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ABSTRACT

Following the removal of equipment and previously detectable radioactivity from the Nuclear Materials Development Facility (NMDF) during the course of the decontamination effort, a formal final radiological survey was performed. The purpose of the final survey is to determine the level of effectiveness of the decontamination effort and to demonstrate that the building meets release criteria for unrestricted use. The results show that all inspection tests were satisfactorily passed and that the area is acceptably clean of radioactive materials.

This survey demonstrates that the facility meets the requirements of Annex B to NRC License No. SNM-21, "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material (July 1982)."

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CONTENTS

TABLES

FIGURES

FIGURES (Cont'd)

I. INTRODUCTION

Located in the Simi Hills of Ventura County, California, the Nuclear Materials Development Facility (NMDF) was designed, constructed, and operated by Rockwell International for research, development, and production work with alpha emitting and/or highly radiotoxic nuclear and radioisotopic fuels. The major effort at this facility involved plutonium-bearing fuels, primarily plutonium-239. The final products were solid reactor fuel materials, radioisotope heat sources, or radiation sources in a variety of forms and compositions. Various forms of plutonium and depleted uranium (oxide, carbide, metallic) were used as feed materials for all projects.

All of the operations involving unencapsulated radiotoxic materials were performed in gloveboxes which contained all aerosols generated during normal handling processes. The facility was operated for a total of about 16 years, and experienced only three contamination incidents. The first occurred in 1973, when a plastic bag connected to a glove port on gloveboxes 17 and 17A ruptured and released measurable plutonium contamination onto the eastern side of the glovebox room. In the second incident, a vacuum pump leak resulted in the release of detectable plutonium contamination on the glovebox room floor, toward the vault. Both releases were determined to be localized to the immediate area of the incident although small quantities of contamination did spread throughout the room, including the overhead pipes and duct work. A spill of contamination also occurred in the process laboratory, which was used as a waste handling and packaging room during operations; consequently, this room was suspect as containing trace quantities of plutonium or depleted uranium.

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 cement foundations, the building has been gutted. Most of the equipment removed was disposed of as radioactive waste under the burial criteria for transuranic waste. All detectable radioactive material was removed. Residual contamination in the facility is well below applicable limits specified by Annex B to Special Nuclear Materials License No. SNM-21.

Surveys were performed during the decontamination work to identify any areas needing further decontamination. After these surveys showed that the facility was completely clean and that the decontamination effort was finished, a formal documented survey was performed to provide a quantitative demonstration of the satisfactory level of residual contamination. This survey is an application of a sampling inspection method, inspection by variables. This application is similar in performance to inspection by attributes and variables discussed in Reference 2 (Decon-1).

In this sampling inspection, a minimum sample of 11% of the surface was performed on the floors, walls, and ceilings to measure the average alpha surface activity, removable alpha surface activity, average beta surface activity, and removable beta surface activity. Because of the very low residual activity found, the surface dose rate was not measured. Samples of soil, drain line sludge, paint, and miscellaneous samples were collected and analyzed as necessary; special structural features were surveyed when determined appropriate. The inspection sample was structured on the basis of a uniform 3-meter-square grid, with a single 1-meter-square location selected for measurement from the nine locations in each grid. The 1-meter-square location in each grid was selected with the intent of choosing a location where there could be potentially higher residual contamination. (The use of the 3-meter-square grid assures roughly uniform distribution of sample locations throughout the facility.) One-meter-square locations were surveyed with alpha and beta sensitive equipment, and 100 cm^2 of the surface in each location was swiped and tested for removable activity. If the results of the 1-m^2 survey exceeded 80% of the release criteria, additional sampling in nearby locations was performed and the results incorporated into the analysis. All areas determined during this survey to be greater than 80% of the acceptance criteria were decontaminated further.

While the Nuclear Regulatory Commission has adopted surface contamination limits established in Annex B of Rockwell International's license SNM-21, docket 70-25, as suitable for release of equipment and facilities for unrestricted use, the goal is to eliminate residual contamination to the extent reasonable. This has been done and is demonstrated by the results of the survey.

The statistical test applied to the survey, inspection by variables, is based on a consumers' risk of acceptance at 10% defective, that is, 0.1, and assumes that the data follows a Gaussian probability density function. In all cases, the measurements show that the test is satisfactorily passed and the building is acceptably clean.

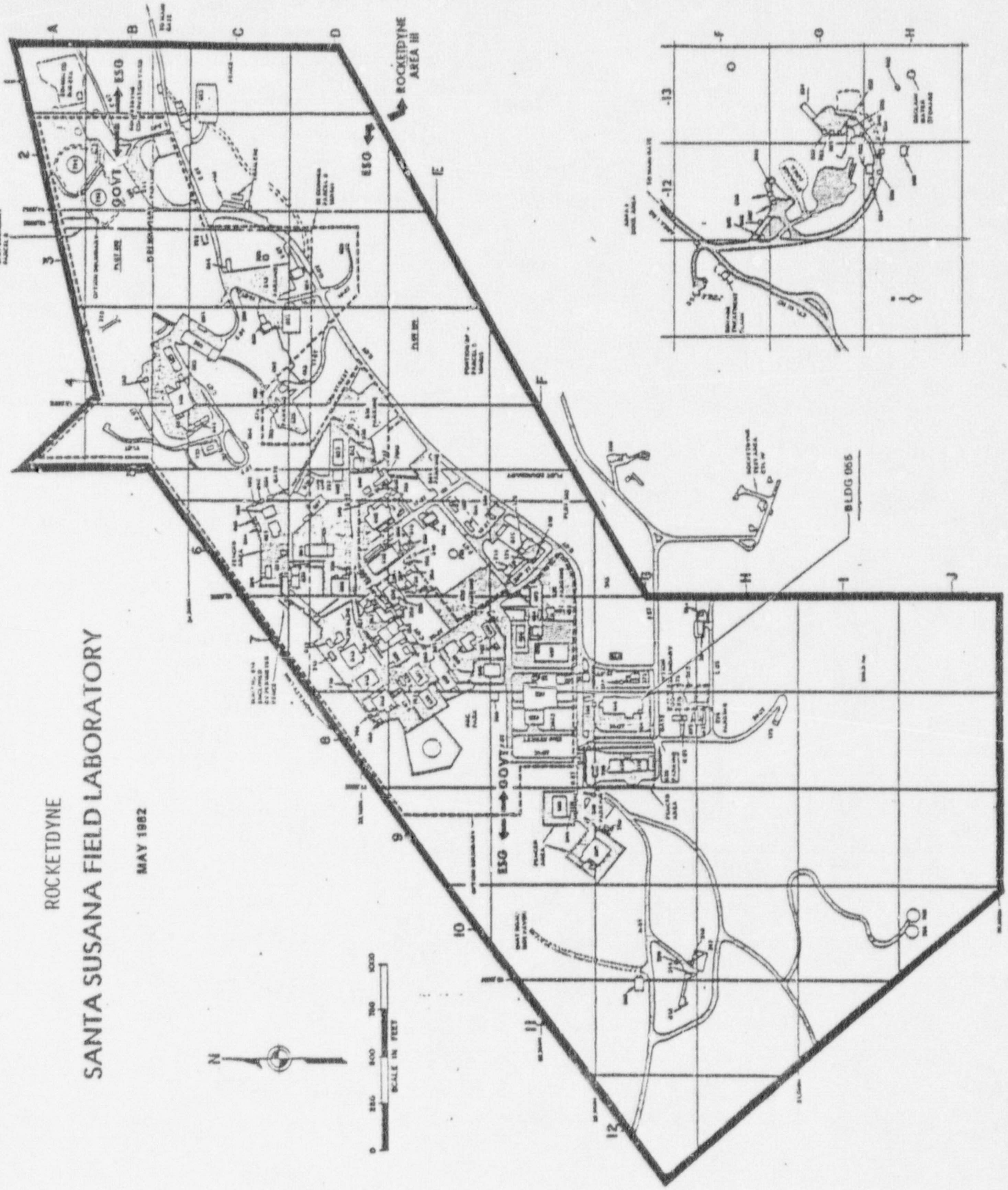
II. IDENTIFICATION OF FACILITY PREMISES

A. BUILDING CHARACTERISTICS

The premises to be released for uncontrolled use consist of Building T055, a security post on the north side of the building, and equipment yards surrounding the building but within the facility security control fence. It is located at the Santa Susana Field Laboratory in the Simi Hills of Ventura County, California, shown in Figure 1. The NMDF site is presented in Figure 2.

The NMDF building enclosure is a tilt-up concrete structure 200 ft long (running north and south), 60 ft wide, and 16 ft high. The building is divided into an administration area, change rooms, chemistry and other service laboratories, a glovebox room, a vault, and facility equipment rooms. The architectural plan is shown in Figure 3. The entire facility site was a controlled access area; however, the building was divided into posted and unposted radiologically controlled areas. Figure 4 identifies each room of the facility and shows the posted and unposted areas.

The 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 concrete, tarred felt, and gravel, is supported on steel deck panels and girders. The portion of the building surrounding the radiologically posted area was totally enclosed by painted concrete surfaces, weatherproofed doors, and suitable partitions. The floors of the glovebox room and chemistry laboratory had polyvinyl sheet covering to provide an easily decontaminable surface. Prior to the demolition of the building interior, systems in place included: air conditioning, radioactive exhaust system for posted areas, a separate radioactive exhaust system for gloveboxes, unshielded gloveboxes, radioactive liquid waste holdup, electrical power distribution, annunciator and controls, alarms and instrumentation, fire protection, and plumbing. Section III of this report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SANTA SUSANA FIELD LABORATORY
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ROCKETDYNE AREA III
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FIGURE 1

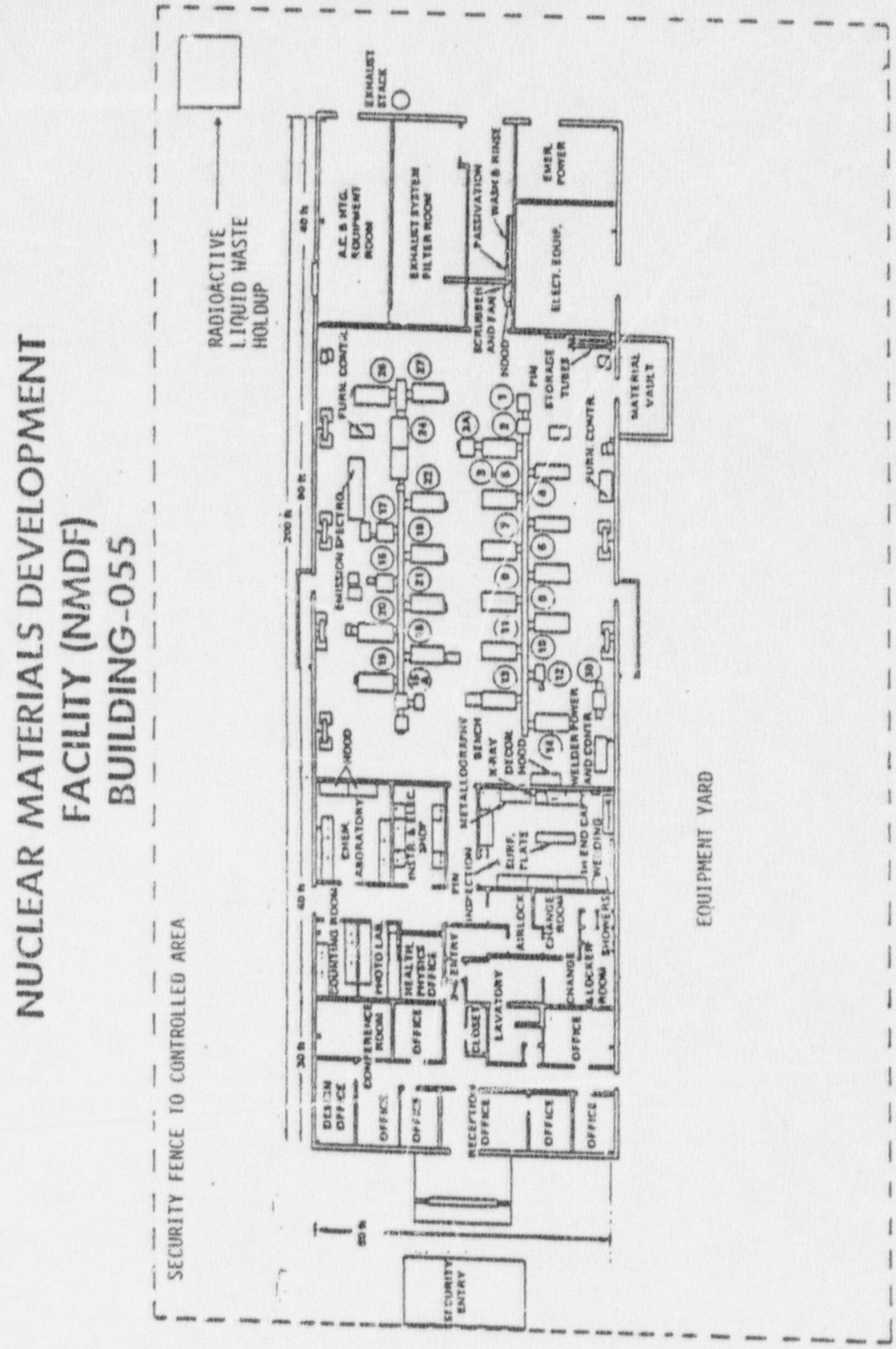

Figure 2. The NMDF Site

Rockwell International

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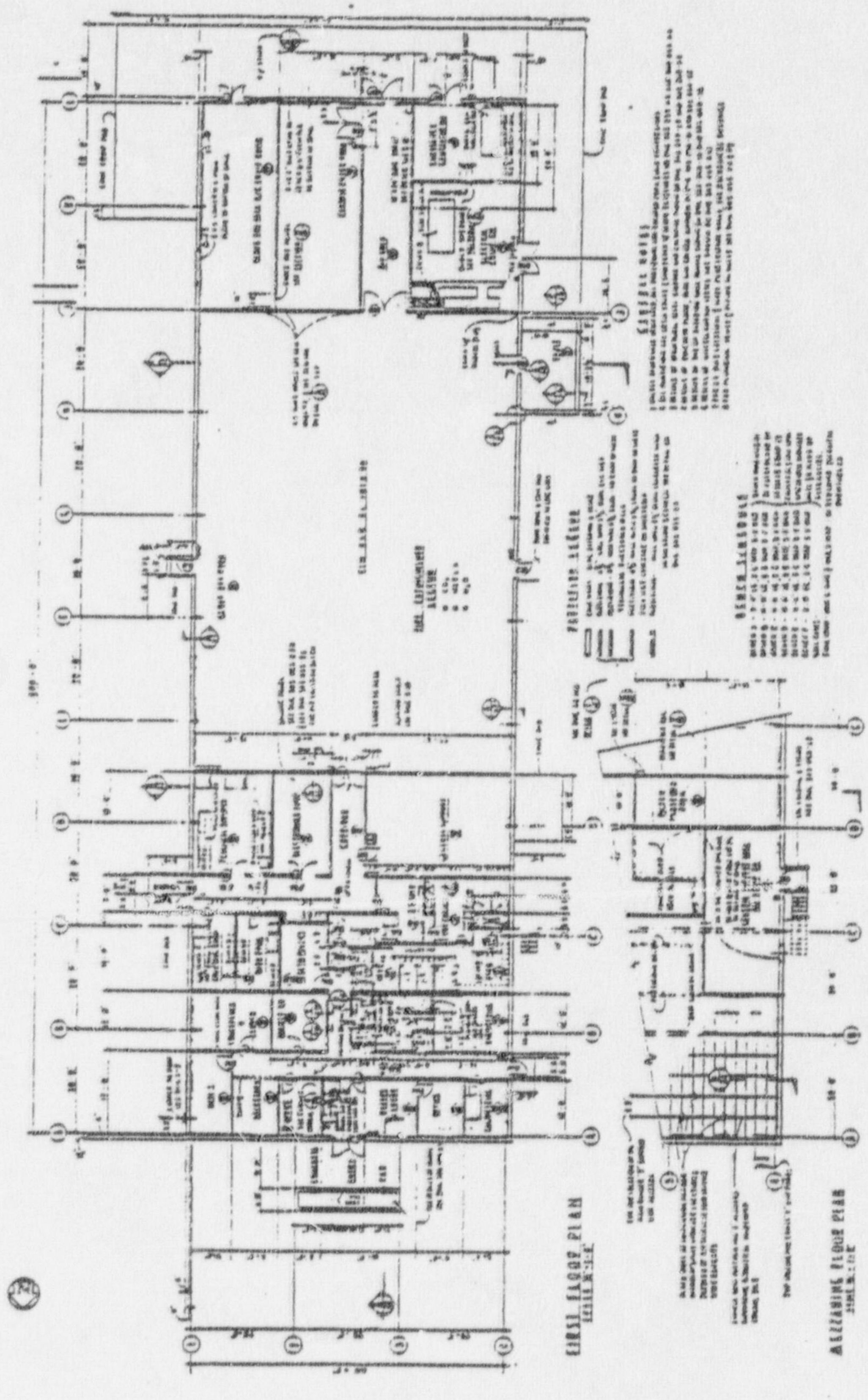


FIGURE 3. THE NNDF ARCHITECTURAL PLAN

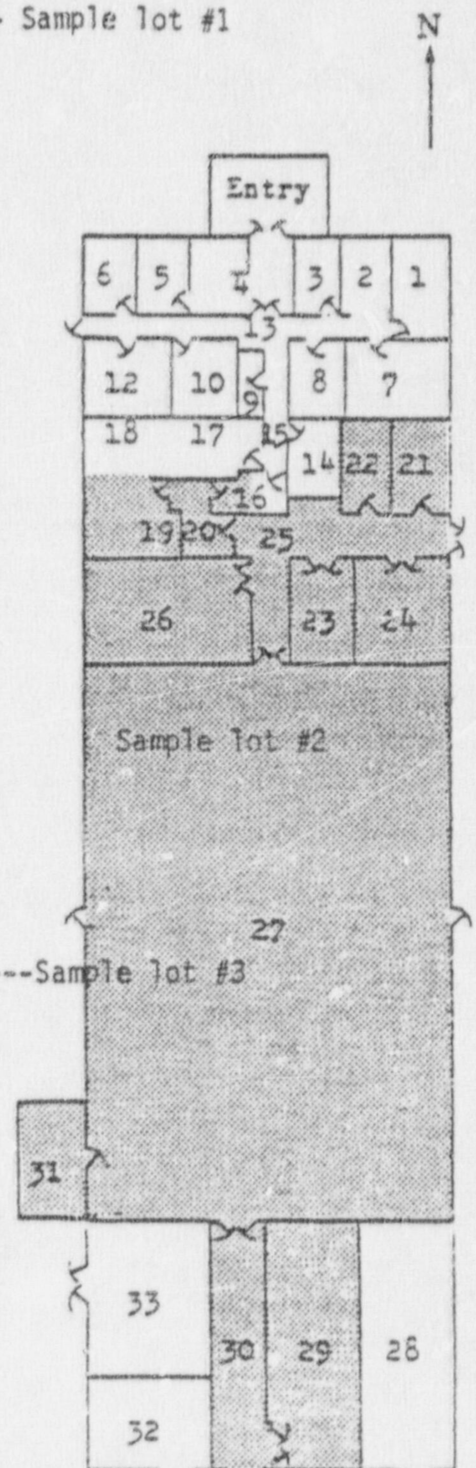
FIGURE 4 - FACILITY LAYOUT AND ROOM DESCRIPTIONS

Radiologically Unposted Areas ☐ ----- Sample lot #1

Layout Number	Room No.	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 & Supply Equipment Room
32	132	Auxilary Power Supply Generator
33	133	Electrical Distribution Equipment

Radiologically Posted Areas ▒ ------Sample lot #3

Layout Number	Room No.	Description
16	116	Change Room
19	119	Shower & Change Room
20	120	Airlock to Controlled Area
21	121	Health & Safety Counting Laboratory
22	122	Photographic Dark Room
23	123	Instrument Laboratory
24	124	Chemistry Laboratory
25	125	Corridor
26	126	Process Laboratory
27	127	Glove Box Laboratory
29	129	Radioactive Exhaust Equipment Room
30	130	Airlock to Controlled Area
31	131	Radioactive Materials Storage Vault



provides information regarding the decontamination effort, equipment removed, radiological problems encountered, and final condition of the building prior to the final survey.

B. RADIOLOGICAL CONDITIONS

The only radioactive materials handled in the facility were plutonium (consisting of mixtures of Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, Am-241) and enriched and depleted uranium. All of the isotopes decay by alpha emission with the exception of Pu-241, which decays by beta emission to Am-241, which in turn decays by alpha emission. In addition, depleted uranium, primarily U-238, decays by alpha emission to thorium-234, which has such a short half life compared to U-238 that the daughter product is in equilibrium with the parent. Thorium-234 decays by beta emission, to Pa-234, which also has a short half-life and decays by beta emission to U-234. There is essentially no U-234 present in the depleted uranium. Therefore, two beta particles are emitted following the emission of the U-238 alpha particle. Since the beta activity is much easier to measure than is the U-238 alpha activity, it has been chosen, for this survey, as the indicator of depleted uranium contamination. Annex B establishes limits for U-238 and associated decay products based upon alpha activity. Since two beta particles are emitted for each alpha decay of U-238, the acceptance limits based on measurements of beta activity are taken to be twice the limits based on alpha activity.

