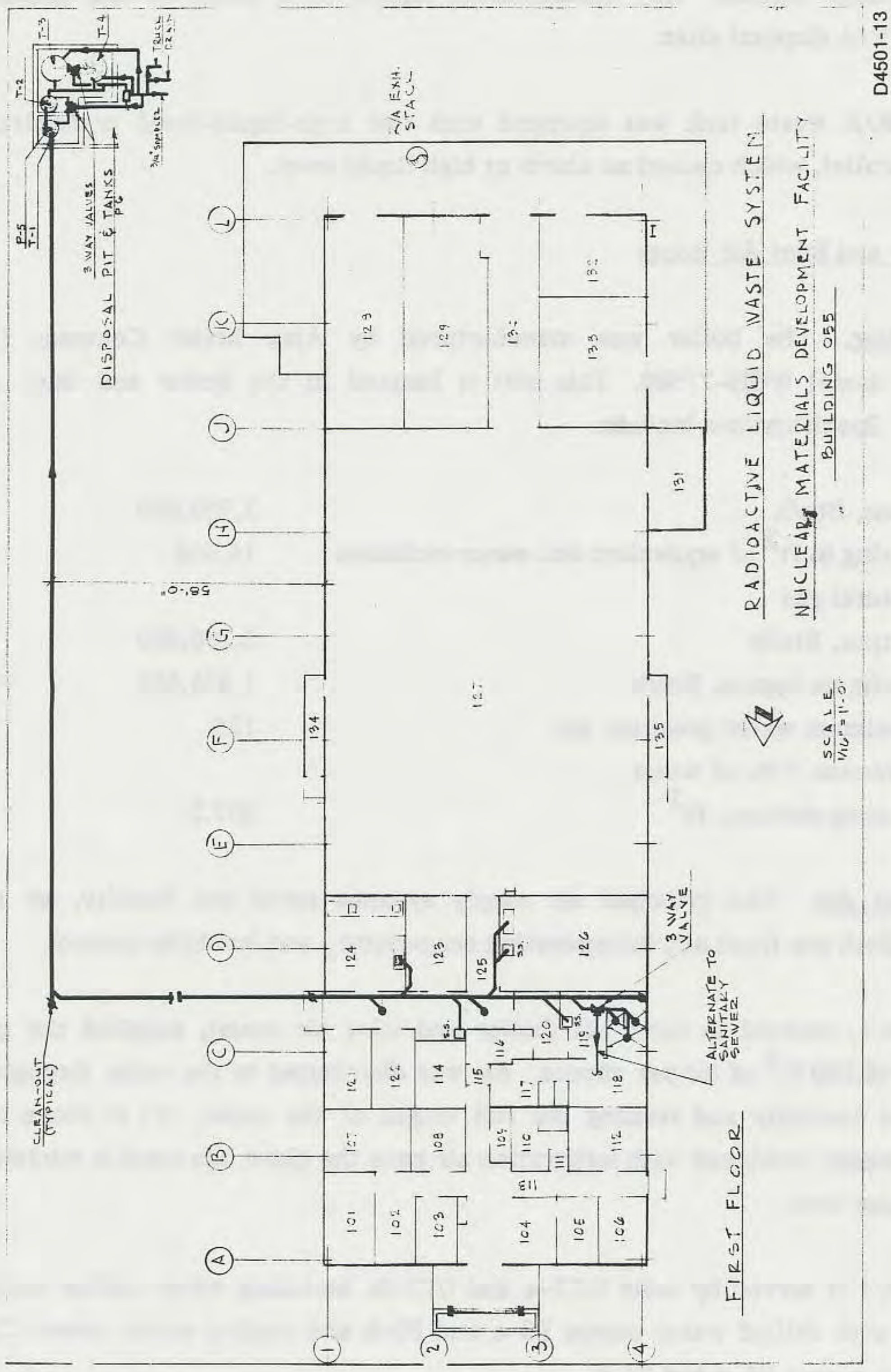

Figure 18. Radioactive Liquid Waste System

Final disposal from holdup tanks was made by pumping (P–6) safe liquids to adjacent surface drainage ditches. Any contaminated liquids were solidified and disposed of at appropriate R/A disposal sites.

Each R/A waste tank was equipped with two high–liquid–level transmitters connected in parallel, which caused an alarm at high liquid level.

2.1.8 Boiler and Inlet Air Room

2.1.8.1 Boiler. The boiler was manufactured by Ajax Boiler Company (Gardena, California), model WGH–27500. This unit is located in the boiler and inlet air room (Figure 14). Specifications include:

• Input, Btu/h	2,750,000
• Rating in ft^2 of equivalent hot water radiation	14,666
• Natural gas	
• Output, Btu/h	2,200,000
• Minimum bypass, Btu/h	1,375,000
• Maximum water pressure, psi	125
• Minimum 7 in. of water	
• Heating surface, ft^2	297.2.

2.1.8.2 Inlet Air. Two principal air supply systems serve the facility, as shown in Figure 19. Both are fresh air, incorporating temperature and humidity control.

System 1, located in room 128 (boiler and inlet air room), supplied the glove box room with ~18,000 ft^3 of air per minute. Air was distributed in the room through a single duct located centrally and running the full length of the room, ~11 ft above the floor. This direct supply combined with infiltration air gave the glove box room a minimum of 10 air changes per hour.

System 1 is served by units UC1–a and UC1–b, including water chiller units WC1–a and WC1–b with chilled water pumps P3–a and P3–b and cooling water tower CT–1 with cooling tower pumps P4–a and P4–b.

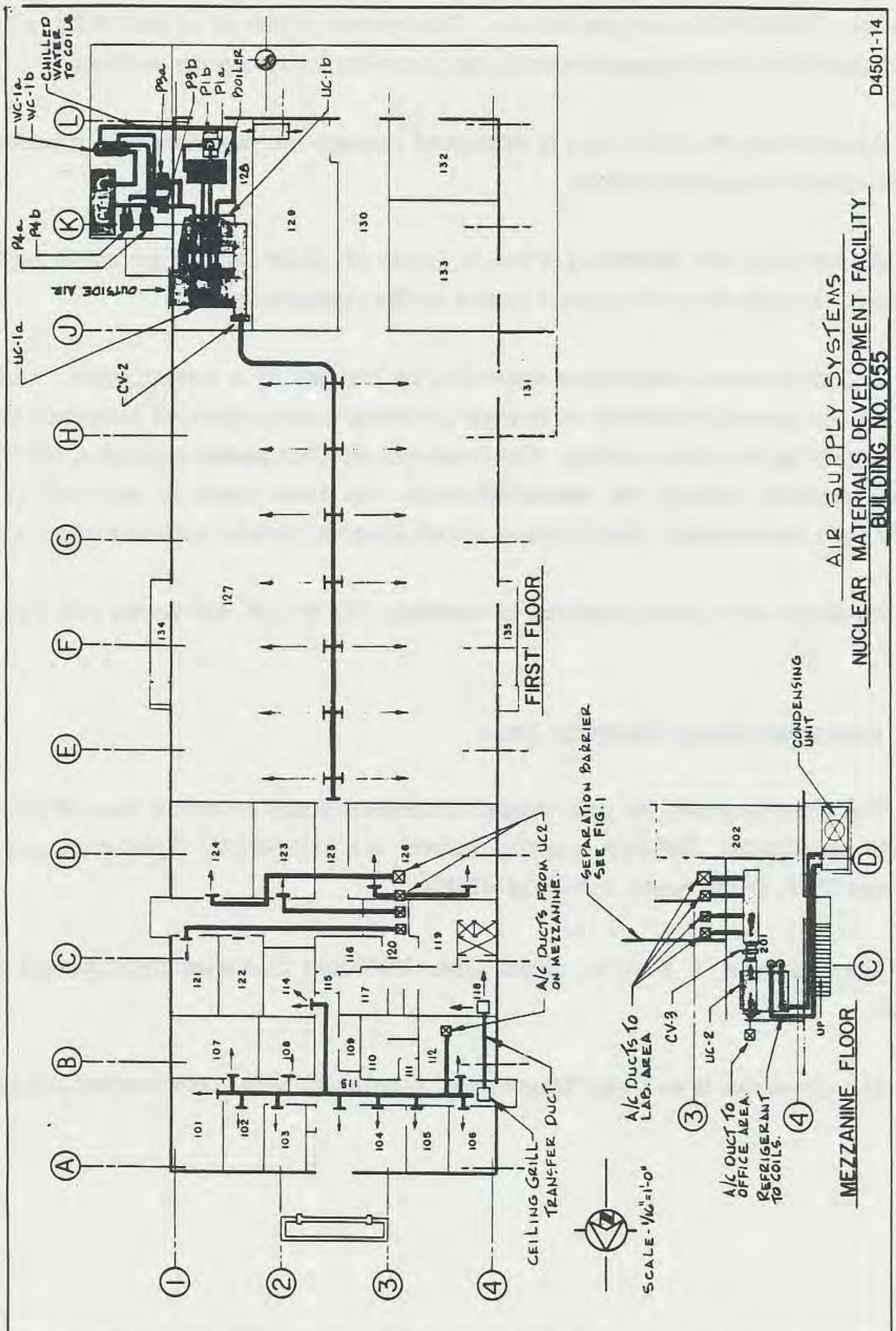

Figure 19. Air Supply Systems

System 2 (located in room 201) supplies the offices, change rooms, and laboratory areas with ~8000 ft^3 of air per minute. This system is served by unit WC2, a four-zone unit that utilizes direct expansion coils and an air-cooled condenser section.

Air entering the office area is exhausted through the corridors to a transfer duct in the toilet and change room areas.

Air entering the laboratory areas at a rate of 10 air changes (or more) per hour was exhausted through the main exhaust system to the atmosphere.

In both systems, humidity is controlled by the use of a reheat cycle. Outdoor air entering the systems is heated as required to bring it to an elevated temperature suitable for humidifying the spray cooling. The saturated air then passes through a chiller coil to provide sensible cooling and dehumidification and from there to zone reheat coils to satisfy zone thermostats. Both systems are single-pass systems with no recirculation.

No direct air is being supplied to corridors 125 or 130, nor rooms 128, 132, 133, or 201.

2.1.9 Emergency Power Generator Room

The standby generator unit located in the emergency generator room (Figure 12) is a 200-kW continuous, 230-kVA standby source and 277/480 V, 3 phase, 4 wire, 60 Hz, 1800 rpm (P. F. Onan, model 230-DFM-4XRS).

The engine is a 4-cycle, diesel-type, 1800-rpm Cummins turbocharged NTA-400 engine.

The alternator is an Onan "Magnetizer" 4-pole unit with static exciter and regulator.

2.1.9.1 Accessories. Accessories include:

- Low oil pressure gage
- High water temperature gage
- Overspeed and overcrank tachometer
- Individual safety lights
- Immersion oil heater
- Above-ground fuel tank and couplings
- Battery rack with 20 nickel-cadmium batteries, Nife model H1P-8
- Battery charger unit, fully automatic, 120-Vac input, Lamarche model A5-10-24.

2.1.9.2 Standby Generator Operating Control. The standby generator is automatically started, by the closure of a set of contacts in the automatic contact switch, after a time delay following the loss of normal power. The standby generator is automatically shut down after a time delay following the restoration of normal power.

2.1.10 Annunciator and Control Panels

The two annunciator panels were located in the administrative area near the main entrance and on the north wall of the glove box room. These were the monitoring, communication, and control centers of the facility and associated glove box system.

The administrative area annunciator panel (Figure 20) lamps, pushbutton controls, and audible signals were operated with the main annunciator chassis and relays in the glove box room annuniciator panel. In essence, the administrative annunciator was a remote station—although it had more alarm points, which enabled it to monitor the entire facility.

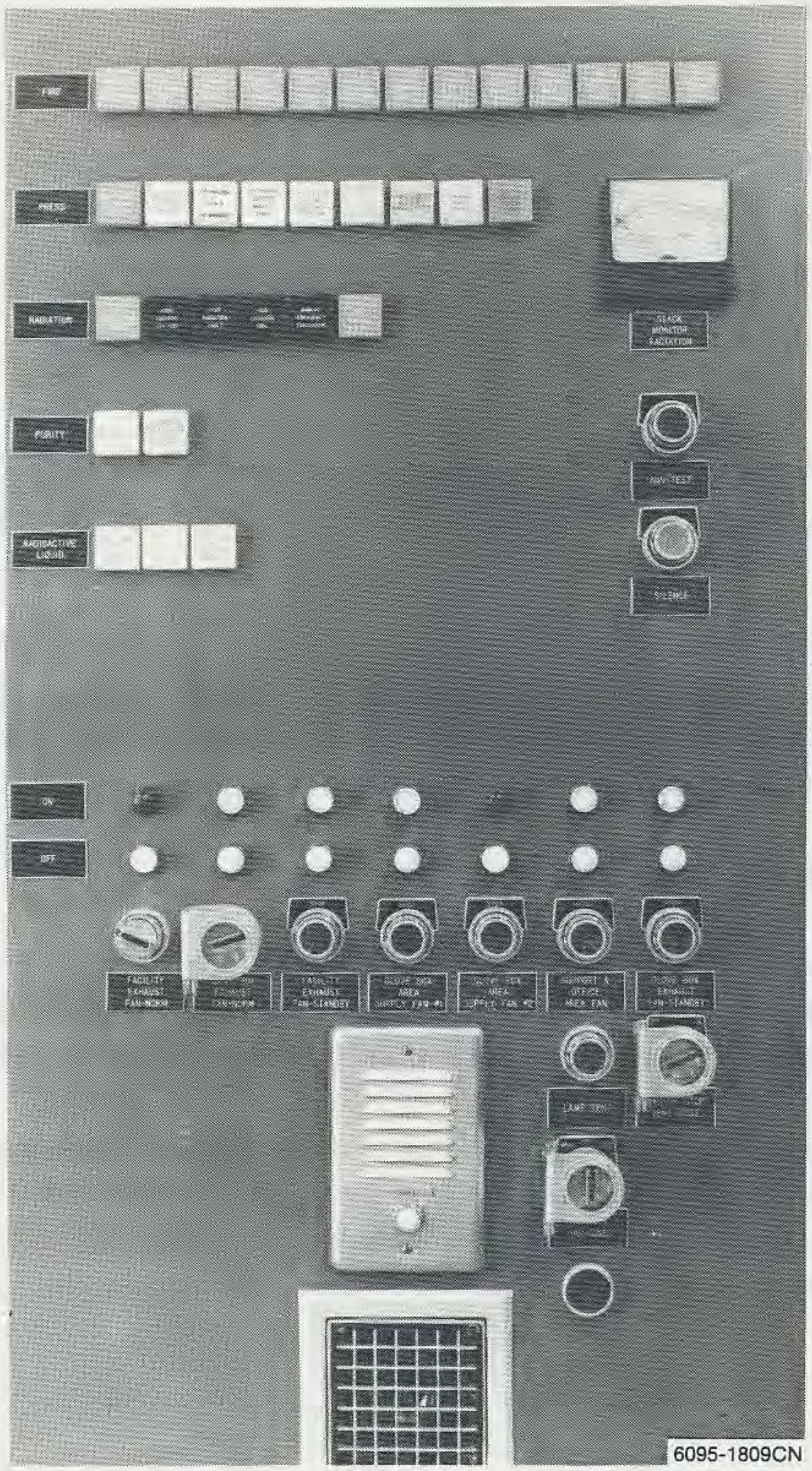

Figure 20. Administrative Area Annunciator Panel

2.1.11 Alarms and Instrumentation

Two separate radiation detection systems, in addition to the usual portable HP radiation equipment, were provided (Figure 21).

The first system was a Tracerlab "TAP" system sensitized to beta-gamma radiation and was used to alarm for criticality. Two detectors were used: one at the south end of the glove box room, the other in the vault. Upon actuation of either detector, a mechanical siren was turned on for 15 s and an automatic signal was transmitted to the Security Center. At the same time, the facility annunciator would actuate the outside beacon and red warning lights would automatically turn on. In addition, an electronic siren would be sounded from the emergency public address speakers. Any siren sound was always a signal for an immediate facility evacuation, per established procedures. The TAP system was strictly under the jurisdiction of the Security Center and under no circumstances was it to be adjusted, calibrated, or altered by building 055 personnel.

The second radiation system was a plutonium air monitor system. This system was directly under the control of the building 055 health physicist. The plutonium air monitor system sampled the air in the glove box room at one or more stations and the stack exhaust with one station. The plutonium monitor used a solid-state detector and monitored alpha radiation only. The pulse output of the detector was screened through a discriminator "window" to reject all pulses except those with the energy value of plutonium alphas. The output meter of the monitor was calibrated in counts per minute. A single alarm point was provided in the exhaust stack to signal the annunciator panels in the glove box room and the administrative area. The annunciator lights were amber and the audible signal was a horn. Another function of the alarm circuit was to automatically instigate a transfer of the glove box exhaust filters to the standby filters. This transfer was based on the premise that a rupture in the on-stream filter had allowed excessive plutonium up the stack and a new fresh filter was necessary for radiation safety.

