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AED-EO-72

Summary Report

Decontamination of Building C-West

U.S. Air Force Plant No. 36

Evendale, Ohio

Submitted To

U.S. Nuclear Regulatory Commission

Region III

Glen Ellyn, Illinois

June 1984

GENERAL ELECTRIC

Advanced Energy Programs Department

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1.0 INTRODUCTION

This report is submitted to the U. S. Nuclear Regulatory Commission, Region III, Glen Ellyn, Illinois, as partial fulfillment of the requirements for completion of decontamination activities within the facility known as Air Force Plant No. 36 located at Evendale, Ohio. One and one half buildings of this facility are included in the Nuclear Regulatory Commission's Industrial Byproduct License No. 34-00499-11. They are known as Building "D" and Building "C-West."

Air Force Plant No. 36 is contiguous with the facilities of the General Electric Company's Aircraft Engine Business Group where commercial and military jet engines are manufactured. This 1-1/2 mile long industrial complex is adjacent to highway Interstate 75 and located 12 miles north of downtown Cincinnati.

The contents of this report summarize the decontamination activities in Building "C-West" that were necessary for the release of the facility from regulatory requirements and for future unrestricted usage. A separate report is issued for Building "D".

This summary report covers all of Building C-West and is supported by separate detailed reports for prescribed areas. These reports identify the premises, type of construction and finishes on surfaces, predecontamination monitoring data, the efforts required to eliminate residual surface and fixed contamination and the post-decontamination monitoring data. The results are stated according to the guidelines issued by the Nuclear Regulatory Commission.

This report contains an overall summary of the decontamination effort, a history of the use of Building C-West, a description of the survey methods and instrumentation used, the statistics of counting removable contamination, a description of the decontamination procedures, and a summary of results. Twenty-five detailed reports describe each area or room of the facility and contain the final survey results.

2.0 SUMMARY

This report documents the successful decontamination of Building C-West, United States Air Force Plant 36, to near-background levels of radiation. The entire Building C-West area has been decontaminated to radiation levels substantially below NRC acceptable guidelines for surface contamination.

This general summary report outlines the overall activities performed for the entire Building C-West decontamination effort. Individual reports document the detailed activities for all the separate areas of the building. Table 2-1 tabulates individual areas of the building and the corresponding number of detailed report, in which each are documented, thus providing a cross-reference for specific details. The final decontamination status is also summarized in this table.

Subsequent sections of this report describe Building C-West and provide a brief description of its history and past usage. The contamination which had to be removed is described. An overview of the work performed and the final decontamination results are provided. As indicated above, specific area-by-area results are documented in separate reports.

TABLE 2-1. BUILDING C-WEST - SUMMARY LIST OF DECONTAMINATION REPORT AND POST-DECONTAMINATION STATUS.

Individual Area Report Number	Room or Area	Prior Usage	Post Decontamination Status(1)			
			Removable		Fixed	
			dpm α/100cm²	dpm βγ/100cm²	dpm α/100cm²	mR/hr βγ@1.0cm
AED-EO-72	Summary Report	- - -	< 20	< 200	< 200	< 0.05
AED-EO-73	Room 120	Powder Production Area	↓	↓	↓	↓
AED-EO-74	Room 117	Fuel Element Fabrication	↓	↓	↓	↓
AED-EO-75	Room 111B (West End)	Fuel Element Fabrication	↓	↓	↓	↓
AED-EO-76	SE Basement Restroom & Lounge	Change and Restrooms	↓	↓	↓	↓
AED-EO-77	Bins 3-10, North Basement	S. S. Vaults	↓	↓	↓	↓
AED-EO-78	Controlled Drain System	Controlled Drain	↓	↓	↓	↓
AED-EO-79	Controlled Exhaust Systems, Attic	Controlled Exhaust	↓	↓	↓	↓
AED-EO-80	Rooms 103, 145, 150, 151, 152, 153, 155 and West Mezzanine	Laboratories and Office	↓	↓	↓	↓
AED-EO-81	Room 111A (East End)	Lab & Fuel Element Fab.	↓	↓	↓	↓
AED-EO-82	Rooms 112, 113, 114, and 115	Autoclave, X-Ray, and Labs	↓	↓	↓	↓
AED-EO-83	Rooms 116, 116A, 116B, 116C & 116D	Mech. Testing and Storage	↓	↓	↓	↓
AED-EO-84	Rooms 118 and 119	Machining, X-Ray and Storage	↓	↓	↓	↓
AED-EO-85	Room 149	Air Lock and Storage	↓	↓	↓	↓
AED-EO-86	Elevator, Elevator Shafts, N & S Stairwells	Building Facilities	↓	↓	↓	↓
AED-EO-87	Remainder of Basement	Storage and Corridors	↓	↓	↓	↓
AED-EO-88	Room 104	S. S. Vault Office	↓	↓	↓	↓
AED-EO-89	Room 108	Foundry and Stamping Press	↓	↓	↓	↓
AED-EO-90	Room 109	Extrusion Press Room	↓	↓	↓	↓
AED-EO-91	Rooms 156 and 157	Office and Building Services	↓	↓	↓	↓
AED-EO-92	Rooms 146 and 147	Restrooms	↓	↓	↓	↓
AED-EO-93	Room 144	Building Services Fan Room	↓	↓	↓	↓
AED-EO-94	Rooms 101, 102, 123, 137, 142 & 143	Hallways	↓	↓	↓	↓
AED-EO-95	Rooms 138, 140, 141, 148, Toilet and Locker Room	Building Services, Toilet and Locker Room	↓	↓	↓	↓
AED-EO-96	Rooms 124-128 and 130-135	Change Room Complex	↓	↓	↓	↓
AED-EO-97	East Mezzanine Area	Office and Inspection Area	↓	↓	↓	↓

(1) See Table 3-2 for full NRC acceptable guideline values.

3.0 HISTORY

This section describes the Building C-West facility and presents a short summary of its use and history.

3.1 FACILITY DESCRIPTION

Building C-West is a portion of the government-owned facility known as Air Force Plant No. 36, located in Evendale, Ohio. Building C is approximately 660 feet long by 280 feet wide. The building construction is structural steel frame supporting a concrete roof. The walls are masonry. The main floor is poured concrete over earth and a partial poured concrete basement. Building C-West, the designation for the western side of Building C, is approximately 280 feet long by 280 feet wide.

Air Force Plant No. 36 is contiguous on its north side with the Evendale Plant of the Aircraft Engine Business Group of the General Electric Company. Figure 3-1 shows an aerial photograph of this entire industrial complex. Figure 3-2 shows the layout of Air Force Plant No. 36 with Building C-West indicated by shading. Figures 3-3, 3-4 and 3-5 show the interior arrangement of Building C-West, including the room numbers and descriptions which are keyed to Table 2-1.

3.2 PAST HISTORY AND USAGE

The following is a list of chronological events involving Building C.

Building C was built during World War II (circa 1941) as a foundry building by the Defense Mobilization Board as part of the Wright Aeronautical Engine Plant. After the war, it remained idle until 1954 when it was partially refurbished and utilized by General Electric for storage, manufacturing, and other purposes for jet engine production.

In 1951 the then Jet Engine Department of General Electric became a Prime Contractor to the U.S. Atomic Energy Commission (AEC) and formed the Aircraft Nuclear Propulsion Program (ANP). This was a joint venture between

General Electric Evendale, Ohio Industrial Complex

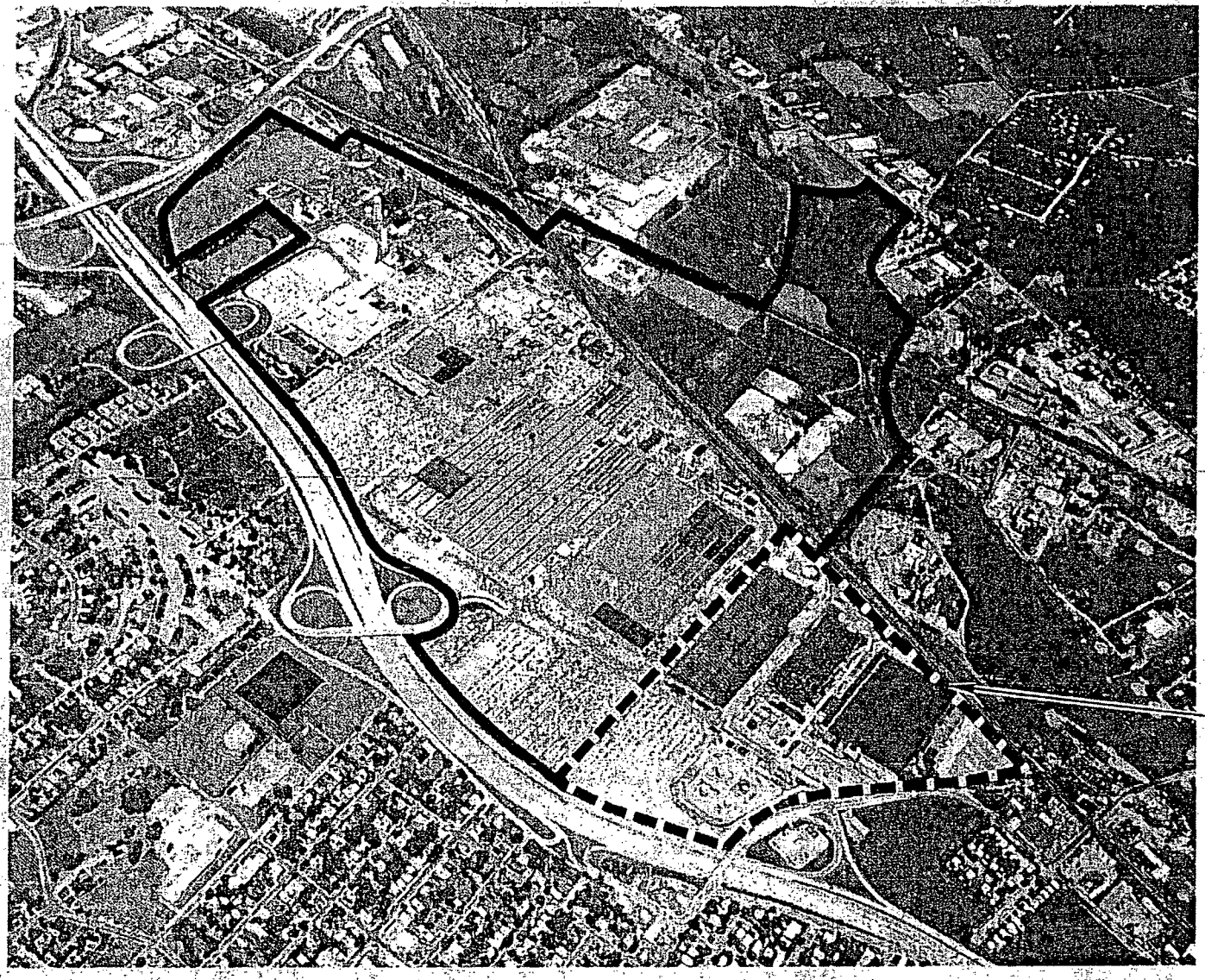

Figure 3-1. Aerial View of Delineating GE Complex and Air Force Plant No. 36.

Air Force Plant 36

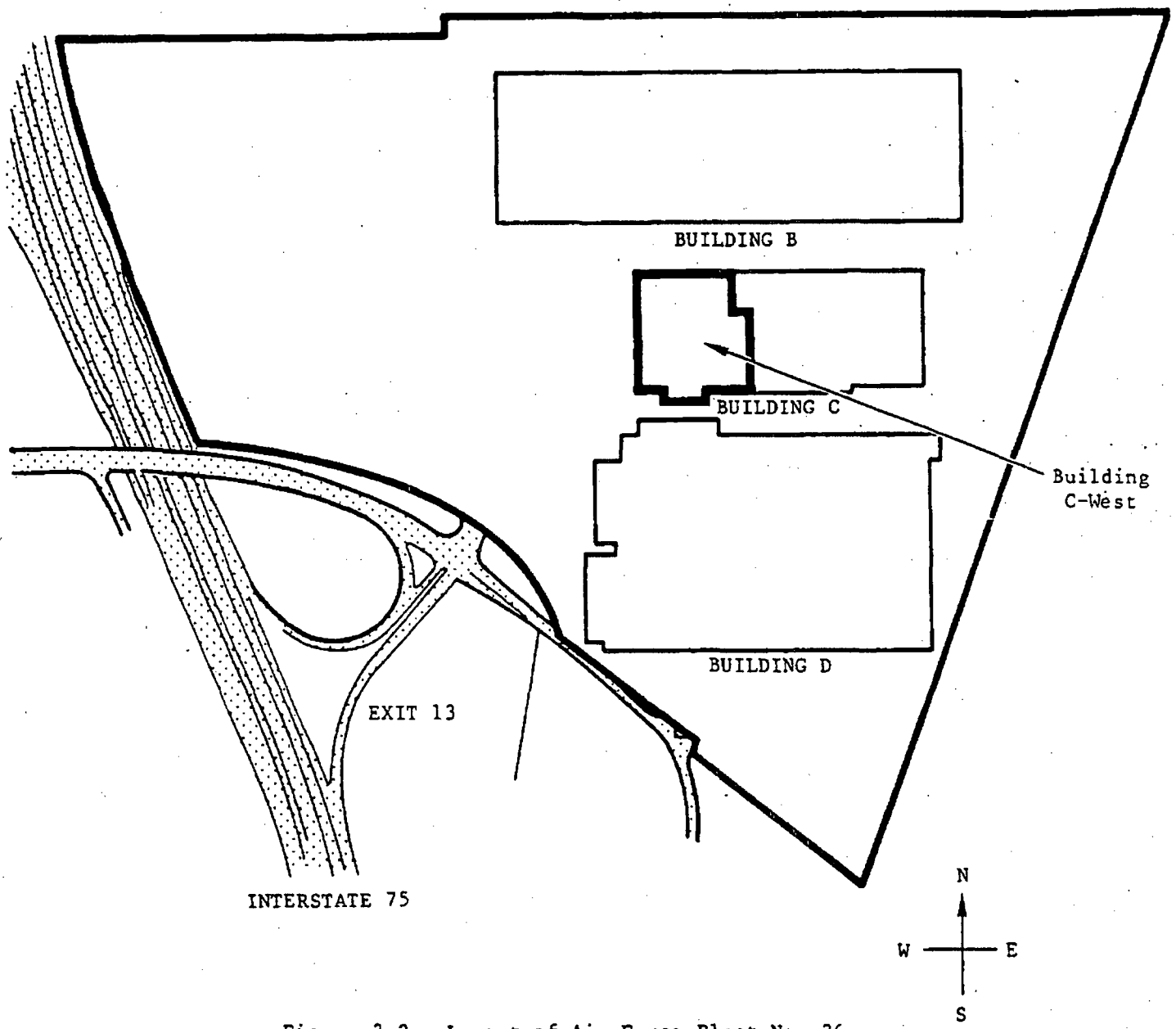

Figure 3-2. Layout of Air Force Plant No. 36, Showing Location of Building C-West.

Building C-West
Main Floor

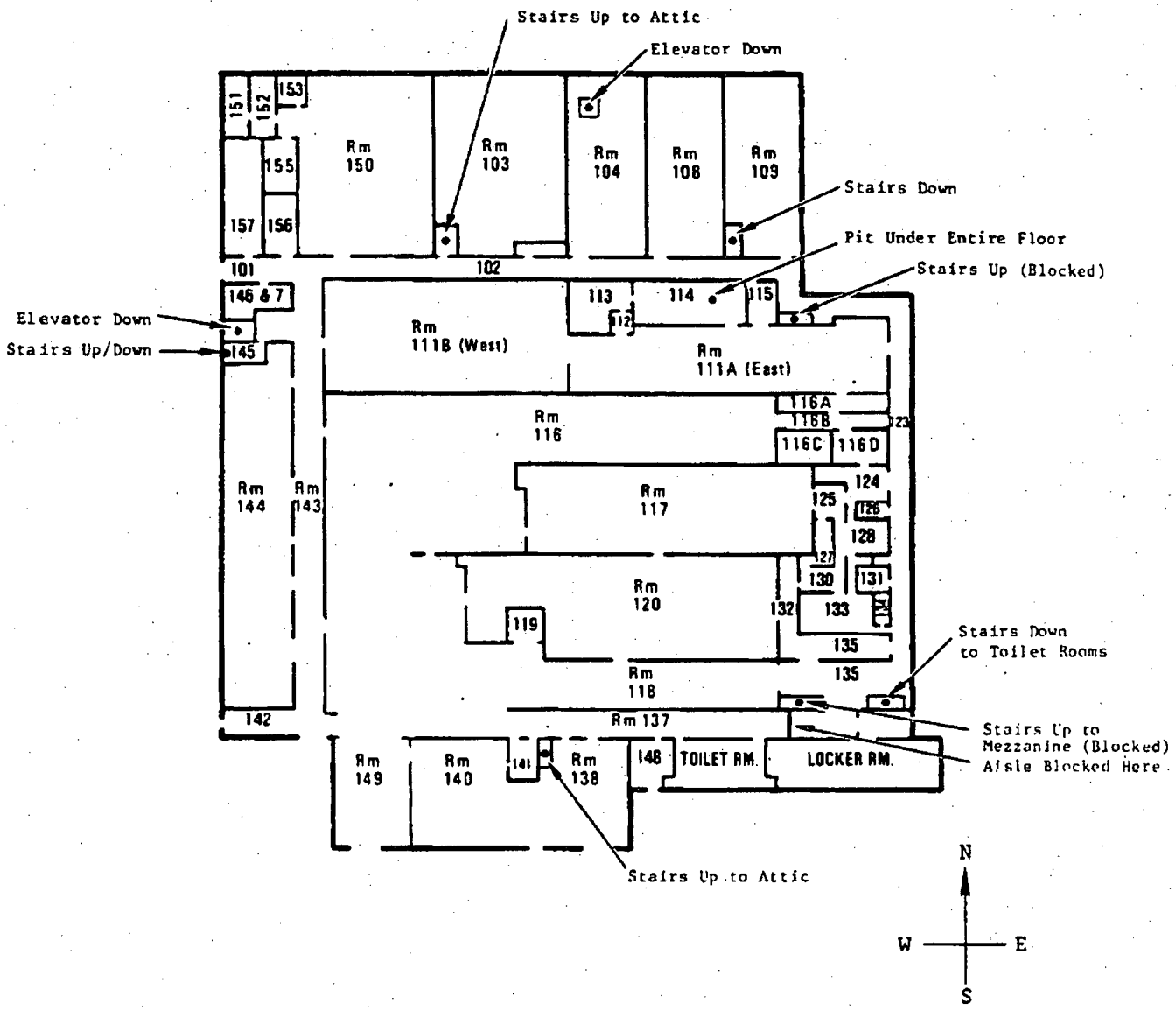

Figure 3-3. General Arrangement - Main Floor, Building C-West.