The facility was operated in a radiologically controlled manner; only three contamination incidents occurred during its operation, two involving the release of plutonium into the glovebox room; one involving release of activity in the Process Lab. Figure 5 shows the location of the releases in the glovebox room. The first release occurred in June of 1973 when gloveboxes number 17 and 17A were inadvertently overpressurized. Although small amounts of contamination were discovered spread over the entire room, the majority was confined to the localized area of the release. Following the incident, the room was cleaned as necessary and returned to service. The second release

Pu RELEASE LOCATIONS IN GLOVE BOX ROOM

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
8	8		Press and Measure Green Density
9			Powder Granulating
11			RAD Waste Combustion
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
31		31	Sodium Preparation and Loading
			Analytical and Development Line
1A	1A		Air Entrance
2A	2A		Inert Gas Entrance
15A	2A		Weighing
19	19		Metallography Sample Preparation
L.F	16		Sample Ignition Furnace
20	20		[illegible]allography Sample Etching, Final Polishing, Auto-[illegible]iography & View Port for Metallograph
M	20		Metallograph
204		204	X-Ray Diffraction Power Supply & Source
16	16	204	X-Ray Fluorescence Analytis [sic]
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
28	28		Transfer
27	27		(U-Pu)C Compact Pressing
H	H		Fume Hood

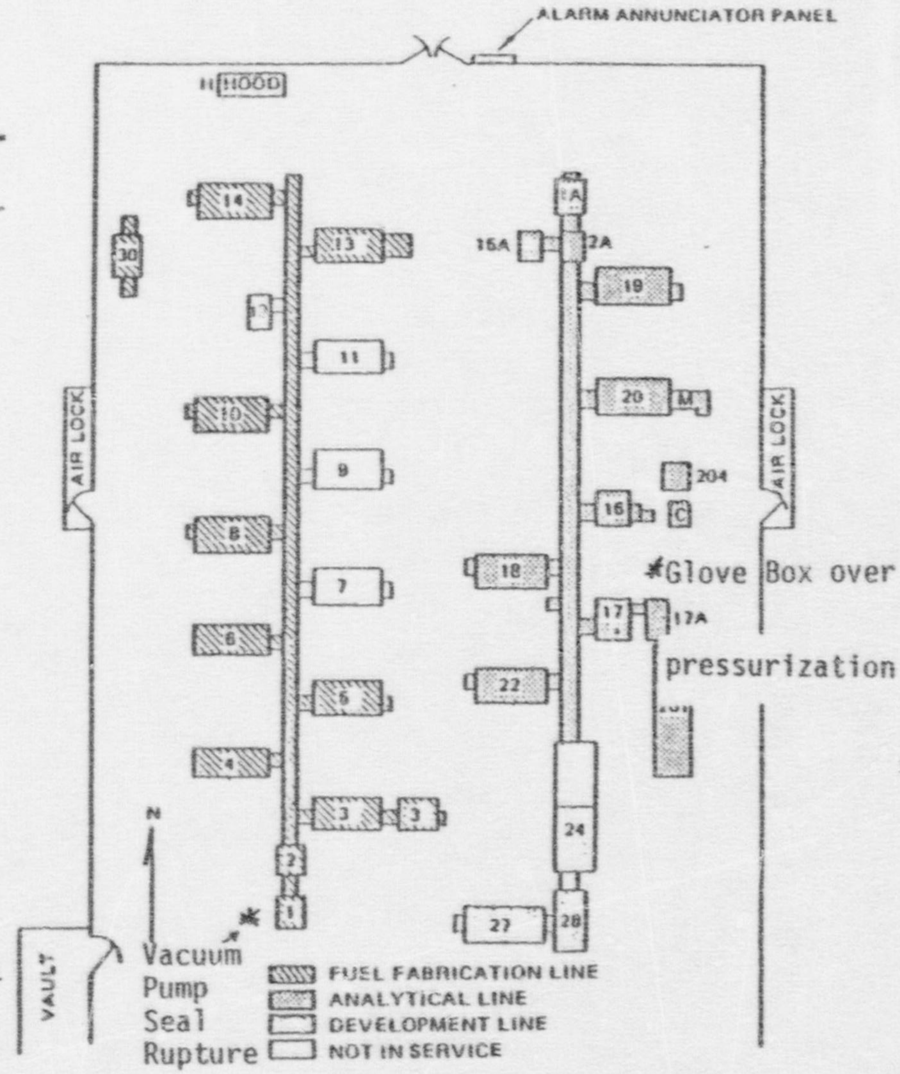


FIGURE 5

occurred when a seal on a vacuum pump used for the gloveboxes ruptured. This release was entirely localized to the immediate area. The leaked oil was removed and the floor cleaned. The building was then returned to service. In the Process Laboratory, a bag of waste broke, releasing a small amount of unidentified contamination. Special care was taken in these areas during the dismantling, demolition, and final survey to ensure that the area is truly clean. No conclusive evidence suggests that the building ever experienced other contamination problems.

III. DECONTAMINATION EFFORTS

Decontamination and deactivation of the Nuclear Materials Development Facility were initiated in November 1982. The progression of the decontamination efforts was as follows: (1) decontamination and then removal of gloveboxes and connecting tunnels, including glovebox equipment, (2) removal of utilities and low-volume exhaust system, (3) decontamination of support area, (4) disposal of NaK in glovebox atmosphere purifiers, (5) removal of liquid waste holdup system, and (6) removal of high-volume exhaust system. The waste generated during cleanup operations was packaged concurrent with the generating operation and shipped for disposal at the discretion of Radioactive Materials Disposal Facility.

Decontamination of the glovebox surfaces was accomplished utilizing ALARA strippable paint. This proved to be an effective and efficient method of surface decontamination. Glovebox and tunnel section removal was completed in November 1985. Survey of the decontaminated gloveboxes was conducted to assure that they were not TRU waste and were within the criteria of LSA waste.

All components of the low-volume exhaust system, consisting of blowers, absolute filter banks, and associated valves and controls, were removed except for the stack which was still linked to the high-volume exhaust system. This was completed in February 1985. The utilities that were removed and dispositioned included those used specifically for glovebox operations, i.e., cooling water, argon, helium, dry air, vacuum, and electrical and control wiring, and those utilities which serviced the glovebox room, i.e., compressed air, electrical power, lighting, PA system, phones, sprinklers, fire alarm circuits, radiation alarm system, and intrusion alarms. Removal of utilities servicing the glovebox room was completed in November 1984.

All equipment and materials in the support area were surveyed and dispositioned according to the level of activity found. This included furniture, sinks, light fixtures, and other office and laboratory equipment. Decontamination of the support areas was completed in October 1984. Only material with no detectable radioactivity was disposed of as conventional waste.

Disposal of the NaK in the glovebox atmosphere purifiers and 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 chemical hazard of NaK but trace quantities of alpha materials were present which required stringent containment. The NaK removal process involved a combination of evaporation of K and Na at ~900°F, steaming, and finally, a water rinse. Following cleaning, the bubblers were surveyed to verify them as LSA waste and transferred to the RMDF for packaging and staging for shipment to a disposal site. The process water generated during the removal of NaK from the bubblers was neutralized, transferred to the RMDF, and evaporated; the residual solids were packaged and staged for shipment to a disposal site. Removal and neutralization of the NaK from the bubblers was accomplished in June 1986.

The removal of the liquid waste system required the removal of all drain lines between the various sources, for example, laboratory sinks and shower drains, and removal of the for process and storage tanks and their associated equipment. All components were packaged and dispositioned as necessary. Complete removal of the liquid waste holdup system was accomplished in May 1986.

The components of the high-volume exhaust system which were removed for disposal as LSA waste include the hood in the glovebox room; all filters, ducting, and controls associated with the hoods and filters; and ducting and controls in the glovebox room and vault. The high-volume exhaust system removal, which was the final step of the decontamination effort, was accomplished in August 1986.

The contaminated waste generated on this program were shown to be within the requirements of low specific activity category with the exception of some process equipment from inside the gloveboxes. This process equipment was handled as TRU waste.

IV. SURVEY SCOPE

A sampling inspection plan using variables, discussed in the next section, has been used to demonstrate that the residual contamination in the building is below the following limits:

Criteria	Alpha (dpm/100 cm)	Beta* (dpm/100 cm)
Total, averaged over 1 m^2	100	10,000
Total, maximum over 100 cm^2	300	30,000
Removable over 100 cm^2	20	2,000

* The acceptable beta contamination limits were derived from alpha contamination limits presented in Annex B of USNRC license SNM-21 for U-nat, U-235, U-238, and associated decay products. The beta values are twice those of the alpha limits reported based on the two beta particles emitted from the decay of Th-234, the first daughter of U-238, and Pa-234. The alpha limits correspond with the license annex limits for transuranics.

For the sake of the NMDF analysis, the building was divided into three sample areas: The office area and Rooms 128, 132, 133, and the air conditioning room (all unposted areas); the glovebox room (posted); and Rooms 117, 118, 119, 120, 121, 122, 123, 124, 126, 129, and 130 (remaining posted areas).

For each of the three sampling lots, the office area (unposted), the glovebox room (posted), and the remaining posted areas, a minimum of an 11% survey was conducted on the walls, floors, and ceilings. Figure 4 pictorially shows the sample lots. The sampling inspection plan that was used is based upon a uniform 3-m^2 grid superimposed on the inspection area. A 3-m^2 grid has been adopted to be consistent with guidance provided in NRC and State of California documents. The grid was superimposed on the wall, floor, and ceiling of each room. Each survey area was identified in matrix notation with codes indicating the surface (F = floor, C = ceiling, N, E, S, W = north, east, south, west, respectively) and a two-figure Cartesian coordinate indicating the distance in meters from a local benchmark. The (1,1) position for the floor was benchmarked as the northwest corner of the room; an identical grid was reflected onto the ceiling. The (1,1) position of the walls was benchmarked as the top left hand corner of the wall as an observer would view it from the middle of the room. From each 3-m^2 grid, a 1-m^2 was surveyed; hence, a minimum 11% survey. Each 1-m^2 area was surveyed for 5 min and a 100 cm^2 area was smeared for removable contamination.

A. DATA ACQUISITION

Within each 3-m^2 grid, a single 1-m^2 area was surveyed. Each area was outlined by paint, with its coordinates marked beside the area. The location of the 1-m^2 area was left to the surveyor's judgment. It was to be the area, in his judgment, that was most likely to have retained the most residual contamination of any similar area within the 3-m^2 grid. The surveyor was instructed to do this conscientiously to assure that any significant residual contamination would be detected before a report of acceptability was made to a regulatory agency. The use of a predetermined grid with discretion for the exact location provides a uniform survey biased toward the high end of the distribution. Selection of the 1-m^2 area out of the nine within each grid square provides an 11% sampling. If a particular surface of a room was smaller than 9 m^2 (3m x 3m), a minimum of 1 m^2 was surveyed for contamination; in many cases within the office area, where a wall measured typically 6 m^2, the sampling area was 17%.

In order to determine the level of effectiveness of the decontamination effort, four radiological characteristics were measured for each m^2; average alpha surface activity, average beta surface activity, removable alpha surface activity, and removable beta surface activity. An alpha probe and beta probe were each connected to Ludlum 2220-ESG scalers for these measurements.

Measurements of the average alpha surface activity were made by use of a large-diameter (9.6-cm) alpha scintillation detector, sensitive only to alpha particles with energy exceeding about 1.5 MeV. This detector was calibrated by use of a Pu-239 alpha source. The energy of the Pu-239 alpha particles (5.1 MeV) is similar to that of the isotopes which are alpha emitters handled at the NMDF; Pu-238, Pu-239, Pu-240, Pu-242, and U-238 (DU).

Measurements of the average beta surface activity were made by use of a thin-window pancake Geiger-Mueller tube. While this detector is equally sensitive to alpha and beta particles and slightly sensitive to X-and gamma-rays, it is so predominately used to measure beta-activity that it is generally called a "beta-detector." This detector was calibrated by use of a Tc-99 beta source. The energy of the Tc-99 beta particles (maximum 0.3 MeV) is close to those from the U-238 daughters, Th-234 (maximum 0.2 MeV) and Pa-234 (maximum 0.5 MeV). The measurements were made over the same area as was used for each measurement of average alpha surface activity.

Measurements of removable surface activity (alpha and beta) were made by wiping approximately 100 cm^2 of surface area, using a Nucon-type cloth disk (NPO cloth sampling smears 2 in. diameter). The activity on the disks was measured using a thin-window gas-flow proportional counter, calibrated using larger diameter Pu-239 and Tc-99 sources.

In order to facilitate the survey, the alpha and beta probes were connected by a face plate such that the separation distance was no greater than a couple of cm. Each m^2 was surveyed using the assembly for 5 min; this corresponds to a transit velocity of approximately 3.3 cm/s. The ANSI draft standard N13.12 states that the transit velocity (in cm/s) shall not exceed one-third the numerical value of the detector window dimension (in cm) in the direction of the scan. The diameter of the window is 10 cm, and therefore, this transit velocity complies with the standard. The number of counts registered by the instrument in a 5-min scan were recorded by location. If a contaminated spot was detected during the course of the "average scan" survey, the location was identified; subsequently, a 5-min stationary survey of the location was conducted. The average surface activity of the m^2, the maximum surface activity of one spot located within the m^2, and the removable activity of 100 cm^2 in the m^2 were recorded.

In order to report the results in disintegrations/min per 100 cm^2 (dpm/100 cm^2), conversion factors were applied as follows. First, "natural background" was determined by measurements made in an area of the building which was known to be uncontaminated. Second, an efficiency factor for the survey instrument was calculated by comparing the number of counts recorded by the instrument to the number of disintegrations yielded by a calibration source. These determinations were made three times each day; first thing in the morning, at noon, and just before quitting time in the evening. Third, the correction factor for the area of the window was calculated in order to present results per 100 cm^2.

Thus, for the surface contamination measurements of alpha and beta activity, data included the sample location, the total counts recorded in the 5-min scan, the maximum hot spot, natural background for 5 min, efficiency factor, and the area factor. The same data was recorded for the removable contamination measurements except for the area factor, which is not applicable for the gas proportional detector since the sample size and check source size are very nearly equivalent.

B. DATA REDUCTION

The data was entered into VISICALC, a spreadsheet software program on the IBM PC. Columns were established to calculate the total, maximum, and removable contamination per 1-m^2 in dpm/100 cm^2. The standard error associated with the measurement was also calculated.

Data input:

1. Room number
2. Grid location, example N(1,3)
3. Alpha total activity, averaged over 1 m^2 (counts in 5 min)
4. Alpha maximum activity for hot spot (counts in 5 min)
5. Alpha removable activity (counts in 5 min)
6. Beta total activity, averaged over 1 m^2 (counts in 5 min)
7. Beta maximum activity, averaged over 1 m^2 (counts in 5 min)
8. Beta removable activity (counts in 5 min)
9. Alpha survey instrument background (5 min), efficiency factor (dpm/cpm), and area factor
10. Alpha gas-proportional detector background (5 min) and efficiency factor (dpm/cpm)
11. Beta survey instrument background (5 min), efficiency factor (dpm/cpm), and area factor
12. Beta gas-proportional detector background (5 min) and efficiency factor (dpm/cpm).

Output:

1. Alpha total activity averaged over 1 m^2 with standard deviation (dpm/100 cm^2)
2. Alpha maximum activity and standard deviation (dpm/100 cm^2)
3. Alpha removable activity and standard deviation (dpm/100 cm^2)
4. Beta total activity averaged over 1 m^2 with standard deviation (dpm/100 cm^2)
5. Beta maximum activity and standard deviation (dpm/100 cm^2)
6. Beta removable activity and standard deviation (dpm/100 cm^2).

The counts observed for the alpha and beta surface activity were converted to dpm/100 cm^2 by:

$$SA = \left(\frac{C - B}{5}\right) E \left(\frac{100}{A}\right) \quad \text{(Eq. 1)}$$

where: SA = surface activity (this is applied to either the average or maximum activity)

C = total count in 5 min

5 = count time, min

B = background count in 5 min (generally 0-5 for alpha and about 440-460 for beta)

E = efficiency factor, dpm/cpm (averages about 4.4 for alpha and about 4.3 for beta)

100 = 100 cm^2 standard area

A = probe sensitive area (71 cm^2 for Ludlum model 43-1 circular alpha scintillator;
20 cm^2 for Ludlum model 44-9 pancake G-M).

Note that the analysis is done using counts rather than count rates. The standard error or deviation of the measurement in dpm/100 cm^2 is given by:

$$\frac{\sqrt{C^2 + B^2}}{5} E \left(\frac{100}{A}\right) \quad \text{(Eq. 2)}$$

The results of the smears counted by the gas-flow proportional counter for the alpha and beta removable surface activity were converted to dpm/100 cm^2 by:

$$SA = \frac{(C - B)(E)}{5} \qquad \text{(Eq. 3)}$$

where the appropriate alpha and beta background and efficiency factos were used. Backgrounds are typically 0-2 counts for alpha and 120-150 counts for beta in a 5-min time period. Efficiency factors are about 3.5 for alpha and 3.9 for beta. Theoretical standard deviations were also calculated.

Software was developed to read the data output from the Visicalc file into a graphics utility which plots the activity (dpm/100 cm^2) against the Gaussian cumulative distribution function (cdf) on a probability scale. For convenience, the distribution function, F(x), is plotted as the abscissa (probability grades), and x, the activity, is plotted as the ordinate (linear grades). The Gaussian function plotted in the following section takes on the shape of a straight line due to the orientation of the axes and the nonlinear x-axis.

C. DATA ANALYSIS

From the plot of activity vs. cumulative probability, the mean contamination value of the lot is the value on the ordinate axis where the distribution intersects the 50% cumulative probability. The figures display the results on an expanded scale so that the variations in the data can be seen in detail. The distribution is analyzed in terms of sampling inspection, "inspection by variables.". The test is satisfied if the Gaussian straight line (clearly visible in the figure) passes below the intersection of the upper limit U on the y axis and 93% cumulative probability. In most cases, however, the upper limit is off scale on the graphs presented; the area is well below contamination limits.

The test statistic $\bar{x}$ + ks is compared to the acceptance limit U, where:

$\bar{x}$ = average (arithmetic mean of measured values)

s = observed sample standard deviation

k = tolerance factor calculated from the number of samples to achieve desired sensitivity to the test

U = acceptance limit.

The State of California has stated that the consumer's risk of acceptance (ß) at 10% defective (LTPD) must be 0.1. For these choices of ß and LTPD, $K_\beta = K_2 = 1.282$. The number of samples is n. Values of k for each sample size are calculated in accordance with the following equations:

$$k = \frac{K_2 + \sqrt{K_2^2 - ab}}{a} \quad ; \quad a = 1 - \frac{K_\beta^2}{2\,(n-1)} \quad ; \quad b = K_2^2 - \frac{K_\beta^2}{n} \qquad \text{(Eq. 4)}$$

where

k = tolerance factor

K_2 = The normal deviate exceeded with probability of ß, 0.10. (from tables, K = 1.282)

K_β = The normal deviate exceeded with probability equal to the LTPD, 10% (from tables, K = 1.282)

n = number of samples

The criteria for acceptance are presented as a plan of action. The plan of action is:

1) Acceptance: If the test statistic ($\bar{x}$+ks) is less than or equal to the limit (U), accept the region as clean. (If any single measured value exceeds 80% of the limit, decontaminate that location to as near background as is possible, but do not change the value in the analysis.)

2) Collect additional measurements: If the test statistic ($\bar{x}$+ks) is greater than the limit (U), but $\bar{x}$ itself is less than U, independently resample and combine all measured values to determine if $\bar{x}$+ks < = U for the combined set; if so, accept the region as clean. If not, reject the region.

3) Rejection: If the test statistic ($\bar{x}$+ks) is greater than the limit (U) and $\bar{x}$ > = U, reject the region.

In addition to the formal survey measurements made for computerized data reduction, search and survey techniques were conducted throughout the building on special structural features and components where contamination might have deposited. Applicable correction factors were used to convert the counts recorded into meaningful data units (dpm/100 cm^2). If the area being measured was contaminated to a level which was 80% of the acceptance limit, the result was recorded and the area decontaminated to ALARA principles.