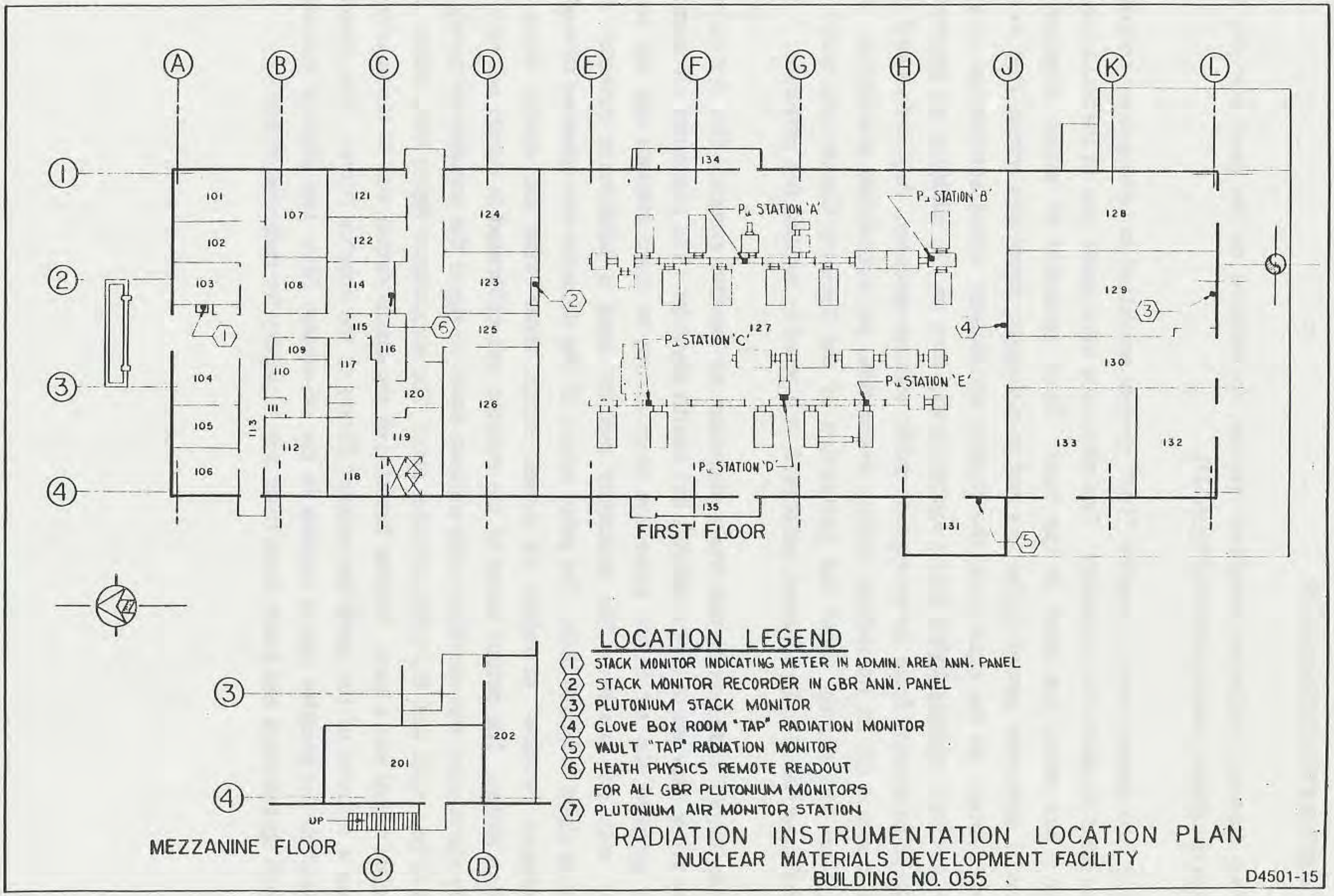

Figure 21. Radiation Instrumentation Location Plan

The plutonium air monitors used in the glove box room were of similar construction to the stack monitor, except that they were designed for portable plug-in use and could be connected to any of the plutonium air monitor stations. The glove box room plutonium air monitor stations included receptacles for instrument power (115-Vac, unregulated), vacuum connection for air sampling lines, vacuum pump power (115-Vac, unregulated) in case of air sampling vacuum failure, and special signal wiring. A maximum of five monitors could be used, although only one unit was required to be in operation at all times. If one was not used, a trouble signal was transmitted to Industrial Security. When a glove box room monitor was operating, it was connected to the building annunciator system and any excessive radiation would be announced.

A remote monitoring meter had been located in the HP room 114 to effectively monitor the five portable plutonium radiation air detectors located in the glove box room. To obtain reading from any one of the monitored locations (labeled A through E), one of the five lever-type switches was momentarily flipped up. Return to the off position was automatic after release of the lever. An additional five future positions were available by downward flipping of the lever switches.

The monitor indicating meter was a narrow, horizontal type made by Sigma Instrument Company. The input to the indicating meter was preceded by a high-input impedance, solid-state preamplifier, mounted in the same sealed case as the meter. No zero or range adjustment was available except mechanical positioning of the meter zero point. A high-limit alarm, with a front-mounted set point indicator, also was included as part of the indicator meter (actually, a meter relay), but the alarm was not actually used. The preamplifier and alarm relay obtain power from a 115-V convenience outlet. As there was no on-off power switch, the device could be shut off only by pulling the power plug or it may be left on continuously.

The indicating meter and the five lever switches were mounted in a cabinet on the south wall of the room. The input to the remote indicating meter was obtained from any of the five plutonium air monitoring stations. The signal was in the low dc mV level, transmitted to the meter by shielded wire.

2.1.12 Fire and Control Switch

The facility fire detection system included three systems with all control panels located in the electrical room. System 1 monitors were all manual stations (break-the-glass type). System 2 monitors were all heat-actuated devices (HADs) located in the individual glove boxes and glove box tunnels. System 3 was a Pry-A-Larm system divided into three-zone coverage. The Pry-A-Larm detectors were of the ionization type, and were used throughout the facility, except inside the glove boxes (Figure 22).

All fire alarm signals were automatically transmitted to the Security Center. In addition, a local horn was turned on and the annunciator panels in both the glove box room and the administrative area were actuated.

Each glove box tunnel had a HAD set to trip at ~150 to 160°F. Electrical contacts were normally open, closing to alarm. The device was bimetallic operated and was of rugged industrial construction. The detector was connected by a cord and could be located anywhere within the glove box. Preferred location was in the center of the glove box near the top. The detectors operated at 115 V, 60 Hz, and normal electrical precautions were observed. Reset action was automatic after restoration from an alarm condition.

A fire signal would cause the following subsequent actions to occur:

- A yellow light on top of the affected glove box or tunnel would flash continuously.
- A miniature yellow flashing light with a glove box station number would turn on. The light was located in the glove box room annunciator panel.
- An amber-colored annunciator window engraved "Fire in Glove Box and/or Tunnel" would flash and horn would sound. Both the annunciator window and horn were located in the glove box room annunciator panel.
- Simultaneously, a slaved amber light and horn would operate in the administrative annunciator panel.
- Horns could be turned off by operating either of the "silence" pushbuttons, which are located on the glove box room and administrative area annunciator panels. The annunciator windows would change from flashing lights to a steady display upon silencing of the horn.

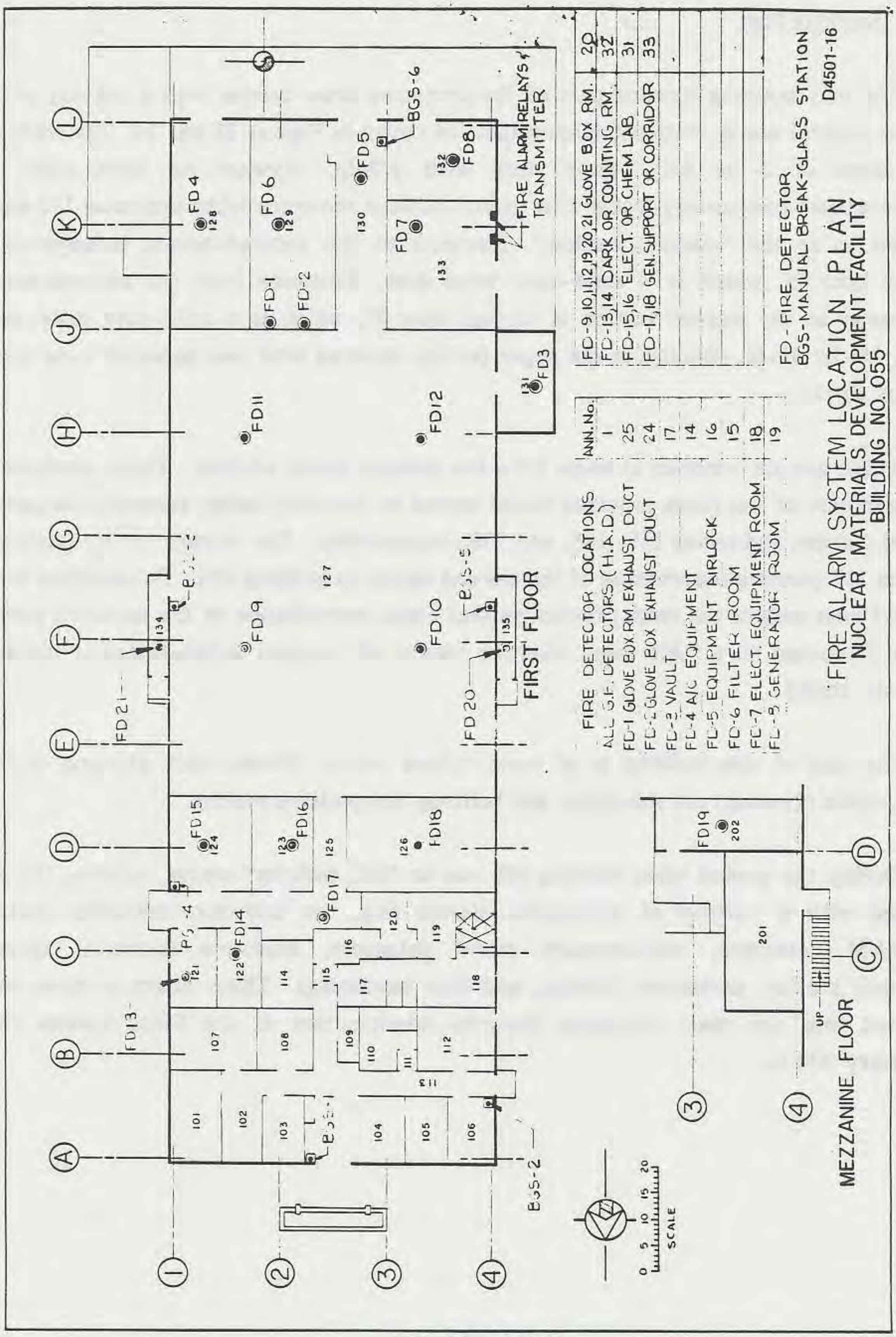

Figure 22. Fire Alarm System Location Plan

2.1.13 Security Post

The only building forming part of the protected area barrier was a portion of the primary central alarm station (building 155), as shown in Figures 23 and 24. The walls are constructed of 2- by 4-in. wood studs with 3/8-in. plywood on both sides. A secured-access passageway (room 136) exists between the entry lobby and room 138 and is referred to as the "manned station." Entrance to the secured-access passageway is through door 45, which is a solid-core wood door. Entrance from the secured-access passageway to the manned station is through door 47, which is a solid-core wood door, with a 25- by 36-in. opening in the upper portion covered with two panes of clear Lexan (3/16 in. thick).

There are six windows in room 137—the primary alarm station. Three windows on the north side of the room provided visual access to the entry lobby; secured passageway; manned station; and rooms 139, 136, and 138, respectively. The window in the south side of room 137 permits observation of ingress and egress to building 055. The windows in the east and west ends of the room provide general visual surveillance of the northern portion of the protected area. All these windows consist of Lexgard bullet-resistant material (1-1/4-in. thick).

The roof of this building is of wood rafters with a 5/8-in.-thick plywood ceiling, 5/8-in.-thick plywood roof sheathing, and built-up composition roofing.

During the period when building 055 was on "full security" status, building 155 was equipped with a variety of safeguards alarms (e.g., an intrusion detection system, fixed-SNM detectors, walk-through metal detectors, explosive detection system, entry-exit station, perimeter lighting, and door hardening). These alarm systems were also tied into the main Industrial Security headquarters at the Santa Susana Field Laboratory (SSFL).

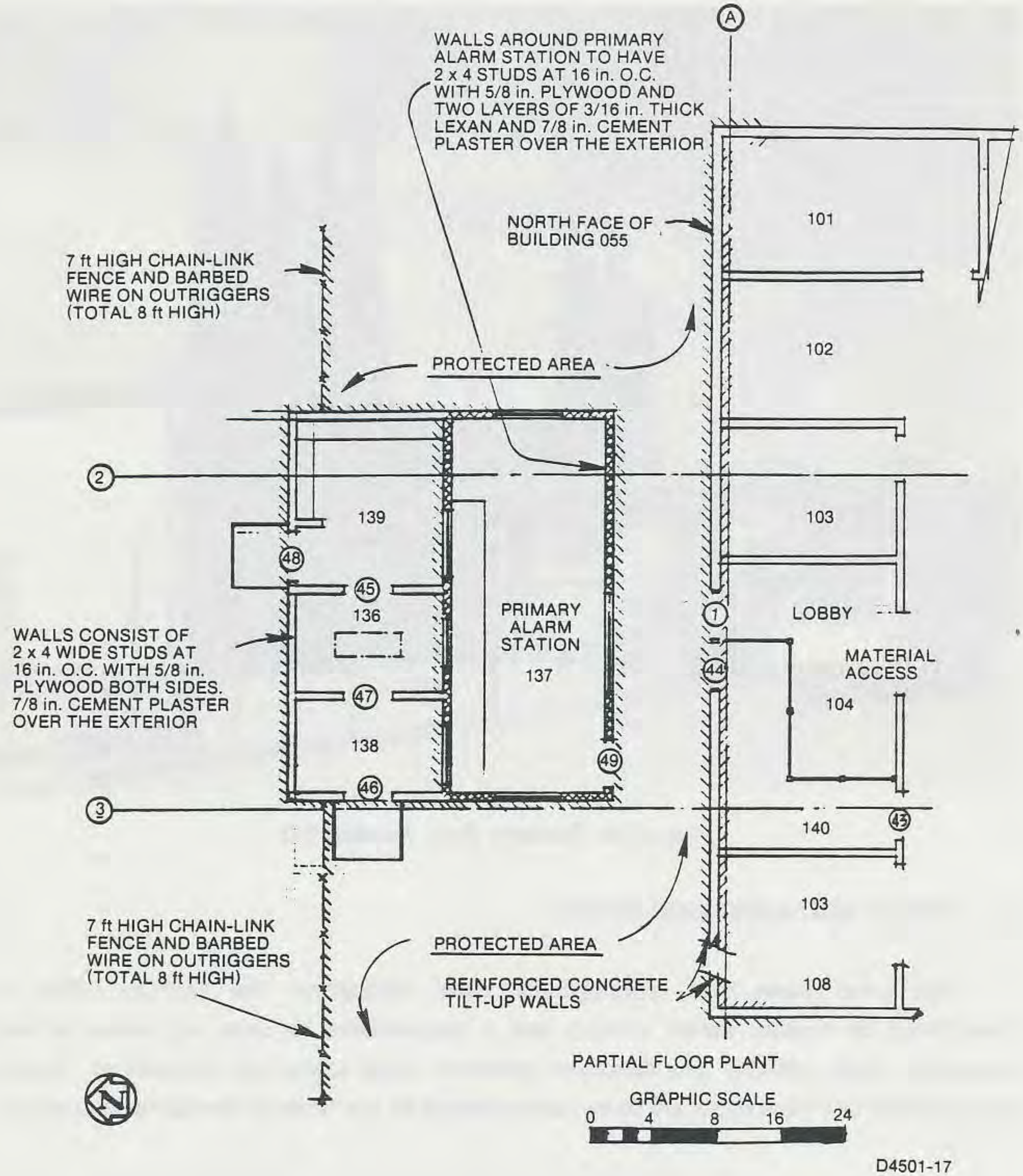

Figure 23. Security Post

Figure 24. Security Post, Building 155

2.2 PREDECONTAMINATION STATUS

All areas were kept radiologically clean throughout the facility. This was determined by routine smear surveys and a requirement to clean any areas in which removable alpha activity was detected; however, some areas had enclosed or confined contamination or were expected to be contaminated on the basis of the operating history.

2.2.1 Support Area

The Chemistry laboratory in the support area had two HEPA-filtered hoods that were known to have fixed contamination. The Quality Assurance laboratory was used for waste package scanning and was suspected of low levels of contamination. Some alpha activity was released to the room when a plastic bag containing waste leaked. Detectable activity was cleaned at the time of the release.