Building C-West Basement Plans

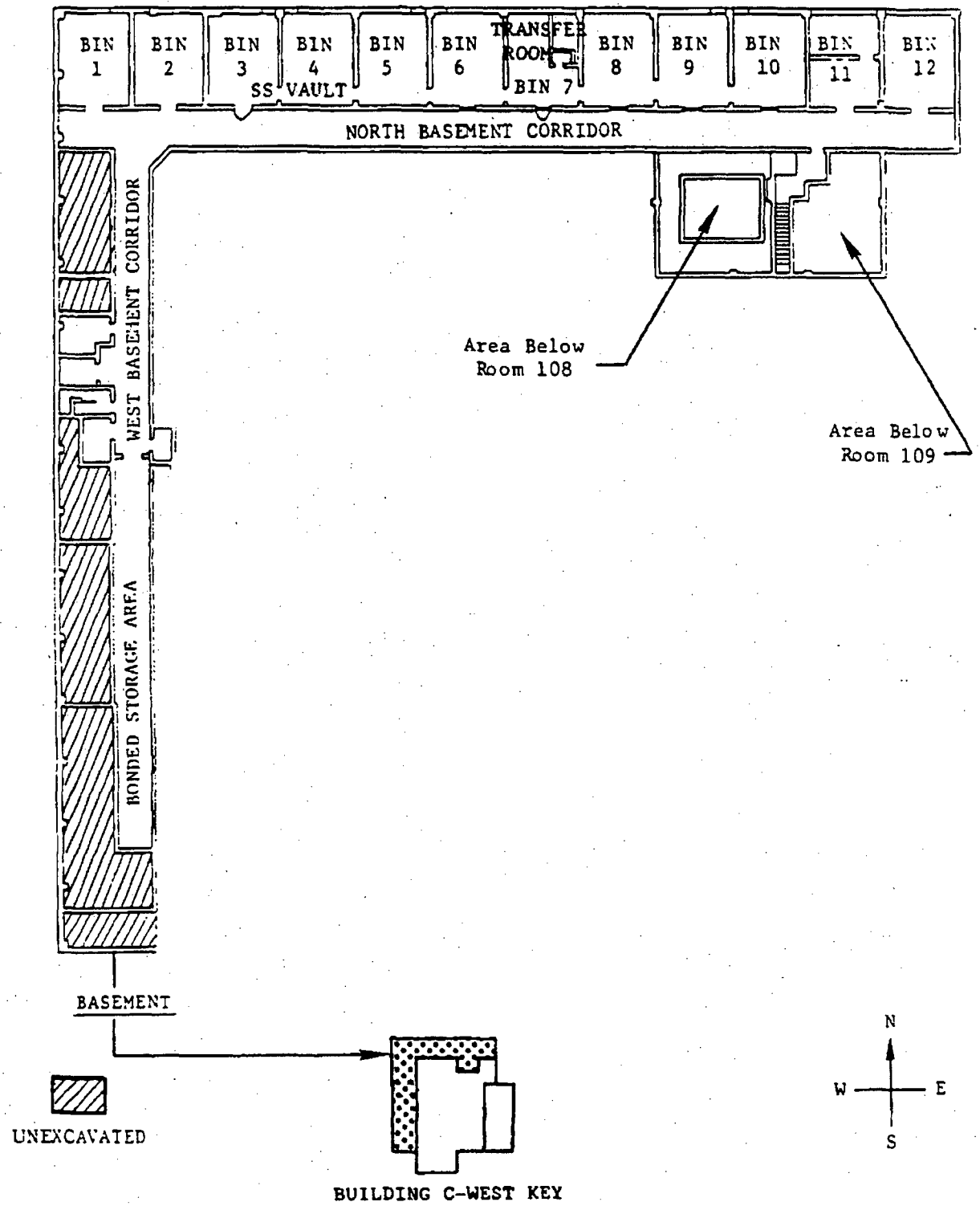

Figure 3-4. General Arrangement - Basement, Building C-West.

Building C-West Mezzanine Plans

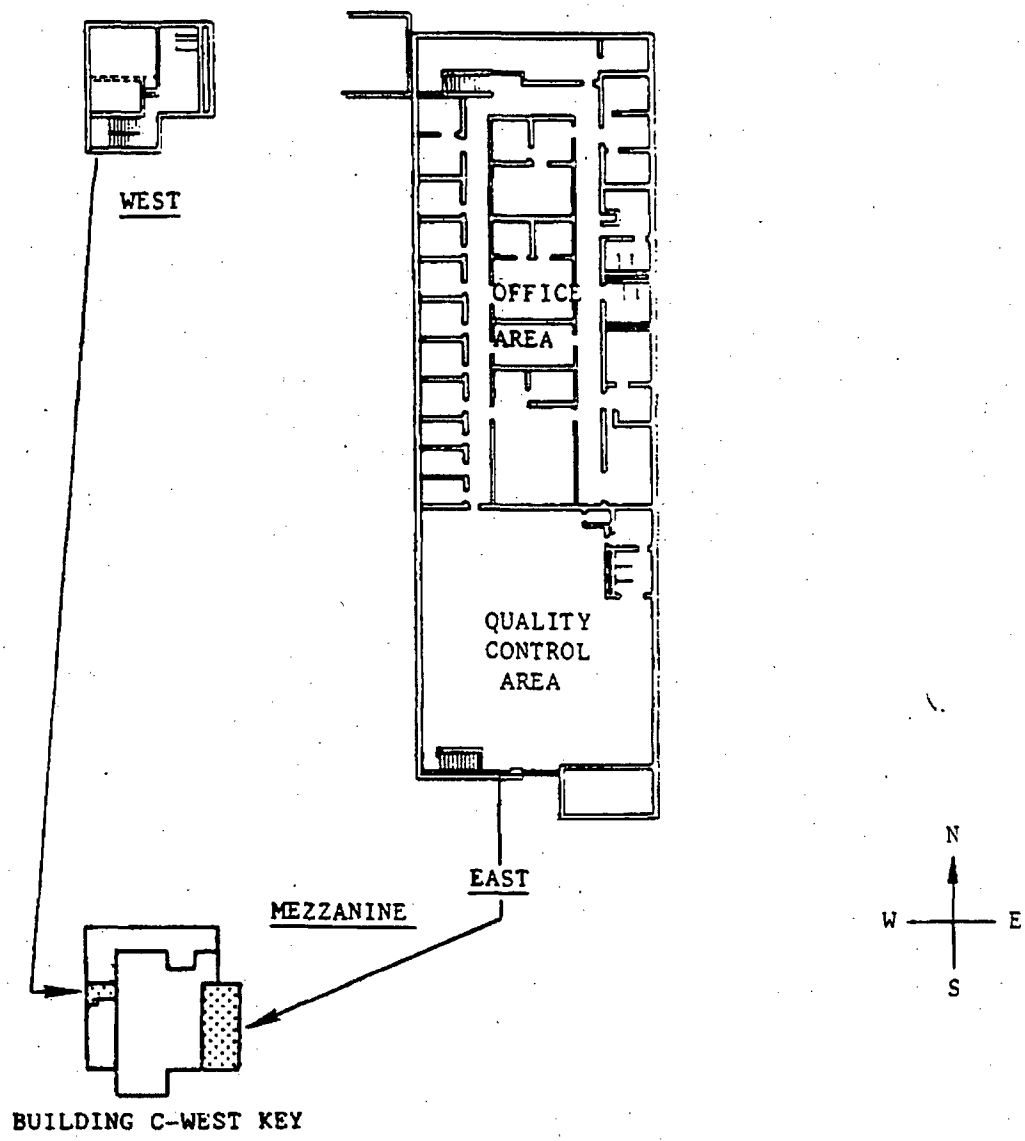

Figure 3-5. General Arrangement - Mezzanine, Building C-West.

the Air Force and the Atomic Energy Commission to develop a nuclear powered aircraft. Building D, south of Building C, was chosen as the operational building for this program.

In 1956 additional space was needed for the ANP program. Forty-two percent of Building C on the west end was allocated and was henceforth called "C-West." This portion of the building was separated by a newly-constructed floor-to-ceiling masonry block wall, and Building C-West was completely gutted and renovated. Portions of the new facility were specifically designed to handle large production quantities of powdered radioactive materials. Floors, walls and all surfaces were chosen for ease of decontamination. The interior of Building C-West was kept at a negative differential pressure with respect to the outside of the building. Work areas where radioactive material was handled were kept at a negative differential pressure with respect to the interior of the building. Glove boxes were maintained at a negative differential pressure relative to the work areas. The ventilation air system was single pass completely High Efficiency Particulate Air (HEPA) filtered and exhausted to the outside. Glove boxes were used for mixing and handling materials until the physical state was such that it would not spread contamination. Criticality safety was the overriding factor because a moderator and fissionable material were intimately mixed in small batches. The area was used as a pilot-plant type production line for ceramic nuclear fuel elements. These facilities were specially designed for a maximum of safety to employees and the environment.

In 1961 the ANP Program was cancelled. General Electric continued as a Prime Contractor to the AEC for development of high temperature fuel elements and reactor materials. The AEC took lease of the building from the Air Force.

Between 1961 and 1968, Building C-West was used for fuel element production in conjunction with the AEC 710 and 630 reactor development programs. The 710 program was concerned with developing a compact, fast-spectrum reactor that could be used as either an open cycle hydrogen cooled system as a nuclear rocket engine or as an inert gas closed cycle powerplant for space or terrestrial applications. The highly enriched fuel elements for this reactor concept were fabricated in Building C-West. The 630 program was

aimed at utilizing the ANP reactor technology to develop a gas or air cooled powerplant for commercial merchant ships. Some fuel element development work for this project was carried on in Building C-West.

In 1970 the AEC terminated their Prime Contract with General Electric's Nuclear and Material Propulsion Operation. General Electric became a licensee and performed subcontract work with other AEC Prime Contractors. At this time, the then AEC removed itself from the facility and the Air Force resumed landiordship of the buildings.

From 1967 until the end of 1974, Room 120 of Building C-West was used to calcine high purity thoria (ThO_2) for the thermal breeder reactor program.

In April 1973 an Air Force decision was made to decontaminate the Facility. They contracted with General Electric to decontaminate buildings "D" and "C-West." By May 1975 the allotted funding was depleted. Decontamination work ceased with the facilities partially decontaminated.

In January 1976, subsequent to this activity, a "Zero-Line Survey for AF Plant 36, Buildings C and D" was conducted by the Department of the Air Force, Air Force Weapons Laboratory (AFSC), Kirkland Air Force Base, which delineated the areas within these two buildings in which radioactive contamination remained.

In December 1976 the Air Force requested an engineering evaluation study as to the costs of various options for the proper disposition of the buildings. The study was performed by A. M. Kinney, architects and consulting engineers, Cincinnati, and submitted to the Air Force on June 15, 1977.

The Kinney Study answered the following questions requested by the Air Force:

1. Cost of partial demolition, which included the complete demolition of the contaminated portion of the buildings (the areas delineated by the Air Force survey where nuclear materials were once handled). These included the laboratory area, or 1/3 of Building

D, and all of C-West. It also involved packaging and disposal of the contaminated material to an approved radioactive burial ground. This estimate was 40 million dollars (1977 dollars).

2. Cost of Partial Entombment (Mothballing) which required isolating only the contaminated portions of the buildings on an indefinite time basis. Areas covered were the same as the demolition study. This estimate was $9.7 million 1977 dollars plus an annual operating cost. It was noted that this option would not have solved the contamination problem. It would only delay a final decision on the proper disposition of the building.

3. Cost of Full Entombment (Mothballing) which required isolating all of Building D and half of Building C on an indefinite time basis. This estimate was $8.6 million 1977 dollars plus an annual operating cost. This cost estimate is less than the cost estimate for Partial Entombment because relocation of utilities and construction of internal walls are not required. This option also would not have solved the problem. It would have only delayed a final decision.

In April 1977 the Air Force requested General Electric [Advanced Energy Programs (AEP)] to submit an estimate for two options for completing decontamination of Buildings D and C-West.

1. Limited decontamination -- This option covered decontamination of the remaining surface areas and flushing of controlled drains and monitoring of controlled exhaust ducts with very limited removal of controlled drains and ducts. This cost estimate was $0.7 million 1977 dollars. This option was not recommended because of problems with NRC guideline criteria for the decontamination of facilities and equipment for unrestricted use.

2. Full decontamination -- This option covered decontamination of the remaining surface areas with excavation and complete removal of laboratory controlled drains and complete removal of exhaust ducting systems. This cost estimate was $2.7 million 1977 dollars.

Since 1977 Building C-West has been maintained by General Electric as a restricted area with no operating activities being performed in the empty building. The only activities performed were those related to preventing deterioration. In October 1982 decontamination was resumed.

At the start of the current decontamination project, Building C-West was over 90 percent decontaminated. There were approximately 14 small areas that need additional decontamination. All special nuclear material isotopes had been removed. The remaining activity was surface radioactive contamination of moderate radiotoxicity and low radioactivity.

3.3 PRE-DECONTAMINATION STATUS

In 1969, prior to the start of decontamination, a survey was made of the contamination levels in Buildings C-West and D. In 1976 the Air Force conducted a survey to establish a "zero-line" outside of which there was no contamination. Based on this, and other file data, rooms and facilities were identified as either contaminated or probably clean. In addition to the rooms themselves, the controlled exhaust ducts in the attic and the controlled drains and retention storage tank system were suspected of being contaminated because they could not be monitored properly. (Note that these two systems were designed to prevent any possible release of radioactivity from the facility.) However, to assure that the facility was thoroughly decontaminated, it was required that all areas be surveyed and monitored for radiation contamination. This was accomplished as discussed in the following sections of this report.

There were several key problem areas identified at the start of decontamination activities. The first was the controlled exhaust ducts. The portions of these systems below the attic area had been removed during prior decontamination activities. Thirteen duct systems and roof penetrations remained in the attic. These systems included blowers, filter housings and plenums, vents, and ducts. The extent of contamination inside these systems was unknown because access to their interior walls was impossible for proper detection of alpha activity. For this reason, a decision was made to completely remove the entire controlled exhaust system. Figure 3-6 shows the locations of these ducts on the building floor plan. Figures 3-7 and 3-8 show

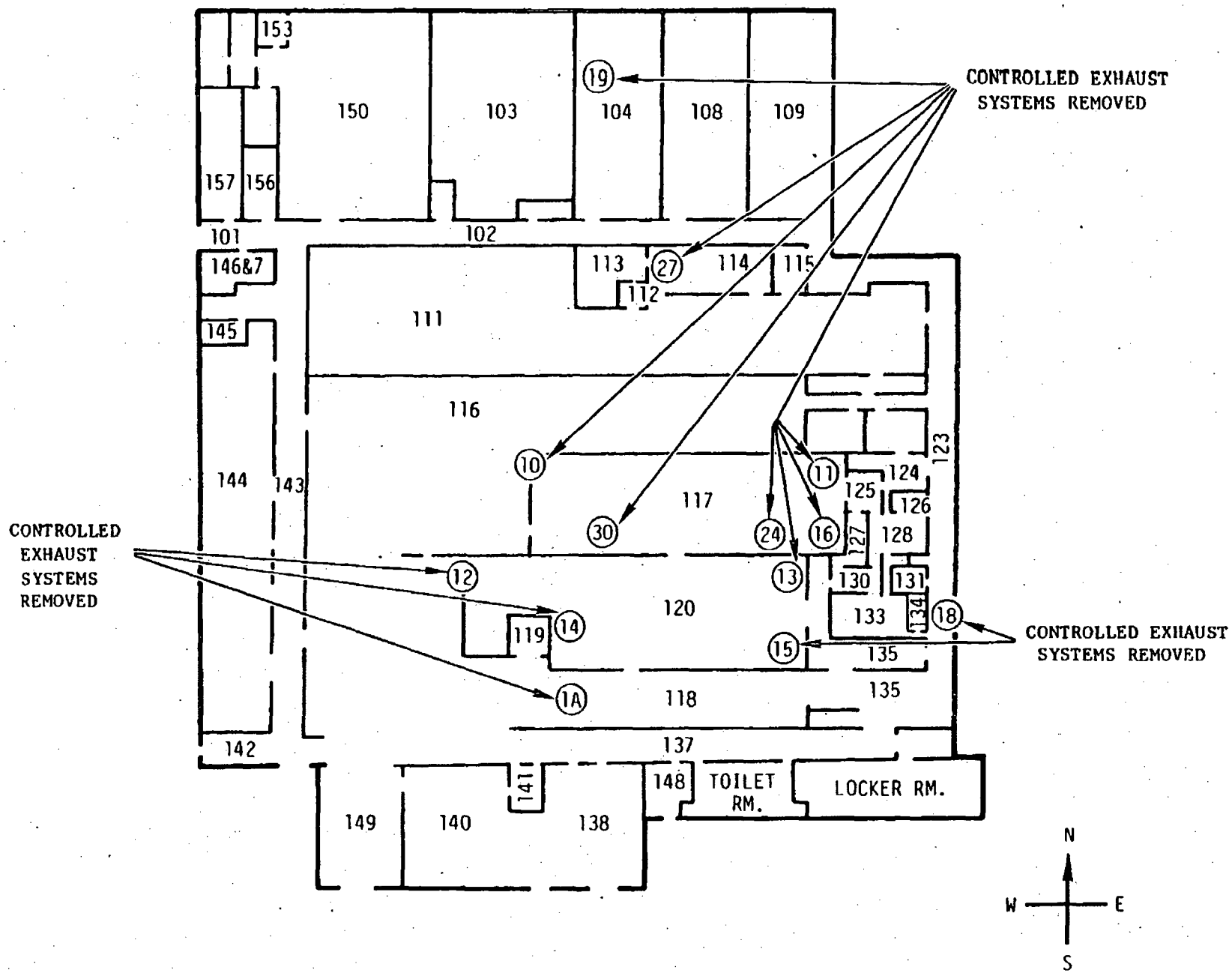

Figure 3-6. Controlled Exhaust Systems Removed From the Attic and Roof of Building C-West.