V. SAMPLING INSPECTION

A. COUNTING STATISTICS

The emission of atomic and nuclear radiation obeys the rules of quantum theory. As a result of this, one can only determine the probability that an emission will occur. If one attempts to measure the number of particles emitted by a radioactive source, that number is not constant in time; it has a statistical variation because of the probabilistic nature of the phenomenon under study. The number of particles emitted per unit time is different for successive units of time. Therefore, one can only determine the average number of particles emitted per unit time and per unit area. Because of the probabilistic nature of particles emitted by radioactive elements, repeated measurements of the average number of emissions per unit time will show a distribution approximated by the Gaussian (or normal) probability density function (pdf). If measurements are made at many similar locations, these measurements will generally show a somewhat greater variability, but the distribution will remain adequately represented by a Gaussian function. Thus the number of occurrences of particular contamination values, f(x), shows a Gaussian pdf relative to the contamination value, and the data can be plotted accordingly. Subsequently, based on the results of the data analysis, a conclusion can be made regarding the level of residual contamination in the building.

The Gaussian distribution, g(x), is given by:

$$g(x)dx = \frac{1}{(\sqrt{2\pi})\sigma} \exp \left[- \frac{(x-m)^2}{2\sigma^2} \right] dx$$

where

- $g(x)dx$ = probability that the value of x, the measured value, lies between x and x + dx
- m = Average or mean of the distribution
- σ^2 = Variance of the distribution.

A graph of g(x) vs x gives the following bell-shaped curve:

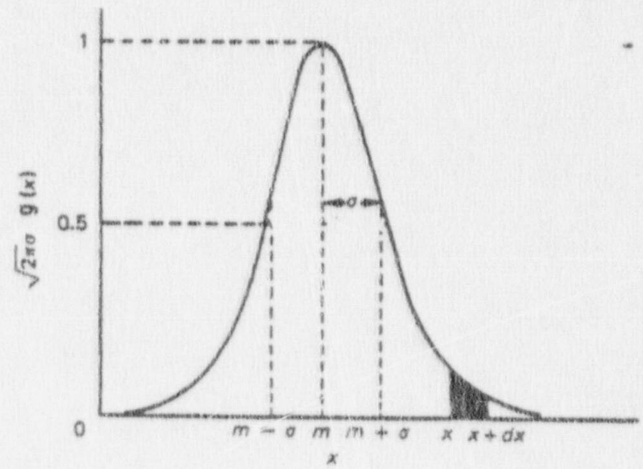


Figure 6. The Gaussian Probability Density Function

Furthermore, the cumulative distribution function (cdf), G(x), (equal to the integral of the pdf, for a continuous random variable) is:

$$G(X) = \int_{-\infty}^{X} g(x)dx$$

$$= P(x <= X)$$

This function is commonly referred to as the error function, (erf). The graph of the Gaussian cdf is:

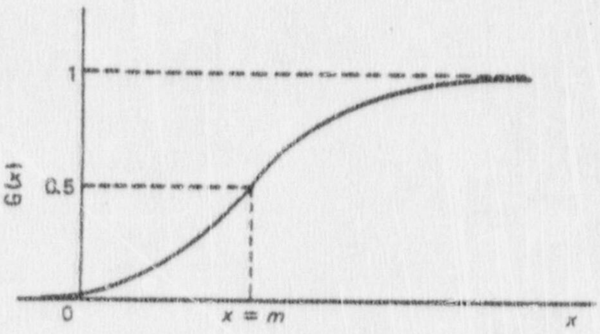


Figure 7. The Gaussian Cumulative Distribution Function

If x is the survey measurement (in the case of radiation measurements, the number of counts), the standard deviation of the measurement is the square root of x. Background radiation must also be considered to calculate the net number of counts. Thus, the error, or standard deviation associated with the measurement, becomes:

$$S = \frac{\sqrt{C^2 + B^2}}{T} \quad \text{(Eq. 5)}$$

where

C = The number of counts recorded in time, T, of the sample

B = The number of counts recorded in time, T, of the background radiation environment

T = Time of count, assumes the sample count time is equal to the background count time.

Finally, corrections must be made for instrumentation parameters including geometry and efficiency.

B. SAMPLING INSPECTION BY VARIABLES

Acceptance inspection by variables is a method of judging whether a lot of items is of acceptable quality by examining a sample from the lot, or population. In the case of determining alpha contamination in the NMDF, it would be unacceptably time consuming and not cost effective to measure and document 100% of the building. However, by applying sampling inspection by variables methods, the confidence of the conclusion made about the level of contamination is not sacrificed due to the decrease in number of sampling locations.

In acceptance inspection by attributes, the radiation measurement in a given area is recorded numerically and classified as either being defective or nondefective, according to regulatory acceptance criteria. A defect means an instance of a failure to meet a requirement imposed on a unit with respect to a single quality characteristic. Second, a decision is made from the number of defective areas in the sample whether the percentage of defective areas in the lot is small enough for the lot to be considered acceptable. In acceptance inspection by variables, the result is recorded numerically and is not treated simply as a boolean statistic, so fewer areas need to be inspected for a given degree of confidence in judging a lot's acceptability.

The test statistic, $\bar{x} + ks$ is compared to the acceptance limit U, where:

$\bar{x}$ = average (arithmetic mean of measured values)
s = observed sample standard deviation
k = tolerance factor calculated from the number of samples to achieve the desired sensitivity for the test
U = acceptance limit.

The sample mean, standard deviation, and acceptance limit are easily calculable quantities; the value of k, the tolerance factor, bears further discussion. Of the various criteria for selecting plans for acceptance sampling by variables, the most appropriate is the method of Lot Tolerance Percent Defective (LTPD), also referred to as the Rejectable Quality Level (RQL). The LTPD is defined as the poorest quality in an individual lot that should be accepted. Associated with the LTPD is a parameter referred to as consumer's risk (β), the risk of accepting a lot of quality equal to the LTPD. USNRC Regulatory Guide 6.6 states that the value for the consumer's risk should be 0.10. Conventionally, the value assigned to the LTPD has been 10%. These a priori determinations are consistent with the literature and regulatory position and are the same values used by the State of California.[2] Thus, based on sampling inspection, we are willing to accept the hypothesis that the probability of accepting a lot as not being contaminated which is in fact 10% defective is 0.10. The value of k, which is a function of the a priori determinations made for β and LTPD is given by Equation 4 in the previous section.

Figure 8 demonstrates this principle. The operating characteristics curve of a Gaussian sample distribution shows the principles of consumer's and producer's risk, in addition to LTPD and the acceptable quality level. The criteria for acceptance of a lot are presented in Section IV.

The coefficients K_2 and K_β are equal because of the choice for the values of β and LTPD as 0.10. Statistics textbooks listed in the reference section (5-7) provide additional explanation of this sampling principle. The a priori values chosen for the sampling coefficients are consistent with industrial sampling practice and regulatory guides.

0

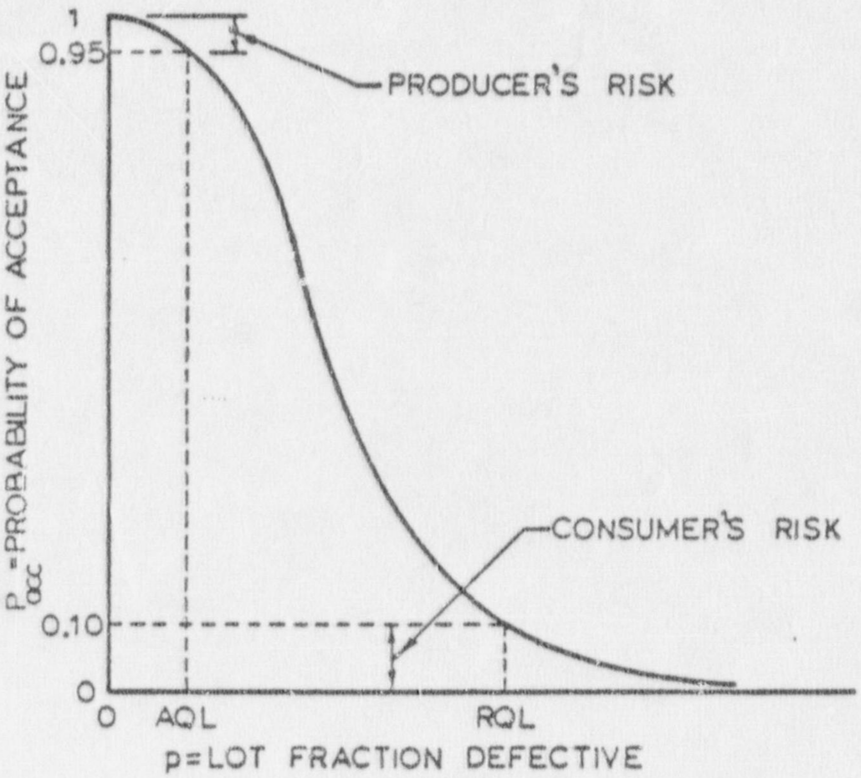


Figure 8. Operating Characteristics Curve

VI. PROCEDURES

The following procedures were used in performing this survey. (Reference supporting document, N704DWP990084, "Final Radiological Survey Detailed Work Procedure").

A. CALIBRATION AND INSTRUMENT CHECKS

Instrument qualification data sheets were recorded for each background and source check. Instruments used for the final survey were calibrated and checked a minimum of every morning, noon, and evening for the duration of the project as follows.

Portable Survey Instruments (Ludlum 2220-ESG Scalers):

1) Turn the instrument 'ON' and allow to warm up for 5 min.
2) Check high voltage (700-750 V alpha, 800-950 V beta).
3) Check threshold (140-190 alpha, 250-350 beta).
4) Window in/out switch is set to out.
5, Check battery (greater than 500).
6) Set range selector to 1, response to fast, and count time to 5 min.
7) Take and record a 5-min background count in an uncontaminated area which typifies the area to be surveyed.
8) Take and record a 5-min count of known alpha and beta standards; an electroplated Pu-239 and electroplated Tc-99 source, respectively. The efficiency factor (dpm/cpm) is calculated as the ratio of 2 times the 2π emission rate of the source (dpm) to the net count rate of the instrument. The radioactivity of the calibration sources is traceable to NBS.

9) Calculate the area of the end window and record value. (This is performed only once for each probe type.).

Gas-flow Proportional:

1) Equipment is to be left in the 'ON' position at all times.

2) Using uncontaminated planchets, take four 5-min background counts.

3) Take and record 5-min counts of known alpha and beta standards; 2-in. Pu-239 and Tc-99 sources, respectively. Calculate efficiency factors accordingly.

Average the Daily Results:

Calculate the average background and efficiency factor of each instrument for morning and afternoon. The morning value should be the average of the 7:00 a.m. and 11:30 a.m. measurements; the afternoon value should be the average of the 11:30 a.m. and 16:00 p.m. measurements.

B. AVERAGE CONTAMINATION MEASUREMENTS

1) Identify 1-m^2 area to be measured: 1 m^2 per 9 m^2 surface should be surveyed to be consistent with a minimum 11% sampling plan.

2) With portable scalar instrumentation (Ludlum 2220-ESG) set for 5-min count time, using an alpha probe (Ludlum Model 43-1) on one instrument and a beta probe (Ludlum 44-9) on another, uniformly scan the area. (Watch and listen for "hot spots" where radioactivity may exceed the average limit. These are to be resurveyed later.)

3) Record the location, total count, background, efficiency factor, area factor, and date/time.

4) Enter the data into Visicalc spreadsheet.

C. MAXIMUM CONTAMINATION MEASUREMENT

1) Return to any area identified as having a "hot spot."

2) Repeat the uniform scan of only the hot spot area, covering approximately 100 cm^2 with the probe.

3) Record the location, total count, background, efficiency factor, area factor, date/time, and maximum contamination value.

4) Enter the data into Visicalc spreadsheet.

D. REMOVABLE CONTAMINATION MEASUREMENTS

1) Using an NPO 2-in.-diam cloth swipe, wipe an "S" pattern, with legs approximately 6 in. long, so as to sample removable contamination from an area of approximately 100 cm^2 within the 1-m^2 grids identified and sampled with the survey meters.

2) Place smear in envelope kit and record the location of the sample grid on the envelope. Save until ready for counting.

3) Count radioactivity using gas-flow proportional counter (NMC Model ACS-77) for 5 min.

4) Record the location, total alpha and beta counts, background, and efficiency factors for each.

5) Enter the data into Visicalc spreadsheet.

E. MISCELLANEOUS GAMMA QUALIFICATION INSPECTION

1) As necessary, collect various samples of debris, dirt, and other material which indicate detectable alpha activity. Because Pu and DU were the only radioactive materials handled at the facility, it is desirable to qualify the measurement.

2) Place the sample in the calibrated high-purity germanium (HPGe) detector and use the multichannel analyzer to qualify the radioactive material.

F. SURVEYS OF SPECIAL STRUCTURAL FEATURES AND COMPONENTS

1) Using a Ludlum Model 12 count rate meter in connection with a Ludlum Model 43-5 rectangular alpha scintillation probe, survey various building features and components which are suspect of containing residual contamination.

2) Perform an instrument calibration check three times daily using the Pu-239 source mentioned above.

3) Ensure that the transit velocity (in cm/s) does not exceed one-third the numerical value of the detector window dimension (in cm), in the direction parallel to the motion of the probe.

VII. SURVEY RESULTS

A. STATISTICAL RESULTS

The survey of the NMDF was conducted using the survey plan previously described. A summary of the survey results appear below in Tables 1 through 3 for each of the inspection lots. The results used in the mathematical statistical analysis are shown in Appendix A.

TABLE 1

SUMMARY OF SURVEY RESULTS
(Office Area and Other Unposted Areas)

		(dpm/100 cm^2)			
Measurement	Number of Location	Average Value	Maximum Value	Inspection Test Statistic	Limit
Average alpha	141	2.6	14	8.1	100
Maximum alpha	0	-	-	-	300
Removable alpha	141	0.3	4	2.3	20
Average beta	141	54.3	1065	744.2	10000
Maximum beta	0	-	-	-	30000
Removable beta	141	5.2	34	19.2	2000

TABLE 2

SUMMARY OF SURVEY RESULTS
(Glovebox Room)

		(dpm/100 cm^2)			
Measurement	Number of Location	Average Value	Maximum Value	Inspection Test Statistic	Limit
Average alpha	202	7.1	94	23.6	100
Maximum alpha	11	-	1067	-	300
Removable alpha	202	0.5	11	2.4	20
Average beta	202	364.5	1361	1156.8	10000
Maximum beta	0	-	-	-	30000
Removable beta	202	5.1	36	20.5	2000

TABLE 3

SUMMARY OF SURVEY RESULTS
(Posted Areas)

Measurement	Number of Location	Average Value (dpm/100 cm^2)	Maximum Value (dpm/100 cm^2)	Inspection Test Statistic	Limit
Average alpha	201	5.7	140	26.7	100
Maximum alpha	11	-	10465	-	300
Removable alpha	201	0.4	15	2.4	20
Average beta	201	183.9	1431	978.6	10000
Maximum beta	9	-	41664	-	30000
Removable beta	201	3.4	28	18.6	2000

Because the number of hot spots discovered were few in number, the average value and inspection test statistic were not calculated; both values are meaningless. Table 4, however, lists the hot spot locations and corresponding levels of contamination. The hot spots found were smaller in area than the detector end window, thus the reported value is greater by a factor of 1.4 for alpha and 5 for beta such that the measurement result is extrapolated to an area equal to 100 cm^2.

In all cases where contamination was determined to be 80% of the acceptance limits, the area was decontaminated to activity levels below the instrument detection limit. From the smears taken during the survey, no removable activity was found throughout the building.

The survey data for each test characteristic are displayed as cumulative distribution functions in Figures 9 through 20. These figures show each survey value, arranged in order of magnitude from left to right, and a straight line representing the derived Gaussian distribution. In most cases the acceptance limit is substantially above the top edge of the graph; the graph is bounded in the positive y direction by the greatest measurement taken for that lot. The mean of each distribution is that value on the ordinate which

TABLE 4

MAXIMUM SURFACE ACTIVITY
(Hot Spots)

Location	(dpm/100 cm^2) Alpha	Beta	Comment
127 E5,14	239	0	Orig. survey, paint sampled
127 E5,13	598	0	Add'l survey, paint removed
127 E5,15	1067	0	Add'l survey, paint removed
127 E5,16	140	0	Add'l survey, paint removed
127 S1,1	87	0	Beam, contamination removed
127 S1,8	102	0	Beam, contamination removed
127 B2S10	58	0	Beam, contamination removed
127 B3N6	79	0	Beam, contamination removed
127 B3S16	29	0	Beam, contamination removed
127 B4N15	118	0	Beam, contamination removed
127 B4S6	146	0	Beam, contamination removed
126 F3,4	10465	1	Cleaned to NDA, add'l surveys
130 F7,2	236	2	Cleaned to NDA, add'l surveys
129 S1,2	0	1230	Cleaned to NDA
VAULT F1,3	42	0	Cleaned to NDA, add'l surveys
VAULT F5,3	0	41664	Cleaned to NDA, add'l surveys
HOLDUP F4,3	92	0	Surveyed add'l locations
HOLDUP F6,5	191	1826	Surveyed add'l locations
HOLDUP F1,3	23	0	Surveyed add'l locations
HOLDUP F4,1	68	1742	Surveyed add'l locations
HOLDUP F4,2	94	1247	Surveyed add'l locations
HOLDUP F3,3	49	1333	Surveyed add'l locations
HOLDUP F3,4	113	882	Surveyed add'l locations
HOLDUP F5,2	158	1333	Surveyed add'l locations