2.2.2 Glove Box Room

All easily accessible surfaces of the glove box room were kept clean. However, some alpha activity was released to the room when a plastic bag covering a glove box port split as a result of overpressurization caused by a solenoid valve failure. All detectable activity was cleaned up during the decontamination effort that followed this incident. Another known source of contamination was from an oil leak from a vacuum pump that penetrated the floor covering. This resulted in a small portion of the concrete slab becoming contaminated.

2.2.3 Stainless Steel Materials Storage Vault

The vault had no known areas of contamination.

2.2.4 Radioactive Exhaust Filter Room

The filter room had no known areas of contamination, but contained the contaminated filter system for the glove box exhaust. The filter system for the glove box room also was in this room and was not known to be contaminated; however, because of the difficulty of demonstrating this by survey measurements, it was assigned a "contaminated" status.

2.2.5 Liquid Radioactive Waste Holdup System

This system had low-level contamination, as the result of evaporation of floor mop water caused by solar heating of the holdup tanks.

3.0 DECONTAMINATION OBJECTIVE AND WORK SCOPE

3.1 OBJECTIVE

The objective of this effort was the decontamination and decommissioning of the NMDF to the extent that it would be suitable for unrestricted future use. Contamination was removed to the extent that no regulatory agencies would place controls, limitations, or conditions on the future use of the NMDF because of the presence of R/A material.

3.2 WORK SCOPE

3.2.1 Planning

The building 055 Decontamination and Deactivation Plan (N704TI990061) defined the overall technical approach to the decommissioning program. The primary SNM materials handled in the building were plutonium and uranium. Contamination from these two materials and decay daughter products, primarily americium 241, was present inside the glove boxes, the transfer tunnels between glove boxes, the hoods in the controlled area, and the glove box exhaust system.

The decontamination and decommissioning (D&D) plan provided for the requirements and detailed procedures of the removal of tooling, equipment, materials, and waste from building 055 and for the decontamination of the building structure itself.

Activity requirements (ACRs) and detailed work procedures (DWPs) were written for major elements of the NMDF D&D. The ACRs describe the requirements and restraints imposed to perform a given task, while the DWPs give detailed instructions on how to perform a given task. Table 3 lists the ACRs and DWPs according to task.

TABLE 3

ACTIVITY REQUIREMENTS AND DETAILED WORK PROCEDURES

Document Title	ACR Number	DWP Number
Glove Box Cleaning	N704ACR990029	N704DWP990072
Glove Box Removal	N704ACR990030	N704DWP990073
Tunnel Cleaning	N704ACR990031	N704DWP990074
Tunnel Removal	N704ACR990032	N704DWP990075
Packaging of Glove Boxes and Tunnels	N704ACR990033	N704DWP990076
Low-Volume Exhaust Removal	N704ACR990035	N704DWP990078
Utilities Removal	N704ACR990036	N704DWP990079
Liquid Waste Retention System Removal	N704ACR990037	N704DWP990080
Support Area Decontamination	N704ACR990038	N704DWP990081
High-Volume Exhaust Removal	N704ACR990039	N704DWP990082
NaK Purifiers	N704ACR990040	N/A
Final Survey	N704ACR990041	N704DWP990084
Waste Shipment and Disposal	N704ACR990042	N704DWP990085
Final Rectification	N704ACR990043	N/A

The processes used in the ACRs and DWPs for D&D were selected after a study of state-of-the-art D&D methods. The study included discussions with several companies currently involved in D&D operations. The companies consulted included General Electric; General Atomics; MSA, Inc.; LANL; and the Rocky Flats Plant (RFP). One direct result of this study was the determination that size reduction of the glove boxes was not economically feasible. Discussions with MSA, Inc., also helped to determine the best way to clean the NaK bubblers that were originally manufactured by MSA, Inc.

3.2.2 Decontamination Operations

The building 055 decontamination operations began with the decontamination of the glove boxes and tunnel sections.

The glove boxes were emptied of equipment, decontaminated, and disconnected from the transfer tunnel and exhaust system. The tunnels were decontaminated and removed from the support systems in sections ~5 ft long. Both the tunnel sections and glove boxes were packaged for disposal as low specific activity (LSA) waste. Hand scrubbing, followed by strippable paint and paint removal, was very effective in reducing contamination levels in the glove boxes and tunnel sections to well under the upper limit for LSA waste. Some hot spots in the glove boxes needed extra effort in the form of wet and dry abrasive materials.

The building's filtered exhaust system remained in operation for as long as possible to maintain a negative pressure in areas of suspected contamination. The filtered exhaust system was removed after both the building interior and the equipment in the building had been decontaminated and the NaK bubbler cleaning process was completed. The liquid waste system was kept in an active condition until the areas of highest known contamination were decontaminated. The system was also used while performing the NaK bubbler cleaning operation. The liquid waste system was removed while the filtered exhaust system was still active. As a general rule, all materials within the building were surveyed, decontaminated if necessary, size reduced, and disposed of as LSA waste. Even clean items within the controlled area were considered suspect contaminated materials and disposed of as LSA waste after size reduction.

Support utilities for the glove boxes, including the low-volume exhaust, were subsequently removed and packaged for disposal. The support areas, along with the glove box room, were decontaminated. The liquid waste system and high-volume exhaust system were then removed and packaged. All waste was packaged to meet shipping and burial requirements. The packaged waste was shipped to a controlled DOE disposal facility.

3.2.3 Radiation Control

All activities and operations performed at the NMDF were governed by the Radiation Safety Plan for NMDF (N704SRR990021). All changes made to the radiation safety procedures had to be authorized by Radiation Safety personnel. Revised procedures were distributed to all personnel directly affected by the changes made.

Removable contamination limits for both radiologically posted and unposted areas are in Table 4. The upper limit of allowable contamination listed in the table was that which, if reached, required an immediate cessation of operations and the immediate decontamination of the contaminated areas. The action limits specified in the table were upper limits of the amount of general area contamination in excess of the action limit required prompt decontamination.

TABLE 4

SURFACE CONTAMINATION LIMITS FOR PLUTONIUM

Area	Activity	Upper Limit	Action Limit
Unposted areas and radiation areas	Total Removable	100 dpm/100 cm^2 20 dpm/100 cm^2	Detectable Detectable
Contamination areas and airborne R/A areas	Total Removable	2500 dpm/100 cm^2 500 dpm/100 cm^2	Detectable Detectable
Restricted access areas	Total Removable	Unspecified Unspecified	Detectable Detectable

Copies of radiation and contamination survey reports have been given to operation and Radiation Safety supervision for retention. The reports indicated contamination and radiation levels at specified locations throughout the facility. Copies of the survey reports will be retained indefinitely by Radiation Safety.

3.2.4 Waste Management

The R/A waste categories were: (1) LSA—less than 100 nCi/g of waste material and (2) TRU—more than 100 nCi/g of waste material. The TRU waste was shipped to Rockwell Hanford Operations (RHO) for long-term storage and the LSA waste was shipped to either RHO or the Nevada Test Site (NTS) for shallow-land burial. The waste has been packaged and shipped in accordance with the following Rocketdyne R/A waste handling procedures and plans:

- 094QAP-00 Inspection Requirements for the Shipment of Radioactive Materials
- N001OP160003 Shipment of Radioactive Waste
- N001OP000002 Radioactive Material—Packaging, Shipping, and Transportation Plan
- 089QPP000001 Radioactive Material Packaging and Shipping Quality Assurance Program Plan.

3.2.5 Quality Assurance

The Quality Assurance Program Plan was initially based on the requirements of the AEC Manual, Chapter 0820, and updated DOE Order 5480-1. As the program progressed, additional requirements were added per DOE Order 5700.6 and ANSI/ASME NQA-1, Quality Assurance Program Requirements for Nuclear Facilities. The primary objective of the plan was preserving the health and safety of the decommissioning personnel and the general public, as well as protecting the environment. This objective was accomplished by reviewing all documents generated for the program, participating in all design reviews, and conducting periodic audits to verify compliance with all procedures used during the decommissioning. The Quality Assurance department also verified that personnel had received the necessary radiation safety training prior to the commencement of work activities and, through audits, verified that radiation-detection instruments were calibrated correctly. In addition, Quality Assurance verified that all R/A waste was properly identified and packaged according to applicable requirements. Final radiological survey sampling plans and results were reviewed and approved by Quality Assurance.

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4.0 WORK PERFORMED

4.1 PROGRAM AND PROJECT MANAGEMENT

The NMDF decommissioning was administered by the Surplus Facilities Management Program Office (SFMPO) of DOE-RL working through DOE-SAN, which managed Rocketdyne's activities on the project. The NMDF D&D program was initiated by the Nuclear Services segment of the program office structure and began with the preparation of the top-level guidance and project plans and concluded with the final report.

A program plan described the task and delineated the objectives of the program. In addition, it described the procedures to be used for cost and schedule control and reporting, purchasing and subcontract control, and program and engineering data control. Requirements for the Quality Assurance Plan, Operational Safety Plan, Training Plan, Dismantling Plan, ACRs, and DWPs were also presented.

The Rocketdyne program office acted as liaison with DOE representatives, who monitored the project and with all organizations that were involved during the performance of the project. The program office also was responsible for the overall schedule and budget performance and for the submission of the schedules and budgets. A performance control system (PCS) was used to monitor progress and to initiate corrective action when necessary. All reporting to DOE and its delegated representatives was done by the program office, including the monthly, annual, technical, and final reports.

4.2 PROJECT ENGINEERING

Project Engineering, within Rocketdyne, followed the guidance of the program plan and prepared the necessary documents to accomplish the physical decommissioning of the NMDF. The top-level document prepared by Project Engineering was the building 055 Decontamination and Deactivation Plan. The second-level documents were the ACRs. To satisfy the ACRs, many subservient documents were prepared, including test plans and reports, specifications, design reviews and reports, operating procedures, and DWPs that were used to direct craftsmen performing the physical work.

Project Engineering also was responsible for developing techniques to be used during the decommissioning of the NMDF, including development of a process to passivate the NaK bubblers and the subsequent design and construction of the system.

Project Engineering, acting through the Rocketdyne Engineering department, was responsible for the technical adequacy and completeness of documents prepared as the program progressed. Day-to-day problems dealing with the dismantlement activity also were handled by Project Engineering.

4.3 DECONTAMINATION OPERATIONS

4.3.1 Glove Box Room

4.3.1.1 Glove Boxes and Tunnel Sections. The flow diagram used in cleaning the glove boxes is shown in Figure 25. Figure 26 shows the glove box room prior to decontamination operations. The equipment from all of the glove boxes was size reduced and removed. Figure 27 shows size-reduced equipment being packaged as TRU waste. The glove boxes were decontaminated, using the ALARA principle, to levels less than those required for classification as LSA waste. Decontaminating the boxes also made handling and packaging the boxes safer and less expensive. All boxes were decontaminated by hand scrubbing and coating with strippable paint. Figures 28 and 29 show the strippable paint being applied and then removed. When localized high-spot contamination collectively caused a glove box to be classified as TRU waste, a decontamination of those areas was always accomplished. Sanding, in addition to scrubbing and using strippable coatings, was used to eliminate these local spot contaminations. Once the glove box had been surveyed and determined to be LSA, the interior surfaces of the boxes were painted to cover open porosity and to fix the residual contamination. Based on a study performed by General Electric, Rustoleum was chosen as the most effective paint to use for fixing the contamination. The Rustoleum was chosen because it adhered well during bend tests of painted samples. Figure 30 shows the glove boxes being surveyed after decontamination. Figures 31 and 32 show a glove box being packaged as contaminated LSA waste. Figure 33 shows the glove box packaged and ready for shipment.