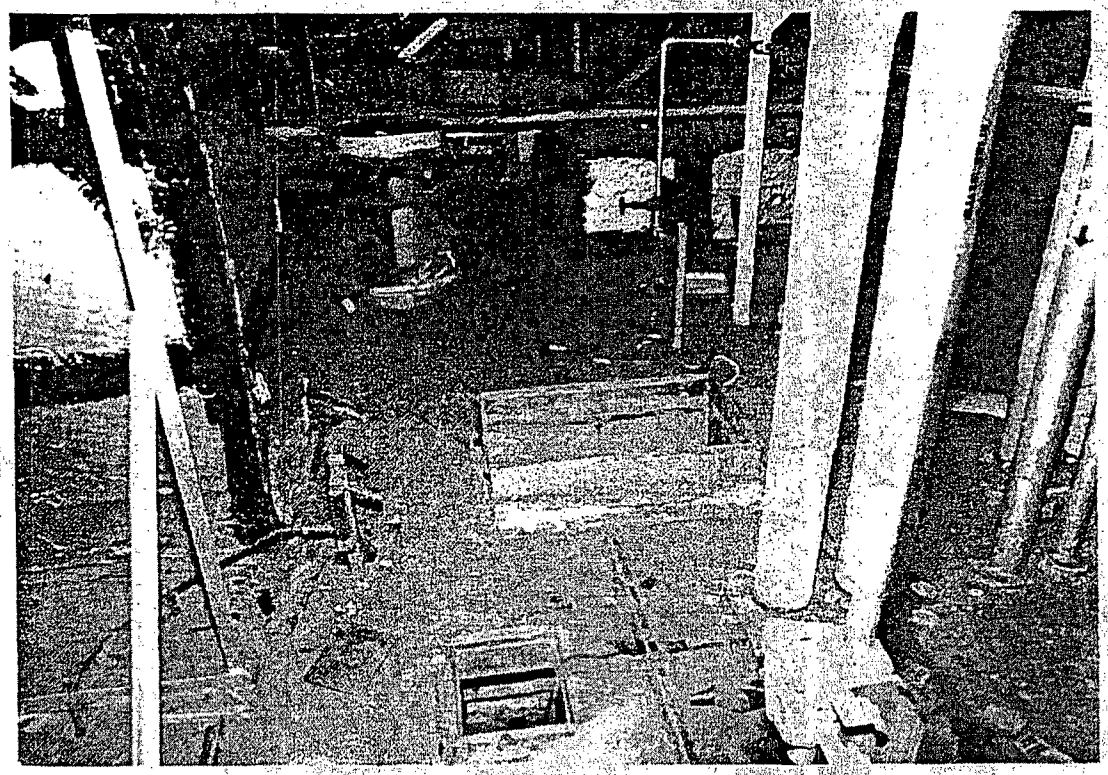

Figure 3-7. Removal of Duct 19 and Duct 16. Contaminated Blower from Duct 13 in Background.

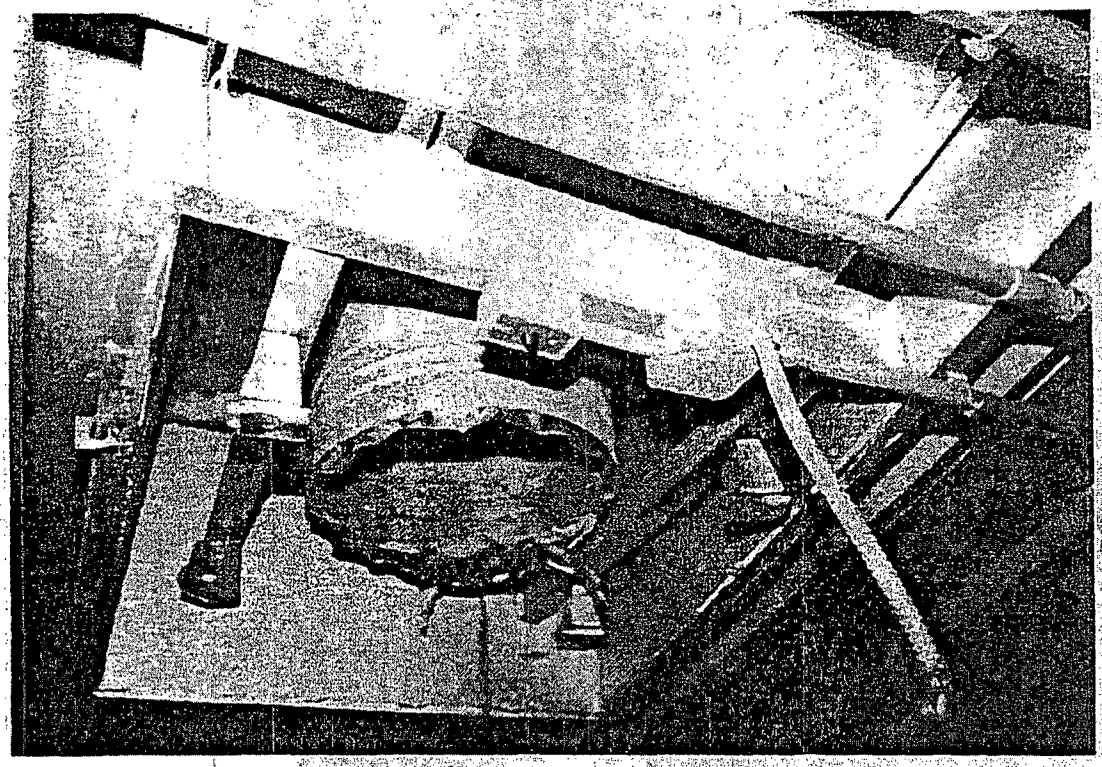

Figure 3-8. Roof Penetration of Duct 13, Subsequently Removed.

typical views of Duct 13 during the removal process. The removal of this equipment was difficult because of its location, the extreme care necessary during removal, the unknown levels of contamination, and the possibility of spreading contamination by careless handling.

The second potential problem was the removal of the controlled drains along with their associated retention storage tank and sump pump. The condition of this drain system, shown in Figure 3-9, was unknown because there was no way to access the system for proper monitoring. However, contamination could exist in concentrations exceeding the NRC guidelines and possibly high enough to constitute a hazard if uncovered. Small leaks at underground pipe joints also could cause potential contamination of the adjacent soil. The presence and effect of such leaks could not be determined before actual excavation and removal of the drain pipes. Figure 3-10 shows a typical drain line.

The remainder of the decontamination, the bulk of the work, involved a combination of non-destructive decontamination such as cleaning, vacuuming, grinding, and vacuum abrasive blasting, and destructive decontamination such as physically removing contaminated material. In addition to the controlled exhaust and drain systems, the removal of some floor coverings and some wall sections was considered a probable requirement.

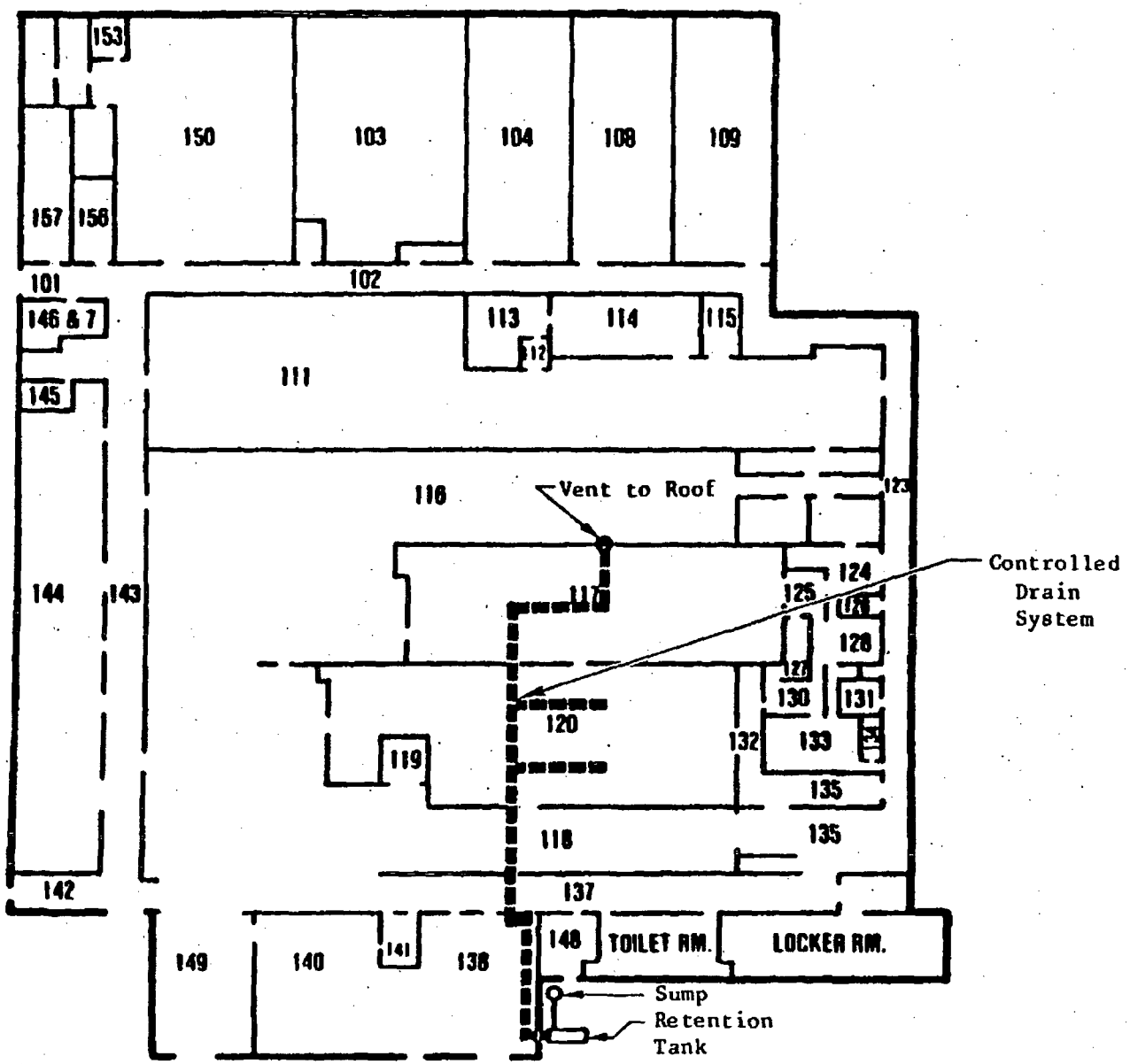

Figure 3-9. Approximate Location of Controlled Drains, Tank, and Sump; Building C-West.

Figure 3-10. Typical Exposed Controlled Drain-Line.

4.0 RADIATION MONITORING SURVEYS

This section describes the instrumentation and survey methods used to measure radioactive contamination and levels of radiation both during the decontamination activity and afterwards to establish, by means of a final monitoring survey, that any contamination remaining is well below the guideline acceptable surface contamination levels of the NRC for release of Building C-West for unrestricted use.

4.1 INSTRUMENTATION

The two classes of instruments used to measure fixed radioactive contaminations are described below. The Minimum Detectable Activity (MDA) and statistical accuracy of the measurements performed are also discussed.

4.1.1 PORTABLE SURVEY INSTRUMENTS

Table 4-1 shows the portable equipment used for radiation detection and radiation measurement.

The Victoreen Model 740 "Cutie Pie" portable ionization chamber was used, when needed, for intermediate-level general beta-gamma surveys during removal phases of the decontamination effort. The beta-gamma surface activity was measured by the Eberline E-500B portable geiger counter, the Eberline PRM-7 (micro-meter) portable scintillation counter, and the Eberline FM-1 floor monitor with an Eberline E-120 GM Survey Meter. The Eberline PAC-4G-3 portable gas flow proportional counter and the Eberline FM-4G floor monitor were used for measuring alpha surface activity.

The salient features of selected instruments are summarized in the following paragraphs.

The Victoreen Model 740 "Cutie Pie" portable ionization chamber was used, when needed, for intermediate-level beta-gamma surveys, especially in removal phases of decontamination where its high scale readings allows the monitors to avoid excessive personal exposure. It was not used for the final monitoring.

TABLE 4-1. PORTABLE SURVEY INSTRUMENTS.

Item No.	Number In Use	Instrument	Manufacturer	Type	Radiation Detected	Sensitivity Range	Window	Nominal Counting Efficiency, Percent	Minimum Detectable Activity	Comments and Primary Use
1.	3	740	Victoreen Inst. Co.	Ion Chamber	Alpha, Beta, Gamma	0 - 10,000 mr/hr	0.0005-in Thick Mylar		N/A	Cutie-Pie, Portable General Survey
2.	5	E-500B	Eberline Inst. Corp.	Geiger Counter	Beta, Gamma	0 - 2000 mr/hr Beta, Gamma	N/A	(1)	N/A	Portable, General Usage
3.	2	PRM-7	Eberline Inst. Corp.	Scintillation Counter	Beta, Gamma	0 - 5 mr/hr (Lowest Range 0-25μr/hr)	1-in Diameter Photomultiplier	(1)	4-10 μR/hr	Low-Level, Sensitive Portable Monitor
4.	1	FM-1(Using E-120 GM-Survey Meter)	Eberline Inst. Corp.	Geiger Counter	Beta, Gamma	0 - 50 mr/hr	N/A	(1)	~ 10 μR/hr	Beta, Gamma Floor Monitor
5.	3	Alpha Counter PAC-4G-3 (with AC-21 Alpha Probe)	Eberline Inst. Corp.	Gas Flow Proportional	Alpha	0 - 500,000 cpm	0.85 mg/cm^2 50 cm^2 Area	50	80-100 dpm/100 cm^2	Portable Alpha Survey
6.	2	FM-4G (Using PAC-4G-3 Counter)	Eberline Inst. Corp.	Gas Flow Proportional	Alpha	0 - 500,000 cpm	0.85 mg/cm^2 335 cm^2 Area	50	12-15 dpm/100 cm^2	Alpha Floor Monitor

NOTES:

1. Energy Dependent
2. The E-120 FM Survey Meter is used solely with the FM-1 Floor Monitor.

The Eberline Model E-500B Geiger Counter was also used for intermediate beta-gamma monitoring. It was used primarly as a health-physics monitoring device for the working decontamination crews and was not used for the final survey monitoring.

The Model PRM-7 portable Micro "R" meter is a self-contained instrument used in field monitoring of low levels of gamma radiation fields from typical natural background (10 μR/h) up to 5000 μR/hr, Cesium-137 equivalent. It operates over four linear ranges: 0-to-25, 0-to-50, 0-to-500, and 0-to-5000 μR/h. Its response is linear within ±5 percent of full scale (±2 percent typical). Its photomultiplier tube is an end-window photocathode with a nominal one-inch diameter window. The PRM-7 response is energy dependent, as illustrated on Figure 4-1. The gamma energy levels of U^{238}, U^{235}, Th^{232}, and their decay daughters ranged from 30 to 180 keV allowing an error on the positive side of between 2 and 10 times the actual reading. The MDA for the PRM-7 Micro R meter is set by the normal background, 4-10 μR/hr at 1 cm. The lowest scale of the meter is marked in increments of 1 μR/hr so that the background does set the MDA at 4-10 μR/hr at 1 cm for the PRM-7 meter.

The FM-1 floor monitor is used solely with an Eberline E-120 Geiger-Mueller survey meter. This meter is marked in increments of 0.02 mR/hr so that the background fluctuates between 0.01 and 0.03 mR/hr at 1 cm due to the random nature of the background beta-gamma radiation. Thus, its MDA is 10-30 μR/hr at 1 cm.

The Model PAC-4G-3 portable gas proportional alpha counter detects and measures alpha radiation in the presence of high humidity, volatile solvent vapors, inlet or other atmospheres, and other types of radiation. This instrument has an operating range of zero to 500,000 cpm in four linear, continuously progressive decades, calibrated to the 2π geometry value of one-inch diameter plutonium-239 sources. Linearity is ±10 percent of the full scale of the decade being read, nominal. Its gamma rejection is 5 R/hr on the middle of the alpha plateau and can be set to reject 50 R/h by setting lower on the alpha plateau.