NDA: No Detectable Activity

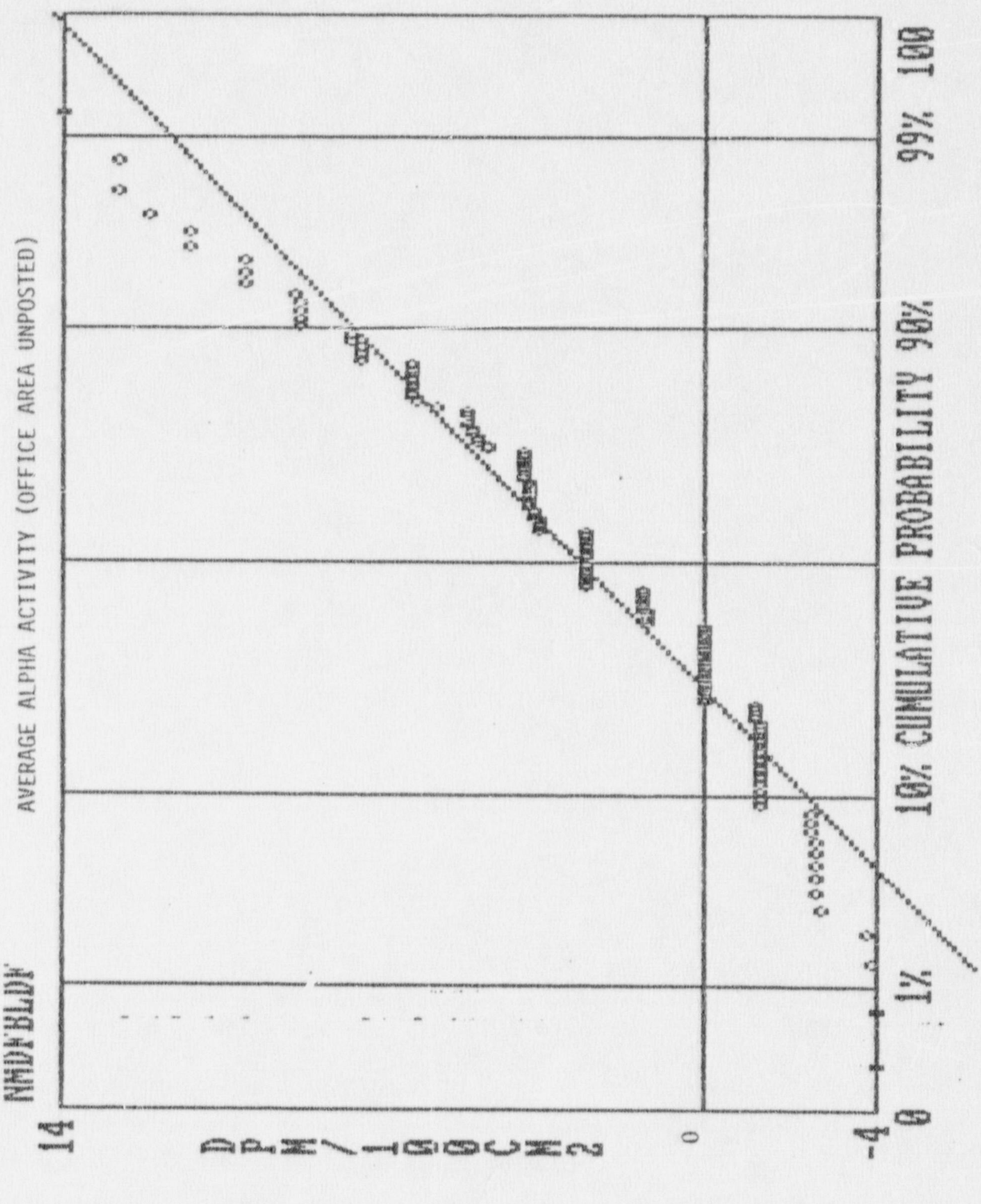

AVERAGE ALPHA ACTIVITY (OFFICE AREA UNPOSTED)
DPM/100CM2
14
0
-4
0
1%
10% CUMULATIVE PROBABILITY 90%
99%
100

FIGURE 9

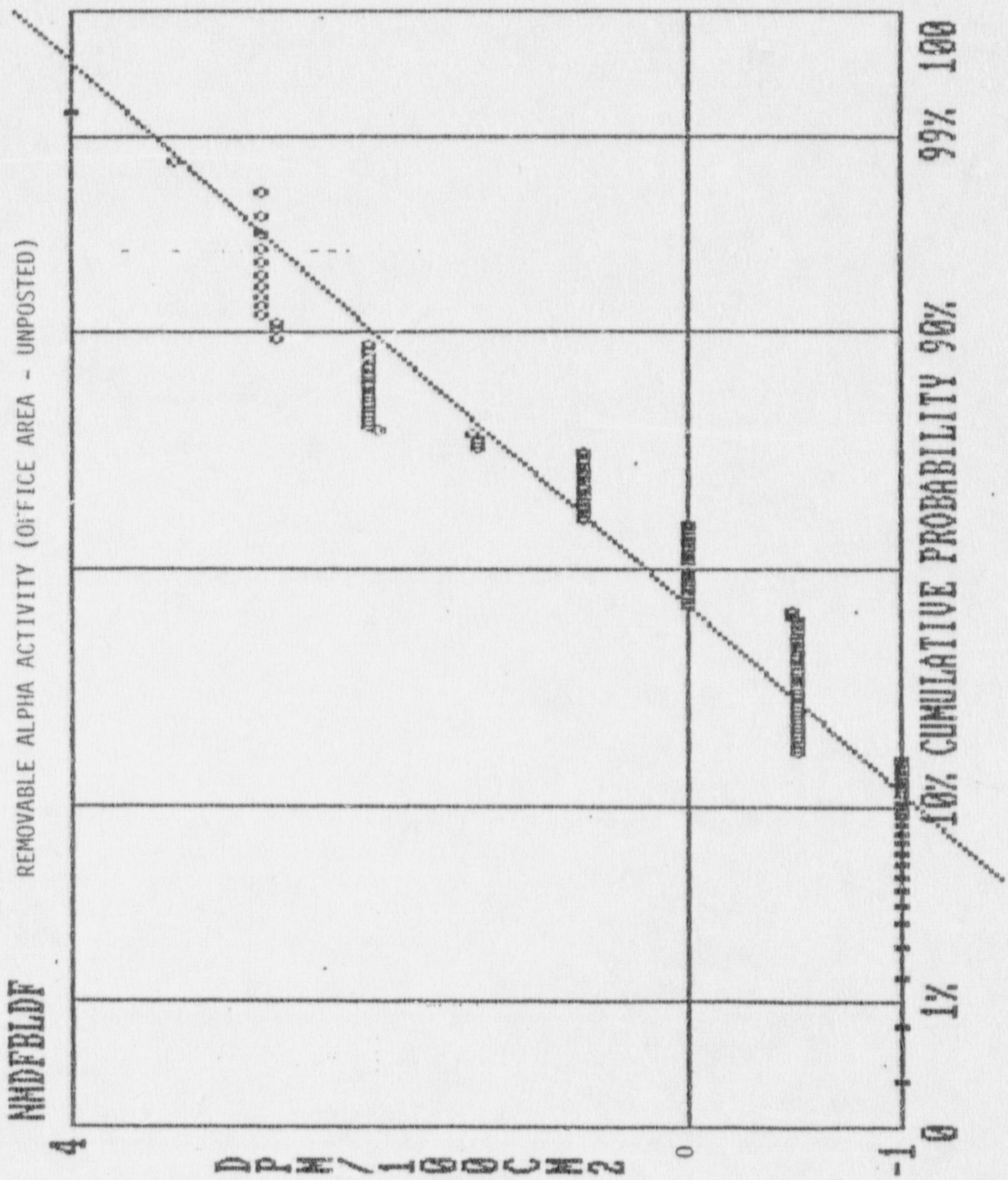

NHDFBLDF
REMOVABLE ALPHA ACTIVITY (OFFICE AREA - UNPOSTED)
DPM/100CM2
4
0
-1
0
1%
10% CUMULATIVE PROBABILITY 90%
99%
100

FIGURE 10

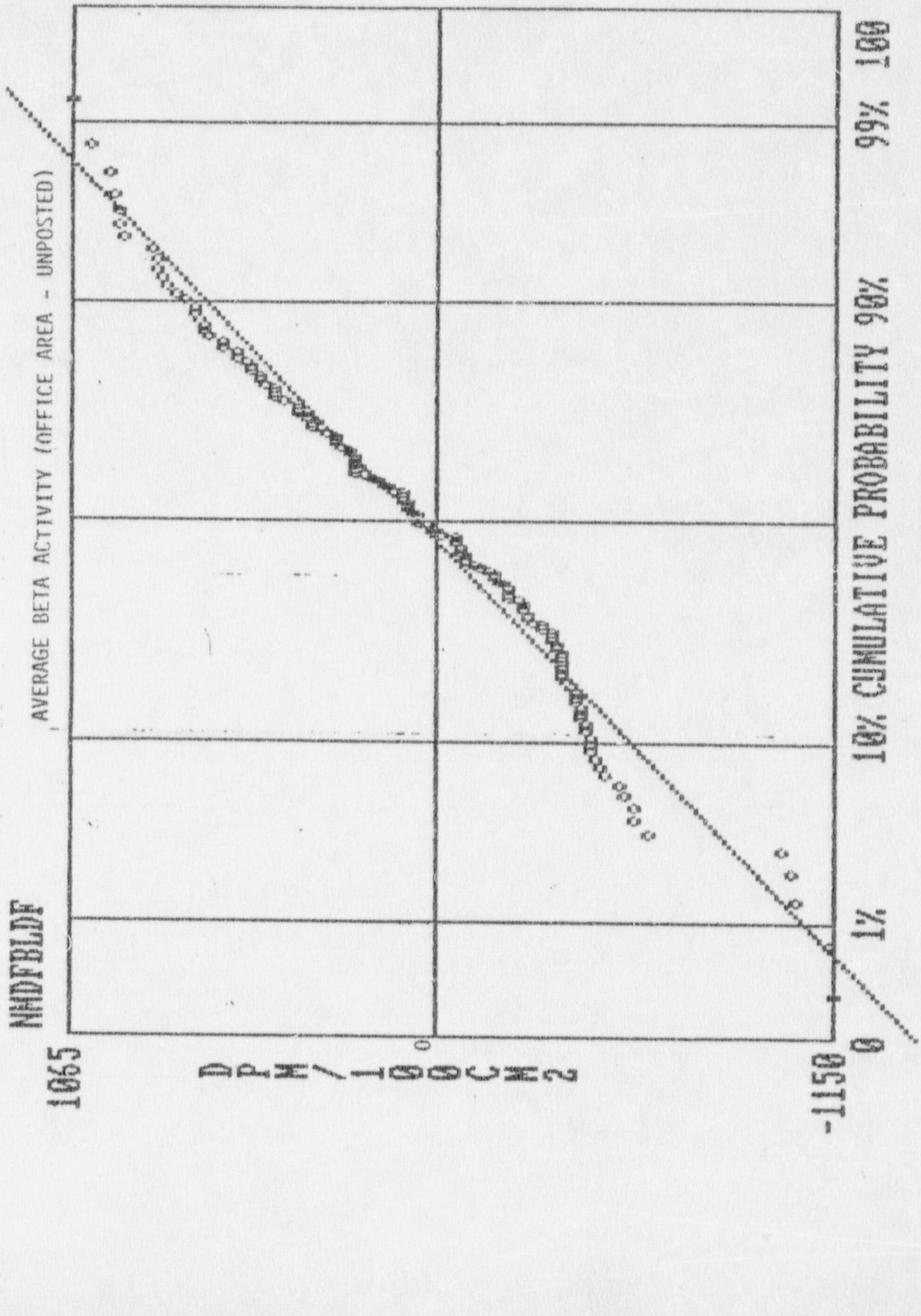

NHDFBLDF
AVERAGE BETA ACTIVITY (OFFICE AREA - UNPOSTED)
1065
0
-1150
DPM/100CM2
0 1% 10% CUMULATIVE PROBABILITY 90% 99% 100

FIGURE 11

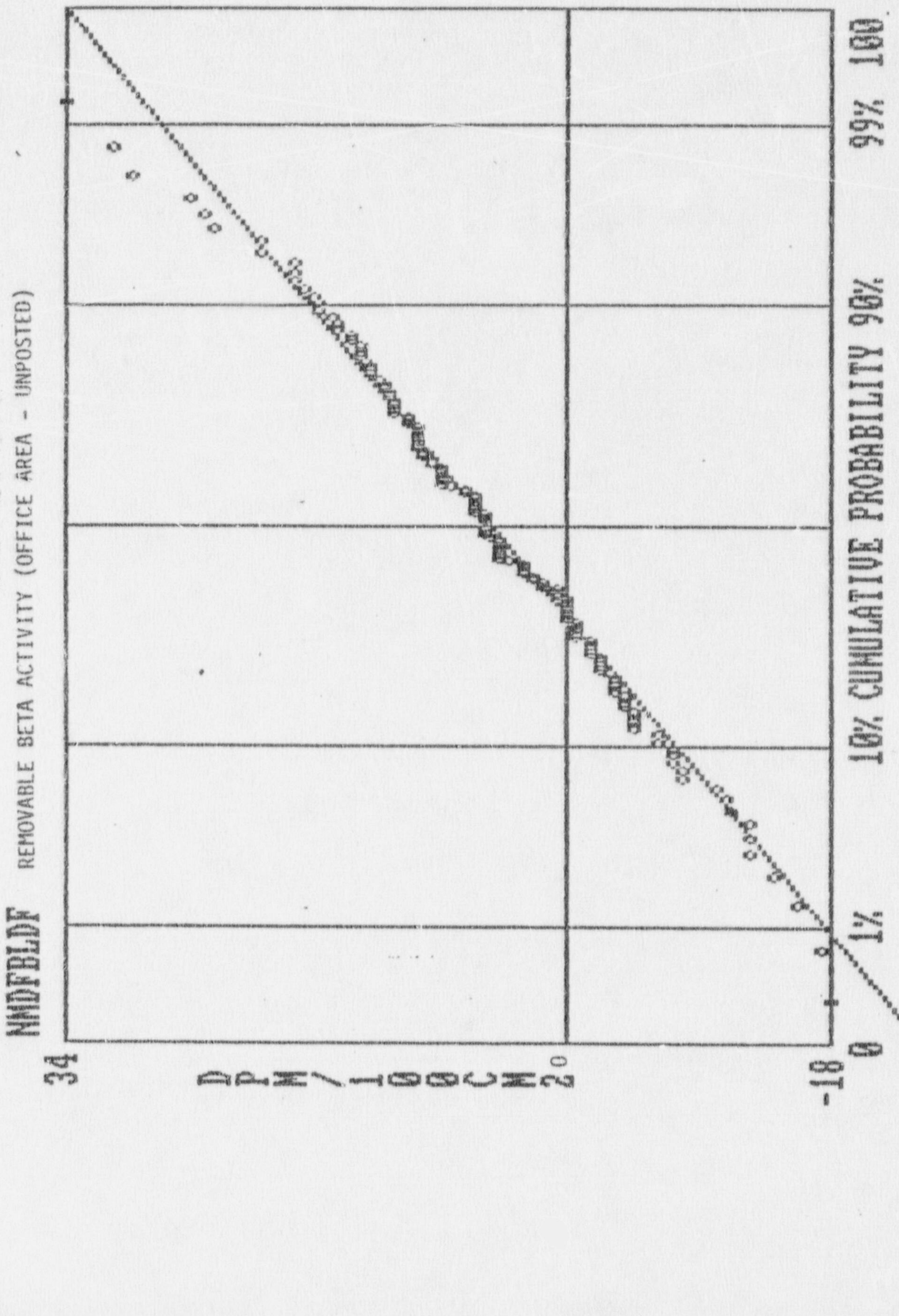

NMDFBLDF
REMOVABLE BETA ACTIVITY (OFFICE AREA - UNPOSTED)
34
DPM/100CM2
0
-18
0
1%
10% CUMULATIVE PROBABILITY 90%
99%
100