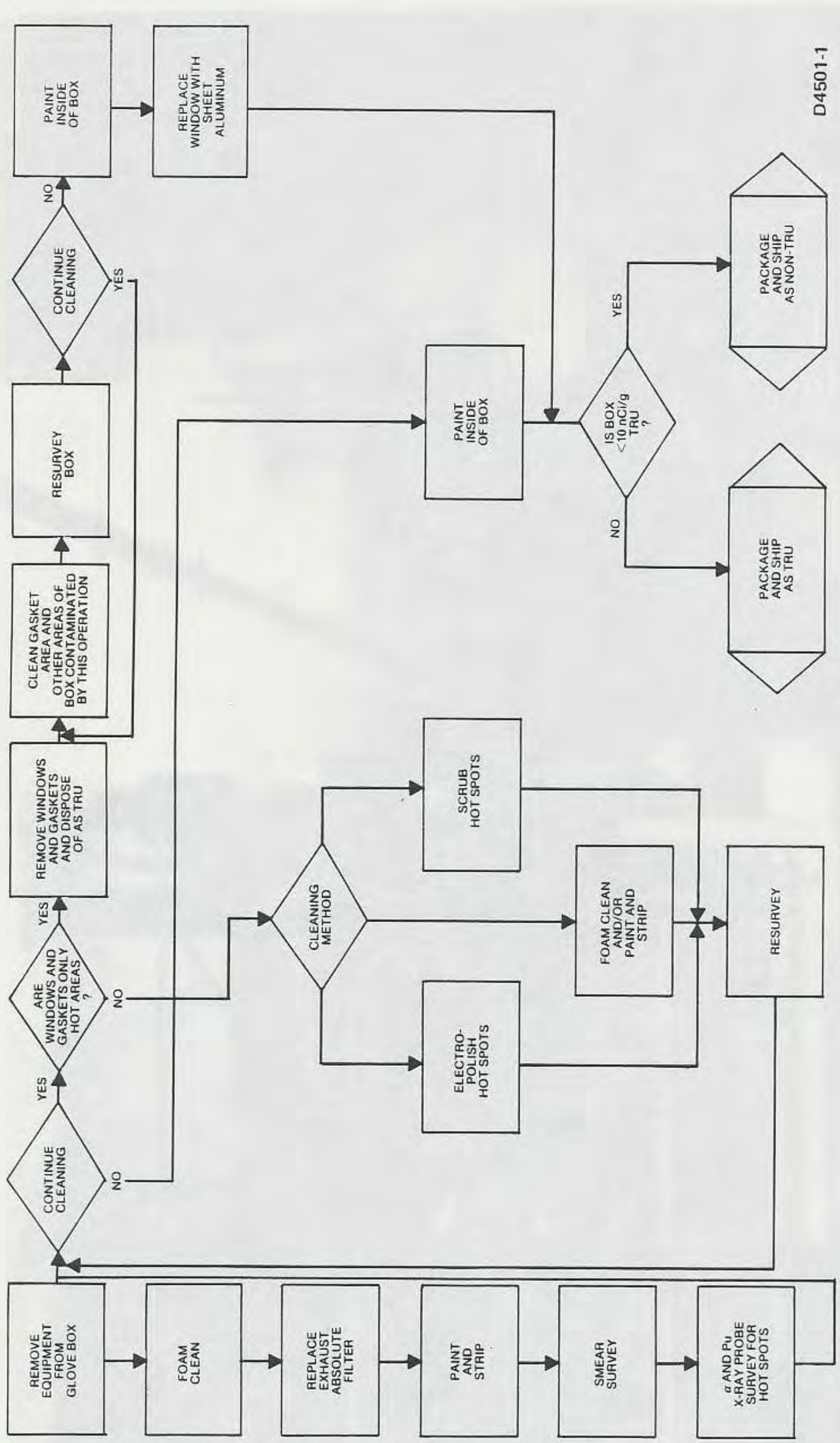

Figure 25. Glove Box Cleaning Flow Diagram

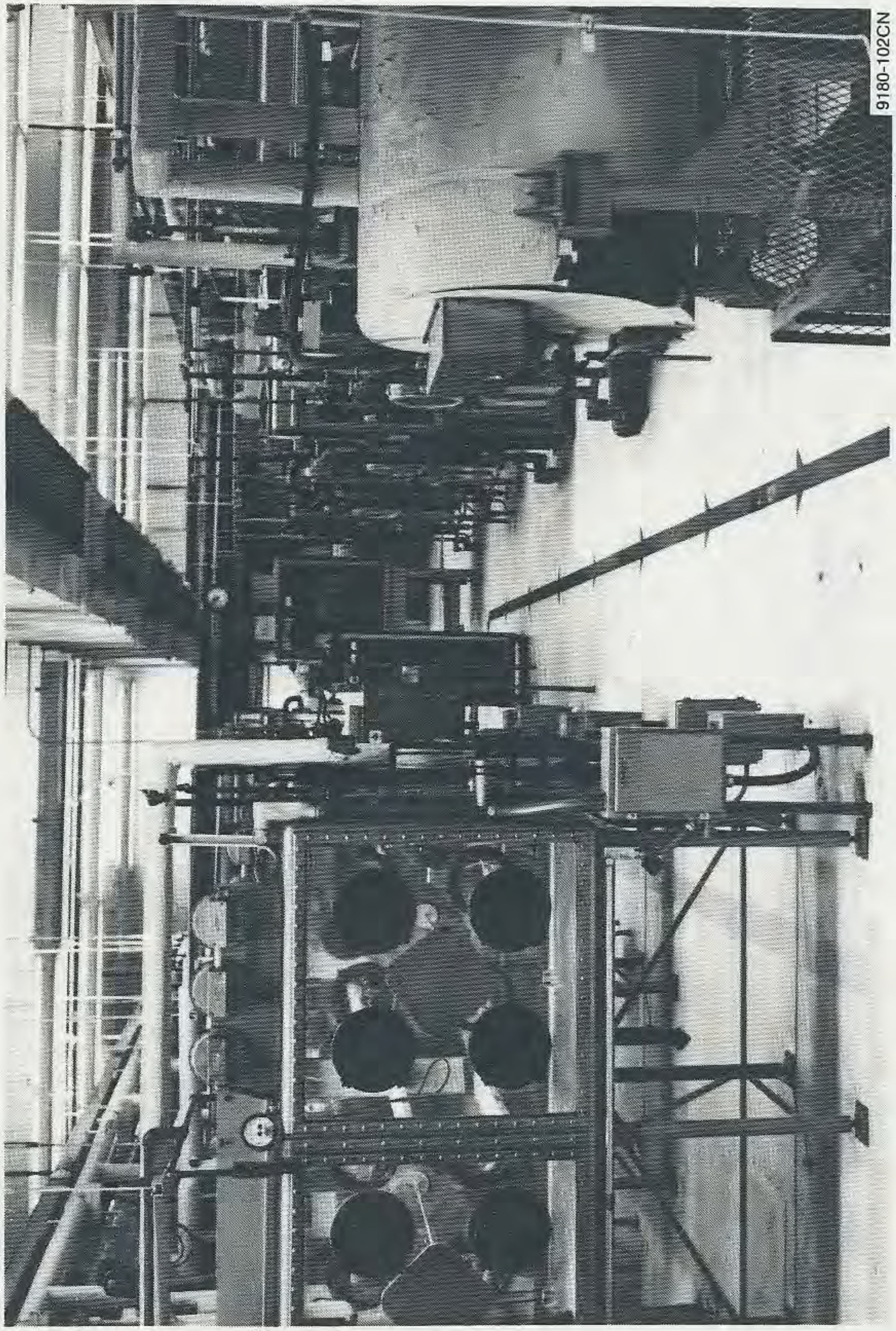

Figure 26. Glove Box Room

Figure 27. Packaging TRU Waste

Figure 28. Strippable Paint Application

Figure 29. Strippable Paint Removal

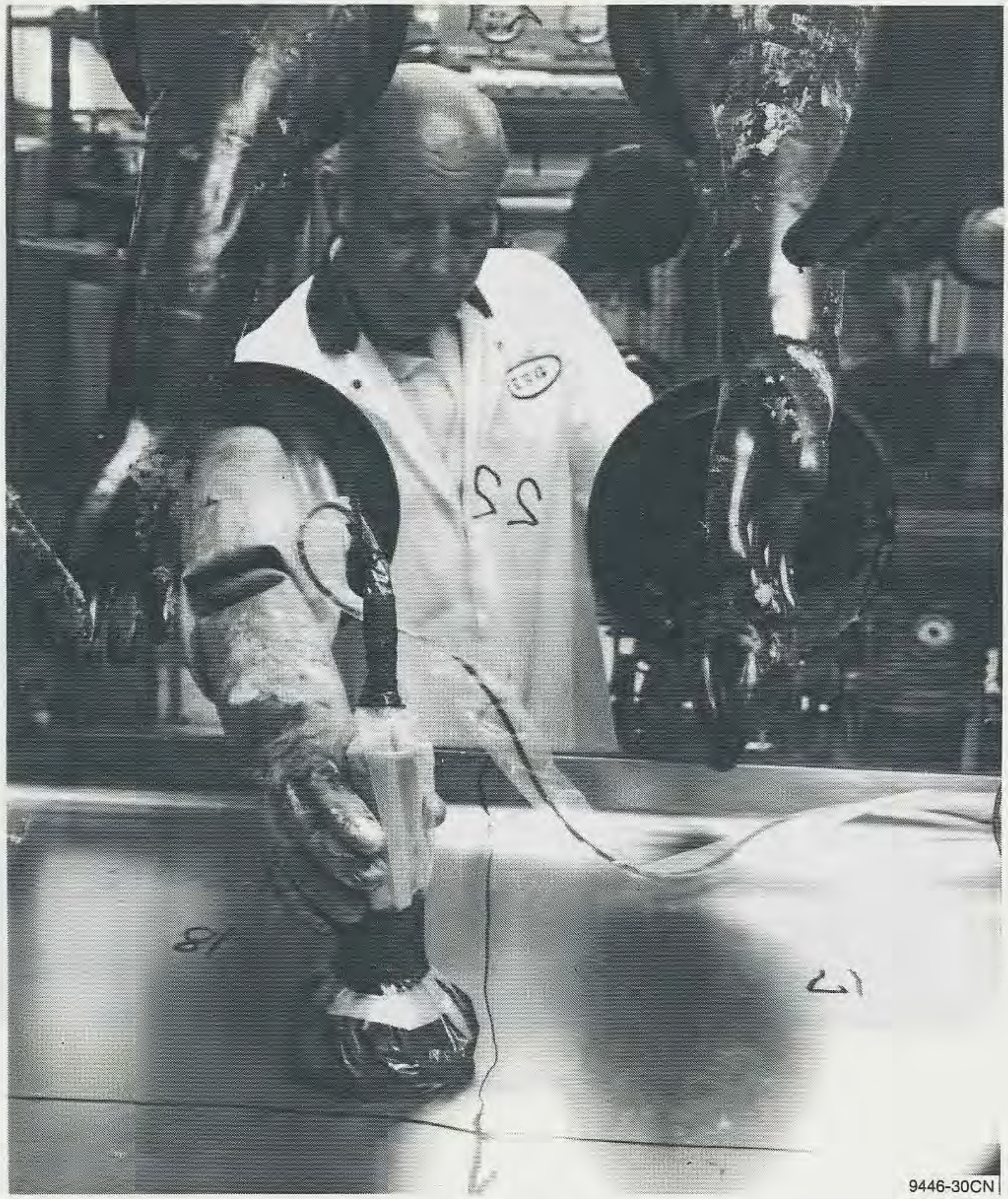

Figure 30. Glove Box Survey

Figure 31. Glove Box Packaging, Structural Support

Figure 32. Glove Box Packaging, Plastic Wrap

Figure 33. Glove Box Packaging, Complete

Removal of the boxes included disconnecting all the utilities from the glove boxes; specifically, removal of all control devices and instruments from the glove boxes, removal of all glove boxes from the tunnels, radiological surveying to determine if the removal operations contaminated the floor of the building or the outside of the glove box or tunnel, and all postremoval decontamination that was necessary. All equipment disconnected from the glove boxes was surveyed, treated as potentially contaminated, decontaminated as necessary, and disposed of as LSA waste.

The tunnels were cleaned in a manner similar to that of the glove boxes and then completely removed. The transfer dolly and track were decontaminated and then removed from the tunnel. Tunnel removal included the disconnection of all utilities from the tunnel, removal of all control devices and instruments from the tunnels, removal of all tunnel sections from the exhaust system, radiological surveying determining whether or not the removal operation contaminated the building floor or the outside of the tunnel, and all necessary postremoval decontamination.

The two tunnel lines were removed in sections. One tunnel consisted of 12 5-ft-long sections, while the other tunnel comprised 8 5-ft-long sections. Both tunnels had cross sections of ~15 in. by 24 in. A small glove box with an exhaust system was located at the end of each tunnel. This removal activity is detailed in DWP N704DWP990075.

4.3.1.2 <u>Glove Box Line Support Systems</u>. Decommissioning of the glove box involved support systems unique to the glove box plus utilities that were common to the facility.

4.3.1.2.1 <u>Low-Volume Radioactive Exhaust System</u>. The low-volume exhaust consisted of two 5-hp blowers, a stack, two double absolute-filter banks, two 8-in. headers, the capped pipe (which formerly connected the glove boxes and transfer tunnels to the system), and the associated valves and controls. The stack was in common with the high-volume exhaust system (room exhaust). The absolute-filter banks and all components upstream of them were contaminated with trace quantities of plutonium and uranium and were handled as contaminated waste. The downstream side and the filter housing itself surveyed clean, but they were still handled as suspected contaminated LSA waste. This activity was detailed in DWP N704DWP990078 and included the removal of all components of the system except for the stack. All items were packaged as LSA waste for disposal. All glove box and transfer tunnel sections were disconnected from the low-volume exhaust system prior to the start of this activity.

4.3.1.2.2 Utilities. The glove box room was serviced by a number of utilities. Those that were used specifically for glove box and transfer tunnel operations were disconnected from the glove boxes and tunnel sections prior to this activity. The utilities that serviced the glove boxes included cooling water, argon, argon-hydrogen, helium, dry-air, vacuum, helium-argon, and electrical and control wiring. Utilities that serviced the glove box room, in general, included compressed air, electrical power, area lighting, a PA system, phones, sprinklers, motion detectors (inoperative), emergency lights, fire alarm circuits, radiation alarm system, and intrusion alarms. The hood and high-volume exhaust system are handled as a separate task. The scope of this activity included the removal and disposal of all contaminated components of the aforementioned utilities within the glove box room. Contamination levels were low and limited to the exterior surfaces of components, except for the vacuum line. All of these materials were handled as contaminated LSA waste.

4.3.1.3 Glove Box Room Structural Surfaces. Because of the nature of work conducted in the facility, all surfaces within the controlled area were considered to be potentially contaminated. The floor covering consisted of 6-ft-wide runs of linoleum. The linoleum was removed and packaged as LSA contaminated waste. The concrete floor, after removal of the linoleum, was radiologically surveyed over 100% of its surface, also due to the previous release of contaminated materials. No contamination was found in the controlled area except for one "hot" spot on the glove box room floor near the nuclear materials vault. The concrete surface at this spot was chipped to remove the contamination.

The ceiling support structure surfaces were found to have measurable fixed-spot contamination in the painted surface. Abrasive pads and detergent decontamination materials were used on the painted surfaces to remove the contamination.

Figures 34 and 35 show the glove box room in the final stages of D&D.

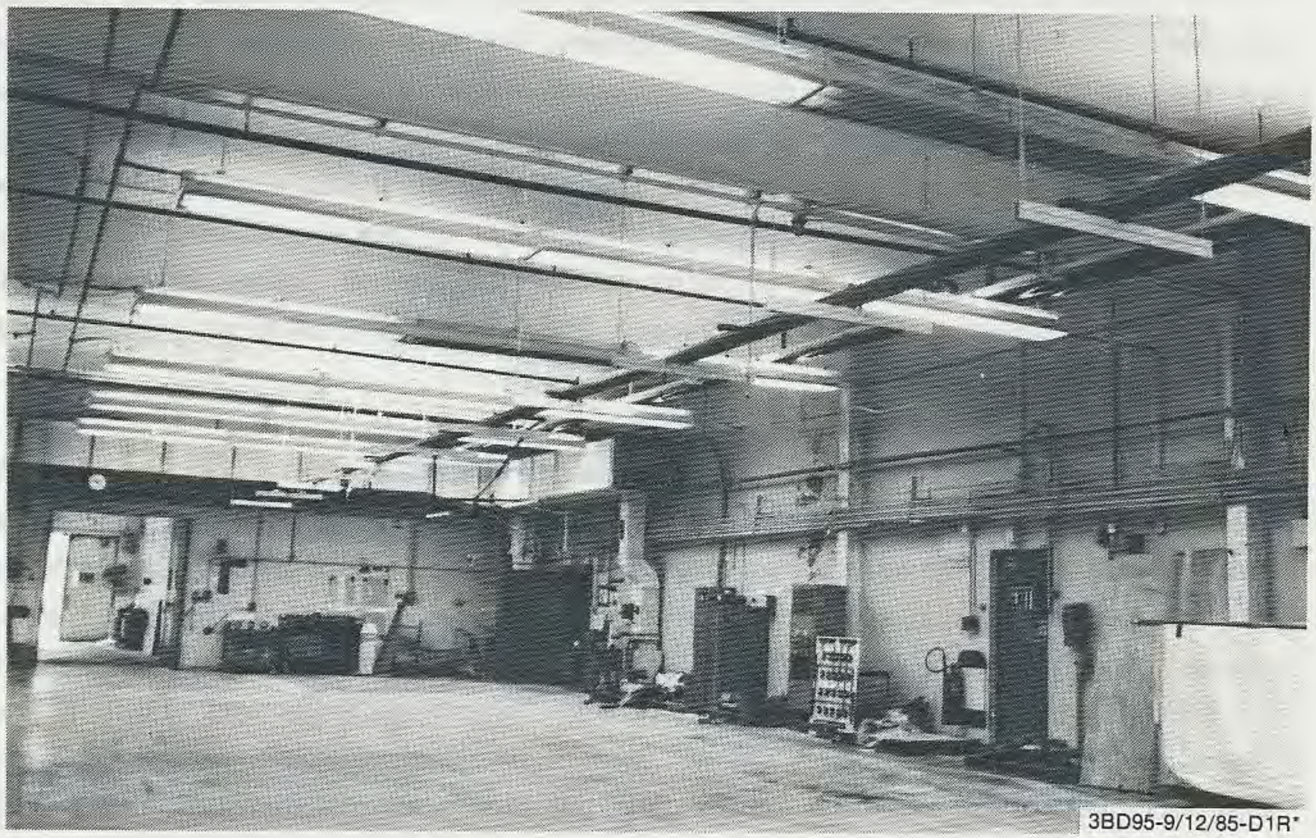

Figure 34. Glove Box Room, Interim D&D

Figure 35. Glove Box Room, Final D&D

4.3.2 Support Areas

The support areas in building 055 included all areas south of the change room entryways except for the air conditioning and heating equipment room, the electrical equipment room, and the emergency power room. Some of these areas were not expected to be contaminated but were surveyed for verification. The shaded areas in Figure 36 indicate those areas considered support areas.

All equipment and materials that were to be removed from the facility were surveyed and, if necessary, decontaminated. All equipment and surfaces remaining in the support areas have been decontaminated to the levels prescribed previously in Table 2. Fixed items such as sinks and light fixtures were surveyed and cleaned or removed and disposed of, as necessary. Other equipment and furniture was decontaminated by wiping with paper towels and a decontamination agent. Decontamination methods used on walls, ceilings, and floors depended on the type of surface involved and whether the contamination had been fixed with paint. Decontamination of the walls, ceilings, and floors required

NONCONTROLLED ACCESS AREA

LAYOUT NUMBER	ROOM NUMBER	DESCRIPTION
1	101	OFFICE
2	102	STORAGE AREA
3	103	OFFICE
4	104	OFFICE
5	105	OFFICE
6	106	OFFICE
7	107	CONFERENCE ROOM
8	108	OFFICE
9	109	JANITORIAL SERVICE STORAGE
10	110	RESTROOM
12	112	OFFICE
13	113	CORRIDOR
14	114	OFFICE
15	115	CORRIDOR
17	117	RESTROOM
18	118	LOCKER ROOM
28	128	AIR CONDITIONING AND SUPPLY EQUIPMENT ROOM
32	132	AUXILIARY POWER SUPPLY GENERATOR
33	133	ELECTRICAL DISTRIBUTION EQUIPMENT

CONTROLLED ACCESS AREA

LAYOUT NUMBER	ROOM NUMBER	DESCRIPTION
16	116	CHANGE ROOM
19	119	SHOWER AND CHANGE ROOM
20	120	AIRLOCK TO CONTROLLER AREA
21	121	HEALTH AND SAFETY COUNTING EQUIPMENT
22	122	PHOTOGRAPHIC DARK ROOM
23	123	INSTRUMENT LABORATORY
24	124	CHEMISTRY LABORATORY
25	125	CORRIDOR
26	126	QUALITY CONTROL LABORATORY
27	127	GLOVE BOX LABORATORY
29	129	RADIOACTIVE EXHAUST EQUIPMENT
30	130	AIRLOCK TO CONTROLLED AREA
31	131	RADIOACTIVE MATERIALS STORAGE VAULT

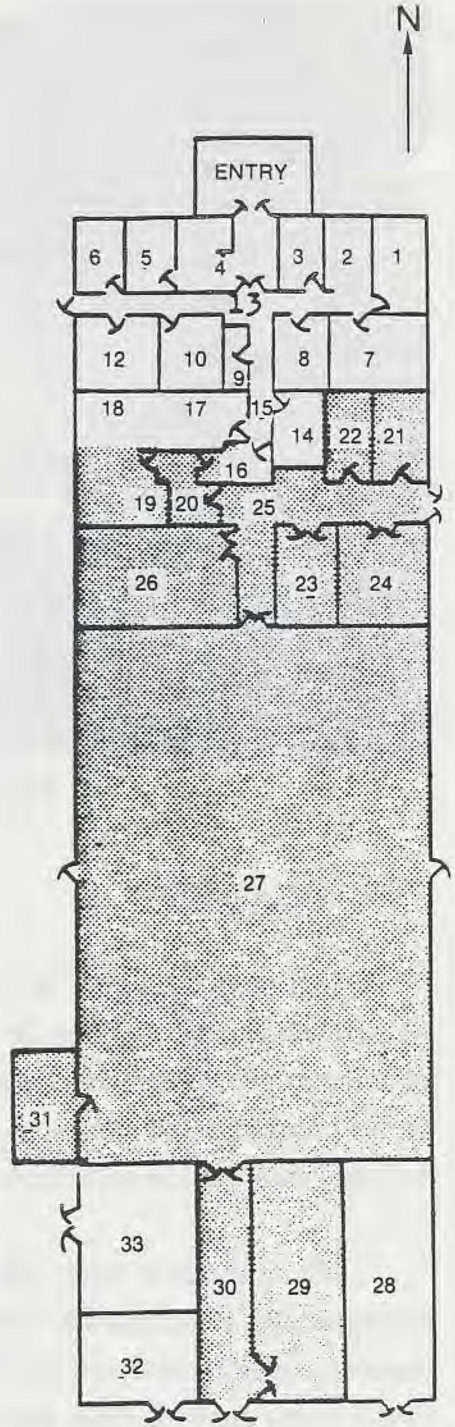

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Figure 36. Access Areas, Building 055

the removal of paint or other surface materials in some areas. Where possible, foam cleaning was the primary method used.