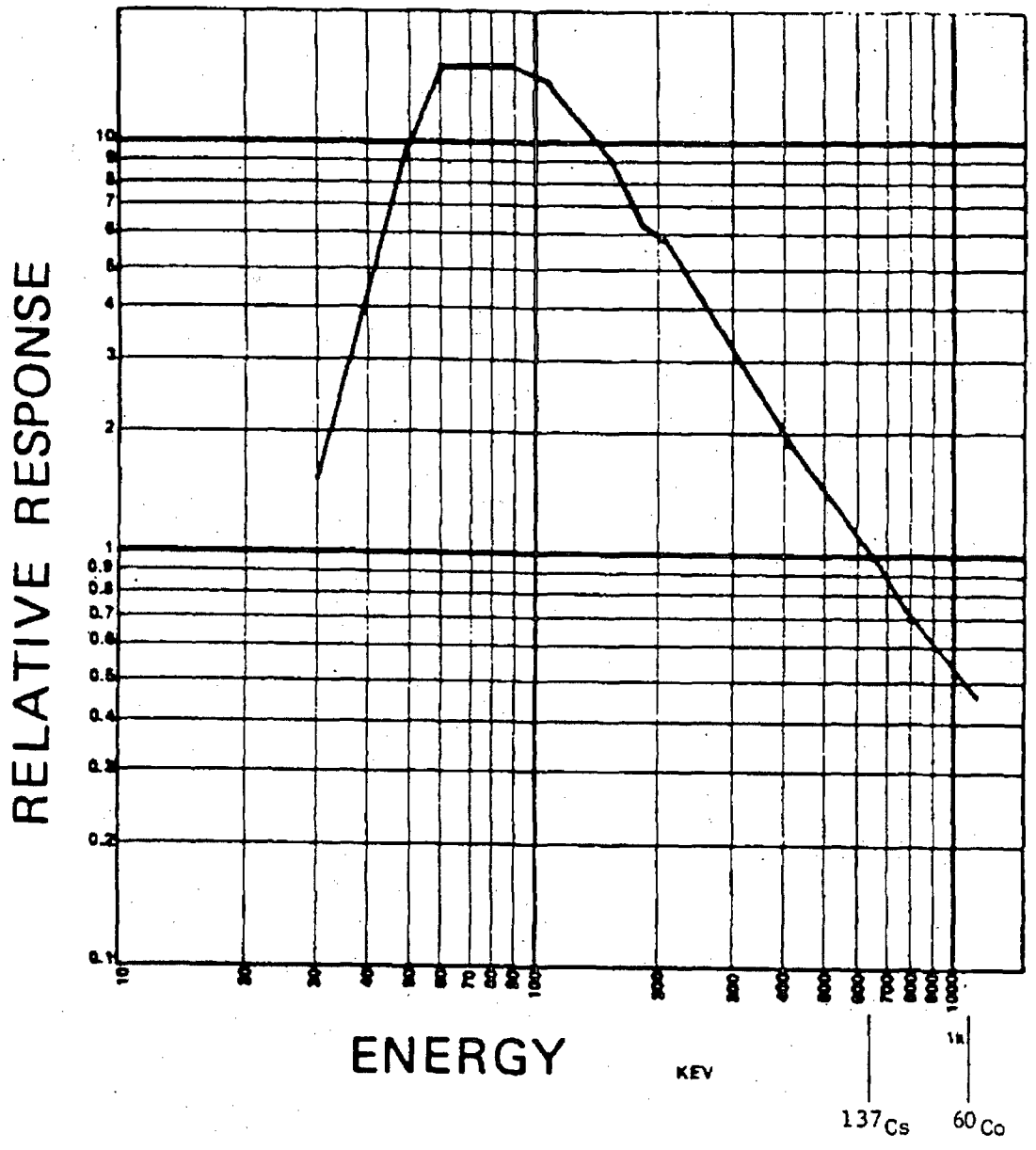

Figure 4-1. Energy Response of the Model PRM-7 Portable Micro "R" Meter.

The Model AC-21 Gas Flow Proportional Probe, used with the Model PAC-4G-3 proportional alpha counter, has a thin window (0.85 mg/cm^2 aluminized Mylar), 50 cm^2 in area. Its efficiency permits detection of approximately 50 percent of the total alpha activity at 2π geometry over a 50 cm^2 surface area. By adjustment of the high voltage, it is capable of rejecting beta-gamma radiation up to 5 R/hr in the middle of the alpha plateau.

The Model FM-4G Gas Proportional Floor Monitor Probe was also used with the Model PAC-4G-3 portable gas proportional alpha counter. It has a larger window area, 335 cm^2, and the same type of thin window. It is mounted in a wheeled carriage with a handle to permit easy monitoring of large floor areas. Its efficiency is the same as the Model AC-21 Probe.

The minimum detectable activity of the two alpha counters is determined by their effective area and the lowest scale reading which can be read by a trained operator. Since both use the same counter, the minimum scale increment is the same, 50 cpm. A trained operator can read a minimum activity of 20-25 cpm by interpolation. There is essentially no alpha background. With a 50% efficiency, this gives a minimum detectable activity of 40-50 dpm. For the hand-held AC-21 probe, (with an area of 50 cm^2) used for all measurements except floors, this gives a specific MDA of 80-100 dpm per 100 cm^2 area. For the floor monitor FM-4G (with an area of 335 cm^2), this gives specific MDA of 12-15 dpm per 100 cm^2.

All of these radiation detection and measurement instruments are calibrated routinely on a monthly basis, with sources traceable to the National Bureau of Standards. Both types are field calibrated with check sources to insure proper operation during use.

4.1.2 LABORATORY MEASUREMENT INSTRUMENTS

Table 4-2 shows the characteristics of the laboratory instruments used to measure removable alpha and beta-gamma activity.

Nuclear Measurements Corporation gas flow proportional counters, Models PC-55 and PC-3A, were used to provide radioassay of samples collected for removable alpha, beta, and gamma contamination as well as assay of air samples

TABLE 4-2. LABORATORY NUCLEAR MEASUREMENT INSTRUMENTATION.

Item No.	Number In Use	Instrument	Manufacturer	Type	Radiation Detected	Sensitivity Range	Window	Nominal Counting Efficiency, Percent	Comments and Primary Use
1.	3	PC-55	Nuclear Meas. Corp.	Gas Flow Proportional	Alpha Beta, Gamma	Six-decade alpha Seven-decade beta-gamma Max. Counting Rate 10^7 cpm	None	35	Use to Measure Smears, Air Samples, and Small Objects
2.	6	PC-3A/B	Nuclear Meas. Corp.	Gas Flow Proportional	Alpha Beta, Gamma	Six-decade	None	50, α 55, β	Use to Measure Smears, Air Samples, and Small Objects

and small objects. The newer Model PC-55 performs simultaneous Alpha and Beta-Gamma analysis and was used for the bulk of the smear counting.

The following procedures were used to measure each instrument's background levels, test each instrument's performance, and count samples. The bulk of the reported data is based on smears taken over a 100 cm randomly wiped area (not a 100 cm^2 square) using the procedures described in the next section.

Procedures used were as follows:

1. A ten-minute background count was taken on each instrument the first thing in the morning and the results were recorded. Figure 4-2 shows a typical background control chart used to determine if the background for each instrument was remaining within a $\pm$ 1.96σ limit. Charts for each instrument, for both alpha and beta-gamma, have been prepared.

2. An NBS calibrated standard alpha source and an NBS calibrated standard beta-gamma source were each counted for one minute and their results recorded. The results were compared with a $\pm$ 1σ limit for each calibrated source. If a reading fell outside of this narrow band, additional readings were taken to insure that the first deviation was only a statistical event.

3. If the above counts fell within the acceptable limits (as discussed above), the instruments were deemed to be working properly.

4. These procedures were repeated during the day if evidence of contamination or malfunction were observed.

5. The smears were then counted for one minute.

6. These gross counts were corrected for the efficiency of the instrument (35% for the PC-55 used for most smears) and for the background.

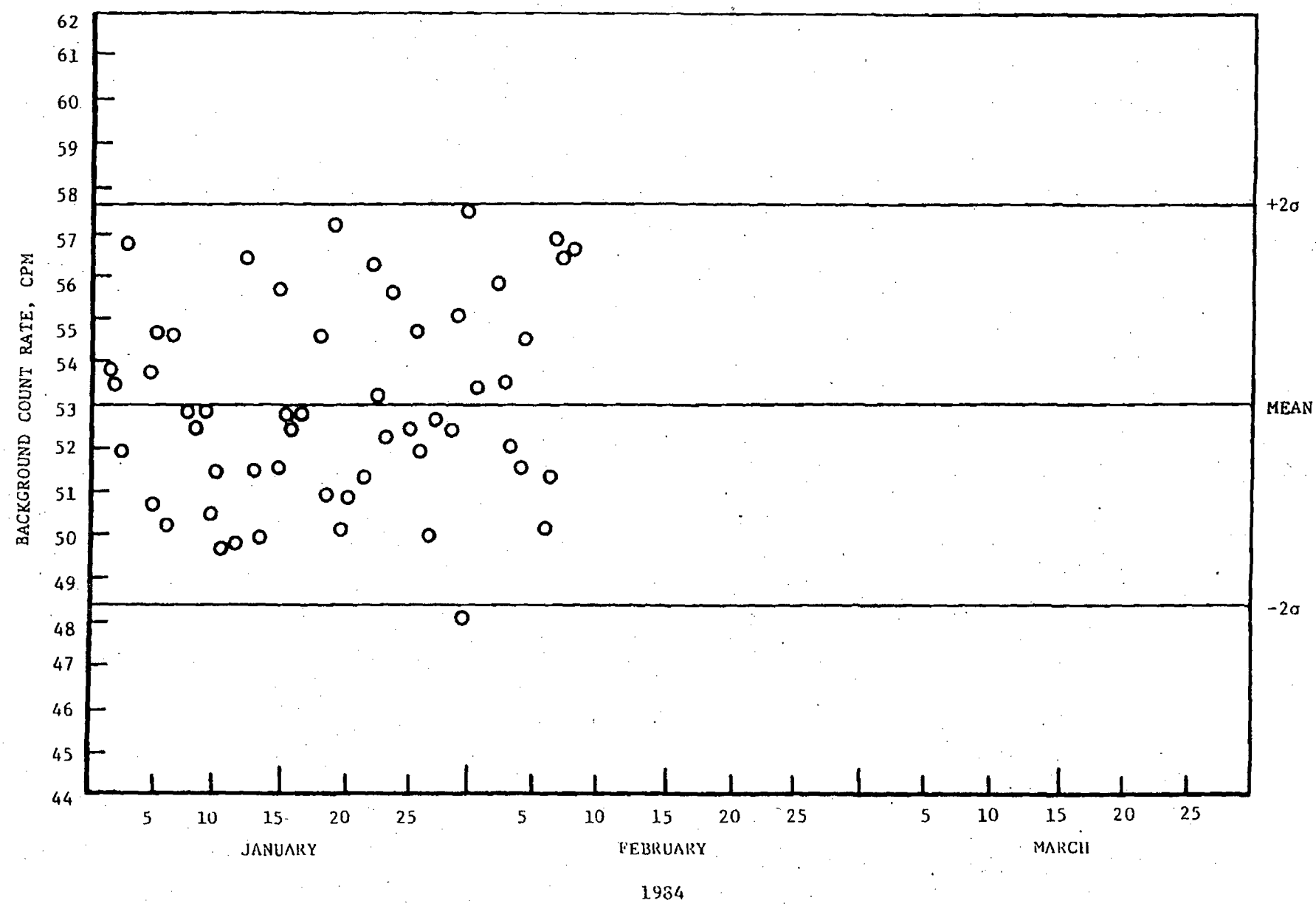

Figure 4-2. Beta-Gamma Background Control Chart PC-55, S/N 2712-07.

a) Since the normal, acceptable alpha background is between 0 and 1 count per minute, this correction had little effect on the statistics of the alpha counting.

b) The normal, acceptable beta-gamma background is about 50 cpm and is a significant correction to both the final reported dpm and, to a lesser extent, the statistics.

c) No correction was attempted for alpha radiation self absorptions due to the thickness of the deposited sample for smears, air samples, or any other objects counted.

Figures 4-3 and 4-4 show the 95% error band (1.96σ) associated with the reported activities in dpm for alpha and beta-gamma counting of smears using the PC-55 counters. Note that the MDA for alpha is 4-5 dpm, while the MDA for beta-gamma is about 40 dpm. A sample calculation, following standard statistical procedures*, is given below for beta-gammas.

Data: Counter efficiency 35% (PC-55)
Background Count Time, t_B = 10 min (Normal Procedure)
Sample Count Time, t_G = 1 min (Normal Procedure)
Background Count, N_B = 500 (Normal Experience)
Sample Count, N_G = 60

Calculation:

Background Rate, $R_B = \frac{500}{10} = 50$ cpm

Gross Rate, $R_B = \frac{60}{1} = 60$ cpm

Net Count Rate, $R_N = 60 - 50 = 10$ cpm

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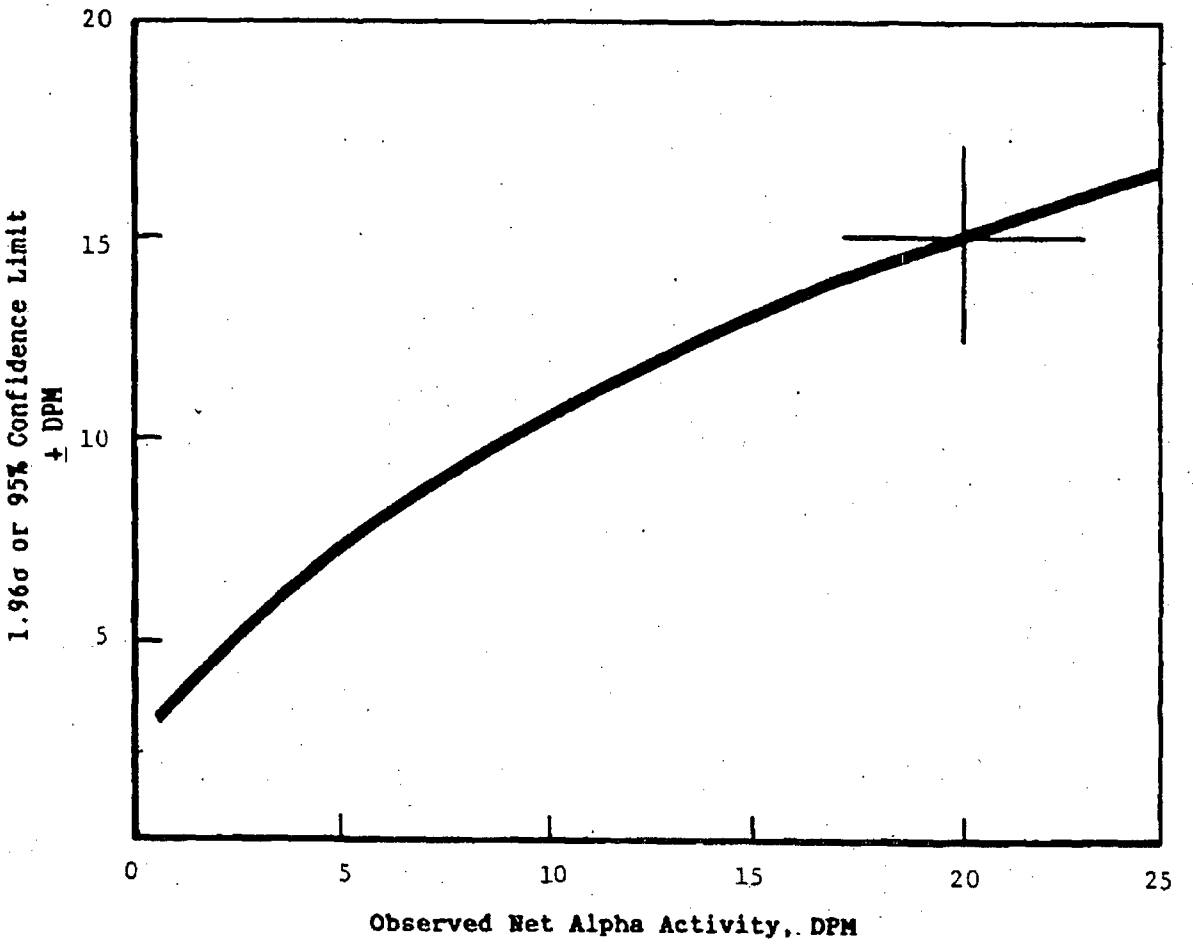
*For example: Volchock, H. L. and de Planque, G. (Editors), "EML Procedure Manual", HASL-300-EI.25, 1982, EML, U.S. Dept. of Energy, 376 Hudson Street, New York, NY 10014, Section A-06.



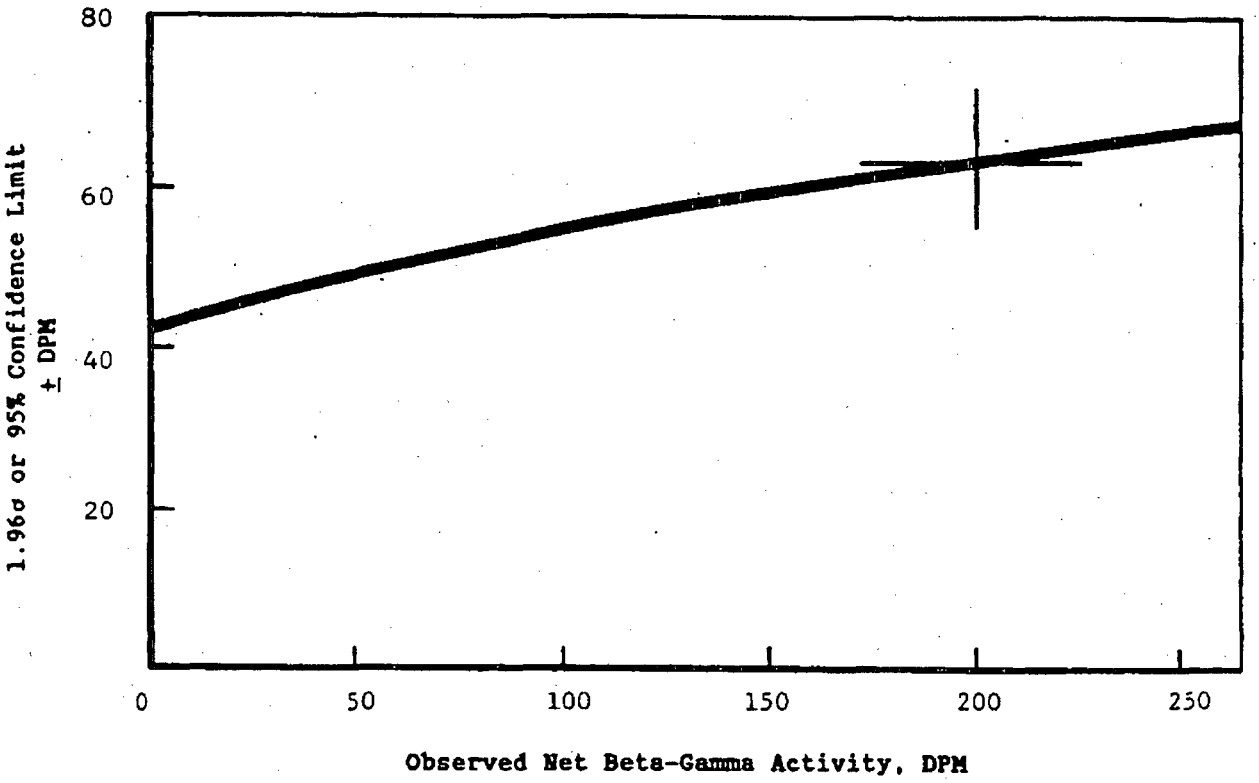
1 Background ≤1 cpm (10 minutes)

2 35% Counter Efficiency

3 1.96σ or 95% Confidence Level

4 1 Minute Counts

Figure 4-3. Statistical Probability of Counting Data at 95% Confidence Limit for Alpha Activity.