FIGURE 12

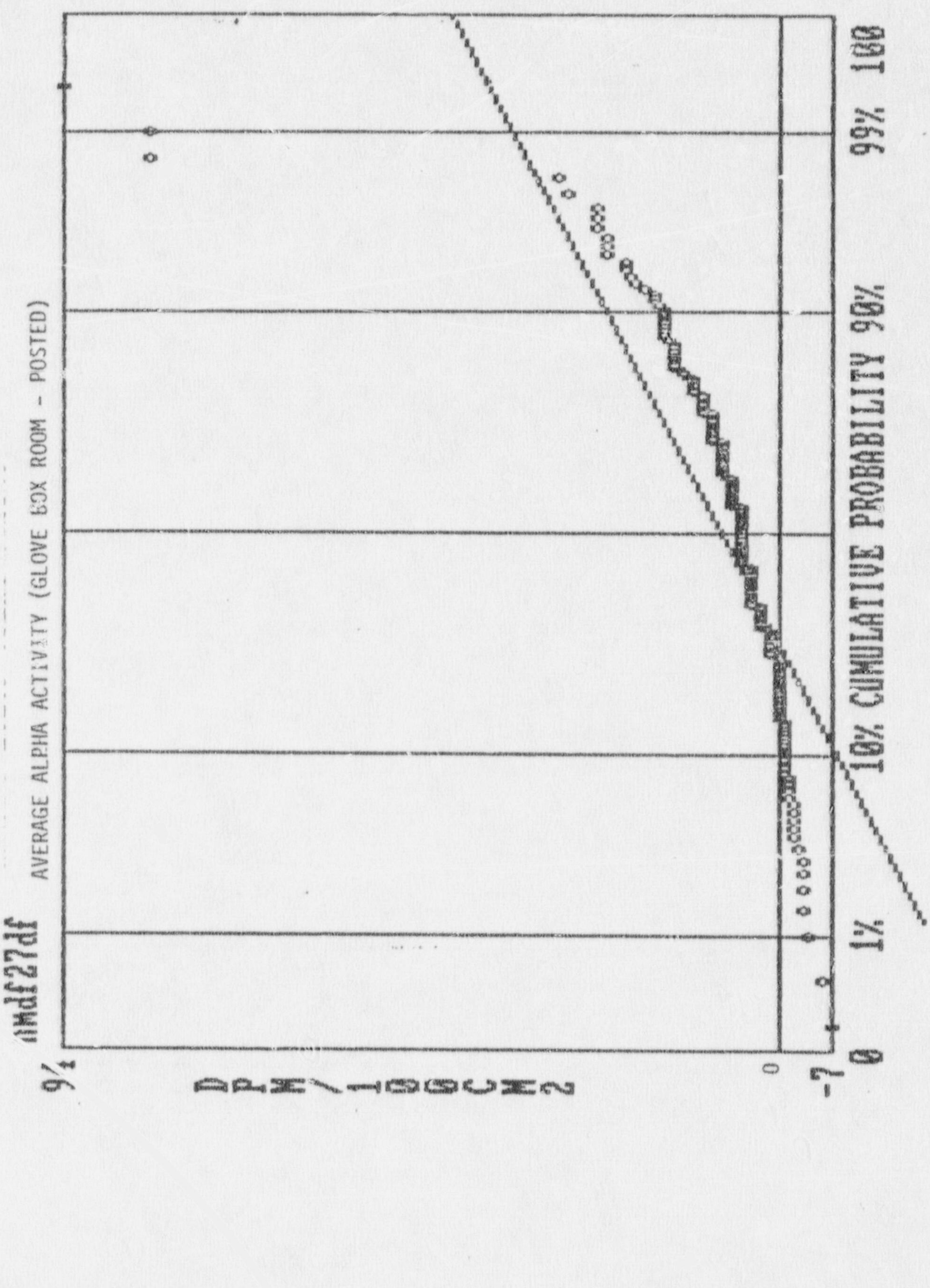

AVERAGE ALPHA ACTIVITY (GLOVE BOX ROOM - POSTED)
DPM/100CM2
0
-7
0
1%
10% CUMULATIVE PROBABILITY 90%
99%
100

FIGURE 13

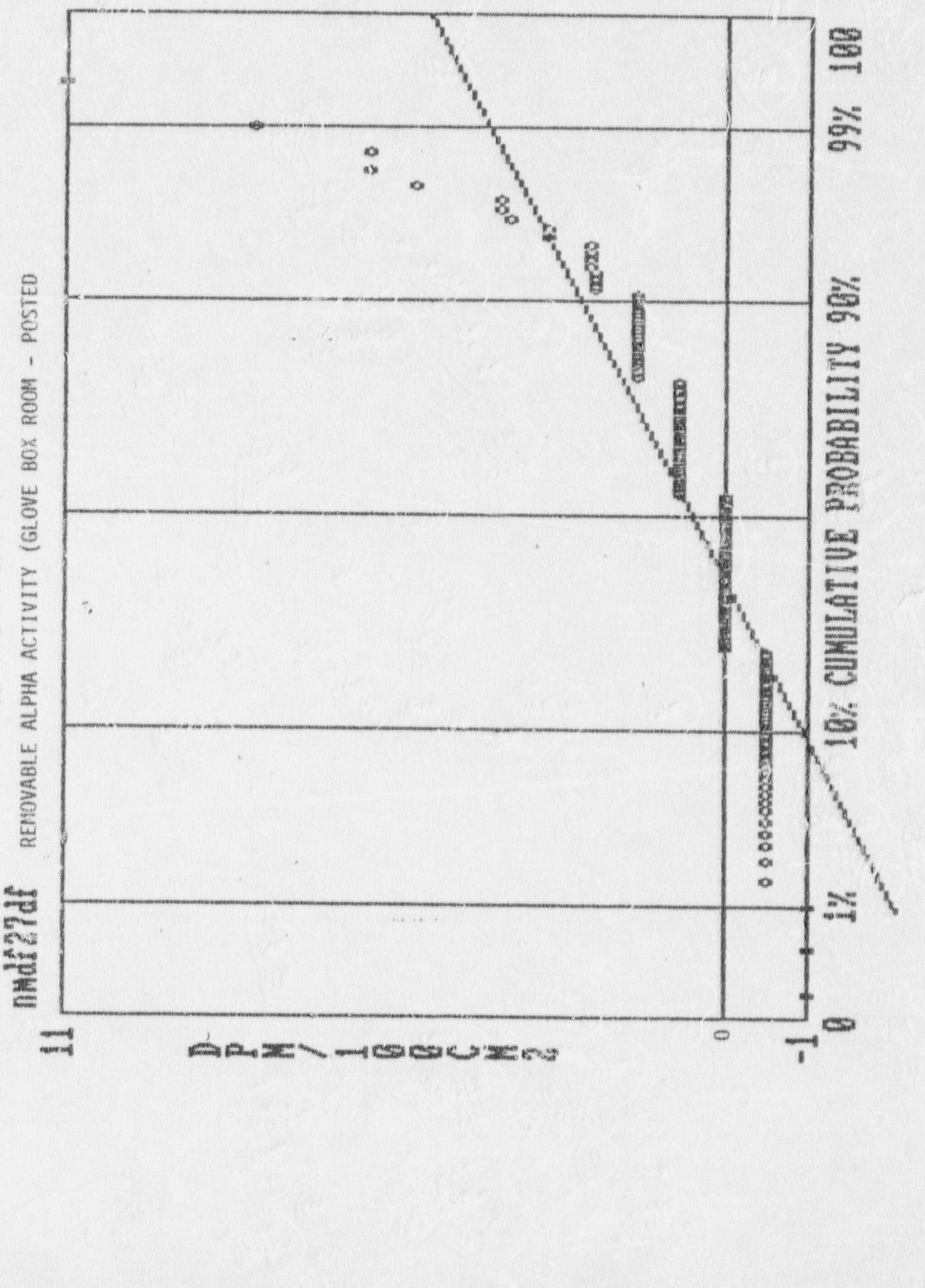

REMOVABLE ALPHA ACTIVITY (GLOVE BOX ROOM - POSTED
DPM/100CM2
11
0
-1
0
1%
10% CUMULATIVE PROBABILITY 90%
99%
100

FIGURE 14

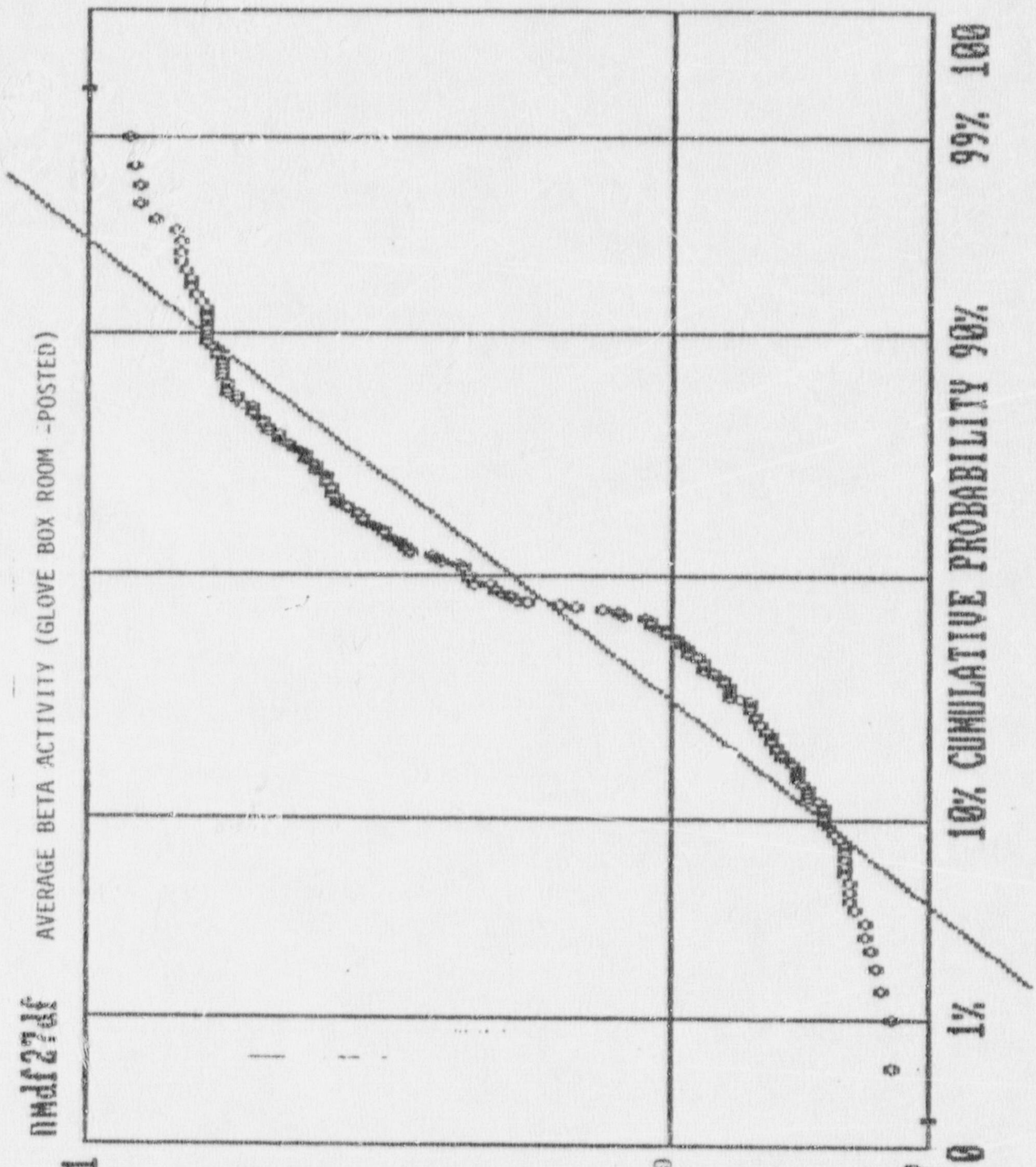

AVERAGE BETA ACTIVITY (GLOVE BOX ROOM -POSTED)
1361
DPM/100CM2
0
-607
0
1%
10% CUMULATIVE PROBABILITY 90%
99%
100

FIGURE 15

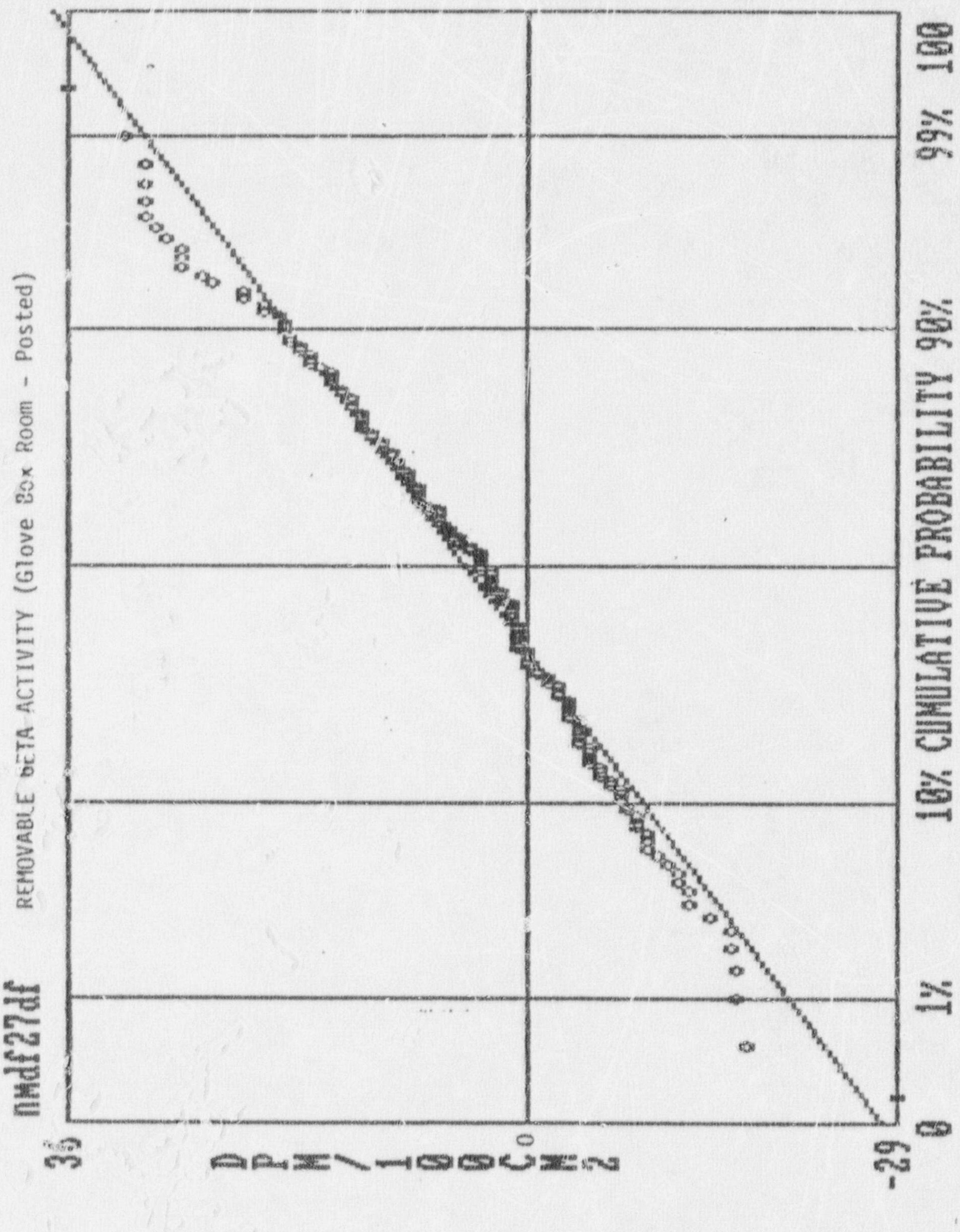

REMOVABLE BETA ACTIVITY (Glove Box Room - Posted)
35
DPM/100CM2
0
-29
0
1%
10% CUMULATIVE PROBABILITY 90%
99%
100

FIGURE 16

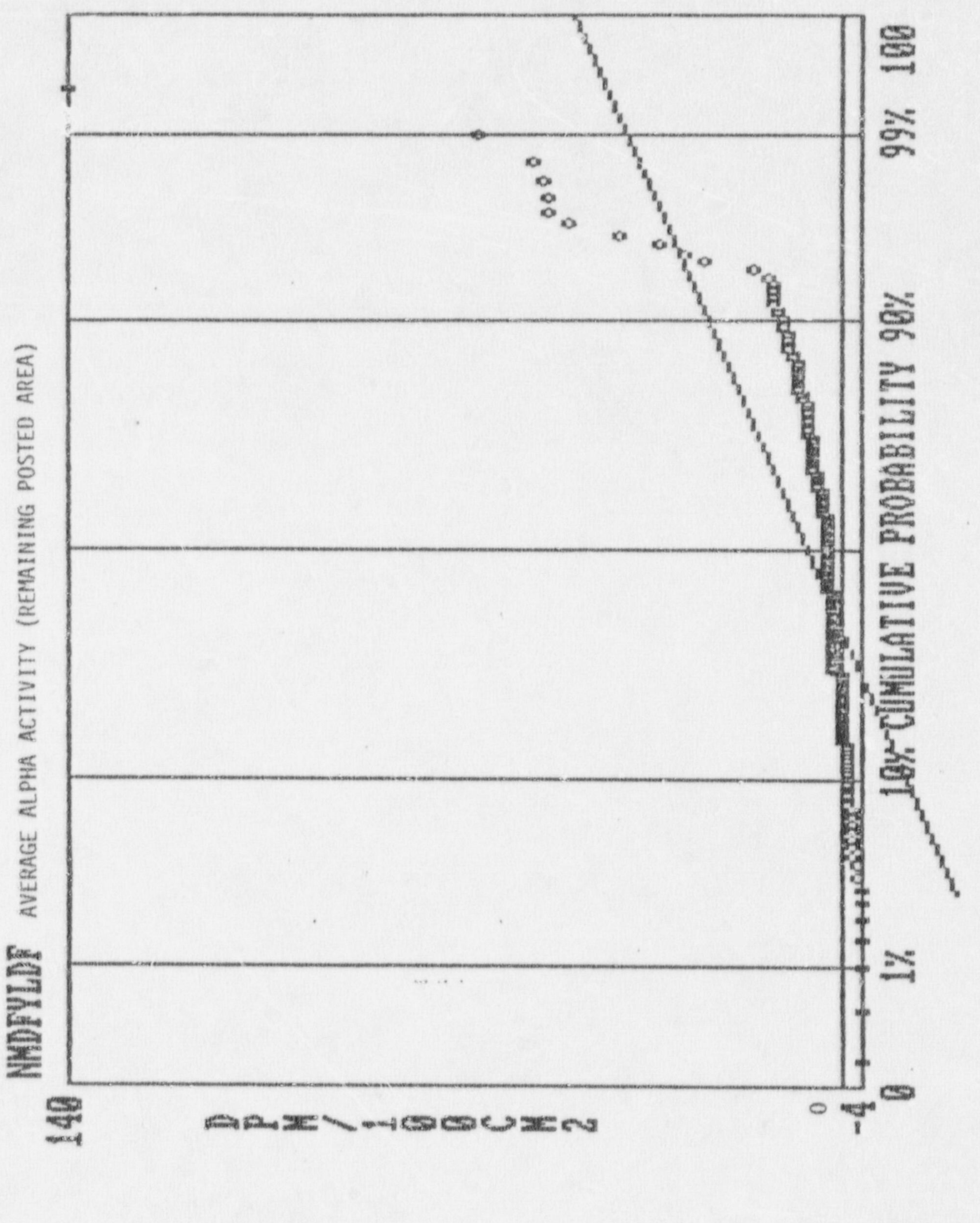

NMDFYLDF AVERAGE ALPHA ACTIVITY (REMAINING POSTED AREA)
140
DPM/100CM2
0
-4
0
1%
10%
CUMULATIVE PROBABILITY
90%
99%
100

FIGURE 17

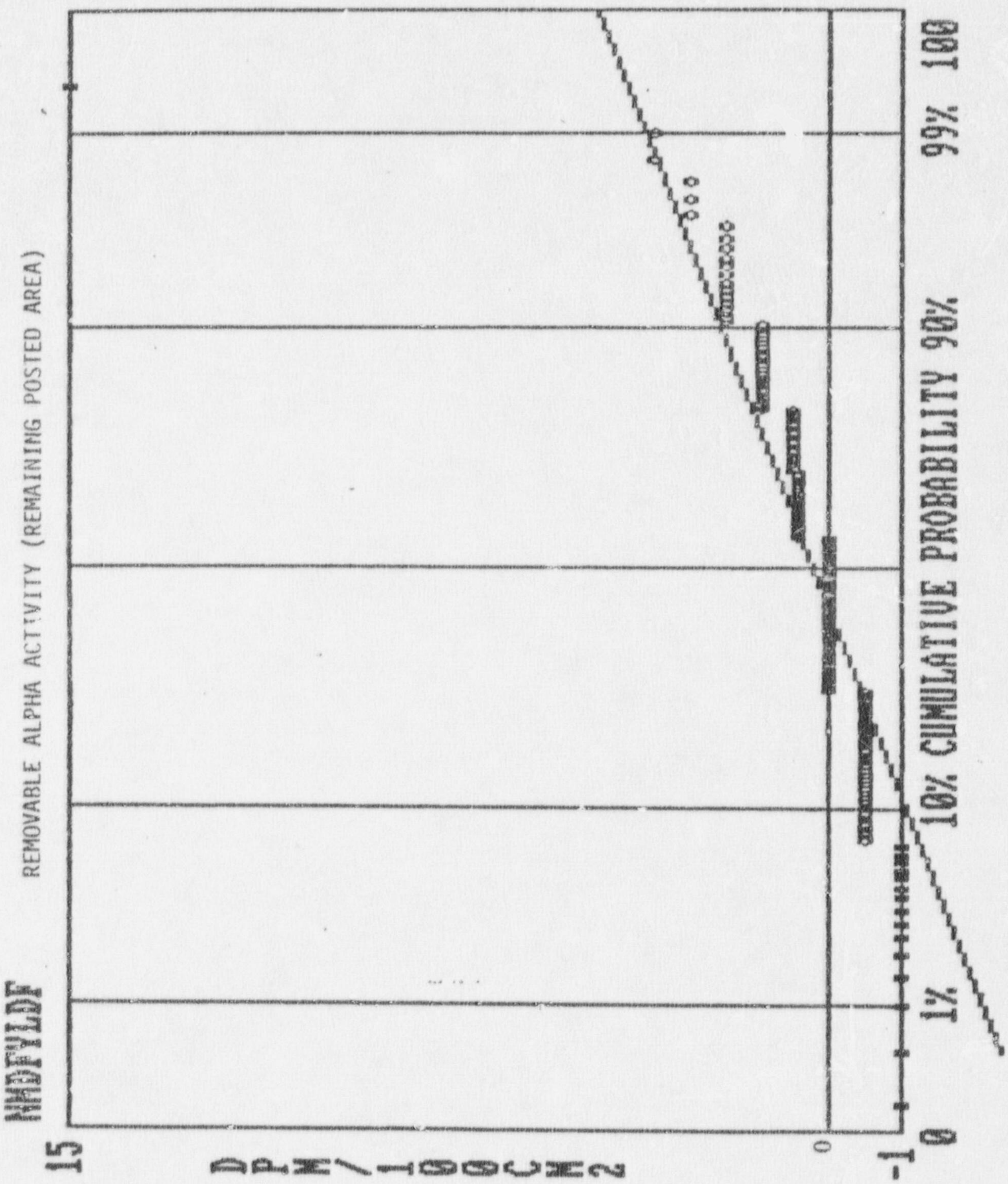

REMOVABLE ALPHA ACTIVITY (REMAINING POSTED AREA)
15
0
-1
0
1%
10% CUMULATIVE PROBABILITY 90%
99%
100

FIGURE 18

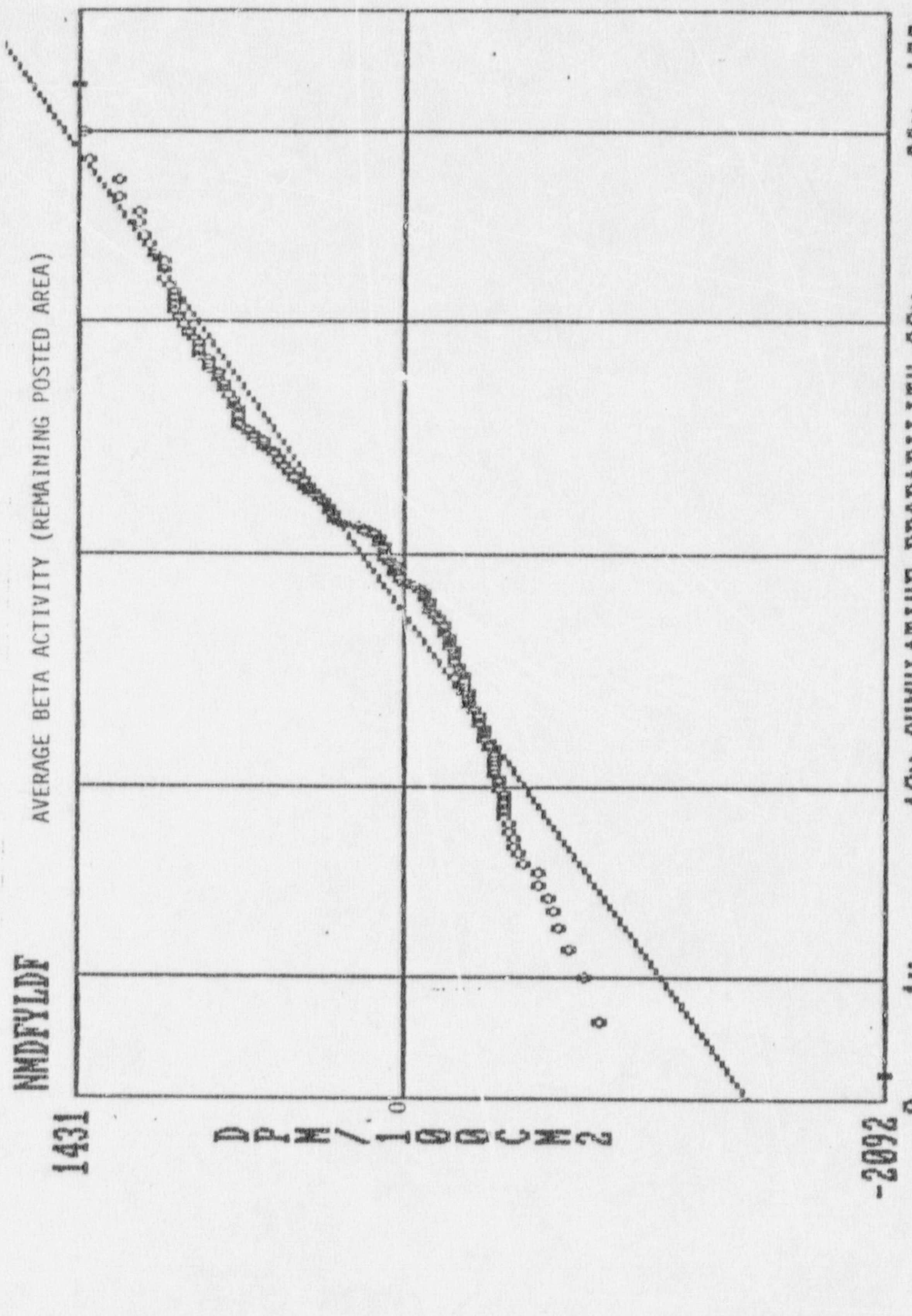

NMDFYLDF
AVERAGE BETA ACTIVITY (REMAINING POSTED AREA)
1431
DPM/100CM2
0
-2092
0
1%
10% CUMULATIVE PROBABILITY 90%
99%
100