After paint or other surface materials had been removed, the subsurfaces were to be surveyed and, as necessary, decontaminated. Foam cleaning and scabbling methods were used when decontamination was required. Contaminated liquids generated during these operations were solidified for disposal.

All areas of the building with vinyl tile flooring had representative floor tiles taken up. These representative tiles, and the substructure of the floor beneath the tile, were surveyed to verify that there was no R/A contamination in those areas.

4.3.2.1 Analytical Chemistry Laboratory. The two hoods were contaminated with depleted uranium and minor amounts of plutonium. The equipment in the hoods and the interior of the hoods was wiped down to remove loose contamination. The utilities were disconnected, the prefilter banks removed, and the hoods disassembled. The liquid drain lines to the hoods were to be removed as described in N704ACR990037. The absolute filters and the high-volume exhaust hood were removed as per N704ACR990039.

Because the hoods were known to be contaminated, all of the equipment and surfaces in the laboratory were potentially contaminated. The internal surfaces of the hoods were painted to fix the contamination prior to packaging as LSA waste. The vinyl tile was removed and packaged as R/A waste. All nonchemical materials and equipment were disposed of as LSA waste. All chemical materials were analyzed to ensure that they were not radioactively contaminated. Chemicals were disposed of as chemical waste per Procedure EC04.10, Disposal of Hazardous Waste by Generating Organization, from the Rocketdyne Environmental Control Manual.

4.3.2.2 Electrical Support Room. The electrical support room was found to be clean, as expected. The electrical panels and the wiring were removed from the room. Panels and wiring were packaged for disposal as LSA waste, although general scanning survey instruments indicated no measurable contamination. This approach was deemed more cost effective than surveying every wire to ensure that no contamination was present.

4.3.2.3 Change Room. This area was shown to be clean. The three floor drains in the shower area and the sink drain were removed during the liquid waste retention system removal activity. The floor tile was removed, and all equipment and surfaces were surveyed. Figure 37 shows the change room during the D&D activity; some benches and equipment have already been removed.

4.3.2.4 Hallway. This area was shown to be clean. The floor drains and the sink drain were to be removed during the liquid waste retention system removal activity. Selected samples of floor tiles were removed for surveying and verified that the floor was not contaminated.

4.3.2.5 Other Support Areas. The remaining support areas, including the nuclear materials vault, radiation instrumentation support room, photographic darkroom, and quality assurance support room, were found to be clean. All areas were surveyed and any equipment that was contaminated was decontaminated when practical. All equipment and furniture, except for radiological survey equipment, were treated as potentially contaminated materials and disposed of as LSA waste. The radiological survey equipment was decontaminated, as necessary, and used during the entire D&D project.

4.3.3 Liquid Waste Retention System

The R/A liquid waste retention system at building 055 was designed to receive and process liquid wastes from the sinks in the chemistry laboratory, support laboratory, change room, and floor drains. A 4-in. drain line carried the waste to the process and storage area that was located southeast of the building. This area contained two settling tanks with capacities of 185 and 230 gal; two 1000-gal storage tanks; and their associated pumps, level gages, filters, valves, and piping.

This activity was described in N704ACR990037 and included the removal of all remaining liquid and sludge waste in the liquid waste retention system, removal of all drain lines between the various liquid sources and the process and storage area, removal of the four process and storage tanks and their associated equipment, and the packaging and disposal of all components, as necessary.

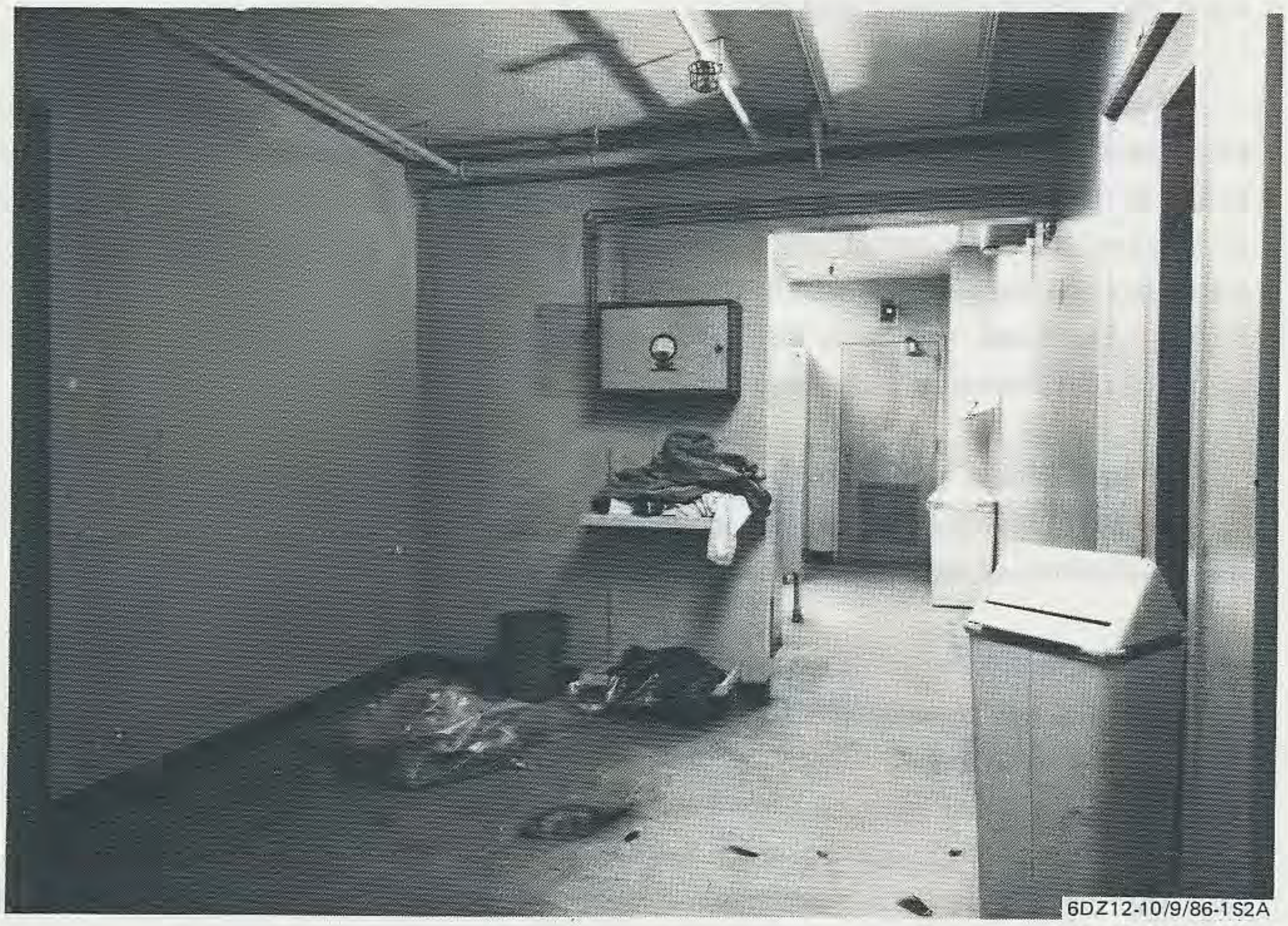

Figure 37. Change Room During D&D

This system was not expected to be highly contaminated. A survey of all components verified this assumption; very little plutonium had been released to the system. The components of the system were size reduced and disposed of as LSA waste. The excavation sites for drain removal were surveyed and soil samples taken. Analysis of the soil samples verified that the soil was not contaminated.

4.3.4 High-Volume Exhaust System

The high-volume triple HEPA-filtered exhaust system filtered and removed air from all areas of building 055. Along with the supply air system, it provided pressure differentials in the building so that air always flowed from areas of low potential contamination to areas of higher potential contamination. The two hoods that were in the chemical laboratory and the one that was in the glove box room were also exhausted through this system. The hoods that were in the chemistry laboratory were disconnected from this system during the support area decontamination activity.

A bank of nine parallel sets of absolute filters was located just upstream of two 30-hp exhaust blowers. Prefilters and absolute filters were also located at each inlet in the glove box room, vault, and each hood. The air was exhausted through the 55-ft stack.

The components of the high-volume exhaust system that were potentially contaminated, and subsequently removed for disposal as LSA waste, included the hood in the glove box room and all filters, ducting, and controls in the glove box room and in the vault. Because there were absolute filters at all inlets to the exhaust system, only the external surfaces of the ducting were suspected to be contaminated. Surveying showed that the ducting was not contaminated either on its inner surfaces or on its outer surfaces. The filters, ducting, and controls that were on the upstream side of the blowers in the exhaust system filter room and the blowers and components that were downstream of the filters were presumed clean and surveyed to verify that this was true. All parts of the high-volume exhaust, after size reduction (where applicable), were handled as suspect contaminated waste and disposed of as LSA waste.

The high-volume exhaust system was not shut down or dismantled until after all the other contaminated systems had been removed from the facility and all decontamination of the building was completed.

4.3.5 NaK Glove Box Atmosphere Purifiers

Ten NaK glove box atmosphere purifiers were used at the NMDF to purify and remove oxygen from the inert atmosphere of the nuclear fuel-handling glove boxes. Absolute filters were located at the inert gas inlet and outlet ports of each glove box, with the bubbler located external to the glove box between the filters (Figure 38). The inlet and outlet of the bubblers were surveyed for plutonium contamination in 1975 (Figure 39), when they were removed from service and have since been treated as radioactively contaminated containers.

The bubblers were ~18 in. in diameter and 28 in. high. They contained ~42 lb (7 gal) of an eutectic solution of NaK. The NaK was either NaK 78 (78 w/o K) or NaK 56 (56 w/o K). Documentation available did not clearly identify the eutectic, which was not of great significance for the cleaning process. The NaK also contained unknown and unidentifiable amounts of KO_2 (potassium superoxide) which is potentially unstable and explosive.

Each bubbler was a welded 300 series stainless-steel container with copper inlet and outlet pipes silver-brazed to the bubbler top (Figure 40). The outlet pipe included a filter canister (containing a phenolic-paper filter). The inlet and outlet pipe flanges were sealed with neoprene-gasketed cover plates. Seven of the ten bubblers had a 2-in.-diameter gasketed and sealed side port approximately half way up the side. The port was added when the bubblers were drained and recharged during their use period. All bubblers had a small-diameter drain line with a welded bellows valve and end cap at its base. The bubblers were internally baffled and included multiple layers of wire mesh to direct gas flow and maximize oxygen removal. Figure 41 illustrates a cross-sectional view of a typical NaK bubbler.

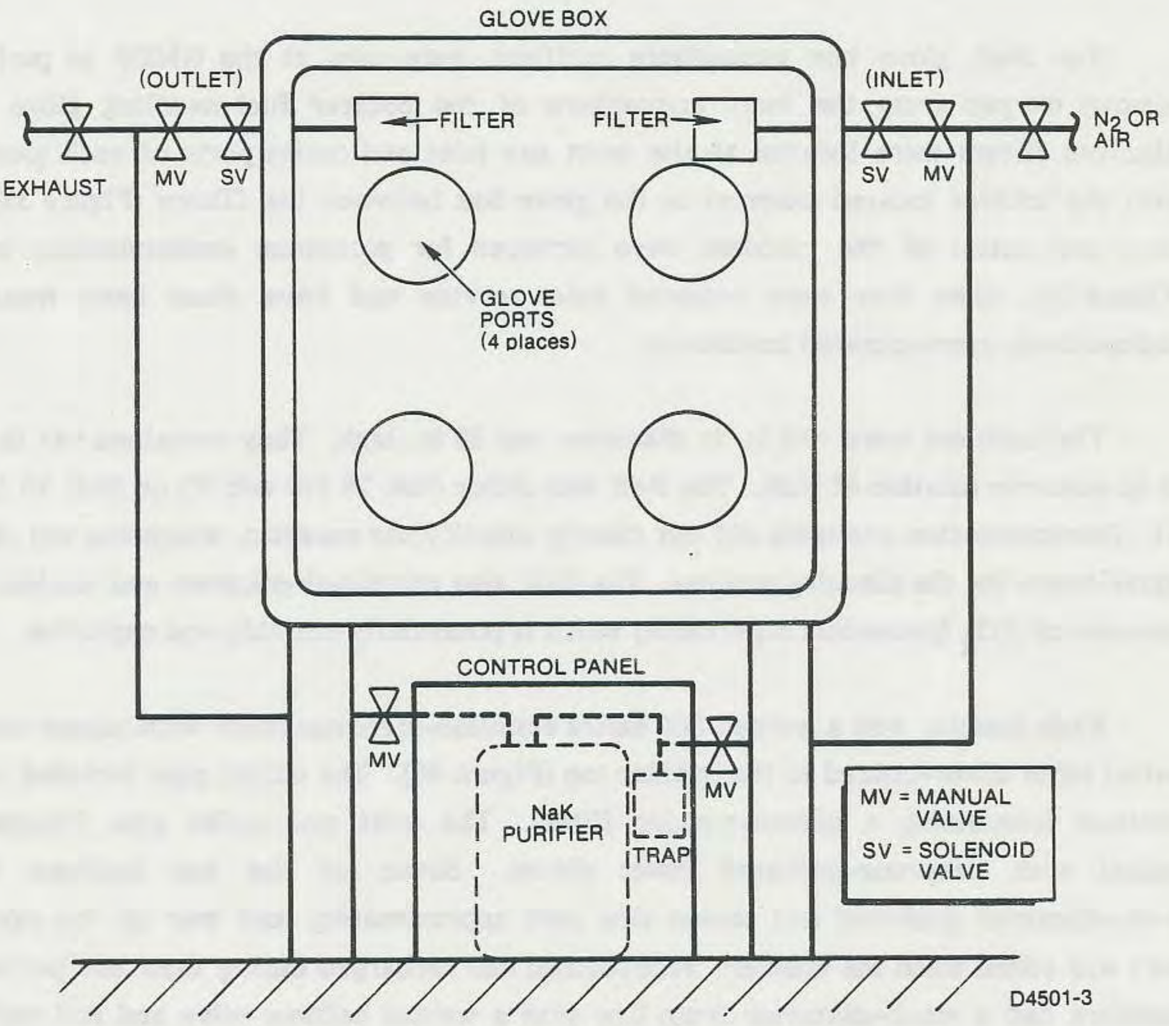

Figure 38. NaK Purifier, Glove Box Location

CHEMICAL ANALYSIS REPORT	Atomics International North American Rockwell	REQUEST NC No. N704ER990011 18996 Page. 20

ORIGINATOR	ORIGINATOR'S DEPT. & GP	APPROVAL SIG.	DATE OF REPORT
J. CARROLL	731-560	[illegible]	5/13/75

CHEMICAL ANALYSIS

ANALYSIS	METHOD	INVESTIGATOR	ANALYSIS	METHOD	INVESTIGATOR
PU	COUNTING	H. Hoisch			

RESULTS OF ANALYSIS

ORIGINATOR'S SAMPLE NUMBER	ANALYTICAL LABORATORY NUMBER	COUNTS PER MINUTE	DISINTEGRAT. PER MINUTE	DPM INLET			
NaK-1	012	3.3	17	186			
2	013	0	0	4170			
3	014	*	*	24,000			
~~4~~	~~015~~	~~0~~	~~0~~	~~60~~ *			
5	016	0	0	2118			
6	017	*	*	1930			
7	018	*	*	66			
~~8~~	~~019~~	~~0~~	~~0~~	~~100~~ x			
~~9~~	~~020~~	~~0~~	~~0~~	~~250~~ x			
10	021	.1	.5	250			
				SMEAR			