1. Background = 50 cpm
2. 35% Counter Efficiency
3. 1.96σ or 95% Confidence Level
4. 1 Minute Counts

Figure 4-4. Statistical Probability of Counting Data at 95% Confidence Limit for Beta-Gamma Activity.

Background Standard Deviation, $S_B = \frac{\sqrt{500}}{10} = 2.236$

Gross Standard Deviation, $S_G = \frac{\sqrt{60}}{1} = 7.746$

Net Standard Deviation, $S_N = \sqrt{2.236^2 + 7.746^2}$
$= 8.062$

Correcting for efficiency to dpm:

$$D_N = \frac{10}{0.35} = 28.6$$

$$S_{DN} = \frac{8.062}{0.35} = 23$$

Using 2 standard deviations for 95% probability gives a net value of 29 $\pm$ 46 dpm. Figure 4-4 gives the same answer when entered with 29 dpm.

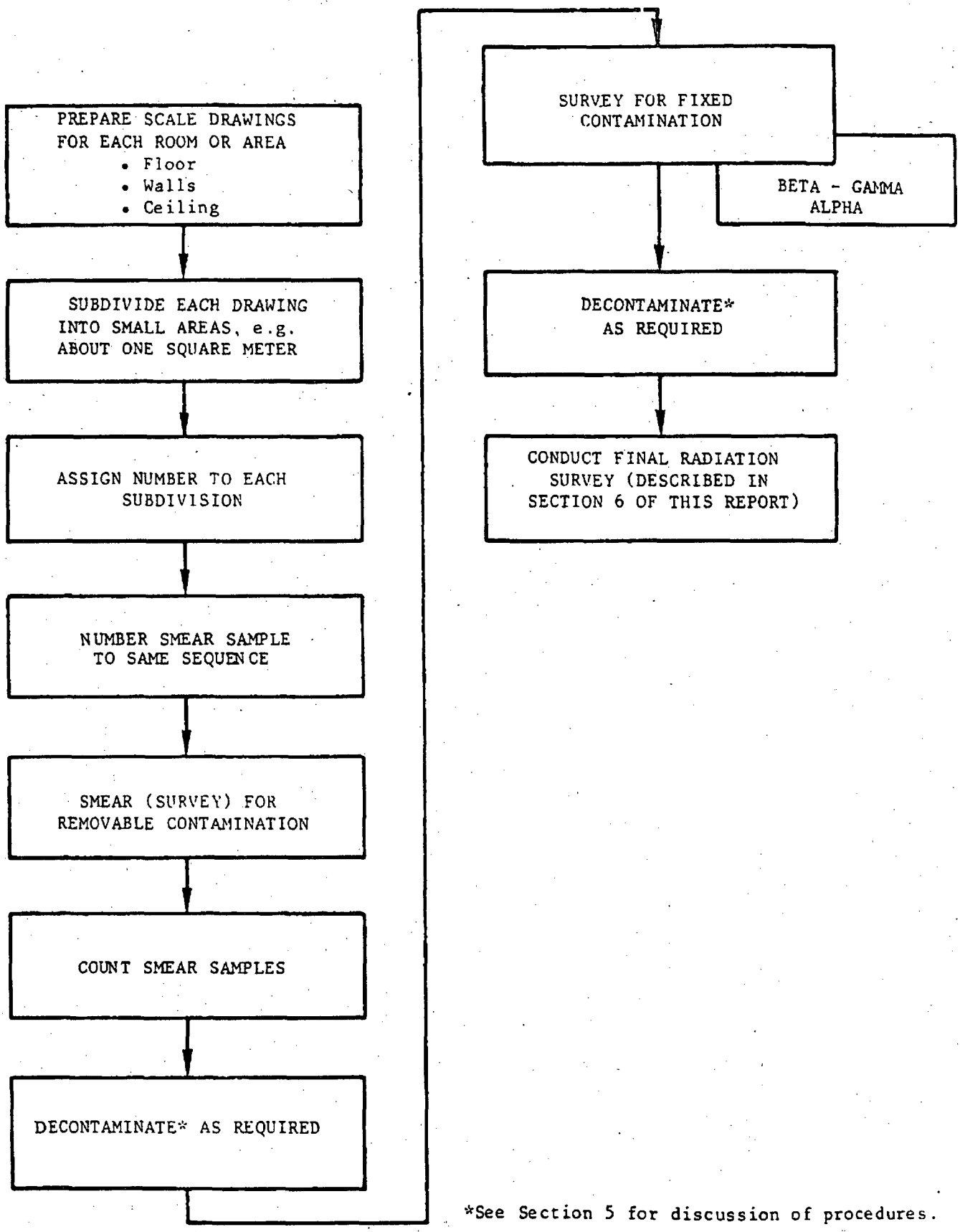
4.2 SURVEY METHODS

The general survey procedure used for each room or area, illustrated on Figure 4-5, was as follows:

1. Scale layout drawings were prepared for each room or area. Separate layout drawings were required for the floor, walls and ceiling. Any special fixtures, such as lighting, were identified.

2. Each drawing was subdivided into small areas, typically, one square meter. A number is assigned to each area, in sequence. Separate numbers are assigned to any special fixtures.

3. The same series of numbers are assigned to blank smear samples, a separate number for each smear sample.



*See Section 5 for discussion of procedures.

Figure 4-5. Summary Flow Chart - Radiation Survey Procedures.

4. Trained radiation monitoring technicians then survey for removable contamination. Each small area of the room is "wiped" with the smear samples numbered to correspond to the same number of the area of that room, as designated on the prepared map. Approximately 100 cm^2 of the one square meter area are covered when the smear paper is wiped over the surface using a moderate pressure. The area covered by the smear is not a small 10 cm x 10 cm square but 100 cm^2 over the entire area. To err or the safe side, most of the time an area greater than 100 cm^2 is wiped.

5. The smear samples are then counted using either the PC-55 or PC-3A/B Gas Flow Proportional Counters.

6. Areas where removable contamination is identified are then cleaned using one of the several procedures applicable to removable contamination. As discussed in Section 5 of this report, these range from simply wiping or dry vacuuming to scrubbing with detergents or strong solvents followed by wet vacuuming.

7. The area is then rechecked using the smear technique and recleaned as necessary until the measured removable contamination is reduced to less than 20 dpm/100 cm^2 for Alpha and less than 200 dpm/100 cm^2 for Beta-Gamma. These levels can be expressed at the 95% confidence level as $< 20 \pm 15$ dpm/100 cm^2 for alpha activity and $< 200 \pm 63$ dpm/100 cm^2 beta-gamma activity.

8. Next, the area is surveyed for fixed Alpha and Beta-Gamma contamination, using two or more of the survey instruments identified in Table 4-1. The Beta-Gamma survey proceeds rapidly, moving the instrument probe at a rate of about one foot per second across all surfaces. The Alpha survey proceeds much more slowly. The instruments have a response time of about 12 seconds for Alpha detection of low-level contamination. Therefore, the probe or sensor must be moved-and-stopped, moved-and-stopped, etc., many times to cover the total room surfaces.

9. Areas where fixed contamination are found are then decontaminated by one of the several methods discussed in Section 5 of this report. These range from vacuum abrasive blasting to destructive removal of the floor, wall, ceiling and/or fixtures.

In general, the initial radiation survey focused on areas where there was a high probability of finding contamination. This approach, permitted by knowledge of the prior uses of the facility by the personnel involved, proved both effective and time saving. The final radiation survey, discussed in Section 6 of this report, was more extensive and surveyed all areas of Building C-West with nearly equal intensity. One measure of the thoroughness of this monitoring effort is that over 41,000 smears were taken and counted for the total surface areas in Building C-West, about 27,000 square meters, or about 1.5 smear per square meter for removable contamination. Alpha and Beta-Gamma surveys for fixed contamination were much more thorough. As delineated in Section 6 of this report, Alpha surveys for fixed contamination covered the complete floor area and were taken about every square foot on walls and ceiling surfaces; Beta-Gamma surveys were essentially continuous with floor monitors used for the floor area and the micro-R-meter for all other surfaces.

4.3 ACCEPTABLE CONTAMINATION LEVELS

Table 4-3 presents the acceptable surface contamination levels as proposed by the NRC for the decontamination of facilities and equipment prior to release for unrestricted use or for termination of licenses. Table 4-4 shows the working limits used by the decontamination contractor. These are lower than the NRC proposed levels by at least a factor of four. These working limits were those used in the radiation surveys to identify areas where decontamination was required.

It should be noted that the combinations of a low working limit and a 1 minute counting time for each smear allows both a rapid counting of the over 41,000 smears and assurance of an acceptably low residual activity. Note that the 20 dpm alpha working limit allows not more than 35 dpm with better than 95% confidence, and the 200 dpm beta-gamma working limit allows no more than 263 dpm with 95% confidence. These values are well below USNRC proposed limits and provide assurance that successful decontamination has been achieved.

TABLE 4-3. ACCEPTABLE CONTAMINATION LEVELS (NRC GUIDELINES).

NUCLIDES[a]	AVERAGE[b,c,f]	MAXIMUM[b,d,f]	REMOVABLE[b,e,f]
U-nat, U-235, U-238, and associated decay products	5,000 dpm α/100 cm^2	15,000 dpm α/100 cm^2	1,000 dpm α/100 cm^2
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm α/100 cm^2	300 dpm α/100 cm^2	20 dpm α/100 cm^2
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000 dpm α/100 cm^2	3,000 dpm α/100 cm^2	200 dpm α/100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000 dpm $\beta\gamma$/100 cm^2 (0.2 mrad/hr @ 1 cm)[f]	15,000 dpm $\beta\gamma$/100 cm^2 (1.0 mrad/hr @ 1 cm)[f]	1,000 dpm $\beta\gamma$/100 cm^2

[a]Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

[b]As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentaton.

[c]Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

[d]The maximum contamination level applies to an area of not more than 100 cm^2.

[e]The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbant paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

[f]The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr at 1 cm and 1.0 mrad/hr at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

TABLE 4-4. DECONTAMINATION CONTRACTOR WORKING CONTAMINATION LIMITS.

Radiation	Average[b,c,f]	Maximum[b,d,f]	Removable[b,e,f]
Alpha Contamination[a]	200 dpm/100 cm^2	600 dpm/100 cm^2	< 20 dpm/100 cm^2
Beta-Gamma Contamination	0.05 mrad/hr @ 1 cm	0.2 mrad/hr @ 1 cm	< 200 dpm/100 cm^2

[a]Due to the nature of the use of Building C-West, natural uranium, enriched uranium, thorium, and associated decay products are the only potential contamination sources.

[b]As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentaton.

[c]Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

[d]The maximum contamination level applies to an area of not more than 100 cm^2.

[e]The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbant paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

[f]The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.05 mrad/hr at 1 cm and 0.2 mrad/hr at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

If any contamination was located, the appropriate steps necessary to remove it were performed. These methods are described in Section 5.0. Surveys and decontamination were repeated as necessary so that the final radiation survey was below working limits in all areas. The final radiation survey is documented in the detailed reports for each room or area and summarized in Section 6.0 of this report.

5.0 DECONTAMINATION PROCEDURES

This section describes the overall decontamination process, including personnel training, equipment used, procedures used, and waste disposal methods.

5.1 ORGANIZATION

The organization of the decontamination project is presented on Figure 5-1. Its two elements, Quality Control and Decontamination, are under the authority of the Program Manager. The decontamination crew monitors its own work as the decontamination proceeds. The separate quality control function performs the final radiation monitoring survey. This approach provides an independent verification that radiation contamination has been reduced well below the guideline levels set forth by the NRC for unrestricted use of the facilities.

The Quality Control organization is managed by an experienced radiation specialist, who is supported by trained Radiation Monitoring and Measurements Technicians. The key responsibilities of the Radiation Monitoring Technicians included:

1. Pre-decontamination surveys
2. Final radiation monitoring surveys
3. Calibrating radiation survey and detection instruments
4. Fitting and cleaning respirators
5. Collection of air samples to assure compliance
6. Calibration of air samples

The key responsibilities of the Measurements Technicians included:

1. Calibration and operation of radiological counting equipment.

2. Processing of large numbers of smear samples collected during decontamination surveys for Alpha and Beta-Gamma contamination, both during decontamination and in support of the final radiation survey.

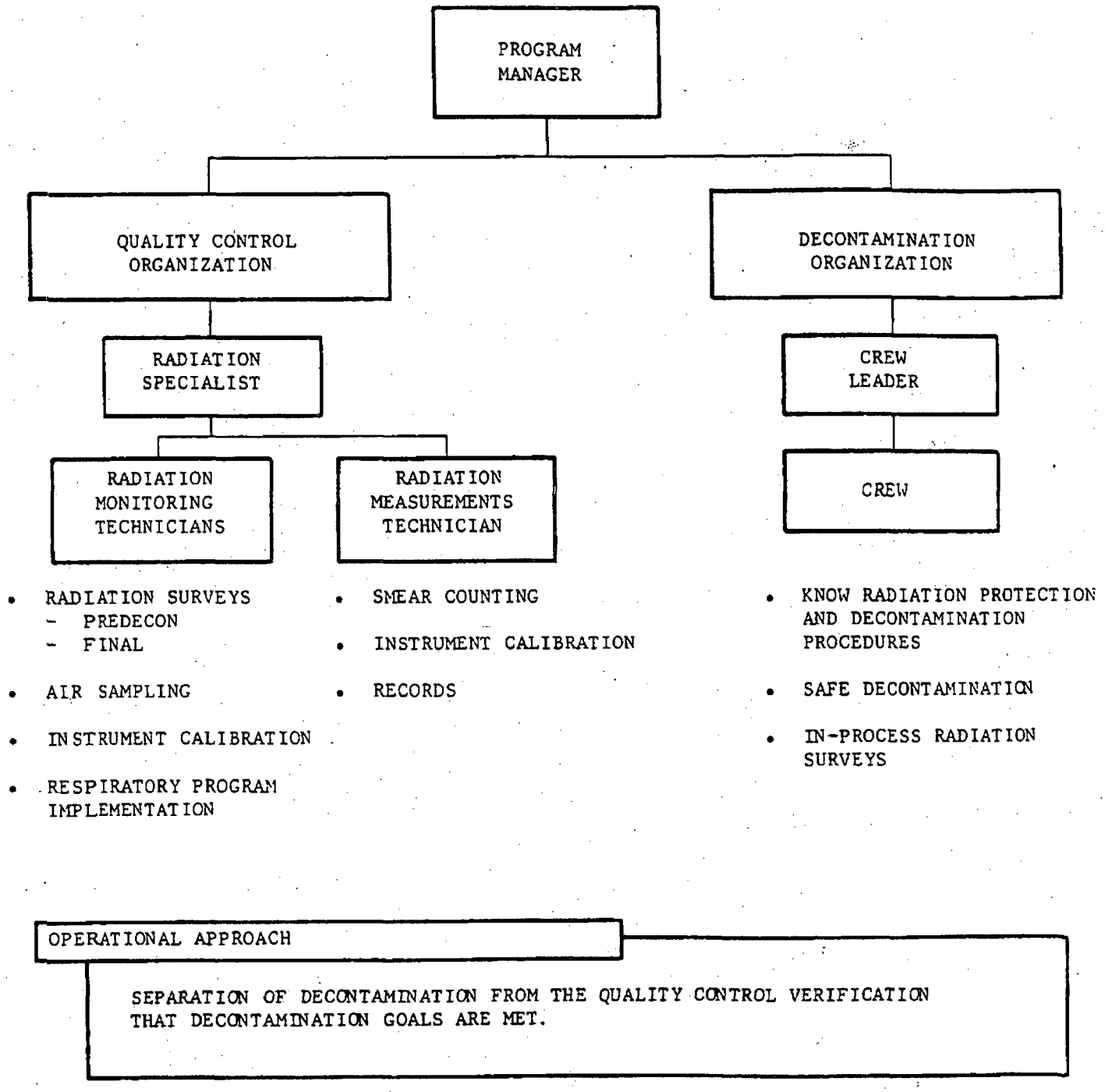


Figure 5-1. Decontamination Program Organization Assures Independent Verification That Decontamination Goals Are Met.

3. Receiving and recording in an organized format data from all aspects of the decontamination work.

4. Maintaining files necessary to (a) permit efficient recovery of information, (b) assist in the evaluation of the status of the decontamination progress, and (c) support full documentation of the results of the decontamination of Building C-West.

The Decontamination Organization is led by a Crew Leader. All personnel are trained in, and are required to demonstrate their knowledge of, radiation protection and decontamination procedures, including the use and limitations of radiation detection and survey instruments. The key responsibilities of the Decontamination Organization included:

1. Assist in pre-decontamination surveys

2. Performing the decontamination work in a safe and prescribed manner.

3. Conduction of contamination surveys as the work progresses.

4. The use of protective clothing and equipment (e.g., respirators).

5. The accomplishment of the decontamination without further spreading of the contamination being removed.

The size of the total decontamination is maintained at a small level, of the order of ten personnel, in order to effectively control and to assure efficient operation.

5.2 TRAINING

All personnel engaged in the decontamination program were trained in radiation safety, including safe decontamination procedures. This training program was organized and instructed by two specialists in the area of nuclear health physics and safety, each with over 25 years' experience in this field. The key elements of this training program addressed:

1. Characteristics of nuclear radiation
2. Principles and practices of radiation protection
3. Radioactivity measurements standardization and monitoring techniques and instruments
4. Calculations basic to the use and measurement of radioactivity
5. Biological effects of radiation
6. Decontamination procedures
7. Respiratory protection
8. Written examination

These are futher amplified in the following paragraphs.