FIGURE 19

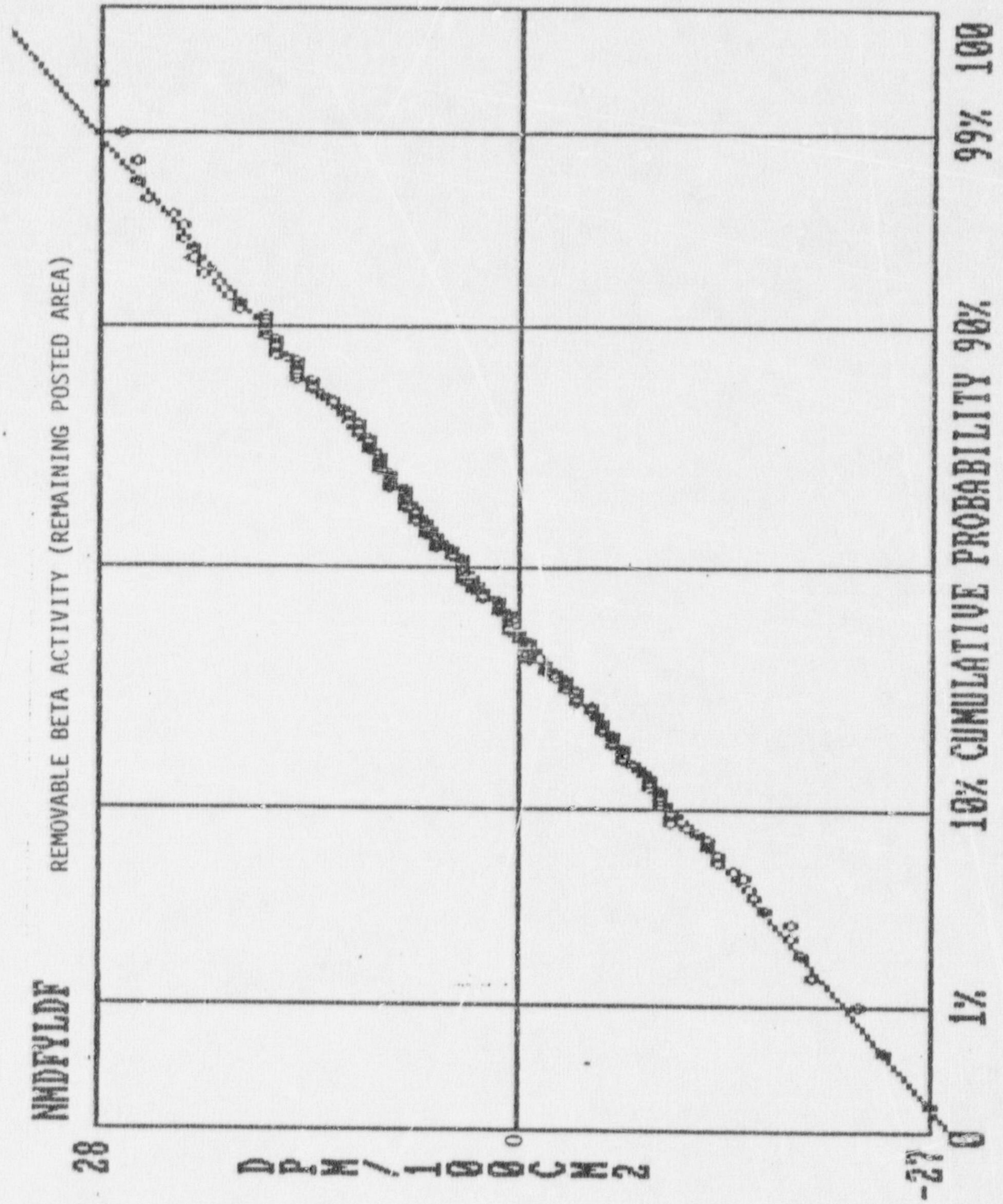

NMDFYLDF
REMOVABLE BETA ACTIVITY (REMAINING POSTED AREA)
DPM/100CM2
28
0
-27
0
1%
10% CUMULATIVE PROBABILITY 90%
99%
100

FIGURE 20

corresponds to a 50% cumulative probability of the abcissa. One, two, and three standard deviations above the mean corresponds to 84%, 97.7%, and 99.8% cumulative probability, respectively. The value of k used in the inspection test is very nearly 1.5 for each case; thus, the "k" line will run perpendicular to the abcissa corresponding to about a 93.3% cumulative probability. The Gaussian distribution line must pass below the intersection of the "k" line (about 93%) and the horizontal line showing the acceptance limit at that point in order to accept the lot as being noncontaminated. For all survey result characteristics, the test statistic, $\overline{x} + ks$, is well below the acceptance limit, U. The results summarized in these tables and graphs confirm that all areas are acceptable for release for unrestricted use at the present time.

Many times, because of the conservative action level we maintained (80% of the acceptance level), additional samples were taken. Areas of increased sampling are discussed in the following subsection, B. Additionally, various components and special features of the building were qualitatively surveyed to determine possible contamination problems in areas beyond the 1-m^2 grids surveyed for statistical analysis. Concurrent with the final survey, additional decontamination was performed. Finally, interesting anomalies were identified during the course of the final survey; these occurrences are described in Subsection E.

B. AREAS OF INCREASED SAMPLING

Sampling was increased above 11% in several areas of the building if either a square-meter grid was found to be contaminated to values exceeding 80% of the acceptance limits or if a particular section of the building was known to have experienced a contamination incident. Sampling was increased in two areas of the building which were suspect of containing residual contamination from contamination incidents: fourteen additional floor samples were collected near the east wall of the glovebox room where the glovebox overpressurization incident took place; five additional floor samples were collected in the vicinity of the location of the vacuum pump, where a seal leaked oil and released contamination. The samples collected above were not taken as a result of a positive indication of contamination. All 19 samples were included in the statistical analysis; no detectable activity was found.

On the other hand, additional sampling was performed in six separate location due to contamination results exceeding 80% of the acceptance criteria. The additional action taken upon discovery of the contamination is summarized in Table 5.

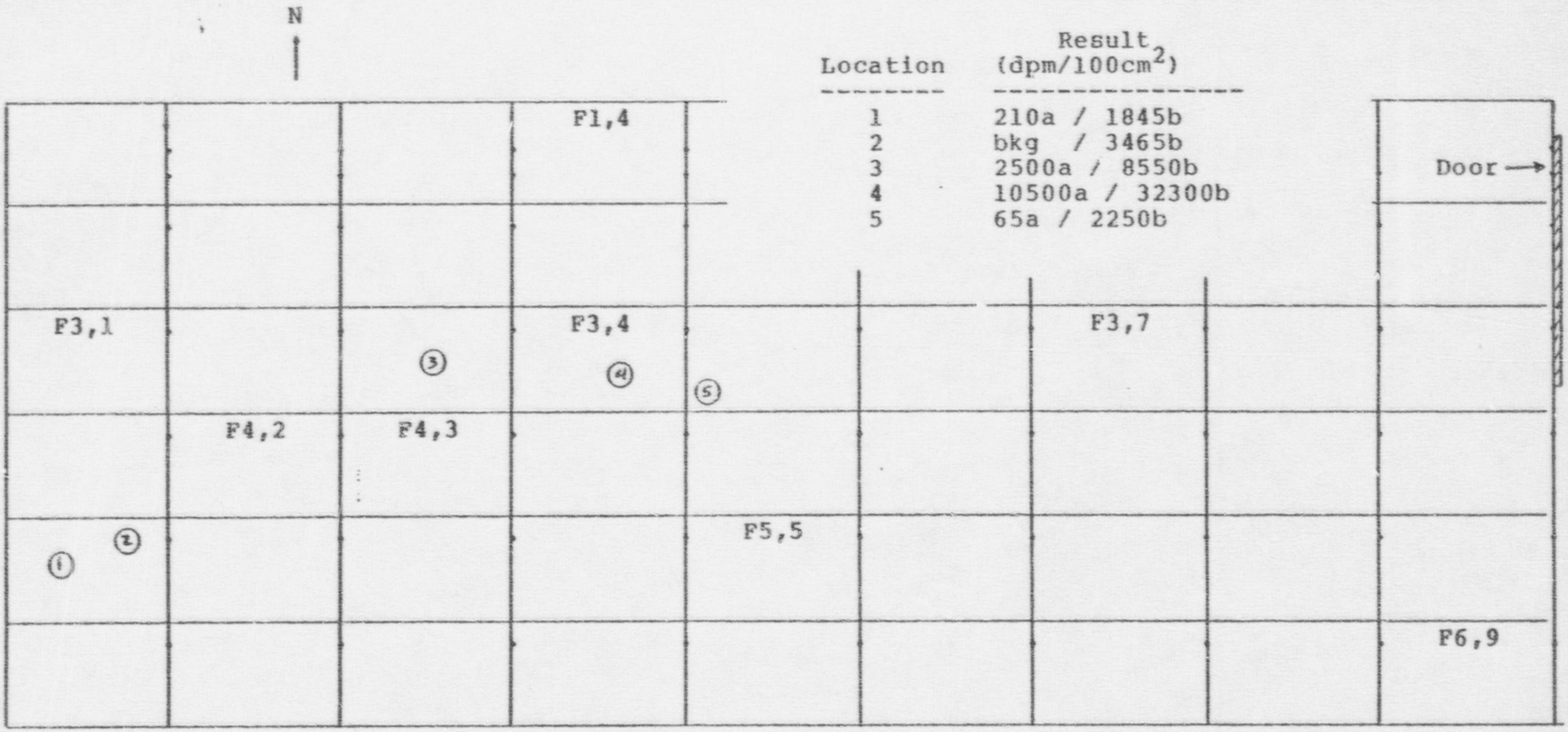
TABLE 5

ADDITIONAL SAMPLING LOCATIONS

Location	Contamination Level (dpm/100 cm^2)	Additional Measurements	Results
Rm 130 F7,2	236 alpha max	F8,2 F7,1 F6,3	No hot spots found avg. alpha = 20
HOLDUP F6,5	49 alpha avg. 191 alpha max	F4,1 F4,2 F3,3 F3,4 F5,2	Activity fairly uniform at about 50 alpha ave. and up to 158 alpha max
Rm 127 E5,14	83 alpha avg. 239 alpha max	E5,13 E5,15 E5,16 E5,9 E5,11 E4,11 E4,17 E5,17 E3,15 E4,14 E3,13 E2,16 E2,12 E2,13	Contamination determined to be localized to the bottom grid, south of the exit door and north of the support beam. Area was cleaned.
Rm 126 F3,4	140 alpha avg. 10465 alpha max	100% survey of floor	See Figure 21 for results
VAULT F1,3	16 alpha avg. 42 alpha max	100% survey of floor	See Figure 22 for results
F5,3	41664 beta max		

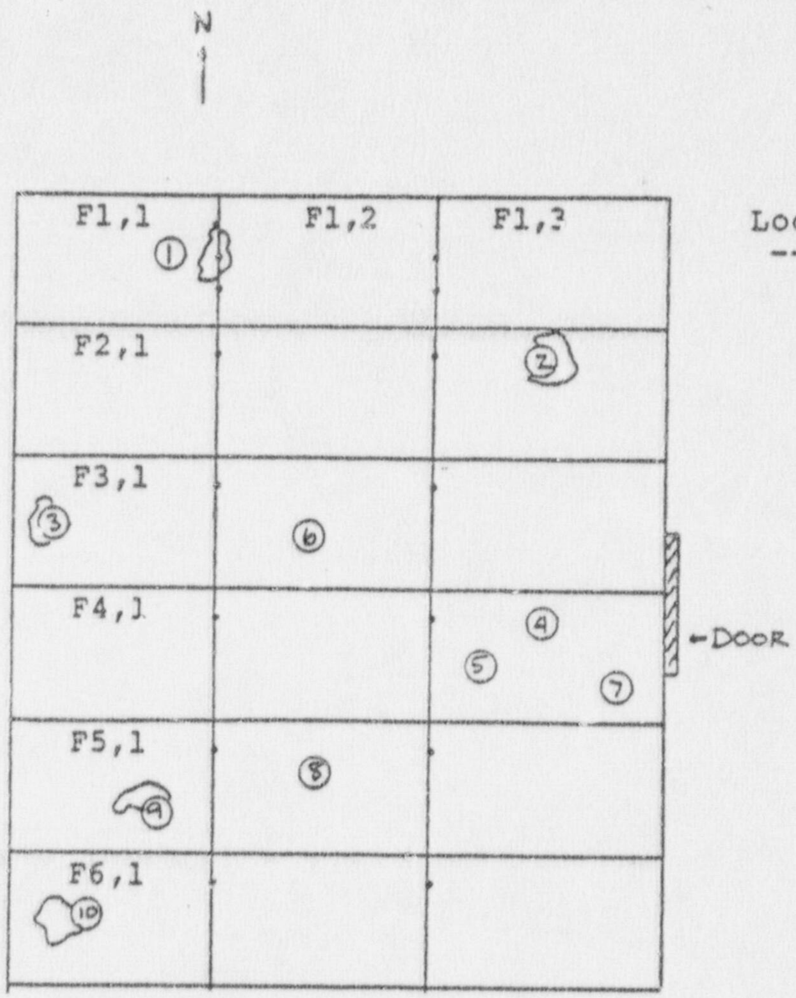
Note: Refer to Appendix B for specific values of contamination.

In all cases, the additional samples collected demonstrate that the contamination (most of it below acceptance criteria) was fairly localized to the immediate area. As mentioned earlier, all areas determined to be contaminated to a level equal to or exceeding 80% of the acceptance limit were decontaminated to levels below the instrument lower limit of detection. The only grid areas with residual contamination above the acceptance limit were localized hot spots on the floor of Room 126, on the east wall of Room 127, and on the floor of the vault.



Location	Result (dpm/100cm^2)
1	210a / 1845b
2	bkg / 3465b
3	2500a / 8550b
4	10500a / 32300b
5	65a / 2250b

FIGURE 21. SURVEY RESULTS OF ROOM 126 (PROCESS LABORATORY) 100% FLOOR SAMPLE
(Grid locations marked in matrix notation were part of the formal survey)



Location	Result (dpm/100cm²)
1	42 alpha
2	42 alpha
3	2250 beta
4	2025 beta
5	2250 beta
6	30 alpha
7	2250 beta
8	1800 beta
9	2025 beta
10	2025 beta
	30 alpha

FIGURE 22. SURVEY RESULTS OF THE VAULT 100% FLOOR SURVEY

C. RESULTS FOR SPECIAL STRUCTURAL FEATURES AND COMPONENTS

During the course of the formal final survey, the surveyors determined special features and components to qualitatively survey with the Ludlum Model 43-5 alpha scintillator in conjunction with the Ludlum Model 12 count rate meter. G-M probes were not considered appropriate because no beta contamination had been detected during the course of the final survey, except for the floor of the vault. Table 6 summarizes the features surveyed and the results of the survey. NDA is conveniently used to designate areas of No Detectable Activity. The contamination level is presented in cpm. The area factor for a planar surface is about 1.3; however, most of the objects surveyed were geometrically disproportionate and only came in contact with about 10% or less of the end window. The phenomenon creates two problems when trying to estimate the amount of activity deposited on the surface in dpm/100 cm^2; first, chances are the alpha particle is depositing all of its energy in air before it reaches the detector; second, the geometry factor applied as the conversion factor is grossly approximated based on the surveyor's judgment. Thus, we use the concept of a qualitative survey; if we observe more than 5 or 6 cpm on the instrument, we conclude that contamination exists on the object, but most likely below acceptance limits. The efficiency factor of the instrument is about 7 for Pu-239 alpha particles. All contaminated objects are cleaned and resurveyed. All findings are reported before further decontamination was performed.

Of the various components and features surveyed, only three major areas were found as containing observable contamination levels: the fire extinguisher mount on the east wall of Room 127, the unpainted tops of the sprinkler pipes in Room 127, and the beams in Room 127. Remaining identifiable contaminated areas were cleaned and resurveyed to ensure a complete decontamination of the premises.

TABLE 6

SUMMARY OF VARIOUS EQUIPMENT AND FEATURES SURVEYED FOR CONTAMINATION
(Sheet 1 of 3)

Location	Alpha Contamination Level (cpm)
The office area which includes Rooms 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 114, 116, front hall, and security. Surveyed tops of doors, door handles, corners of rooms, parts of the baseboards/floor, and electrical outlets.	NDA
102 - 2 (ea) 1-in. x 8-in. x 24-in. boards	NDA
104 - ledges of plastic partitions, telephone service panel, closet, entry and exit passageways	NDA
108 - wood cover mounted on west wall	NDA
109 - sink, floor area of sink, cleaning supply shelves, top and under hot water heater	NDA
111 - sink, shelf, floor drain	NDA
112 - "I" beam on west wall	NDA
116 - two doors and 100% baseboard survey	NDA
Front Hall - ledges, door facings, electrical panels	NDA
128 - top, bottom sides of miscellaneous equipment, electrical control panels, meters, water pump, valves, holes in walls, cracks in floor, ducting, tubing, removed section of fiberglass from inside of a/c exhaust duct for gamma spectroscopy	NDA
132 - horizontal surfaces of EDG, top of batteries and pipes, fire extinguisher bracket, junction boxes, door threshold	NDA
133 - holes in wall, conduit seals, top of transformer housings, fire alarm boxes, switch boxes, door and threshold, top of buss units	NDA
A/C - spot checked floor; walls; ceiling; top, bottom, and sides of a/c equipment; air intake; door	NDA

TABLE 6

SUMMARY OF VARIOUS EQUIPMENT AND FEATURES SURVEYED FOR CONTAMINATION
(Sheet 2 of 3)

Location	Alpha Contamination Level (cpm)
117 - towel and soap dispensers, plumbing stools, sinks, trash can, miscellaneous floor and wall locations	NDA
118 - instrument shelves, magnahelic unit, electrical outlets, plumbing, entry to shower, 100% baseboard	NDA
119 - overhead pipes, a/c supply duct, metal plate on floor, 100% baseboard survey	NDA
120 - door and door kickplate, electrical outlet, 100% baseboard survey	NDA
121, 122, 123, 124 - 100% baseboard survey, various floor and wall locations, electrical control box	NDA
126 - overhead pipes, beams, electrical conduit and junction box, a/c inlet, 100% baseboard survey	NDA
BH - electrical panel, fire alarm box, fire extinguisher rack, 100% baseboard survey	NDA
MEZRM - pipe, edge of beam, top of a/c ducting	NDA
130 - light fixtures, all upper horizontal surfaces, beams, pipes, top of doors to high bay, floor cracks, thresholds, door handles, 100% baseboard survey	NDA
129 - facility exhaust stack, louvers to blowers	NDA
louvers to outside	10-30
threshold, inside pipe to roof, cutouts in north wall, 100% baseboard survey	NDA
Vault - east wall south port	40
ledge above door, round port above door, north square port and round ports, 100% baseboard	NDA

TABLE 6

SUMMARY OF VARIOUS EQUIPMENT AND FEATURES SURVEYED FOR CONTAMINATION
(Sheet 3 of 3)

Location	Alpha Contamination Level (cpm)
ExitE - entrance door threshold	4
exit door threshold	4
porch	10-12
door jamb	6
ExitW - horizontal surfaces, door window ledges, handles, top of sprinkler, thresholds	NDA
HOLDUP - top of rails, ladder rungs, bottom of gauge rack, drain sump in pit, wall studs in pit	NDA
127 - beams 2, 3, and 4 (numbered from the north wall)	20-30
top of fire extinguishers, exit door locks	8
top of vault door	20
east wall fire extinguisher mounting board	6
baseboard on east wall at meter 14	60
baseboard on east wall at meter 15	21
baseboard on west wall, meter 10-16	7

Concurrent with the final survey, all flooring in the posted area was removed, the fire extinguishers and the mounts located in the glovebox room were removed, the fire protection sprinkler system in the glovebox room was removed, the beams in the glovebox room were scrubbed, lights were removed from Room 130, paint was removed from the east wall of the glovebox room, and the east emergency exit door was scrubbed. All ventilation components surveyed during the decontamination effort were found to be clean. In addition, the stack plenum is clean.

During periods of rain, water samples were collected from around the building and analyzed for Am-241 in a gamma spectrometer. The soil around the removed drain lines was analyzed previously and found to be well below release criteria of 25 pCi/g of Pu.(9) All water samples contain no Am-241.

D. ANOMALIES

This section briefly describes the natural radiological phenomenon and miscellaneous limitations which have impacted the data reduction and analysis methods used in the final survey.

Because the range of alpha particles is so short, the instrument background for detecting the presence of alpha particles is typically very low, on the order of no more than 2 counts per minute. However, under certain atmospheric conditions (i.e., when a building is locked tight for the night), radon tends to build up within the building. During the final survey, an increase in natural alpha background was observed in the morning for a period of a couple of hours, until the building could be opened up and allowed to air out. The activity tended to collect more towards the ceiling of the glovebox room. Furthermore, the "natural" background of alpha radiation will be increased by natural activity, such as Th-232 in shower tile located in Room 119. During the survey, we noticed a substantial increase in the alpha count rate when placed directly over the shower tile. A tile sample was taken and analyzed in a gamma spectrometer. The results showed conclusively the presence of Ac-228, a daughter of Th-232. The tile was not removed, and the data was not used in the analysis.

In the case of the outside intake louvers on the exhaust stack, an increase in activity was observed. This phenomenon is to be expected due to the large flow rates of bypass achieved through the damper assembly. Insofar as the distribution of low-level alpha activity is present on this equipment, we can only conclude that it is due to the natural environmental radioactivity.

A few difficulties in the survey were experienced. The entrance ways to Rooms 128, 132, and 133 are standard 7.5-ft doors, and the man-lift could not be moved into these rooms. The ceilings in each of these rooms is 16 ft. The top two meters and the ceilings were not surveyed in these rooms. Because these areas were unposted and since no radioactivity was found, it is felt that this omission did not significantly affect the results of the analysis.

In regard to the hot spct problems observed on the east wall of the glovebox room, paint samples were taken and analyzed on a gamma spectrometer to determine the amount of Am-241 in the sample. Several additional surveys were performed in the area to determine the extent of the contamination and whether the first or second coat of paint was contaminated. Evidently, the glovebox room was painted in about 1974, after the glovebox overpressurization incident. The paint condition at the present is very spotty due to excessive peeling from the concrete sweating phenomenon; in many places there is no paint, one coat, and two coats. Consequently, the entire area was surveyed (approximately 16 m^2) and detectable activity exceeding 80% of the acceptance criteria was removed.