OTHER MEASUREMENT OR PREPARATION

2/86-ALL BUBBLERS AT RMDF, BLDG. 621

REMARKS: * Insufficient sample

Figure Original Plutonium Analyses (1975)

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Figure 39. Chemical Report, NaK Purifier Contamination

Figure 40. NaK Bubbler

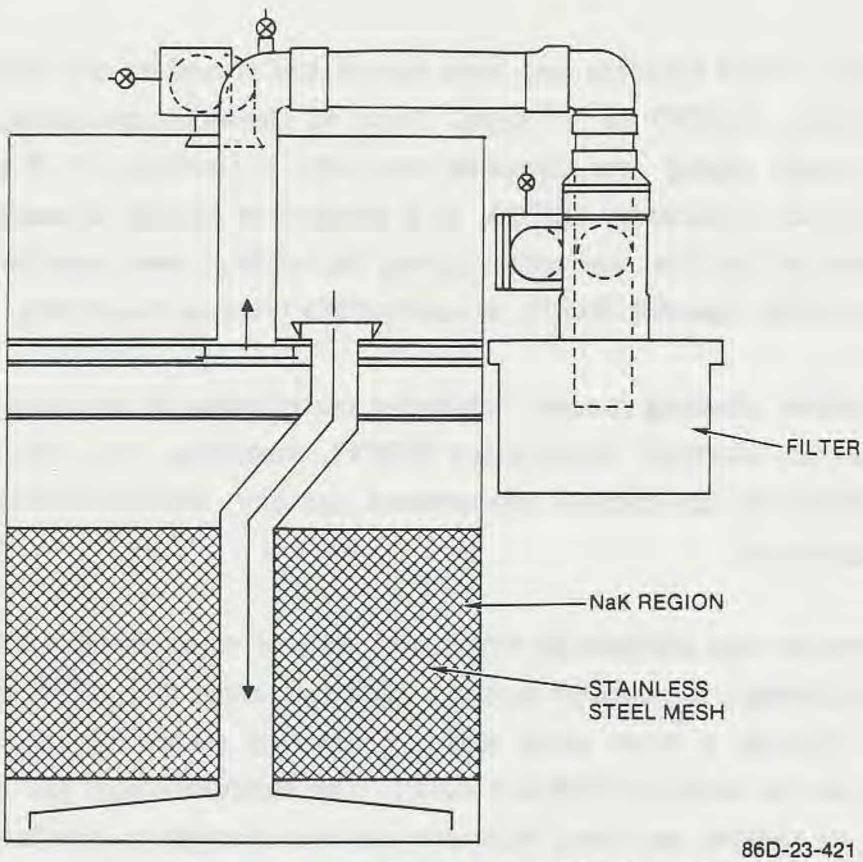

Figure 41. Cross-Sectional View of NaK Bubbler

Process design for cleaning the bubblers (removal and disposal of the NaK) required addressing two potential hazards:

- Chemical hazards associated with handling liquid metal and unknown quantities of KO_2, which is potentially explosive
- Radiation hazards associated with handling internal plutonium contamination.

The cleaning process and resulting facility requirements were established in N704TI99065, Plan for Disposal of NaK Bubblers from Nuclear Materials Development Facility, building 055, by A. E. Stewart and J. V. Leece (29 July 1985).

The NaK-filled bubblers had been sealed and stored at the Radioactive Materials Disposal Facility (RMDF) for 10 years. Prior to chemical processing, the nonessential inlet and outlet piping was removed remotely at building 20 (Figure 42), Rockwell International Hot Laboratory (RIHL), as a precaution against a possible KO_2 reaction. After removal of the inlet and outlet piping, the bubblers were transferred to and cleaned at the NaK bubbler cleaning facility in building 055 (Figures 43 and 44).

The bubbler cleaning process involved a combination of evaporation of sodium and potassium at an elevated temperature (900°F), steaming, and, finally, a water rinse. Figure 45 illustrates the nominal temperature and time characteristics of each phase in the cleaning process.

The process was designed to evaporate ~95% of the metallic NaK by passing 900°F nitrogen gas through the bubbler during a period of about 40 h. The vapor-laden N_2 gas was passed through a water spray and a single-tray absorption unit (mixing vessel) to precipitate out the metal as KOH and NaOH. The moisture-laden gas was passed through a demister to remove entrained moisture and then through an absolute filter to prevent any release of potential R/A material before being discharged into the atmosphere. The liquid was collected in the system reaction vessel and periodically transferred to holding tanks where it was neutralized by sparging with CO_2.

Upon completion of the hot nitrogen evaporation phase, the bubbler containment vessel and N_2 gas temperature were decreased to <300°F. Dry steam was progressively introduced into the nitrogen stream and temperatures decreased until saturated conditions were achieved. The metals and oxides remaining were reacted in the bubbler and carried into the system reaction vessel. At the end of the steam phase, the vessel was cooled to 212°F and H_2O was added to the bubbler for a final rinse. Lastly, the vessel was flushed with hot gaseous nitrogen to evaporate the residual H_2O.

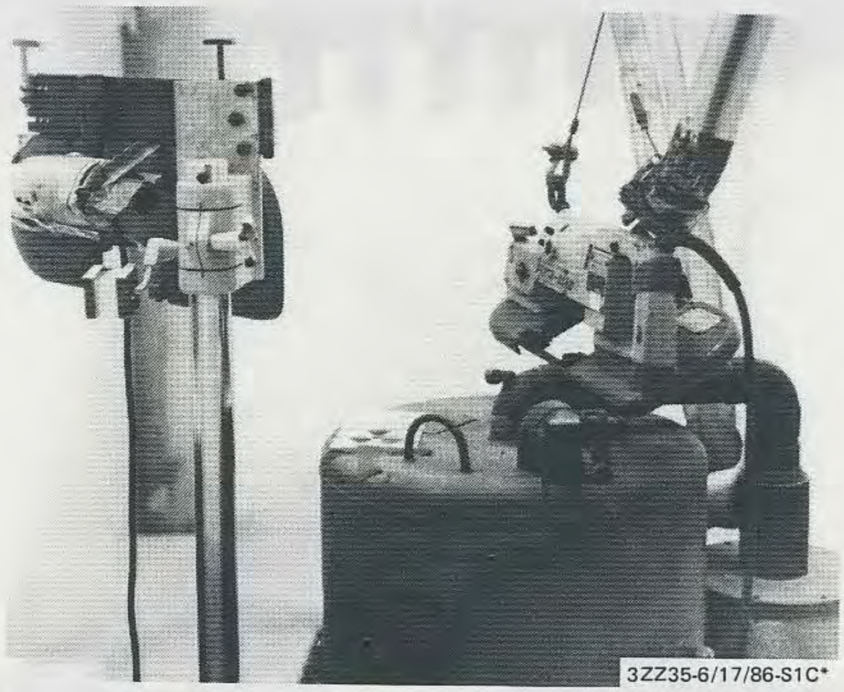

Figure 42. Nonessential Piping Removed Remotely from RIHL

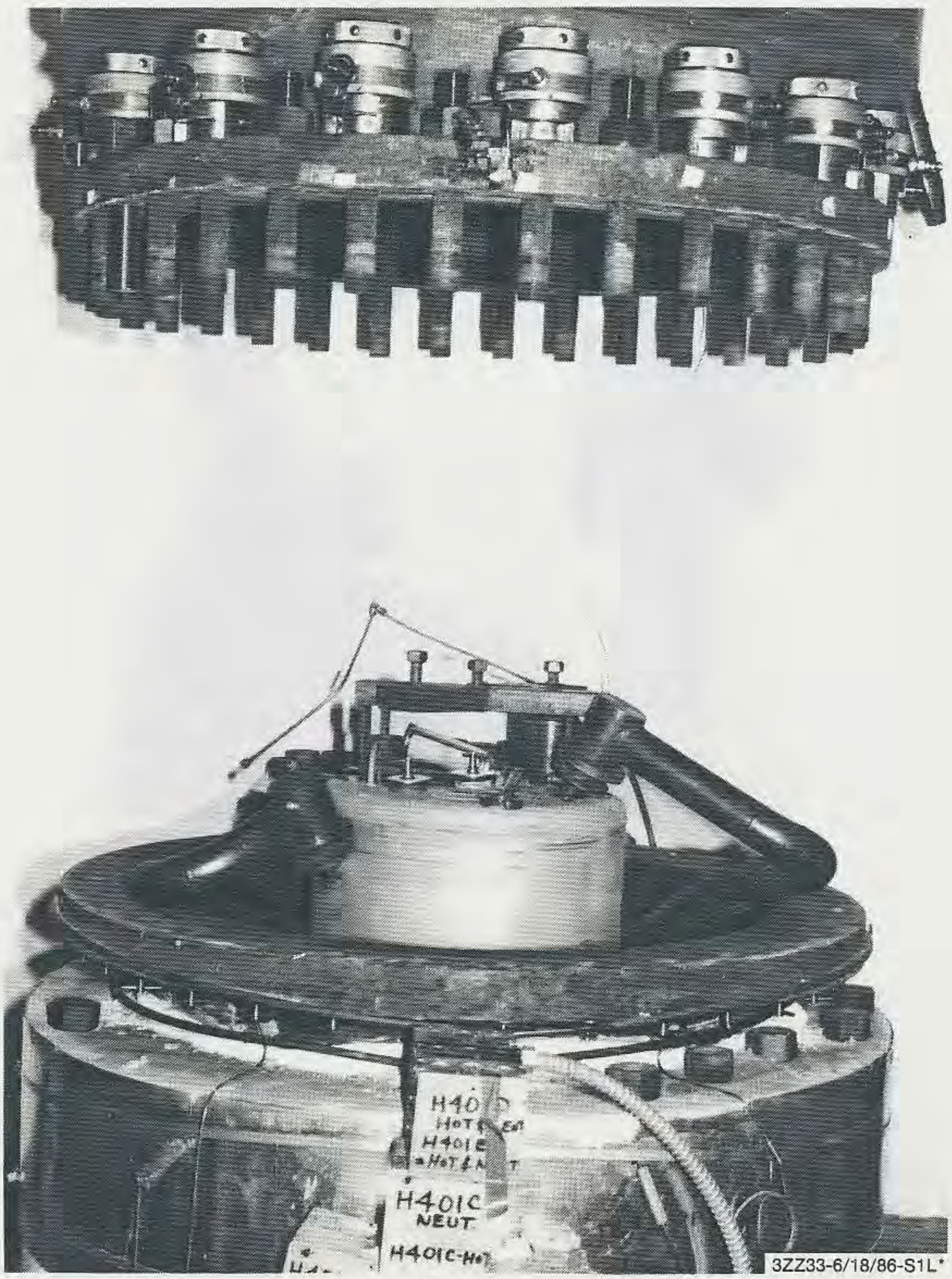

Figure 43. NaK Bubbler Cleaning Vessel

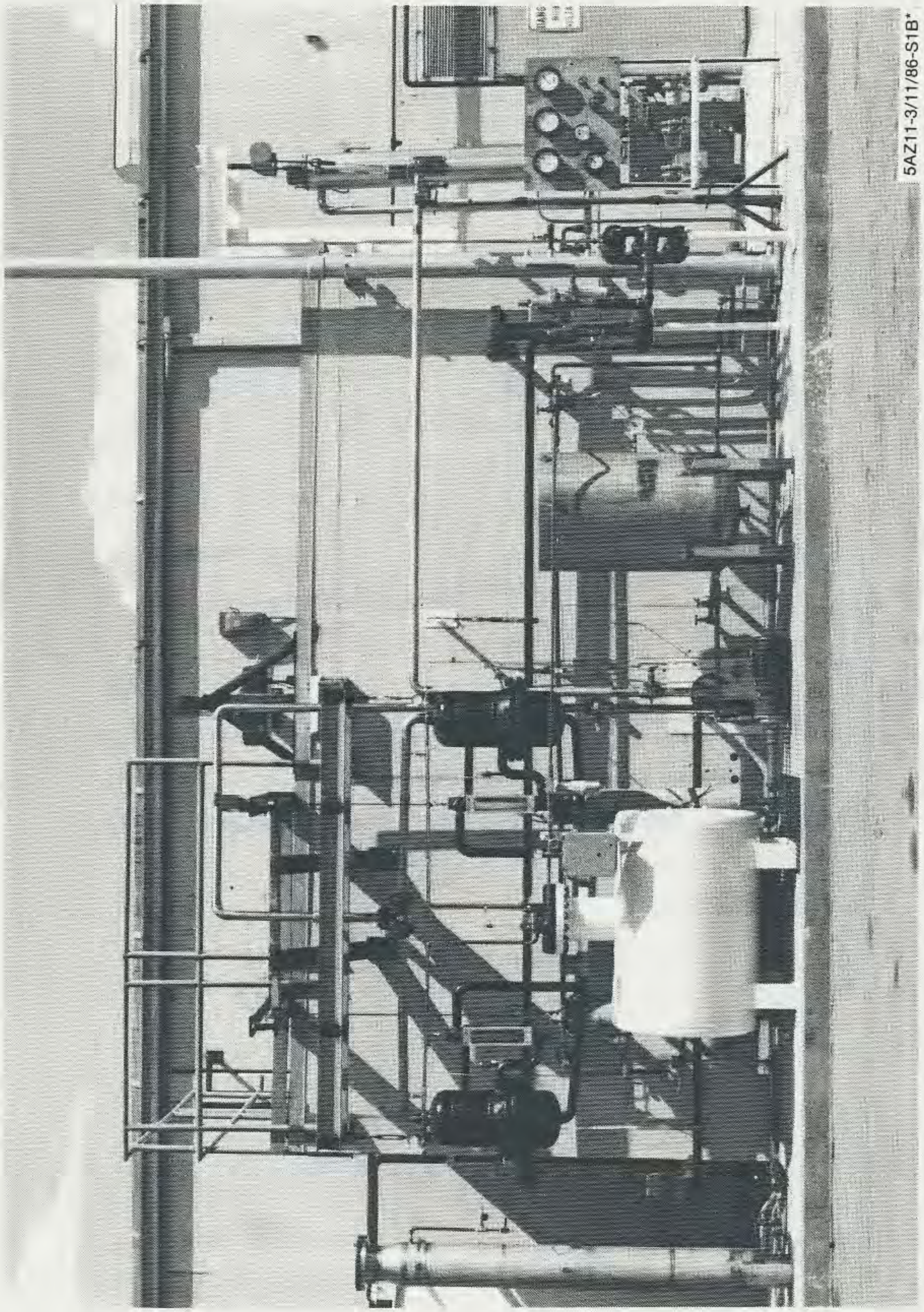

Figure 44. NaK Bubbler Cleaning Facility

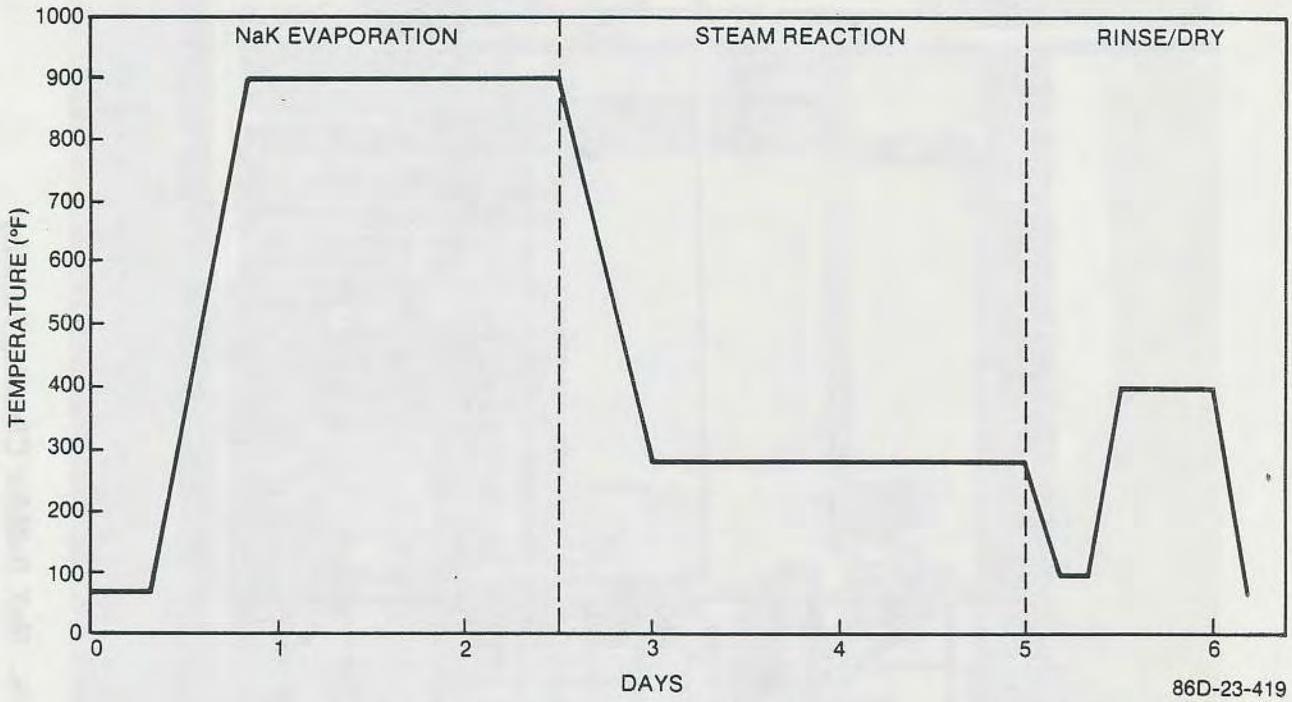

Figure 45. Bubbler Cleaning Process Time–Temperature Graph

Following cleaning, the bubblers were surveyed and verified as LSA waste and returned to the RMDF for packaging and staging for shipment to a disposal site. The process water generated during the cleaning of the bubblers, ~1960 gal, was neutralized with CO_2, transferred to the RMDF, and evaporated; the residual solids were packaged into three 55-gal drums at the RMDF for shipment to a disposal site. Removal and neutralization of the NaK from the bubblers was accomplished in June 1986. N704ER990011, NaK Bubbler Cleaning Final Report, by P. H. Horton, describes the cleaning process, presents the process data, and offers recommendations for any similar cleaning of radioactively contaminated NaK containers.