5.2.1 CHARACTERISTICS OF NUCLEAR RADIATION

Neutron, Alpha, Beta and Gamma radiation were described and reviewed to the level necessary to provide a basic understanding of their sources and characteristics and to provide the basis for the balance of the training; radiation effects, detection, measurement and protection. The major portion of this instruction employed a course developed for and published by the AEC[1]. Emphasis was placed on the radiation types known to be present in the decontamination of Building C-West; Alpha and Beta-Gamma, no neutron sources.

5.2.2 PRINCIPLES AND PRACTICES OF RADIATION PROTECTION

The element of the training addressed the safe principles and practices of radiation protection with emphasis on the procedures targeted for this decontamination program. The care, selection and use of protective apparel and equipment was addressed, including respirators, safety glasses, coveralls, and shoe covers. Surveying and monitoring procedures required for day-to-day operations were explained and delineated. Requirements for posting and control of access to the contaminated areas were defined. The care and use of personnel monitoring devices (e.g., film badges, pocket dosimeters and air

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[1] Wade, J.E., and G.E. Cunningham, "Radiation Monitoring, A Programmed Instruction," USAEC Division of Technical Information, 1967.

samples) and requirements for bioassay were presented. The requirements for packaging the contaminated material removed during decontamination for shipping and burial were reviewed. This included the requirement to safely reduce all aqueous waste that results from scrubbing operations to its solid form.

5.2.3 RADIOACTIVITY MEASUREMENTS

Monitoring techniques and the use of the instruments described in Section 4.0 of this report were covered, including the need and procedures to calibrate these instruments to standard sources traceable to the National Bureau of Standards. Survey and monitoring techniques were defined and practiced with the various instruments for both area surveys and for equipment and small items. Removable and fixed contamination were described, e.g., fixed contamination is defined as radioactivity remaining on a surface after repeated decontamination attempts fail to reduce the contamination level significantly. The different monitoring approaches for removable (smear technique) and fixed contamination were reviewed and practiced. Air sampler techniques for both personnel and area samples were reviewed and practiced, including air sampler calibration procedures.

5.2.4 CALCULATIONS

The calculations necessary to support and utilize radiation monitoring data were reviewed and practiced. These include items such as calculation of allowable exposure time and calibration of air samplers.

5.2.5 BIOLOGICAL EFFECTS

The potential effects of exposure to radiation, both internal and external, were reviewed. Emphasis was placed on the "as low as reasonably achievable" (ALARA) exposure guideline to minimize the biological effects.

5.2.6 DECONTAMINATION PROCEDURES

The procedures employed in the decontamination of Building C-West are detailed in paragraph 5.4, below. The training program provided instruction in these areas, followed by practice work conducted in non-contaminated areas.

5.2.7 RESPIRATORY PROTECTION

As an essential requirement of the training program, all personnel were instructed on the respiratory protection program already in place at the decontamination contractor's facility. The scope of this documented program included:

1. The need for air sampling and other surveys sufficient to identify the hazard, to evaluate individual exposures, and to permit proper selection of respiratory protection equipment.

2. Adequate individual personnel fitting of respirators and the procedures to ensure their testing for operability prior to each use. (All personnel underwent a qualitative fit test using amyl acetate and an acid fume smoke tube to emphasize the need to obtain a proper fit.)

3. Procedures for maintenance to ensure full effectiveness of respiratory protective equipment, including procedures for cleaning and disinfections, decontamination, inspection and storage.

4. Operational and administrative procedures for control, proper use, and return of respiratory protective equipment.

5. Bioassays and other surveys, as appropriate, to evaluate individual exposures and to assess protection actually provided.

6. Requirement for records sufficient to permit periodic evaluation of the adequacy of the respiratory program.

7. The need for medical examination by a physician, prior to assignment of any individual to tasks requiring the use of respirators that such an individual does not have a respiratory ailment and is physically able to perform the work and use the respiratory protection equipment. The medical status of each respirator user is to be reviewed at least annually.

8. The requirement to use only equipment approved under appropriate Approval Schedules in 30 CFR Part II of USBOM/NIOSH.

5.2.8 FINAL EXAMINATION

At the conclusion of the formal training, all personnel were required to take and pass a final exam. A grade of 90 percent or better was required of all radiation monitoring personnel. Continuing education and discussion of problem areas were held on a monthly basis, more frequently if deemed necessary.

5.3 EQUIPMENT

The equipment used to clean or otherwise remove contaminated material included HEPA filtered vacuum cleaners, steam cleaners, water evaporators, HEPA filtered vacuum grit blasters, and power grinders for removal of surface contamination in ways that avoided spreading the contaminated waste. Also required were devices for the removal of larger amounts of material, such as air hammers, electric saws, and power drills. In order to reach the upper areas of several rooms, safety scaffolding and platform lifts were used.

5.4 OPERATIONAL APPROACH

This paragraph details the operational approach employed in the decontamination of Building C-West. This delineation of effort integrates and expands the monitoring and survey work outlined in Section 4.0, showing the close interrelation between the decontamination work and the survey work necessary to assess the decontamination status throughout the decontamination process to or below the levels previously set forth in Table 4-3. As presented in Paragraph 5.1, final radiation monitoring was accomplished by the separate Quality Control Organization to assure that these goals were met.

The operational approach, summarized on Figure 5-2, generally included the following steps:

1. Monitor rooms; α, $\beta\gamma$; Fixed, Removable; Predecontamination report written or file maintained.

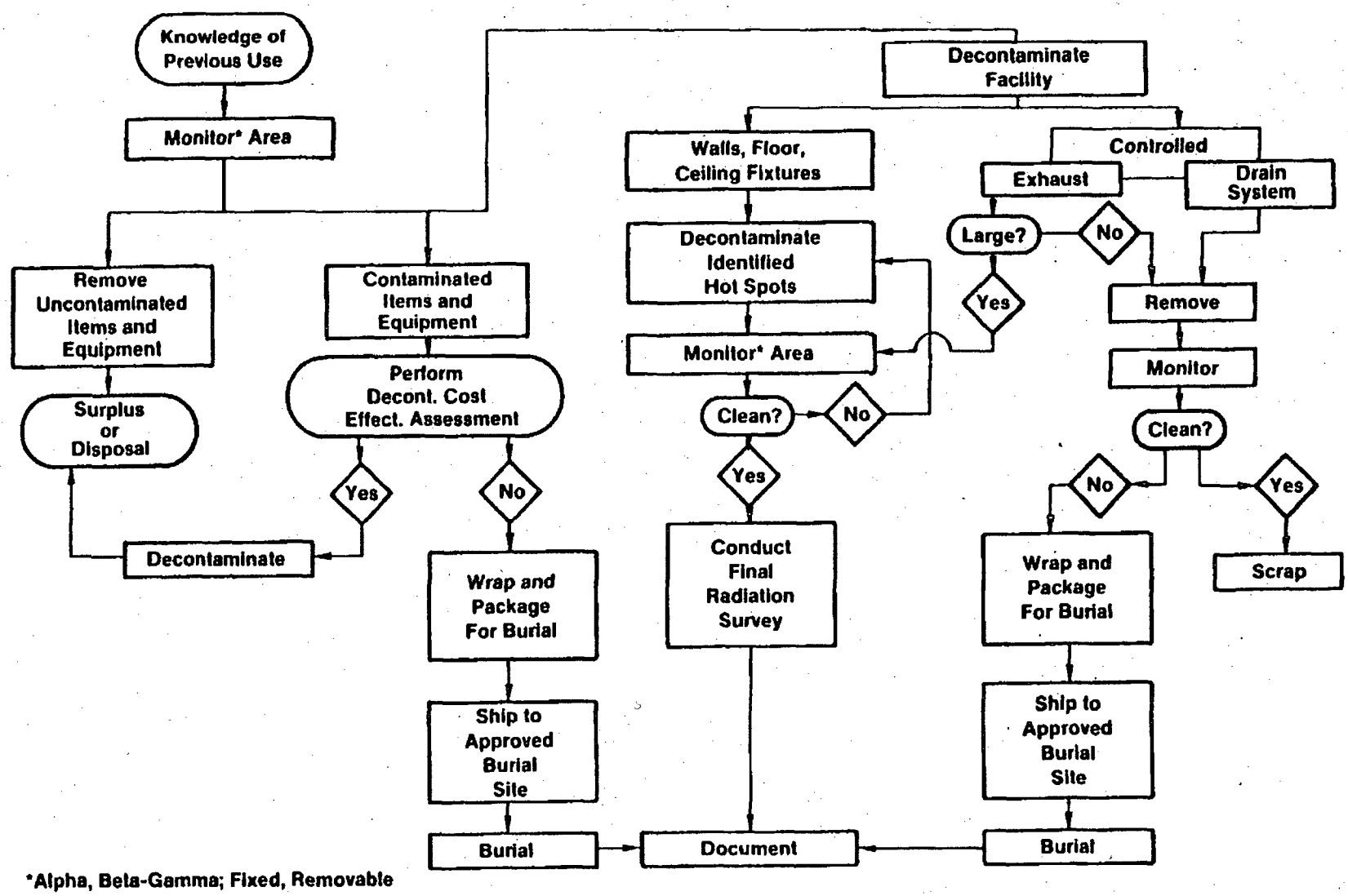

Figure 5-2. Operational Procedure Summary.

2. Monitor all furniture, materials, equipment; α, $\beta\gamma$; Fixed, Removable.

3. Remove all items free of contamination for surplus and/or disposal.

4. Remove all hazardous chemicals for disposal. Decontaminate containers if needed.

5. Decontaminate all easily decontaminated items for surplus or disposal.

6. Wrap and seal all contaminated items (equipment) for surplus or disposal.

7. Monitor ceilings; α, $\beta\gamma$; Fixed, Removable. Decontaminate hot spots. Remonitor.

8. Monitor all ceiling light and electrical fixtures; inside, outside; α, $\beta\gamma$; Fixed, Removable. Decontaminate hot spots. Remonitor.

9. Monitor all walls; α, $\beta\gamma$; Fixed, Removable. Decontaminate hot spots. Remonitor.

10. Monitor all wall fixtures; α, $\beta\gamma$; Fixed, Removable. Decontaminate hot spots. Remonitor.

11. Monitor all floors; α, $\beta\gamma$; Fixed, Removable. Decontaminate hot spots. Remonitor.

12. Remove controlled exhaust systems except large wall plenums.

13. Monitor all removed exhaust systems; α, $\beta\gamma$; Fixed, Removable. Wrap and crate contaminated elements for subsequent burial. Move clean elements to scrap metal for disposal.

14. Monitor large exhaust plenums. Decontaminate hot spots. Remonitor.

15. Remove controlled drain system, retention storage tanks, pumps, underground and above ground piping. Wrap and crate contaminated elements for subsequent burial. Monitor all openings from which controlled drains were removed. Remove any contaminated soil for disposal. Remonitor.

16. Restore all holes in floors, ceiling, walls, roof, etc., to safe condition.

17. Final monitor, separately conducted by the trained Quality Control organization:

    a. Smears taken randomly over a one square meter area α, $\beta\gamma$. (Exception: attic area smears taken randomly over nine square meter areas; α, $\beta\gamma$.)

    b. β,γ instrument survey taken by moving instrument or probe across surface being monitored at about one foot per second, two to three inches from surface while observing all readings greater than background.

    c. Alpha instrument survey taken by holding probe 0.25 inch or closer to surface being monitored and allowing the 12-second instrument response time for correct readings. Observe all readings greater than background. Move instrument across surface taking one reading per foot.

    d. When moving any instrument, keep it close to the surface being monitored. If a reading or instrument needle indication is observed, check area immediately around probe area to see if there is any evidence of contamination.

    e. Require the decontamination crew to reclean any spots or areas where radiation is found above the limits set forth in Table 4-3. For these areas, return to Step 17a and re-initiate the final monitoring process.

f. This final monitoring process was conducted for all surfaces and fixtures (e.g., lighting) in all rooms and areas of Building C-West.

5.5 METHODS OF DECONTAMINATION

Decontamination procedures followed acceptable industrial practices for maintaining cleanliness and removing contaminants such as surface dirt, oils, scale deposits, chemical stains, oxide film, etc. Decontamination methods ranged from simple procedures such as hand wiping to complex operations involving heavy mechanical equipment. Techniques used also depended upon the type of material contaminated.

5.5.1 NON-DESTRUCTIVE DECONTAMINATION

Non-destructive decontamination includes those areas of contamination which may be cleaned by conventional means such as manual or mechanical cleaning, soaking and spraying, grinding, or vacuum blasting.

There were a number of localized areas in Building C-West which required non-destructive decontamination of low-level fixed alpha and/or gamma radiation. The techniques that were employed are discussed in the following paragraphs.

5.5.1.1 Manual Cleaning

Manual cleaning includes such procedures as wiping, scrubbing, mopping, etc., and in general is an effective method of removing low or moderate levels of contamination on non-porous or nearly non-porous surfaces. Water or a variety of detergents, solvents, chelating agents, and other chemicals were used. Manual cleaning usually presents minimal airborne and surface contamination control problems. Care was taken in surface cleaning to remove Alpha contamination to assure that any residual activity is not coated or shielded in any manner that would prevent its detection. For example, a floor that is monitored for Alpha contamination immediately after washing and initial drying will not indicate any Alpha activity. But if allowed to dry thoroughly for 24 hours, gross contamination will be detected if not truly clean.

5.5.1.2 Mechanical Cleaning

Mechanical cleaning includes such decontamination methods as vacuuming, high-pressure steam and water cleaning, and soaking. These methods are generally associated with decontamination of highly contaminated equipment but have application with lower levels of contamination on facilities.

Vacuuming, Wet or Dry

Vacuuming is generally effective in removing loose particulate contamination and is frequently used as an initial decontamination step preparatory to manual cleaning. Vacuum systems were properly filtered with High Efficiency Particulate Air (HEPA) filters to prevent spread of contamination to surrounding areas and reduce the hazard of airborne contamination. A photograph of one type HEPA filtered vacuum unit that was used is presented on Figure 5-3. The Hild unit is designed such that it can be mounted on a standard 55-gallon drum as illustrated. The vacuumed waste, wet or dry, is collected in this drum. The operation of this HEPA filtered unit is illustrated on Figure 5-4. The salient feature of this vacuum system is that the electric motor cooling air flow is separate and independent from the HEPA filtered vacuum air flow. The vacuum air flow does not cool the electric motor. This feature, therefore, assures that the electric motor does not become contaminated.

The Nilfisk HEPA filtered vacuum unit was also used in this work. This system is illustrated schematically on Figure 5-5. It features a first stage centrifugal separation, a main filter to collect the larger dust particles, and a final pre-filtering micro filter to protect the motor, followed by an absolute exhaust filter. The dust is collected in sealable bags for safe disposal.

The retention efficiency of the HEPA filtered vacuum units exceeds absolute standards of 99.9 percent at 0.3 microns. Care was taken to ensure that the concentration of radioactive material in the vacuum hose or filtered collection tank did not create excessive radiation exposure rates to personnel.

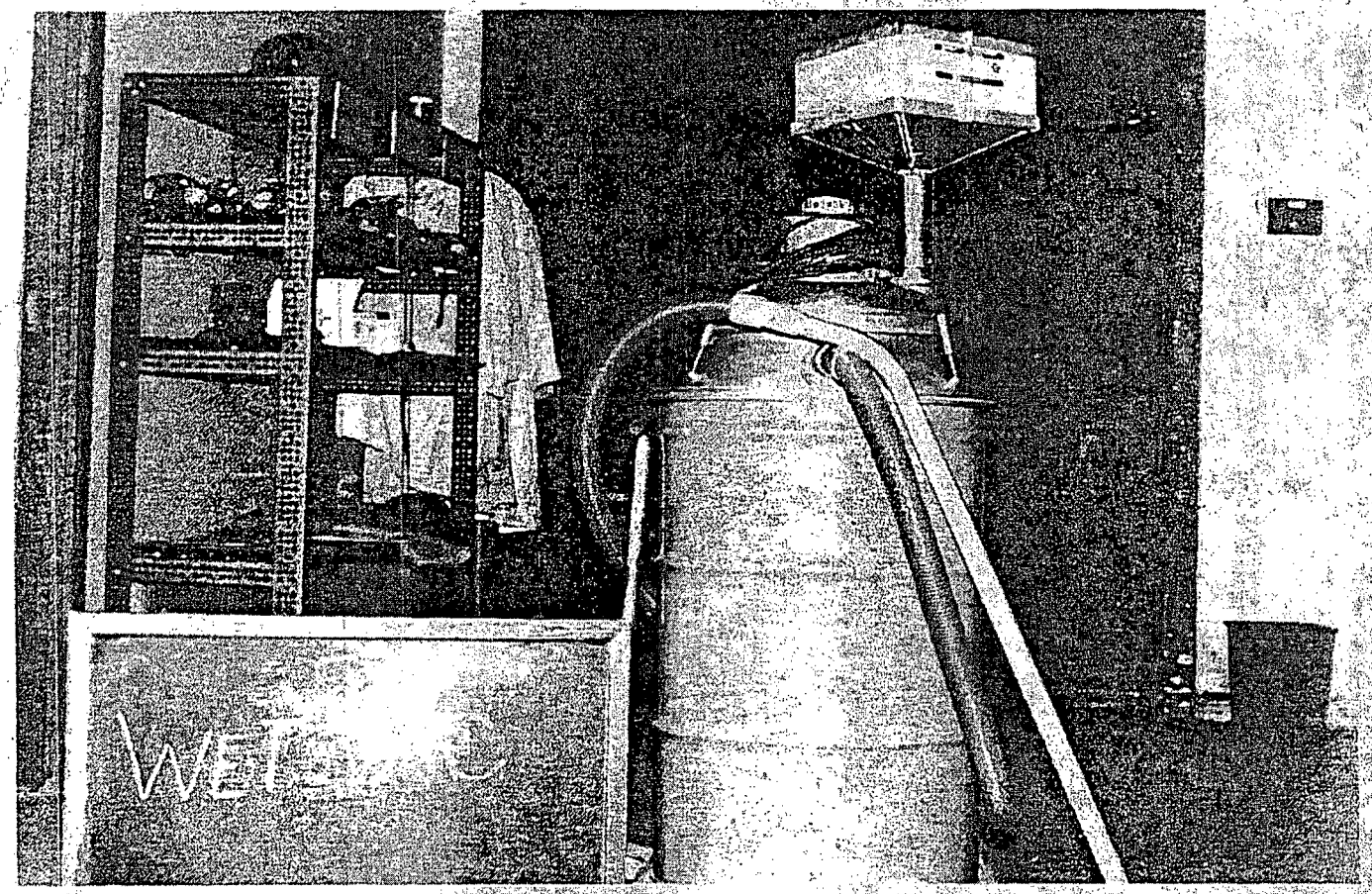

Figure 5-3. HEPA Filtered Wet-or-Dry Vacuum Unit Mounted on 55-Gallon Drum.