VIII. CONCLUSIONS

An appropriate survey has been conducted throughout the area to be released. Although a few localized hot spots were detected, the results of this survey show statistically that no residual contaminaion remains in the area and demonstrate a negligible risk of there being any undetected contamination exceeding the acceptance limits. With the concurrence of the U.S. Nuclear Regulatory Commission, the facility license will be voluntarily terminated and the area will be released for unrestricted use.

REFERENCES

1. "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," Annex B, USNRC License SNM-21, Docket 70-25, issued to Energy Systems Group of Rockwell International, last revision June 5, 1984.

2. "State of California Guidelines for Decontaminating Facilities and Equipment Prior to Release for Unrestricted Use," DECON-1, revised March 24, 1983.

3. "Draft American National Standard Control of Radioactive Surface Contamination on Materials, Equipment, and Facilities to be Released for Uncontrolled Use," ANSI N13.12, August 1978, American National Standards Institute, Inc.

4. "Building 055 Decontamination and Deactivation Plan," N704TI990061, J. W. Carroll, F. C. Schrag, and V. A. Swanson, Rockwell International, October 1, 1982.

5. "Selected Techniques of Statistical Analysis," Statistical Research Group, Columbia University, McGraw-Hill Book Co., Inc., 1947.

6. "Some Theory of Sampling," W. E. Deming, Dover Publications, Inc., New York, 1950.

7. "Statistics in Research," B. Ostle and R. Mensing, The Iowa State University Press, 1979.

8. "Measurement and Detection of Radiation," N. Tsoulfanidis, Hemisphere Publishing Corp., Washington, D.C., 1983.

9. "Radiation Survey for Release for Unrestricted Use - L-85," N001SRR140087, F. E. Begley, Rockwell International, March 6, 1986.

10. "Plutonium Concentrations in Soil Around Drain Lines at NMDF," N704SRR9900124, R. J. Tuttle, Rockwell International, April 3, 1986.

11. "Final Radiological Survey Detailed Work Procedure," N704DWP990084, V. A. Swanson, Rockwell International, September 22, 1982.

APPENDIX A

SAMPLING INSPECTION DATA GROUPED BY LOT

The inspection data was entered into Visicalc, a spreadsheet program which runs on the IBM PC. The output of the Visicalc program gives the data which follows in three lots: one for the lot located in the unposted areas (office area, Rooms 128, 132, 133, Security, and the air conditioning room); one for the glovebox room; and one for the remaining posted areas in addition to the liquid waste holdup platform located outside the building.

The grid locations are identified in matrix notation by room; measurements were made on the floor (F), ceiling (C), north wall (N), east wall (E), south wall (S), and west wall (W). The beams in the glovebox room (127) were surveyed, identified by (B) (beam number) (south or north) (grid location), for example B1S9. A few of the room number identifiers bear further explanation:

FH - front hall (unposted);

SEC - security building;

A/C - air conditioning room located above Room 126. Accessible only from outside;

VAULT - storage vault adjacent to the glovebox room;

BH - back hall, connecting Rooms 120, 121, 122, 123, 124, 126, and 127;

MEZRM - a small room accessible from the mezzanine;

EXITW - the west emergency exit from the glovebox room;

EXITE - the east emergency exit from the glovebox room;

HOLDUP - The liquid waste holdup tanks cement slab located outside of the building.

The output shows the alpha and beta total average contamination per square meter, maximum in one square meter, and removable in one square meter; the standard deviations of the measurement are also calculated.

TABLE A.1

Sampling Inspection Results of the office area and oth[illegible] [illegible]nposted areas.

ROOM NUMBER	GRID NAME	ALPHA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-	BETA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-
101	F1,2	6	3			-1	1	672	142			12	13
101	F5,3	4	2			2	2	55	133			-4	12
101	C1,2	4	5			-1	1	697	142			-3	12
101	N2,2	5	5			2	2	542	140			26	13
101	E1,5	-2	4			2	2	533	140			3	12
101	S3,3	9	3			-1	1	-365	126			5	13
101	W2,2	4	2			-1	1	-172	129			12	13
102	F2,1	1	1			-1	1	672	142			-7	12
102	F3,1	4	2			-1	1	-80	131			16	13
102	C3,1	5	3			2	2	235	136			-16	12
102	N2,2	4	5			-1	1	516	140			0	12
102	E2,2	1	4			2	2	-116	130			-5	12
102	W2,1	8	3			-1	1	-210	128			-2	12
103	F2,2	4	5			1	2	907	146			-1	12
103	F2,4	6	3			1	2	-88	130			-2	12
103	C2,2	0	4			2	2	211	135			16	13
103	N1,1	4	2			2	2	328	137			5	13
103	E2,2	0	0			-1	1	-129	129			-5	12
103	S1,1	0	0			2	2	-307	127			5	13
103	W3,4	-2	4			-1	1	-69	130			11	13
104	F1,3	6	3			2	2	580	138			9	13
104	F1,4	6	3			-1	1	819	144			10	13
104	F2,1	-1	1			-1	1	176	132			10	13
104	F3,4	6	3			-1	1	294	136			2	12
104	C1,4	13	4			2	2	235	136			13	13
104	C2,1	3	3			2	2	374	135			25	13
104	N2,2	4	3			-1	1	294	133			9	13
104	E2,2	4	2			-1	1	-256	128			-4	12
104	S2,4	1	2			2	2	-365	123			3	12
104	SG3,3	1	3			0	1	-572	125			0	12
104	NG2,2	0	0			1	1	-167	132			8	12
104	W2,2	3	3			2	2	-21	128			12	13
105	F1,2	-1	3			3	2	1065	151			-3	12
105	F3,2	-1	3			-1	[illegible]	387	141			-2	12
105	C[illegible],2	14	5			2	2	235	133			-8	12
105	N2,2	3	3			3	2	323	134			12	13
105	E3,1	0	2			3	2	76	130			5	12
105	S2,2	3	4			-1	1	-211	131			-7	12
105	W3,1	-2	3			-1	1	-53	134			3	12
106	F2,2	5	4			-1	1	955	150			24	13

TABLE A.1

ROOM NUMBER	GRID NAME	ALPHA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-	BETA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-
106	F1,4	-1	1			-1	1	92	130			19	13
106	C2,2	1	3			-1	1	233	139			-2	12
106	N2,1	5	4			3	2	475	142			-8	12
106	E3,4	-1	1			-1	1	122	131			0	12
106	S3,1	1	2			-1	1	-214	125			17	13
106	W1,2	0	3			-1	1	502	143			6	12
107	F1,3	5	3			3	2	659	139			-14	12
107	F1,2	-1	1			-1	1	290	133			-6	12
107	C1,2	3	4			-1	1	356	141			6	13
107	N1,3	1	2			3	2	-332	123			1	12
107	E1,2	3	3			3	2	403	135			-1	12
107	S3,1	3	4			-1	1	-4	135			-3	12
107	W2,1	-1	3			1	1	-334	129			2	12
108	F3,2	-1	3			-1	1	801	147			21	13
108	F1,3	0	2			0	1	92	130			5	12
108	C1,3	4	3			-1	1	76	130			13	13
108	N1,2	-1	1			-1	1	-374	123			-12	12
108	E2,1	-1	1			3	2	-361	123			0	12
108	S1,1	0	3			3	2	-348	129			0	12
108	W3,2	0	3			3	2	-458	127			6	12
109	F2,1	1	2			0	1	924	143			1	12
109	C2,1	0	2			-1	1	231	132			4	13
109	E2,2	0	2			0	1	-613	118			-5	12
109	W2,2	-1	1			-1	1	-441	121			8	12
110	F1,1	3	4			0	1	-53	134			-6	12
111	F2,3	-2	3			1	1	783	147			21	13
111	C2,3	0	3			-1	1	53	136			5	13
111	N2,3	0	3			0	1	-282	130			14	13
111	E3,2	6	4			-1	1	-150	132			15	13
111	S2,1	-2	3			-1	1	-405	128			0	12
111	W2,3	0	3			-1	1	-365	129			1	12
112	F3,1	9	4			-1	1	582	136			11	13
112	F1,3	0	2			-1	1	76	130			-2	12
112	C1,3	13	4			-1	1	248	133			5	13
112	N1,2	2	2			-1	1	-267	123			13	13
112	E3,3	-1	1			-1	1	-185	126			-12	12
112	S1,1	0	2			-1	1	-59	128			-5	12
112	W2,3	2	2			-1	1	365	133			-17	12
114	F3,2	10	4			1	1	554	136			30	13
114	F1,2	4	3			-1	1	144	130			-2	12
114	C3,2	9	4			-1	1	-66	126			0	12

TABLE A.1

ROOM NUMBER	GRID NAME	ALPHA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-	BETA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-
114	N3,1	4	3			0	1	-566	118			6	12
114	E2,2	7	3			-1	1	-443	120			19	13
114	S1,1	11	4			0	1	-467	120			-2	12
114	W2,2	6	3			0	1	-357	121			10	13
116	F1,1	10	4			-1	1	767	139			10	12
116	C1,1	7	3			2	2	-189	124			10	13
116	N1,3	2	2			-1	1	-533	118			8	12
116	E3,1	1	2			0	1	-418	120			14	12
116	S3,2	2	2			-1	1	-332	122			14	13
116	W2,1	4	3			0	1	-82	126			12	13
FH	F2,9	4	3			1	1	726	138			-1	12
FH	F1,1	10	4			-1	1	238	131			3	12
FH	F7,9	2	2			-1	1	33	128			-4	12
FH	C1,1	5	4			-1	1	-359	136			5	13
FH	C7,9	12	5			2	2	-1021	124			10	13
FH	N2,3	4	3			-1	1	-312	122			8	12
FH	N2,10	4	3			0	1	-361	121			8	12
FH	E3,4	2	2			0	1	-439	120			16	12
FH	S3,2	5	3			-1	1	-230	124			7	12
FH	S2,12	4	3			1	1	-262	123			13	12
FH	W2,3	5	3			-1	1	-422	120			17	12
SEC	F2,3	-1	3			0	1	-994	125			12	12
SEC	F5,1	-4	3			-1	1	-1044	124			-2	12
SEC	F1,5	0	3			0	1	-1132	122			10	12
SEC	F4,5	-2	3			-1	1	-1150	122			9	12
128	F1,4	11	5			1	1	701	141			-1	12
128	F4,2	7	5			1	1	937	145			11	13
128	F8,2	9	5			1	1	836	143			10	13
128	F12,3	2	4			3	2	626	140			18	13
128	N4,4	2	4			0	1	-437	123			-3	12
128	E4,12	-2	3			0	1	403	137			-18	12
128	S3,3	2	4			3	2	470	138			10	13
128	W5,13	-1	4			0	1	-214	127			2	12
128	W3,1	0	4			-1	1	-248	126			-11	12
132	F1,2	-1	4			1	1	819	143			5	13
132	F3,4	-2	3			1	1	706	141			15	13
132	N3,2	-1	3			1	1	-395	123			5	13
132	N5,4	-1	4			1	1	470	138			5	13
132	E4,1	0	3			1	1	-353	124			2	12
132	E3,5	-4	2			0	0	-399	123			17	13
132	S4,2	1	3			1	1	71	131			14	13

TABLE A.1

ROOM NUMBER	GRID NAME	ALPHA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-	BETA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-
132	S3,6	3	4			0	0	441	137			-12	12
132	W4,3	1	3			4	2	403	136			12	13
132	W5,4	4	4			3	1	273	134			-7	12
133	F2,1	6	4			3	2	626	140			5	12
133	F5,3	8	4			1	1	1004	145			9	13
133	N4,1	5	4			2	1	-546	121			7	13
133	N5,6	5	4			0	0	-403	123			-10	12
133	E3,2	-4	2			1	1	-412	123			5	13
133	E4,5	-3	3			0	0	-483	122			6	13
133	S5,1	3	4			1	1	-437	123			6	13
133	S4,5	-1	3			0	0	-252	126			31	13
133	W4,1	0	3			1	1	160	133			34	13
133	W4,6	6	4			1	1	252	134			19	13
A/C	F5,2	-4	4	15	6	0	1	518	141	1085	150	9	12
A/C	F6,3	9	5			1	1	14	133			5	12
A/C	C5,2	0	4			-1	1	99	134			12	12
A/C	C6,3	2	5			-1	1	149	135			-11	12
A/C	S2,2	-1	4			1	1	-72	131			-3	12
A/C	W1,4	4	5			0	1	923	147			-1	12

TABLE A.2

Sampling Inspection Results of the Glove Box Room

NMDF12

ROOM NUMBER	GRID NAME	ALPHA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-	BETA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-
127	N1,3	1	4			2	1	-435	116			30	14
127	N2,5	4	4			1	1	-189	120			-3	13
127	N4,3	4	4			-1	1	-126	134			12	13
127	N5,6	14	5			-1	1	-108	134			5	13
127	N3,9	14	5			0	1	-365	130			2	12
127	N1,11	13	5			1	1	-184	136			13	13
127	N3,13	20	6			-1	1	-491	128			2	12
127	N5,14	22	6			-1	1	9	136			-2	12
127	N2,17	5	4			1	1	-83	138			4	13
127	E2,1	6	5			0	0	-70	122			25	13
127	E3,1	14	5			-1	1	1004	152			12	13
127	E2,5	7	5			0	0	405	146			20	13
127	E3,7	0	3			-1	1	779	148			2	12
127	E1,10	16	6			0	0	386	146			-8	12
127	E2,15	5	4			1	1	616	149			-2	12
127	E1,17	1	4			0	0	478	147			30	13
127	E2,19	4	4			1	1	667	150			2	12
127	E3,23	5	4			1	1	630	146			8	13
127	E3,27	6	4			1	1	369	142			9	13
127	E5,3	15	6			1	1	153	138			-5	12
127	E4,10	10	5			0	1	464	143			14	13
127	E5,14	83	11	239	18	3	2	554	145			10	13
127	E4,19	5	4			0	0	527	144			-7	12
127	E5,25	6	4			0	0	410	143			-2	13
127	S1,1	19	6	87	11	6	2	-350	134			-9	12
127	S2,5	4	4			1	1	-419	132			0	12
127	S1,8	14	5	102	12	1	1	-14	139			10	13
127	S3,10	-1	3			1	1	-256	122			-12	12
127	S2,13	4	4			1	1	-607	129			1	12
127	S3,18	0	3			7	2	-34	126			4	12
127	S5,3	-4	3			1	1	-118	124			1	12
127	S4,7	-2	3			1	1	-189	123			-5	12
127	S5,12	7	5			0	0	-277	122			9	13
127	S4,16	-4	3			0	0	-386	120			5	13
127	W1,2	1	4			0	0	322	145			13	13
127	W3,6	-1	3			0	0	252	135			6	13
127	W2,7	0	3			1	1	124	142			26	13
127	W3,11	0	3			2	1	710	138			3	12
127	W1,14	0	3			0	0	474	147			9	13
127	W1,16	2	4			0	0	359	145			32	13

TABLE A.2

ROOM NUMBER	GRID NAME	ALPHA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-	BETA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-
127	W3,19	2	4			1	1	605	136			7	13
127	W3,24	-2	3			0	0	655	137			11	13
127	W3,26	5	4			0	0	403	133			18	13
127	W5,3	4	4			1	1	-130	124			3	12
127	W5,8	1	4			0	0	601	136			19	13
127	W4,15	-2	3			0	0	223	130			7	13
127	W5,21	0	3			1	1	643	137			3	12
127	W4,27	-1	3			0	0	357	132			12	13
127	W1,29	4	4			1	1	623	133			3	13
127	F2,2	8	5			1	1	1041	139			-4	13
127	F1,5	1	4			0	0	779	135			-4	13
127	F3,9	0	4			1	1	882	137			-2	13
127	C2,2	1	4			0	0	-205	120			-5	12
127	C1,5	0	4			4	2	-213	120			-5	12
127	C3,9	4	4			3	1	-303	118			16	13
127	F4,1	11	5			0	1	1025	140			-3	12
127	F5,5	8	5			-1	1	1235	143			7	13
127	F6,7	5	4			1	1	869	138			-3	12
127	F4,10	9	5			0	1	1142	142			10	13
127	F4,14	5	4			-1	1	1046	140			1	13
127	F5,16	5	4			-1	1	1079	141			9	13
127	F7,2	0	4			0	1	1256	143			-16	12
127	F9,4	9	5			-1	1	1100	141			-12	12
127	F8,7	4	4			2	2	1079	141			-6	12
127	F7,12	5	4			-1	1	1033	140			-2	13
127	F8,13	5	4			1	1	714	135			14	13
127	F8,19	1	4			-1	1	1147	142			-11	12
127	F12,2	8	5			-1	1	1243	143			1	13
127	F10,5	3	4			-1	1	1138	142			-7	12
127	F12,9	5	4			-1	1	1109	141			0	13
127	F11,10	9	5			-1	1	1075	141			-12	12
127	F11,14	6	5			1	1	1042	140			7	13
127	F10,17	3	4			0	1	798	137			-2	13
127	F13,1	10	5			1	1	1037	140			5	13
127	F14,6	5	4			-1	1	832	137			-29	12
127	F15,8	-1	3			-1	1	1260	144			-1	13
127	F13,12	-1	3			1	1	1067	141			17	13
127	F15,15	4	4			1	1	764	142			2	13
127	F15,17	10	5			0	1	1058	141			-4	12
127	F17,3	0	4			-1	1	962	139			2	13
127	F16,5	-3	3			0	1	785	136			1	13

TABLE A.2

ROOM NUMBER	GRID NAME	ALPHA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-	BETA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-
127	F18,9	5	4			1	1	1058	141			12	13
127	F16,10	5	4			1	1	1197	143			2	13
127	F17,13	15	6			1	1	1084	141			13	13
127	F18,18	4	4			1	1	932	139			-10	12
127	F21,2	5	4			-1	1	991	140			-9	12
127	F20,5	8	5			0	1	1361	145			4	13
127	F19,8	4	4			-1	1	748	136			-12	12
127	F21,12	23	6			0	1	844	143			-4	12
127	F21,14	15	6			1	1	806	141			-7	12
127	F19,16	23	6			-1	1	899	142			9	13
127	F23,1	6	4			-1	1	853	141			6	13
127	F22,6	14	5			-1	1	903	142			-4	12
127	F23,6	15	6			1	1	764	140			-16	12
127	F24,6	10	5			0	1	1004	145			21	13
127	F25,6	9	5			1	1	727	139			13	13
127	F23,9	6	4			1	1	790	140			-9	12
127	F24,11	15	6			-1	1	773	140			4	13
127	F23,13	14	5			0	1	752	140			-5	12
127	F23,19	15	6			1	1	773	140			-2	12
127	F25,2	10	5			1	1	966	139			3	12
127	F27,4	9	5			1	1	1029	140			0	12
127	F26,8	6	4			0	0	823	143			27	13
127	F27,12	17	6			0	0	1088	145			9	13
127	F25,13	16	6			2	1	941	143			7	13
127	F26,17	9	5			1	1	928	144			-14	12
127	F30,1	16	6			0	0	538	137			3	12
127	F29,5	9	5			1	1	706	139			2	12
127	F30,9	9	5			1	1	911	142			7	13
127	F30,10	14	5			1	1	815	141			9	13
127	F28,14	0	0			0	0	680	141			5	13
127	F29,17	7	5			1	1	798	141			5	13
127	C4,1	-1	3			0	0	0	142			14	12
127	C5,5	1	4			1	1	-163	129			8	12
127	C6,7	0	3			0	0	-405	135			18	12
127	C4,10	5	3			1	1	-99	130			15	12
127	C4,14	1	4			0	0	-230	138			36	13
127	C5,16	15	5			1	1	-456	124			20	12
127	C7,2	5	4			1	1	-78	141			30	13
127	C9,4	6	4			1	1	-30	132			19	12
127	C8,7	5	3			1	1	-301	127			3	12
127	C7,12	7	4			1	1	-378	126			11	12