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5.0 SCHEDULE AND COST

5.1 SCHEDULE

Fuel fabrication programs terminated in late 1979. The facility was maintained and a minimal carbide oxidation, SNM recovery, and glove box cleaning effort was performed on a surveillance and maintenance level of funding. Negotiations with the SFMPO of DOE-RL working through DOE-SAN began with trade-off studies and analysis of costs versus length of schedule for decommissioning the NMDF. A significant savings could be realized (~$1 million) by performing a 2-year program, but available yearly funding limitations for the SSFL site dictated a schedule stretch out to 4 years. The decision was made to proceed with physical decommissioning. Actual dismantlement would begin in fiscal year (FY) 1983.

The Building 055 Decontamination and Deactivation Plan was completed in September 1982. The plan defined the methods and techniques to clean out, disconnect, and package the glove box line and all associated ventilation and support systems. The plan also identified the need for an engineering study to determine the safest way to handle and dispose of 10 NaK purifiers used at the NMDF from 1967 to 1973. These purifiers were extremely hazardous because of the plutonium contamination and the explosive potential of potassium super oxide.

The decommissioning of Rockwell's NMDF began in October 1982 and was completed in October 1986. Final surveys, waste shipments, and the final report were completed by March 1987. The final schedule for the project is shown in Figure 46.

5.2 COST

The original cost estimate of 8 October 1982 was divided into 11 major activities and came to a grand total $4,230,000. The final cost was $4,438,000. Table 5 shows the actual costs versus the original estimate for the 11 major activities. This information is graphically presented in Figures 47 and 48.

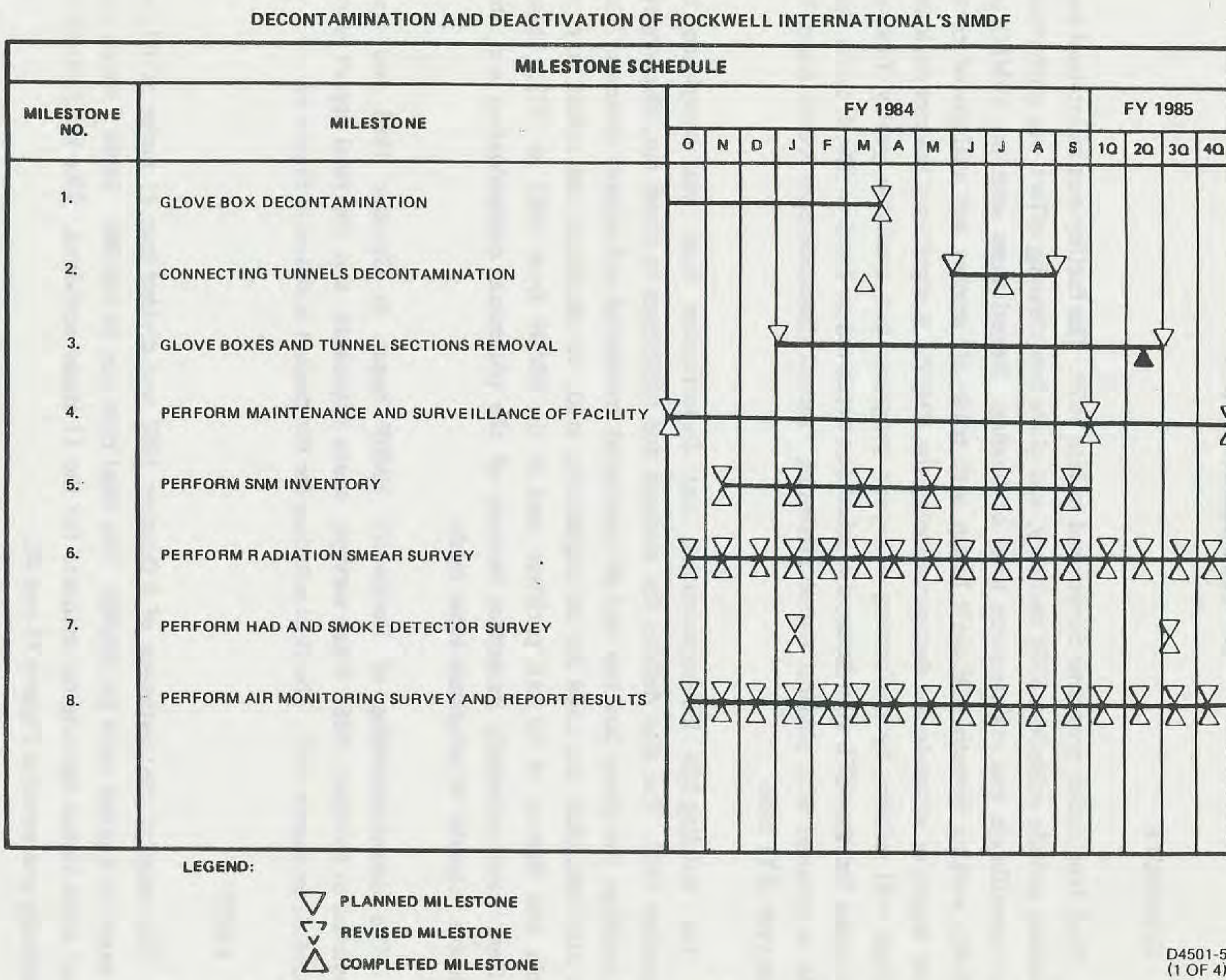

Figure 46. Decontamination and Deactivation of Rockwell International's NMDF (Sheet 1 of 4)

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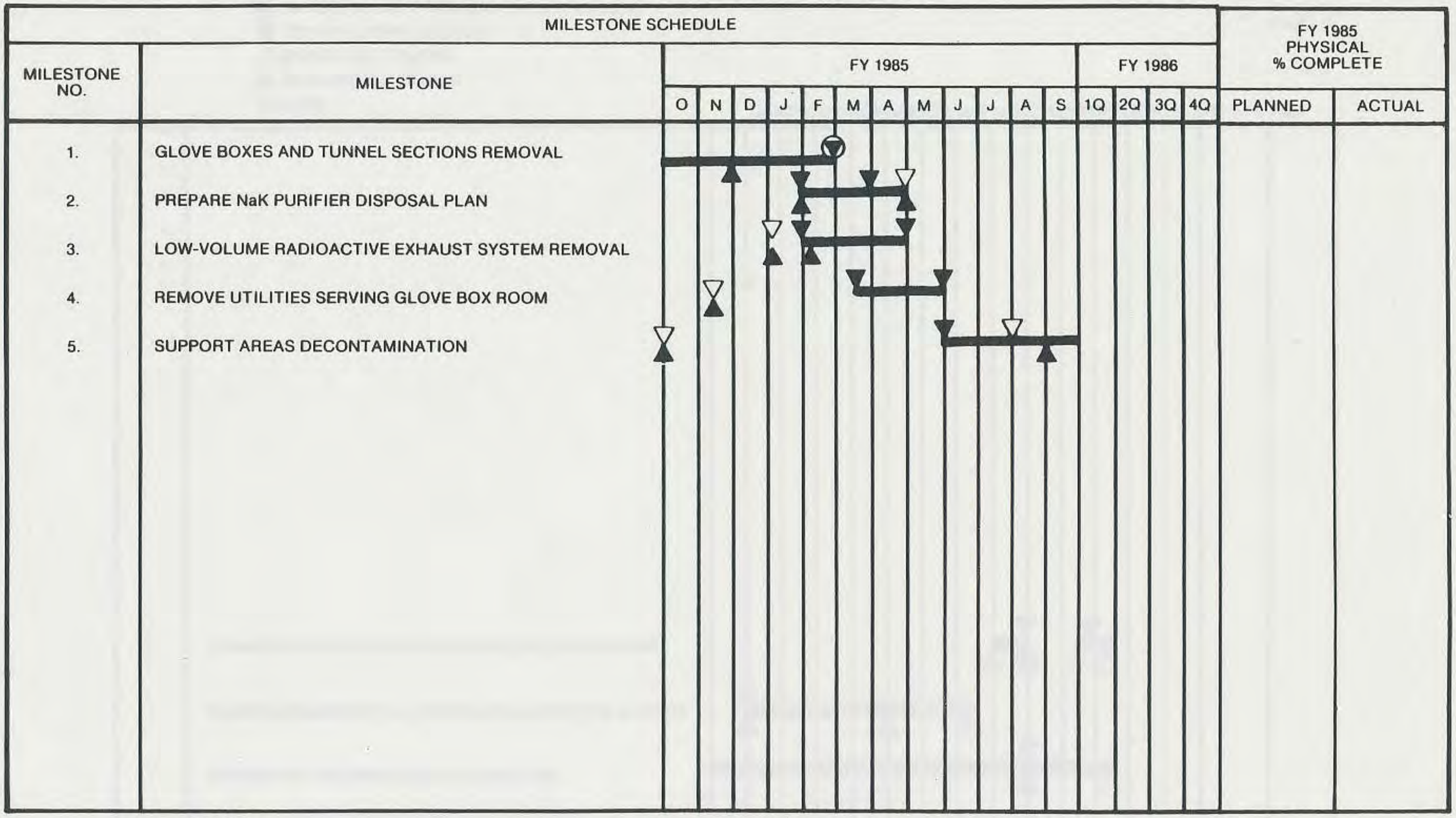
DECONTAMINATION AND DEACTIVATION O F ROCKWELL INTERNATIONAL'S NMDF



LEGEND:
- PLANNED MILESTONE
- REVISED MILESTONE
- COMPLETED MILESTONE
- HEADQUARTERS CONTROLLED

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(2 OF 4)

Figure 46. Decontamination and Deactivation of Rockwell International's NMDF (Sheet 2 of 4)

WBS: 4.8.8 B&R CATEGORY: AH 10-20-4
DECONTAMINATION AND DEACTIVATION OF ROCKWELL INTERNATIONAL'S NMDF

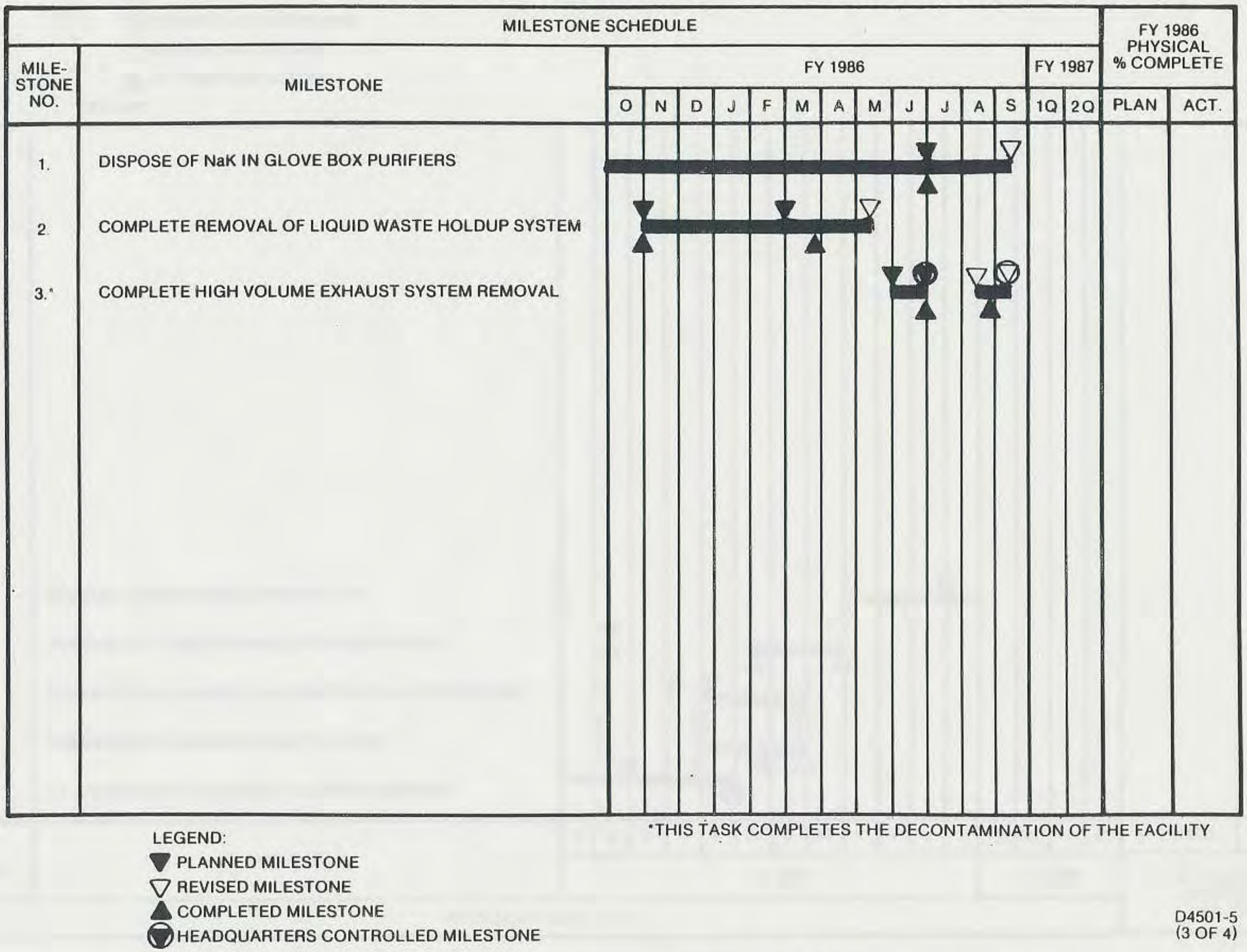

Figure 46. Decontamination and Deactivation of Rockwell International's NMDF
(Sheet 3 of 4)