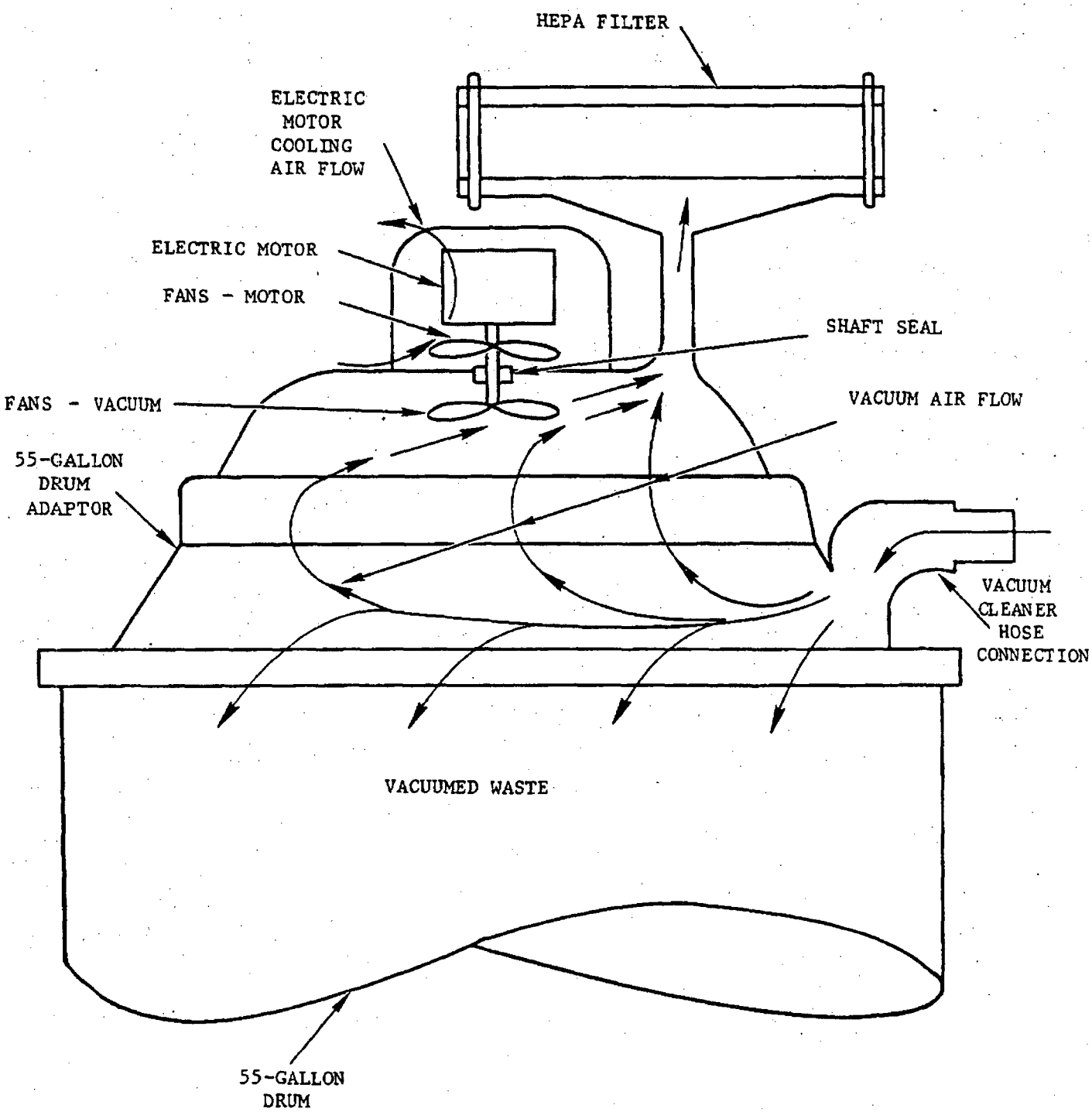

Figure 5-4. Operating Schematic - Hild Wet-or-Dry Vacuum Cleaner.

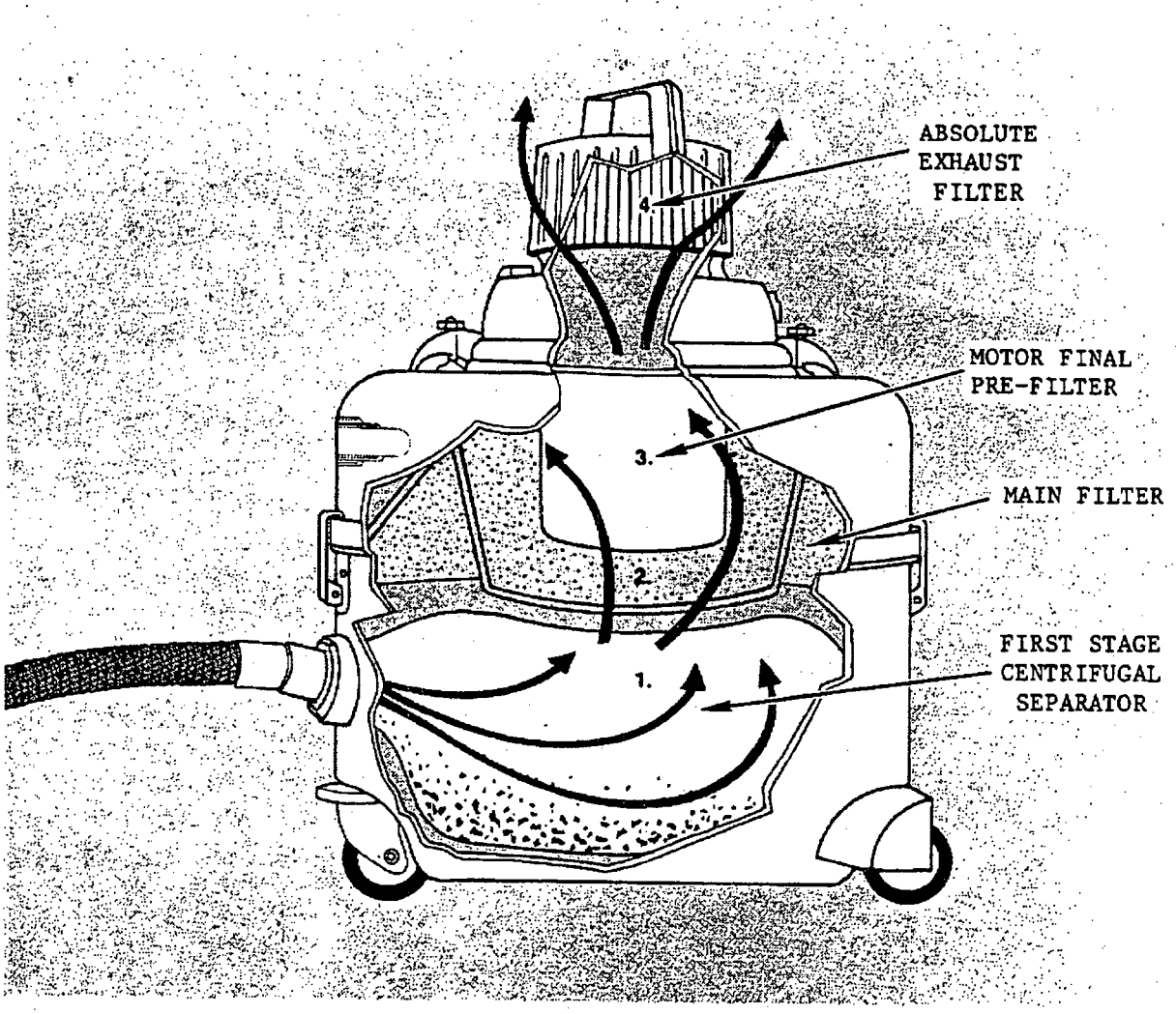

Figure 5-5. Nilfisk HEPA Wet-or-Dry Vacuum.

Jet Cleaning

High-pressure steam and water used alone or mixed with chemicals and detergents are effective methods for attaining high decontamination factors. Equipment of this type is ideally suited for remote operation and for cleaning large surface areas. High-pressure jet cleaning has the disadvantage of spreading contamination over a large area. However, it can be effective when used in an area where preplanning countermeasures assure that this spreading problem is avoided.

Soaking and Spraying

Soaking and spraying is used extensively for decontamination of small and moderate size material and equipment. Both methods make use of chemical solutions and may require support services such as catch tanks, liquid recycle ability and filtered ventilation systems. Spraying has the advantage of combining mechanical action as well as chemical action; however, in some cases the shape of the object being cleaned prevents effective cleaning action on all surfaces. Soaking provides good access to surfaces but does not provide mechanical action.

5.5.1.3 Grinding and Abrasive

Cleaning procedures employing grinding or abrasive action are effective means of decontaminating metal and concrete surfaces provided alteration of the surface area of the object being cleaned can be tolerated.

Grinding

Grinding of surfaces to remove contamination is usually limited to small objects or isolated spots of contamination where the surface is reasonably smooth. Grinding normally produces a high decontamination factor (DF) and is economical. Commercial grinders were used. Grinding inherently leaves residual contamination on the surface of the object being cleaned and therefore usually requires final cleaning by some other method (vacuuming, wiping, etc.). Grinding frequently produces particulate air activity and is generally not economical for large surface areas.

Vacuum Abrasive Blasting

Vacuum abrasive blasting has a number of advantages over grinding. It is rapid, provides a high DF, is effective on irregular shaped surfaces and can be used for large areas. Abrasive blasting makes use of a large variety of abrasives (sand, shells, glass beads, metals, etc.) with velocity, shape and size of the abrasive influencing surface removal characteristics. Airborne contamination and the spreading of surface contamination, which are the prime disadvantages of ordinary abrasive cleaning, were minimized by using a vacuum abrasive blasting cleaning system equipped with high efficiency filters. The HEPA filtered vacuum abrasive blaster is illustrated on Figure 5-6 and the details of its operation are presented schematically on Figures 5-7 through 5-9. Figure 5-6 shows the abrasive blaster unit beside the portable structure which contains the vacuum unit and HEPA filters.

The operation of the vacuum blaster unit is presented schematically on Figure 5-7. Operation is conventional in that the air hose, connected to a 100 psi shop air supply entrains the abrasive material and delivers the mixture to the standard gun (see Figure 5-8) which is in contact with the surface being abraded. The mixture of air, abrasive, and abraded products are immediately and continuously removed through the vacuum hose. The abrasive material and medium weight dust (abraded products) are separated by the vacuum blaster unit as shown on Figure 5-7.

The air and the lightweight dust (abraded products) then travel via a hose to the vacuum unit illustrated schematically on Figure 5-9. The "as purchased" vacuum and filter unit was encased in a wooden structure which is air-tight except for the large HEPA filter through which the exhaust passes. This HEPA filter feature was especially added for this decontamination program to minimize, to the greatest extent possible, the chance of spreading contamination.

This method of decontamination was used most effectively and predominately for the removal of fixed contamination from Building C-West.

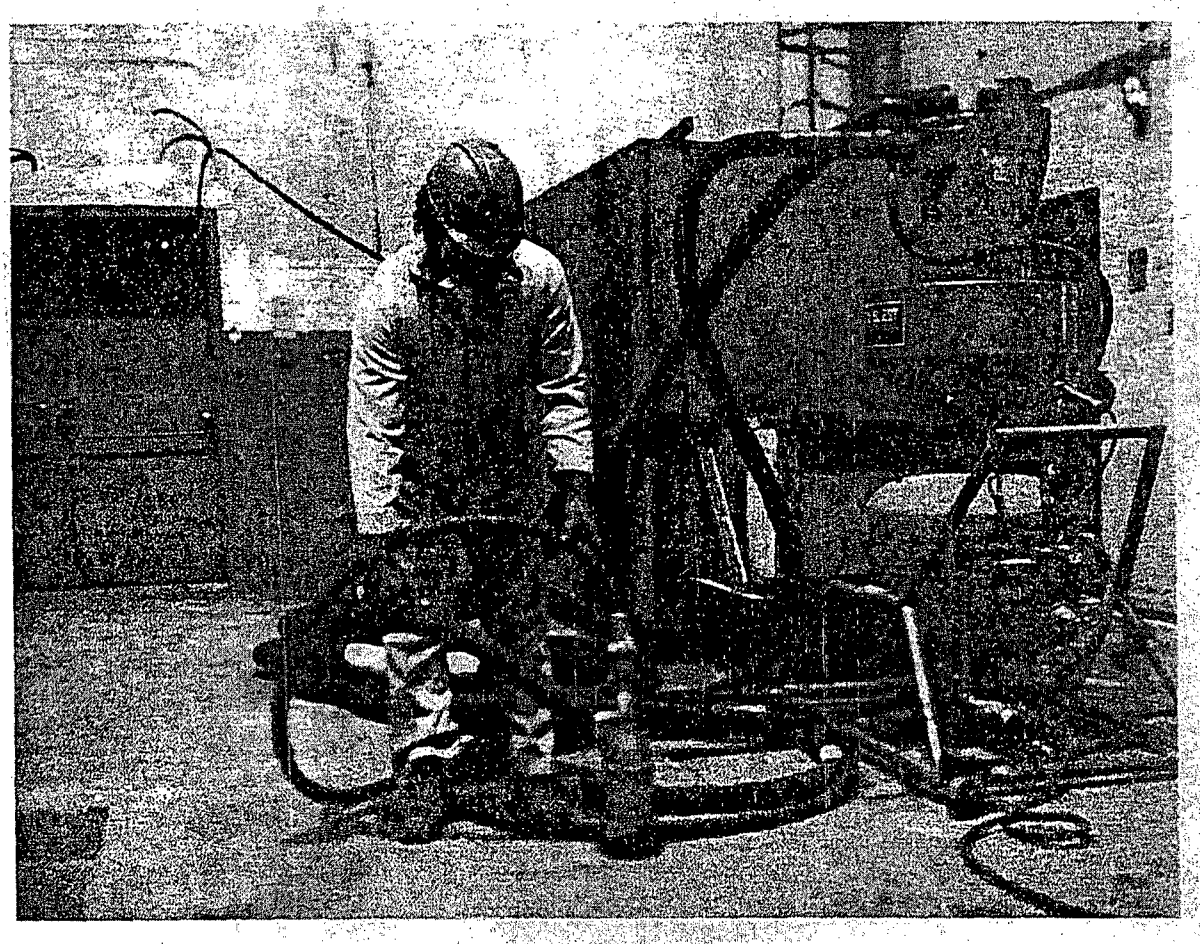

Figure 5-6. Vacuum Abrasive Blaster System with HEPA Filter.

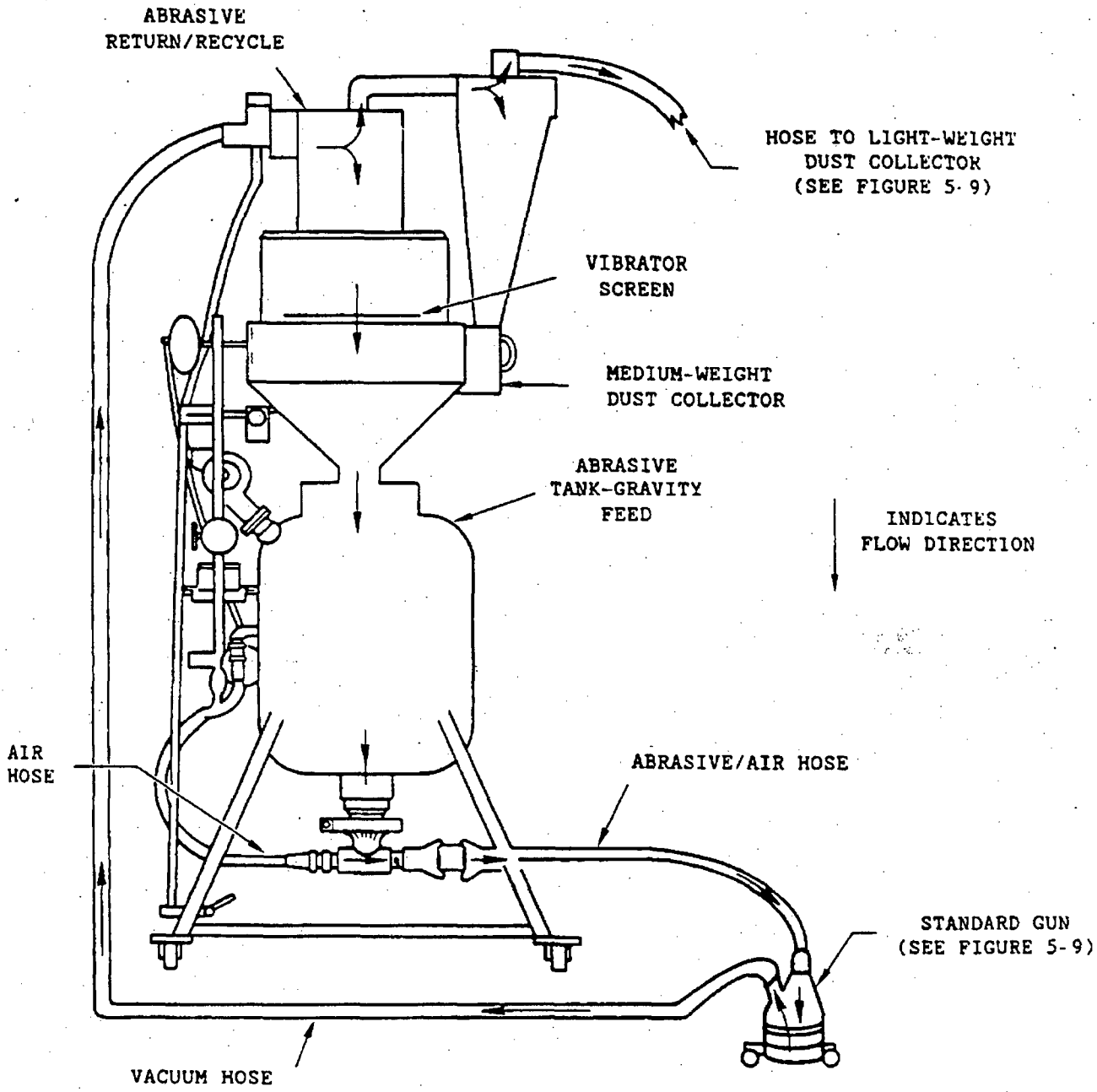

Figure 5-7. Schematic - Operation of Super Utility Vacu-Blaster.