TABLE A.2

ROOM	GRID	ALPHA DPM/100CM2						BETA DPM/100CM2					
NUMBER	NAME	TOT	+/-	MAX	+/-	REM	+/-	TOT	+/-	MAX	+/-	REM	+/-
127	C8,13	5	3			1	1	-413	125			7	12
127	C8,19	5	3			1	1	-318	127			1	12
127	C12,2	4	3			0	0	-262	128			-8	12
127	C10,5	5	3			0	0	9	132			14	13
127	C12,9	7	4			0	0	-258	128			-3	12
127	C11,10	-1	4			-1	1	-414	137			3	12
127	C11,14	0	5			0	1	-294	139			9	12
127	C10,17	-7	3			-1	1	-423	137			0	12
127	C13,1	-4	4			-1	1	-235	140			12	13
127	C14,6	-1	4			-1	1	-189	141			7	12
127	C15,8	-6	4			-1	1	-235	140			-1	12
127	C13,12	-1	4			1	2	-18	135			-5	12
127	C15,15	11	6			-1	1	-36	134			16	13
127	C15,17	8	5			0	1	32	136			6	12
127	C17,3	-4	4			0	1	-207	132			17	13
127	C16,5	0	4			1	2	-144	133			-3	12
127	C18,9	-1	3			0	1	-410	132			-17	12
127	C16,10	2	4			0	0	-144	133			-1	12
127	C17,13	2	4			1	1	5	136			1	12
127	C18,18	-2	3			0	1	59	137			15	13
127	C21,2	-1	3			0	1	-36	135			-4	12
127	C20,5	5	4			0	1	50	136			2	12
127	C19,8	8	5			-1	1	-144	133			-9	12
127	C21,12	0	3			-1	1	-72	134			2	12
127	C21,14	0	3			-1	1	-203	132			-16	12
127	C19,16	5	4			0	1	-324	130			-5	12
127	C23,1	7	5			0	1	-81	134			10	13
127	C22,6	7	5			1	1	104	137			16	13
127	C23,9	2	4			-1	1	41	136			9	13
127	C24,11	5	4			-1	1	-140	133			0	12
127	C23,13	0	3			0	1	-45	135			11	13
127	C23,19	2	4			0	1	-212	132			16	13
127	C25,2	0	3			0	1	-140	133			4	13
127	C27,4	0	3			1	1	-290	126			9	13
127	C26,8	-2	3			-1	1	-412	124			17	13
127	C27,12	-4	3			0	1	-466	123			12	13
127	C25,13	-1	3			-1	1	-84	129			4	13
127	C26,17	-1	3			-1	1	-319	125			14	13
127	C30,1	1	4			-1	1	-365	125			2	13
127	C29,5	0	3			-1	1	-361	125			2	12
127	C30,9	-1	3			0	1	-395	124			23	13

TABLE A.2

ROOM NUMBER	GRID NAME	ALPHA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-	BETA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-
127	C30,10	0	3			0	1	-294	126			5	13
127	C28,14	-1	3			-1	1	-231	127			-4	12
127	C29,17	4	4			0	1	-248	126			3	13
127	B1N9	4	4			1	1	-424	119			13	13
127	B1S7	28	7			0	0	-458	118			-9	12
127	B2N3	12	5			0	0	-521	117			6	13
127	B2S10	7	4	58	9	1	1	-525	117			12	13
127	B3N6	22	6	79	11	1	1	-311	121			-9	12
127	B3S16	18	6	29	7	0	0	-487	118			27	13
127	B4N15	29	7	118	13	5	2	-244	122			13	13
127	B4S6	24	6	146	14	1	1	-361	120			9	13
127	F13,16	2	2			0	0	1079	141			29	13
127	F15,13	7	3			2	1	1138	142			9	13
127	F15,18	7	3			0	0	949	139			21	13
127	F16,18	4	3			1	1	1084	141			2	12
127	F17,11	9	4			1	1	970	139			-16	12
127	F17,15	6	3			1	1	1037	140			15	13
127	F19,13	11	4			0	0	1109	141			0	12
127	F20,15	9	4			2	1	1075	141			27	13
127	F21,17	11	4			1	1	945	139			16	13
127	F22,11	6	3			1	1	781	136			1	12
127	F23,15	12	4			1	1	1033	140			9	13
127	F24,17	5	3			0	0	907	138			-2	12
127	F26,15	4	3			2	1	1121	141			30	13
127	F27,18	11	4			0	0	815	137			-6	12
127	E5,13	94	11	598	27	0	0	122	128			20	13
127	E5,15	83	10	1367	36	1	1	664	137			0	12
127	E5,16	23	6	140	13	1	1	697	137			2	12
127	E5,9	5	4			3	2	598	141			-5	13
127	E5,11	14	5			4	2	469	139			1	13
127	E4,11	14	3			-1	1	447	138			-3	13
127	E4,17	-1	2			-1	1	718	143			-3	13
127	E5,17	10	4			11	3	839	144			30	14
127	E3,15	6	4			1	1	533	140			1	13
127	E4,14	20	6			1	1	482	139			5	13
127	E3,13	10	4			1	1	796	144			-4	13
127	E2,16	6	4			2	2	628	141			23	14
127	E2,12	3	3			1	1	460	139			1	13
127	E2,13	6	4			6	2	843	144			20	13

TABLE A.3

Sampling Inspection Results of the Posted Area Except for the Glove Box Room

nmdfvl

ROOM NUMBER	GRID NAME	ALPHA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-	BETA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-
117	F1,3	4	3			1	1	727	141			-1	12
117	F3,3	4	3			0	0	-59	129			9	13
117	C1,3	1	3			0	0	-2092	96			23	13
117	C3,3	1	3			1	1	126	132			10	13
117	N1,1	1	3			1	1	-735	118			5	13
117	E2,2	1	3			0	0	-592	120			16	13
117	S3,5	3	3			0	0	-143	128			-5	12
117	S3,1	0	3			1	1	-361	124			1	12
117	W1,2	0	3			0	0	-479	122			8	13
118	F3,2	6	3			0	0	722	141			4	13
118	F2,2	4	3			0	0	176	133			-7	12
118	C2,2	4	2			0	0	331	135			4	13
118	N2,3	3	3			0	0	-869	115			1	12
118	E3,1	-4	3			1	1	-185	127			5	13
118	S3,3	-2	3			0	0	-172	127			-13	12
118	W2,1	-1	3			1	1	340	135			-7	12
119	F1,4	-1	3			1	1	813	143			1	12
119	C1,4	0	3			0	0	305	135			4	13
119	N3,4	-4	3			0	0	-211	126			-8	12
119	E3,1	0	3			1	1	-344	124			19	13
119	S2,2	2	4			1	1	13	130			7	13
119	W2,1	0	3			0	0	624	140			-9	12
120	F1,2	0	3			0	0	740	142			-5	12
120	C1,2	0	3			1	1	181	133			19	13
120	N3,3	1	4			1	1	-284	125			7	13
120	S1,2	-4	3			0	0	-189	127			-9	12
121	F3,2	6	3			1	1	538	135			21	13
121	C3,2	0	2			-1	1	315	131			5	12
121	N2,2	5	3			1	1	-118	124			-3	12
121	E1,5	5	3			2	2	546	135			20	13
121	S3,3	2	2			0	1	-151	123			11	12
121	W3,5	-1	1			-1	1	118	128			-2	12
122	F5,2	1	2			-1	1	853	139			-8	12
122	C5,2	2	3			0	1	256	131			9	12
122	N1,2	5	3			0	1	-210	123			11	12
122	E3,3	1	3			-1	1	-252	123			2	12
122	S2,2	1	3			1	1	-223	123			-27	11
122	W3,2	1	3			0	1	-97	125			-8	12
123	F5,2	1	3			0	1	1042	143			12	12
123	F2,1	2	3			-1	1	1063	143			0	12

TABLE A.3

ROOM	GRID	ALPHA DPM/100CM2						BETA DPM/100CM2					
NUMBER	NAME	TOT	+/-	MAX	+/-	REM	+/-	TOT	+/-	MAX	+/-	REM	+/-
123	C5,2	1	3			2	2	84	128			7	12
123	C2,1	-1	2			0	1	84	128			-1	12
123	N1,4	0	2			1	1	-210	123			-5	12
123	E1,5	-2	2			1	1	-160	124			3	12
123	S3,1	1	3			-1	1	-202	124			10	12
123	S1,4	-2	2			-1	1	-265	123			-4	12
123	W2,3	-1	2			0	1	-214	123			14	12
124	F1,3	6	4			1	1	655	137			14	13
124	F4,5	10	4			-1	1	991	142			6	12
124	F5,3	7	4			-1	1	815	140			22	13
124	C1,3	1	3			-1	1	315	128			2	12
124	C4,5	0	3			-1	1	101	124			10	13
124	C3,3	2	3			0	1	67	123			20	13
124	N2,2	0	3			1	1	38	123			9	13
124	N3,4	1	3			1	1	-265	123			9	13
124	E2,3	1	3			2	1	420	129			8	13
124	E5,5	10	4			2	1	449	134			8	13
124	S2,3	2	3			0	0	34	123			-3	12
124	W3,1	-1	2			0	0	-118	125			8	13
124	W2,5	0	3			1	1	-113	120			-12	12
124	W4,3	4	3			1	1	-4	127			8	13
126	F3,1	4	4			-1	1	941	138			4	12
126	F3,4	140	13	10465	114	1	1	1252	142	32302	388	17	13
126	F1,4	10	5			1	1	1050	139			-16	12
126	F3,7	0	3			1	1	802	135			9	13
126	F4,2	1	3			1	1	1264	142			25	13
126	F4,3	2	3			1	1	1163	141			15	13
126	F5,5	0	3			1	1	1046	139			17	13
126	F6,9	2	3			0	1	911	137			17	13
126	C3,1	6	5			1	1	103	125			11	13
126	C1,4	3	4			1	1	82	124			-5	12
126	C3,7	-1	3			1	1	291	128			2	12
126	C4,2	0	4			0	1	385	129			20	13
126	C5,5	5	4			0	1	70	124			-7	12
126	C6,9	9	5			0	1	357	129			1	12
126	N2,2	0	3			2	2	-109	120			22	13
126	N1,6	0	3			1	1	-176	119			3	12
126	E1,4	-1	3			0	1	-273	118			-1	12
126	S3,2	0	3			-1	1	-193	119			-5	12
126	S2,5	1	3			-1	1	-4	122			14	13
126	W3,1	2	3			1	1	752	135			1	12

TABLE A.3

ROOM NUMBER	GRID NAME	ALPHA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-	BETA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-
130	W5,9	-2	3			0	1	-391	123			-13	13
129	F1,2	10	5			-1	1	616	153			13	13
129	F3,4	1	3			-1	1	570	153			6	12
129	F5,1	7	4			0	1	782	156			2	12
129	F8,3	11	5			-1	1	672	154			-9	12
129	F10,1	6	4			-1	1	727	155			2	12
129	F10,5	7	4			-1	1	497	151			-6	12
129	C1,2	2	4			-1	1	-324	131			-7	12
129	C3,4	1	4			-1	1	-347	130			-10	12
129	C5,1	-1	3			-1	1	-275	132			23	13
129	C8,3	1	4			0	1	-311	131			4	12
129	C10,1	2	4			-1	1	-230	132			10	13
129	C10,5	1	4			-1	1	-297	131			16	13
129	N2,2	4	3			-1	1	-324	132			11	13
129	N3,5	7	3			-1	1	-450	129			5	12
129	N5,4	2	2			-1	1	-432	130			15	13
129	E1,3	6	3			-1	1	-405	130			9	12
129	E2,5	4	3			-1	1	-455	129			-2	12
129	E1,8	2	2			1	2	-293	132			-1	12
129	E3,12	5	3			-1	1	-252	133			2	12
129	E5,1	2	2			-1	1	-428	130			10	13
129	E4,7	12	5			-1	1	-335	127			5	12
129	E5,12	14	5			-1	1	-684	120			-9	12
129	E5,13	6	4			-1	1	-636	121			4	12
129	S1,2	2	3			-1	1	409	139	1230	151	11	13
129	S3,5	4	3			0	1	490	140			0	12
129	S5,3	6	4			-1	1	679	143			26	13
129	W2,2	4	3			-1	1	-366	126			9	12
129	W3,4	4	3			-1	1	-335	127			7	12
129	W1,8	7	4			-1	1	-430	125			11	13
129	W2,11	5	3			-1	1	-443	125			6	12
129	W4,7	4	3			-1	1	-391	126			6	12
129	W5,10	6	4			-1	1	-421	125			-6	12
VAULT	F1,3	16	5	42	8	0	0	924	144			-4	12
VAULT	F5,3	9	4			0	0	907	144	41664	438	23	13
VAULT	C1,3	5	4			0	0	571	139			-2	12
VAULT	C5,3	1	3			1	1	475	137			15	13
VAULT	N3,2	4	3			0	0	542	138			-9	12
VAULT	E1,2	8	4			1	1	617	139			-5	12
VAULT	E2,4	7	4			1	1	92	131			1	12
VAULT	S3,1	4	3			0	0	731	141			-12	12

TABLE A.3

ROOM NUMBER	GRID NAME	ALPHA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-	BETA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-
BH	F1,1	5	4			-1	1	812	136			-11	12
BH	F1,11	3	4			1	1	750	135			15	13
BH	F8,2	1	4			0	1	726	135			5	12
BH	F3,2	6	5			-1	1	763	135			-4	12
BH	C2,1	3	4			1	1	123	125			11	13
BH	C1,11	3	4			1	1	447	130			5	12
BH	C8,2	-3	3			1	1	189	126			-6	12
BH	C3,2	6	5			-1	1	41	124			2	12
BH	N3,1	-4	3			-1	1	-133	128			-1	12
BH	N2,4	0	4			0	1	-82	122			12	13
BH	N3,11	5	4			1	1	-287	118			-2	12
BH	E3,3	3	4			0	1	-176	120			12	13
BH	E2,7	3	4			-1	1	41	124			17	13
BH	S1,1	9	5			1	1	-86	122			-10	12
BH	W1,2	-1	3			0	1	-148	121			9	13
MEZRM	F3,2	13	5			0	0	767	135			0	13
MEZRM	C3,2	5	4			1	1	-271	119			12	13
MEZRM	S1,2	3	4			1	1	-234	119			9	13
130	F1,1	1	4			3	2	727	141			-20	13
130	F5,3	7	5			1	1	1021	145			-9	13
130	F7,2	12	5	236	17	2	2	848	143	1121	147	-2	14
130	F12,2	0	3			3	2	487	138			-5	13
130	C1,1	1	4			0	0	-395	130			9	13
130	C5,3	1	4			2	1	-382	130			-18	12
130	C7,2	-4	3			2	1	-533	127			-5	12
130	C12,2	5	5			1	1	-466	128			6	13
130	N2,2	-4	3			1	1	-487	128			10	13
130	N4,1	-2	3			-1	1	-416	123			-14	13
130	E3,3	-2	3			3	2	-311	125			-19	13
130	E1,6	0	4			0	0	-651	125			4	13
130	E2,7	-3	3			1	1	-584	126			1	13
130	E1,11	4	4			1	1	-391	130			-3	13
130	E5,2	2	4			1	1	-202	127			-23	13
130	E4,8	2	4			1	1	-260	126			-9	13
130	S2,1	1	4			2	1	357	141			16	13
130	S5,3	1	4			1	1	-118	128			-6	13
130	W1,3	1	4			1	1	-437	129			9	13
130	W2,5	-3	3			2	1	-500	128			14	13
130	W1,8	3	4			0	0	-794	123			5	13
130	W3,12	1	4			1	1	-349	124			-24	13
130	W4,2	1	4			-1	1	-286	125			-18	13

TABLE A.3

ROOM NUMBER	GRID NAME	ALPHA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-	BETA DPM/100CM2 TOT	+/-	MAX	+/-	REM	+/-
VAULT	W1,2	5	4			0	0	596	139			6	13
VAULT	W3,4	8	4			0	0	504	138			-3	12
EXITE	F1,1	11	5			0	0	962	145			-16	12
EXITE	C1,1	8	4			0	0	382	136			16	13
EXITE	N1,1	11	5			1	1	-80	129			-1	12
EXITE	E3,3	4	3			0	0	-50	129			3	12
EXITE	E2,6	1	3			0	0	-185	127			15	13
EXITE	S2,1	3	3			1	1	-214	126			-15	12
EXITE	W1,2	5	4			0	0	445	137			28	13
EXITE	W3,5	8	4			2	1	374	136			1	12
EXITW	F1,5	4	4			0	0	1012	146			0	12
EXITW	C1,5	-1	3			1	1	21	131			-2	12
EXITW	N2,1	5	4			1	1	-59	130			-4	12
EXITW	E2,3	-1	3			0	0	311	135			17	13
EXITW	E3,5	-1	3			1	1	319	136			9	13
EXITW	S3,1	2	4			1	1	92	132			26	13
EXITW	W1,2	-4	3			1	1	42	131			9	13
EXITW	W2,5	2	4			2	1	-193	127			-1	12
HOLDUP	F2,1	33	7			1	1	1104	154			-15	12
HOLDUP	F4,3	53	9	92	11	1	1	1385	158			27	13
HOLDUP	F6,5	49	8	191	16	-1	1	1431	159	1826	165	2	12
HOLDUP	N3,2	6	4			-1	1	994	153			8	12
HOLDUP	E4,1	4	4			0	1	1012	153			-5	12
HOLDUP	S1,2	55	9			2	2	1164	155			11	12
HOLDUP	F1,3	12	5	23	6	0	1	902	151			-10	12
EXITE	F6,1	1	3			1	1	865	140			8	13
EXITE	W3,1	0	2			1	1	-407	119			5	13
EXITE	W3,2	2	3			1	1	668	137			8	13
130	F8,2	12	5			15	3	525	138			-1	13
130	F7,1	7	4			0	0	941	144			7	13
130	F6,3	25	6			4	2	718	141			4	13
BH	F5,2	3	3			0	0	550	141			-4	13
BH	F6,2	10	4			1	1	802	145			-12	13
HOLDUP	F4,1	28	7	68	10	1	1	1419	153	1742	158	2	13
HOLDUP	F4,2	53	9	94	11	-1	1	1144	149	1247	151	3	13
HOLDUP	F3,3	54	9	49	8	0	1	1118	149	1333	152	21	13
HOLDUP	F3,4	40	8	113	12	1	1	894	146	882	146	4	13
HOLDUP	F5,2	66	10	158	15	4	2	1015	147	1333	152	16	13

GUIDELINES FOR DECONTAMINATION OF FACILITIES AND EQUIPMENT

PRIOR TO RELEASE FOR UNRESTRICTED USE

OR TERMINATION OF LICENSES FOR BYPRODUCT, SOURCE,

OR SPECIAL NUCLEAR MATERIAL

U.S. Nuclear Regulatory Commission
Division of Industrial and
Medical Nuclear Safety
Washington, DC 20555

August 1987

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The instructions in this guide, in conjunction with Table 1, specify the radionuclides and radiation exposure rate limits which should be used in decontamination and survey of surfaces or premises and equipment prior to abandonment or release for unrestricted use. The limits in Table 1 do not apply to premises, equipment, or scrap containing induced radioactivity for which the radiological considerations pertinent to their use may be different. The release of such facilities or items from regulatory control is considered on a case-by-case basis.

1. The licensee shall make a reasonable effort to eliminate residual contamination.

2. Radioactivity on equipment or surfaces shall not be covered by paint, plating, or other covering material unless contamination levels, as determined by a survey and documented, are below the limits specified in Table 1 prior to the application of the covering. A reasonable effort must be made to minimize the contamination prior to use of any covering.

3. The radioactivity on the interior surfaces of pipes, drain lines, or ductwork shall be determined by making measurements at all traps, and other appropriate access points, provided that contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, or ductwork. Surfaces of premises, equipment, or scrap which are likely to be contaminated but are of such size, construction, or location as to make the surface inaccessible for purposes of measurement shall be presumed to be contaminated in excess of the limits.

4. Upon request, the Commission may authorize a licensee to relinquish possession or control of premises, equipment, or scrap having surfaces contaminated with materials in excess of the limits specified. This may include, but would not be limited to, special circumstances such as razing of buildings, transfer of premises to another organization continuing work with radioactive materials, or conversion of facilities to a long-term storage or standby status. Such requests must:

    a. Provide detailed, specific information describing the premises, equipment or scrap, radioactive contaminants, and the nature, extent, and degree of residual surface contamination.

    b. Provide a detailed health and safety analysis which reflects that the residual amounts of materials on surface areas, together with other considerations such as prospective use of the premises, equipment, or scrap, are unlikely to result in an unreasonable risk to the health and safety of the public.

5. Prior to release of premises for unrestricted use, the licensee shall make a comprehensive radiation survey which establishes that contamination is within the limits specified in Table 1. A copy of the survey report shall be filed with the Division of Industrial and Medical Nuclear Safety, U. S. Nuclear Regulatory Commission, Washington, DC 20555, and also the Administrator of the NRC Regional Office having jurisdiction. The report should be filed at least 30 days prior to the planned date of abandonment. The survey report shall:

   a. Identify the premises.

   b. Show that reasonable effort has been made to eliminate residual contamination.

   c. Describe the scope of the survey and general procedures followed.

   d. State the findings of the survey in units specified in the instruction.

   Following review of the report, the NRC will consider visiting the facilities to confirm the survey.

TABLE 1

ACCEPTABLE SURFACE CONTAMINATION LEVELS

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/100 cm^2	300 dpm/100 cm^2	20 dpm/100 cm^2
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1000 dpm/100 cm^2	3000 dpm/100 cm^2	200 dpm/100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5000 dpm $\beta\gamma$/100 cm^2	15,000 dpm $\beta\gamma$/100 cm^2	1000 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 instrumentation.

[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 absorbent 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.