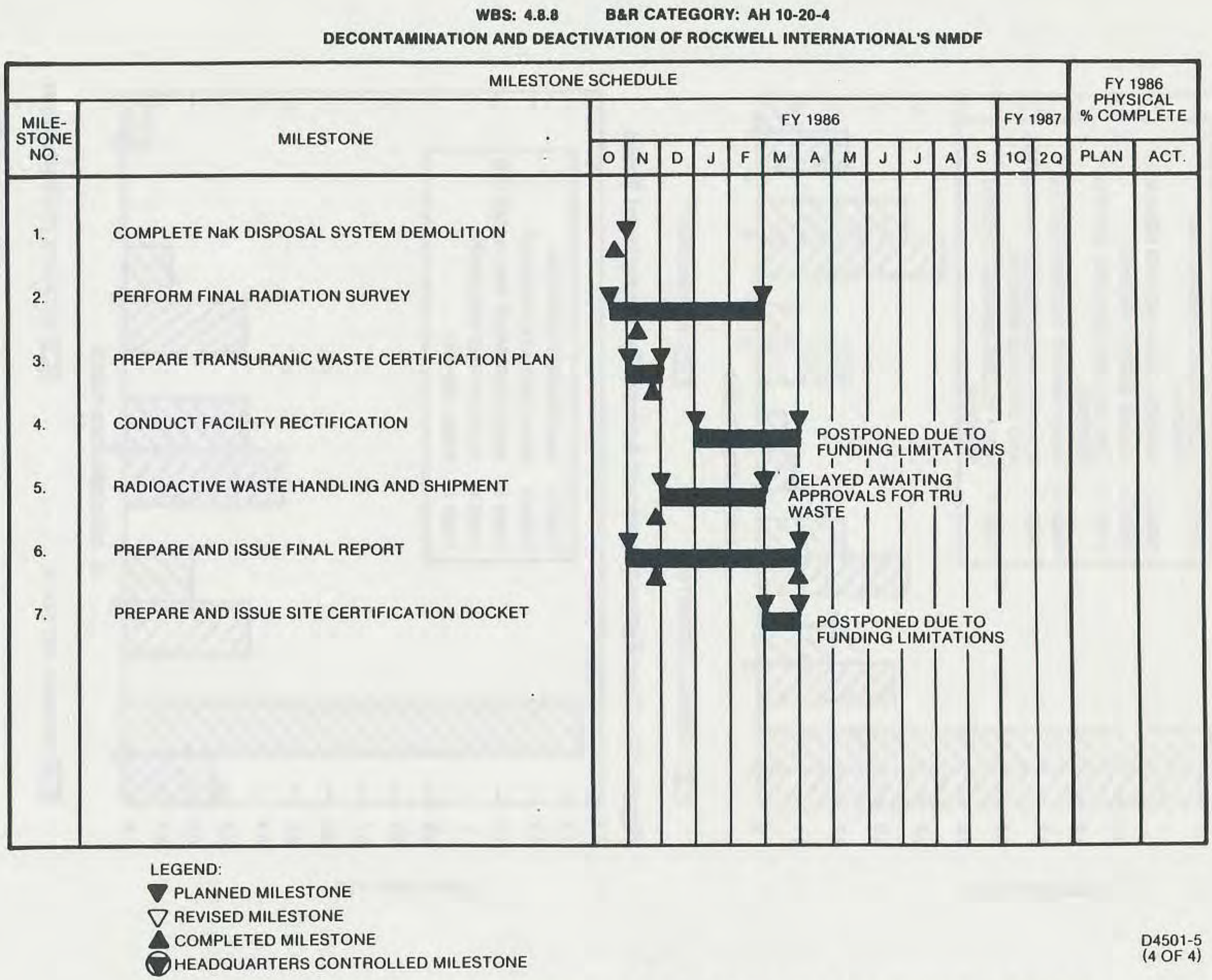

Figure 46. Decontamination and Deactivation of Rockwell International's NMDF (Sheet 4 of 4)

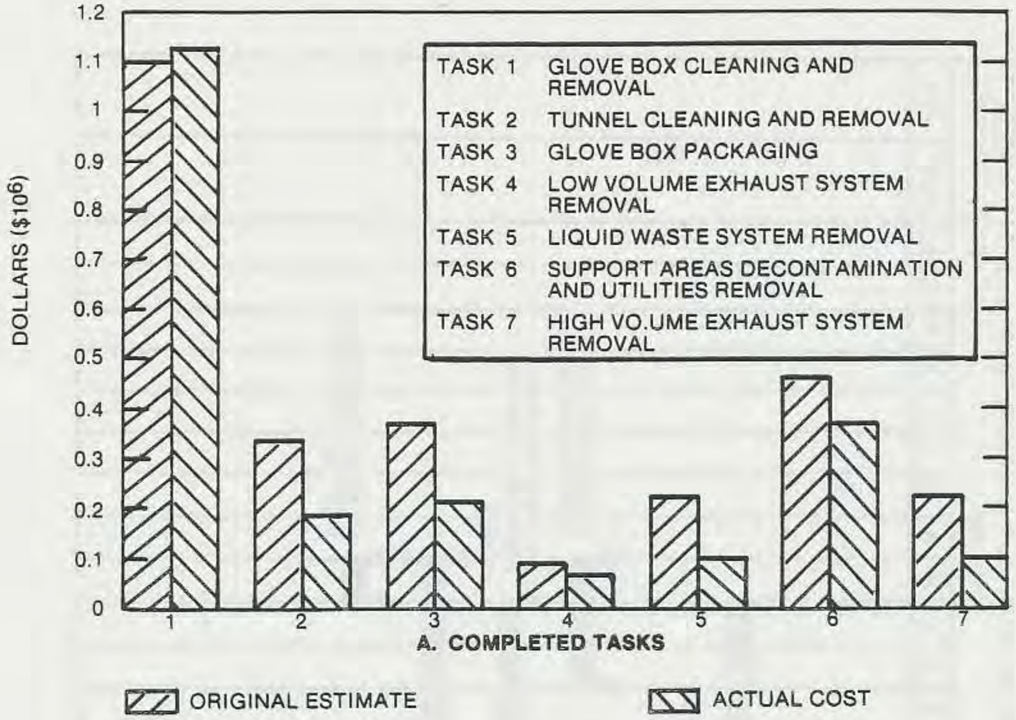

Figure 47. Cost Estimates versus Actuals for Completed Tasks

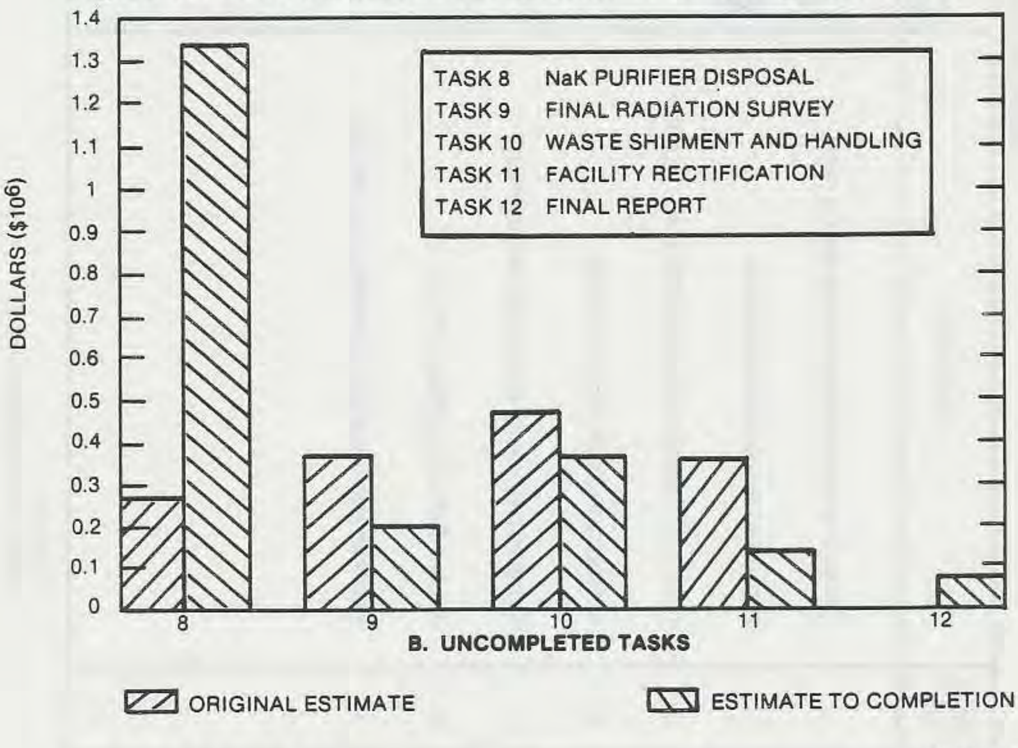

Figure 48. Cost Estimates versus Actuals for Uncompleted Tasks

TABLE 5

ACTUAL COSTS VERSUS ESTIMATED COSTS, D&D

Task	8 October 1982 Estimate ($)	Actual Cost ($)	Completion Funding Required ($)	Estimated Cost at Completion ($)	Difference ($)	Percent Change
Glove box cleaning and glove box removal	1,092,100	1,123,219	0	1,123,219	31,119	3
Tunnel cleaning and tunnel removal	335,400	185,941	0	185,941	(149,459)	-45
Glove box packaging	369,700	211,032	0	211,032	(158,668)	-43
Low-volume exhaust removal	87,100	64,557	0	64,557	(22,543)	-26
Liquid waste system removal	221,600	98,088	0	98,088	(123,512)	-56
Support areas decontamination and utilities removal	461,700	369,923	0	369,923	(91,777)	-20
High-volume exhaust removal	221,400	96,308	0	96,308	(125,092)	-57
NaK purifier disposal	263,200	1,334,912	10,623	1,345,535	1,082,335	411
Final radiation survey	362,000	105,643	91,377	197,020	(164,980)	-46
Waste shipment and handling	464,600	212,389	144,973	357,362	(107,238)	-23
Facility rectification	351,200	0	134,511	134,511	(216,689)	-62
Final report	0	0	72,952	72,952	72,952	
Total	4,230,000	3,802,012	454,436	4,256,448	26,448	

With the exception of the glove box cleaning activity and the NaK purifier disposal activity, all accounts were completed 20 to 57% under the original 1982 estimate. The major contributors to the under-budget completion were the extremely low levels of contamination found in the glove box line support systems. The estimate was based on a moderate contamination level that would require more containment measures, more suit-up, and more cleanup of contamination activity than was actually experienced.

Both the design and good maintenance practices of the glove box line and the overall facility during fuel fabrication operations contributed to minimal decommissioning costs by limiting high levels of contamination to glove box interiors only. Secondary contributors were the previous experience of the decontamination workers on other jobs and improvement of methods and techniques as the project progressed. The rectification activity final estimate was under the original estimate because of a change of scope.

The only activities that were over the original estimate were the glove box and removal activity by 3% and the NaK purifier disposal (411%). The gross difference for the NaK purifiers is a result of not knowing the magnitude of the task until the engineering study was performed in 1985. The original estimate assumed a minimum of equipment and facility requirements from a very rough process outline. When the engineering study was performed, a host of safety-related systems, equipment, and facility requirements were identified. A detailed report of the facility and process can be found in N704ER990011, NaK Bubbler Cleaning Final Report.

The overall decommissioning effort is considered a very successful project. A comparison of previous plutonium facility decommissioning costs versus building 055 costs per ft^2 of facility is shown in Table 6. A major difference was the ability to reduce waste to the non-TRU category by cleaning techniques proven early in the project. This allowed costs to be reduced by 52 to 62% based on constant TRU disposal costs. TRU disposal charges have actually increased 760% during the period 1982 to 1986. The lessons learned here have been applied to the planning and successful decontamination effort in building 371 at Rocky Flats on the plutonium recovery option verification exercise (PROVE) project.

TABLE 6

COMPARISON DATA—GLOVE BOX DECOMMISSIONING PROJECTS

Location	Total Area (ft^2)	Number of Glove Boxes	Volume of Glove Boxes (ft^3)	Volume Vent System (ft^3)	Volume TRU (ft^3)	Volume LSA (ft^3)	Container Cost ($)	Transportation Cost ($)	Disposal Charge ($)
GE Fuels Laboratory	4,000	30	4,490	370	14,413	2,688	471,000	61,000	No charge
W-ARD Cheswick	5,000	28	3,000	2,400	16,500	125	123,000	224,000	No charge
Building 055 (NMDF)	8,040	30	6,117	1,585	692	16,527	65,800	140,000	100,000

		Cost/Unit Area
GE Fuels Laboratory*	$3,790,000 total (completed 1982) =	$948 ft^2
W-ARD*	$4,000,000 total (completed 1981) =	$800/$ft^2$
Building 055	$4,438,000 total (completed 1986) =	$552/$ft^2$

*GE and W-ARD figures not adjusted to 1986 dollars (i.e., inflation, transportation, burial rate, or labor rate increases).

Table 7 shows the funding by FY for the decommissioning of building 055. The schedule stretched out beyond the original 4 years because of delayed funding and performance of out-of-scope tasks at the request and direction of DOE-SAN.

TABLE 7

FUNDING BY FISCAL YEAR, BUILDING 055 D&D AND COST THROUGH FISCAL YEAR 1987

	$ (K)
FY 1983	$ 570
FY 1984	1,105
FY 1985	1,125
FY 1986	1,302
FY 1987	336
Total funding through 1987	$4,438

6708F/sjv

6.0 WASTE VOLUMES GENERATED

The waste volume generated from the D&D of building 055 is summarized below (Table 8) and segregated into four groupings: (1) LSA solid waste, (2) LSA glove boxes, (3) LSA tunnel sections, and (4) TRU.

TABLE 8
WASTE VOLUMES GENERATED

	(ft^3)
1. Low specific activity (LSA)	10,410
2. Glove boxes (LSA)	5,256
3. Tunnel sections (LSA)	861
4. Transuranic (TRU)	692
Total	17,219

7.0 OCCUPATIONAL EXPOSURE TO PERSONNEL

The facility was operated in a radiologically controlled manner. ANSI N13.12 (draft), DOE 5480.1, Chapter III, and other SNM licensing requirements established guidelines for radiation safety, industrial safety, and industrial hygiene throughout the D&D project. In addition, Rocketdyne Standard Operating Policies and the Rocketdyne Health, Safety, and Environment Procedures Manual were strictly adhered to for all activities governed by their requirements. The use of these operational guidelines were continued from the project operations into decommissioning operations.

Film badges were worn by all persons entering the radiologically posted areas. These badges, which contained beta-gamma-sensitive film packets with the appropriate shields for radiation quality assessment, were processed quarterly by an independent laboratory and provided the legally documented record of external exposure.

Direct-reading pocket dosimeters were issued in conjunction with film badges during certain operations at the discretion of the Radiation Safety representative, providing additional control on planned radiation exposure.

Whenever operations were performed that posed a potential for significant extremity exposure, particularly operations that required significant quantities of americium 241, extremity monitoring was provided. Finger ring film badges and/or thermoluminescent dosimeters (TLDs) were utilized for extremity monitoring.

Because of the nature of the facility operations, the primary radiation exposure concern was the possible ingestion of alpha radiation. The facility operational and decommissioning procedures and controls contained the alpha radiation hazard such that there were no incidents of ingestion or contamination during the D&D operations. Those operations that involved a potential for extremity or whole body exposure from beta and/or gamma radiation were minimal, and the personnel performing those operations were experienced in exposure-minimizing techniques that further reduced the overall D&D exposure to ionizing radiation to below minimum detectable limits.

Film badge dosimeter results for persons assigned exclusively to the facility during any typical quarter were reported as "M," denoting that the dose equivalents were below the limit of detectability of 10 mrem for those persons. Also, urinalyses for fission/activation product and/or plutonium were performed; typically, the results were below the appropriate minimum level of detectability for the analyses performed.

6708F/sjv

8.0 FINAL FACILITY CONDITION

The total site has been decontaminated and all R/A materials have been removed from the site. Except for the boiler located in room 128, the emergency diesel generator located in room 132, and associated compressors and air conditioning units located outside of the building on concrete foundations, the building interior has been stripped to the walls. Most of the equipment removed from glove box interiors was disposed of as R/A waste under the burial criteria for TRU waste. All other detectable R/A material was removed, packaged, and sent to a licensed disposal site as LSA waste. Residual contamination in the facility is well below applicable limits specified by Annex B to Special Nuclear Materials License No. SNM-21. The results of the final radiation survey may be found in N704SRR990027, "Final Radiation Survey of the NMDF," J. A. Chapman, 19 December 1986.

6708F/glb

9.0 LESSONS LEARNED

A review of the technical and managerial approaches taken to accomplish the NMDF decommissioning indicates that, as in any program, the total performance could be improved if the project were to be repeated. This review has produced recommendations that will be useful in future programs.

9.1 GLOVE BOX DECONTAMINATION

Several methods of glove box decontamination were investigated, such as electropolishing, dry and wet abrasives, and scouring with metal brushes. Ultimately, decontamination of the glove box surfaces was accomplished utilizing ALARA strippable paint. This proved to be an effective and efficient method of surface decontamination. Surveys of the decontaminated glove boxes ensured that they were not TRU waste and were within the criteria of LSA waste. The glove boxes were, therefore, disposed of as LSA waste.

9.2 NaK TREATMENT IN GLOVE BOX ATMOSPHERE PURIFIERS

Disposal of the NaK in the glove box atmosphere purifiers, NaK bubblers, required the installation of a special NaK disposal facility at the NMDF, incorporating remnants of the facility utilities and liquid waste system. The NaK bubblers were not only a problem because of the chemical hazards of NaK but because trace quantities of alpha materials were present, which required stringent containment. Because of the potential hazards involved, all aspects of the process were conducted with extra caution and heavy emphasis on safety. Based on the single incident involving small detonation during the remote removal of the bubbler inlet and outlet piping in RIHL cell 1, it was demonstrated that the extra safety precautions taken were justified. Controlled vaporization of NaK and reacting the NaK vapors with water in a controlled manner proved to be a successful process for disposing of contaminated NaK. All aspects of the cleaning operation were conducted safely, and all goals were achieved.

9.3 STRUCTURES DECONTAMINATION

It is recommended that in the future, careful attention be paid to the possibility of fixed contamination in painted surfaces, particularly fixed contamination in the overhead structures. The overhead structures were surveyed for removable/smearable contamination during the decommissioning activity. The final survey discovered fixed contamination in the painted surfaces on the overhead structures. As a result, the additional decontamination of the overhead structures was conducted inopportunely after the completion of the decommissioning operations during the final survey activities.

6708F/sjv