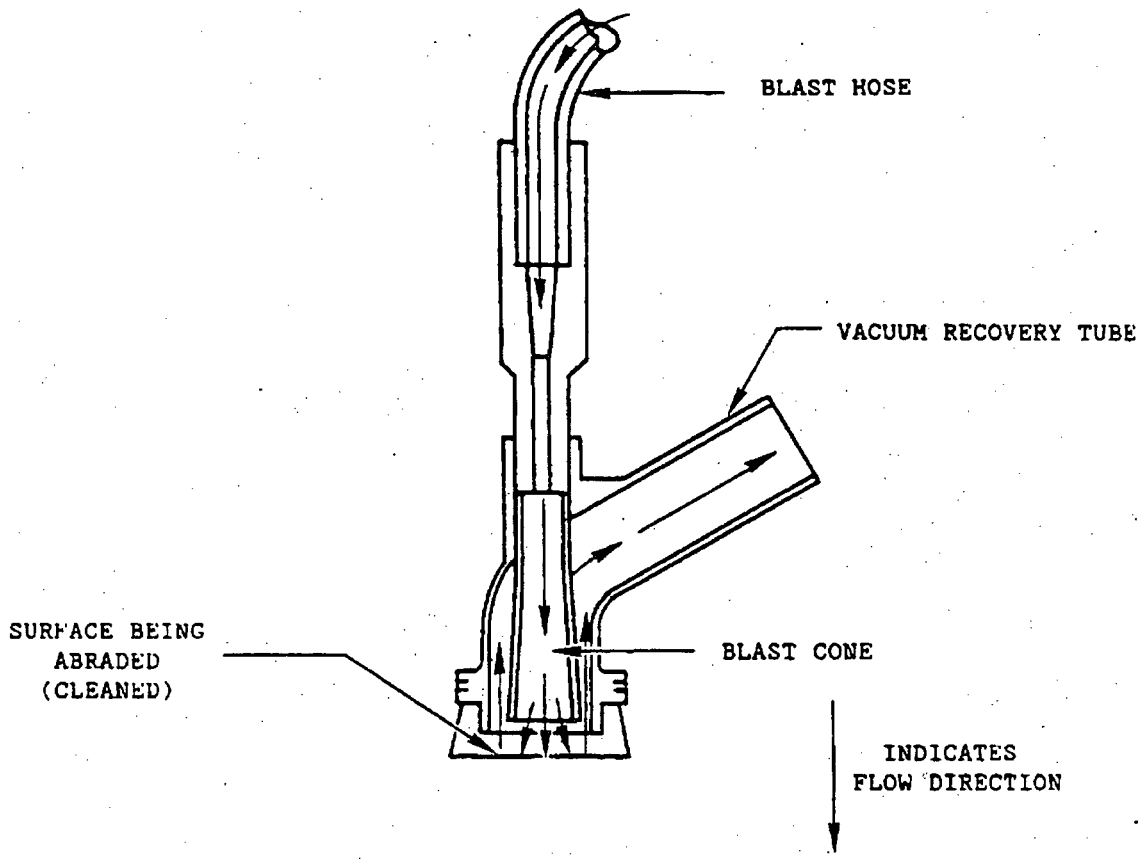

Figure 5-8. Schematic - Details of Standard Gun Operation, Vacuum Abrasive Blaster System.

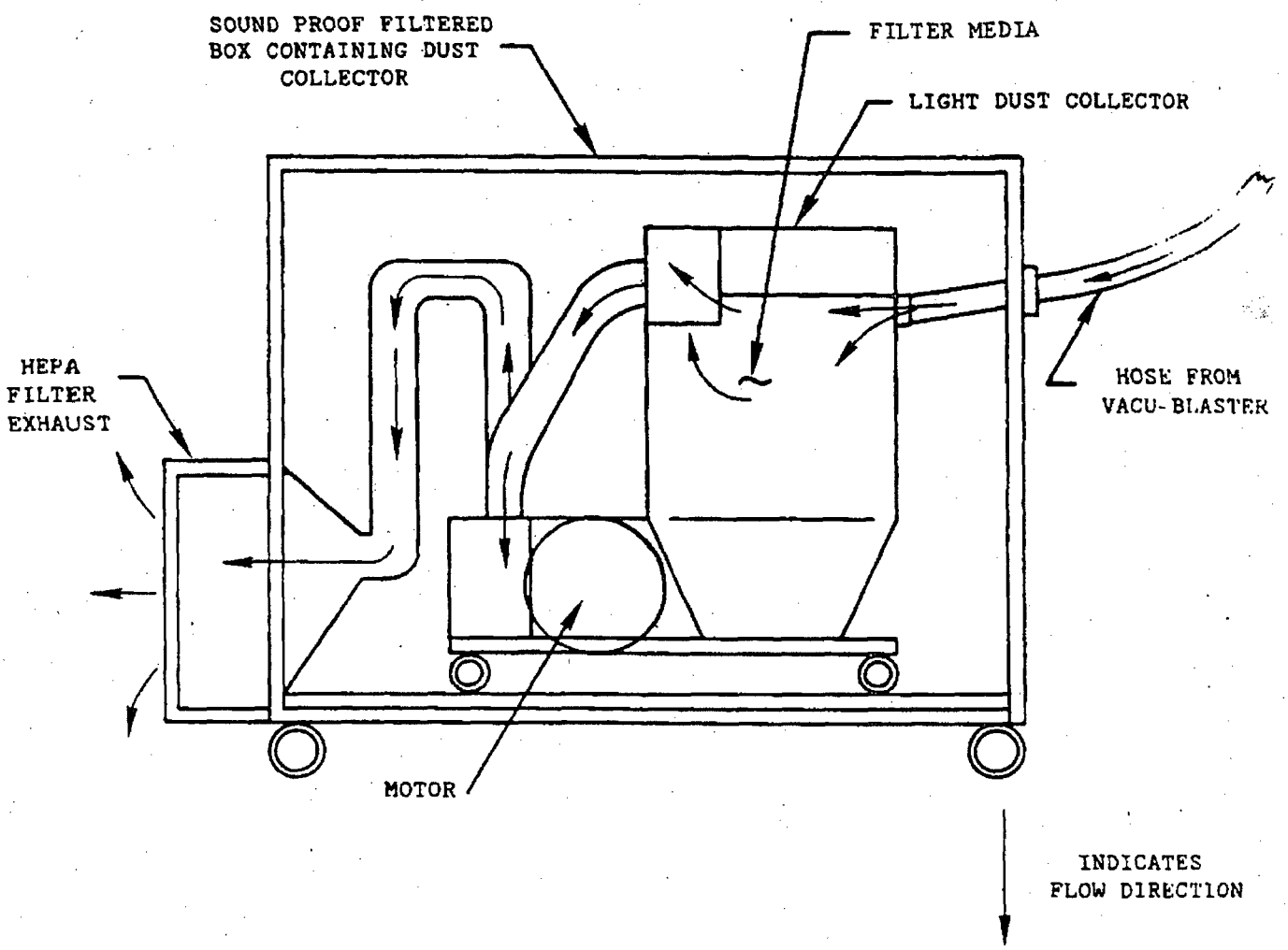

Figure 5-9. Schematic - Operation of Vacuum and HEPA Filter Unit, Vacuum Abrasive Blaster System.

5.5.2 DESTRUCTIVE DECONTAMINATION

Destructive decontamination requires physical removal of contaminated parts or sections. Generally, little or no effort is made to clean the contaminated items prior to disposal as radioactive contaminated waste. Containment and other radiological controls associated with destructive removal are dependent on contamination levels, nature of containment and physical characteristics of the part.

There were two major items that required destructive decontamination in Building C-West.

1. The controlled drains, and
2. The controlled exhaust systems.

In addition, there was some destructive decontamination in the form of partial removal of walls and floors required in Building C-West.

5.6 WASTE DISPOSAL

Disposal of contaminated waste was performed by sealing the material in DOT approved shipping containers with burial at an NRC approved site.

6.0 FINAL RADIATION SURVEY

This section describes how the final radiation survey was accomplished and summarizes the results of this survey of Building C-West at the conclusion of decontamination.

6.1 OPERATIONAL APPROACH

The final monitoring of the various rooms and areas in Building C-West was initiated when it was demonstrated by radiation surveys that all contamination had been removed. Ideally, the final monitoring would prove that all contamination had indeed been removed. Realistically, the final monitoring initially identified additional localized contamination in about 20 percent of the rooms and areas of Building C-West. These contaminated spots were then cleaned and the monitoring of that location repeated until it was cleaned to the levels consistent with the goals established for this program (previously presented in Table 4-3).

The operational approach used in the final monitoring process is presented on Figure 6-1 and includes the following steps:

1. Scale maps of the floor, walls, and ceiling were prepared for each room or area.

2. Each map was then divided into separate areas, usually about one square meter. Each of these areas was given a separate number which forms the basis for the records of this final survey.*

3. Smear papers are prepared by numbering each with a number assigned to each area of the floor, walls, and ceiling maps for each room or area.

4. Each room or area is smeared to determine the presence of removable contamination. This is performed using the numbered smear papers and their corresponding maps.

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*These numbered maps, together with the corresponding survey results, are included in the detailed reports prepared for each room or area of Building C-West.

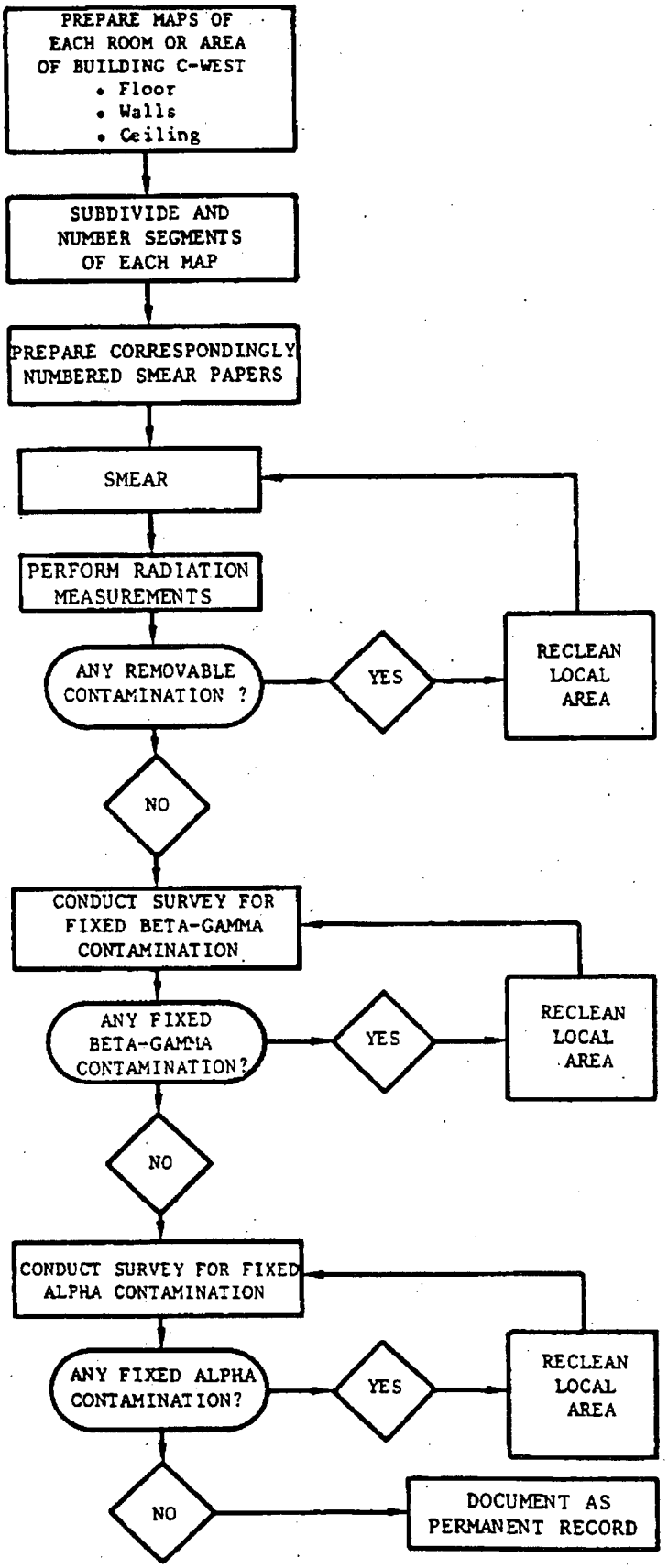

Figure 6-1. Summary Flow-Chart - Final Radiation Monitoring Survey Procedures.

5. The smear samples are then counted for Alpha, Beta or Gamma contamination using either the PC-3A/B or the PC-55 Gas Flow Proportional Counter.

6. All smear counts are tabulated against the area number established for the map of the floor, walls and ceiling of the room or area being monitored. Should any removable contamination be found, the necessary cleaning is completed in the appropriate local area and Steps 4 and 5 are repeated for that area of that particular map. This is repeated as necessary until the levels of removable contamination are reduced to below the guidelines delineated in Table 4-3.

The final monitoring process then continues as follows:

7. The final survey for fixed Beta-Gamma contamination is conducted using the appropriate instrument such as the PM-1 Geiger Counter or the PRM-7 Scintillations Counter (see Table 4-1). This survey is conducted using the same maps as prepared for the final monitoring of removable contamination (Step 2).

8. The final survey for fixed Alpha contamination is conducted using the appropriate instrument such as the PAC-4A-3 or PM-3G Alpha counter (see Table 4-1). This survey is also conducted using the same maps as prepared for the final monitoring of removable contamination (Step 2). Should any fixed contamination be found, the necessary cleaning is completed in the appropriate local area and Steps 7 or 8 are repeated for that area of that particular map. This is repeated as necessary until the levels of fixed contamination are reduced to below the guidelines delineated in Table 4-3.

6.2 RESULTS OF FINAL MONITORING

The results of the final monitoring, summarized in Table 6-1, show that Building C-West has been decontaminated to levels below the NRC guideline levels for unrestricted usage. The detailed results of the final survey are reported in the area-specific reports.

TABLE 6-1. FINAL RADIATION MONITORING SURVEY SHOWS BUILDING C-WEST DECONTAMINATED TO LEVELS FAR BELOW NRC GUIDELINE ACCEPTABLE SURFACE CONTAMINATION LEVELS.

Room or Area	Prior Usage	Post Decontamination Status(1)			
		Removable		Fixed	
		dpm α/100cm²	dpm βγ/100cm²	dpm α/100cm²	mR/hr βγ@1.0cm
Summary Report	- - -	< 20	< 200	< 200	< 0.05
Room 120	Powder Production Area	↓	↓	↓	↓
Room 117	Fuel Element Fabrication	↓	↓	↓	↓
Room 111B (West End)	Fuel Element Fabrication	↓	↓	↓	↓
SE Basement Restroom & Lounge	Change and Restrooms	↓	↓	↓	↓
Bins 3-10, North Basement	S. S. Vaults.	↓	↓	↓	↓
Controlled Drain System	Controlled Drain	↓	↓	↓	↓
Controlled Exhaust Systems, Attic	Controlled Exhaust	↓	↓	↓	↓
Room 103, 145, 150, 151, 152, 153, 155 and West Mezzanine	Laboratories and Office	↓	↓	↓	↓
Room 111A (East End)	Lab and Fuel Element Fab.	↓	↓	↓	↓
Rooms 112, 113, 114, and 115	Autoclave, X-Ray, and Labs	↓	↓	↓	↓
Rooms 116, 116A, 116B, 116C & 116D	Mech. Testing and Storage	↓	↓	↓	↓
Rooms 118 and 119	Machining, X-Ray and Storage	↓	↓	↓	↓
Room 149	Air Lock and Storage	↓	↓	↓	↓
Elevator, Elevator Shafts, N & S Stairwells	Building Facilities	↓	↓	↓	↓
Remainder of Basement	Storage and Corridors	↓	↓	↓	↓
Room 104	S. S. Vault Office	↓	↓	↓	↓
Room 108	Foundry and Stamping Press	↓	↓	↓	↓
Room 109	Extrusion Press Room	↓	↓	↓	↓
Rooms 156 and 157	Office and Building Services	↓	↓	↓	↓
Rooms 146 and 147	Restrooms	↓	↓	↓	↓
Room 144	Building Services Fan Room	↓	↓	↓	↓
Rooms 101, 102, 123, 137, 142 & 143	Hallways	↓	↓	↓	↓
Rooms 138, 140, 141, 148, Toilet and Locker Room	Building Services, Toilet and Locker Room	↓	↓	↓	↓
Rooms 124-128 and 130-135	Change Room Complex	↓	↓	↓	↓
East Mezzanine Area	Office and Inspection Area	↓	↓	↓	↓

(1) See Table 3-2 for full NRC proposed values.