U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES • Public Health Service
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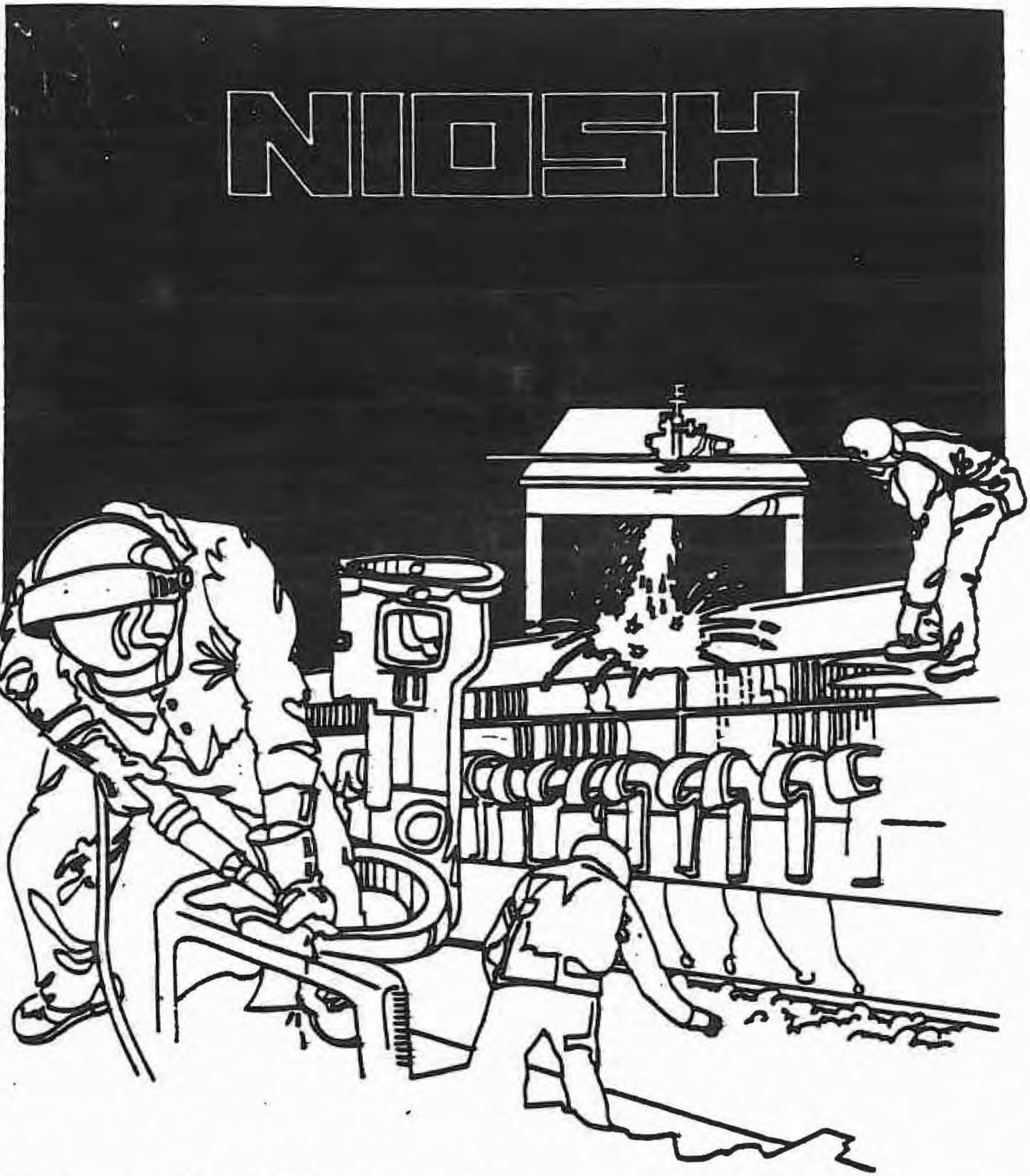

Health Hazard Evaluation Report

HETA 85-289-1738
PAGE BELCHER FEDERAL BUILDING
TULSA, OKLAHOMA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 85-289-1738
October 1986
PAGE BELCHER FEDERAL BUILDING
TULSA, OKLAHOMA

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1.0 SUMMARY

In April 1985 and February 1986, researchers from the National Institute for Occupational Safety and Health (NIOSH) conducted an assessment of potential contamination associated with a 1982 soot-producing electrical transformer malfunction at the Page Belcher Federal Building in Tulsa, Oklahoma. The transformer contained a polychlorinated biphenyl (PCB) dielectric fluid; the PCB was believed to be Aroclor 1260 (commercial mixture of PCBs with 60 weight percent chlorine). The assessment involved measurement of both surface and airborne concentrations of PCBs, polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzo-p-dioxins (PCDDs) throughout the entire Building (sub-basement through 4th floor inclusive). Surface measurements for PCBs also were made in the interior of the heating, ventilation, and air-conditioning (HVAC) system.

The surface and airborne concentrations of PCBs and PCDF/PCDDs (converted to 2,3,7,8-tetrachlorodibenzo-p-dioxin equivalents) were compared to the guidelines listed below: (These guidelines were developed by the Governor of New Mexico appointed Expert Advisory Panel for cleanup of the New Mexico State Highway Department General Office Building in Santa Fe; the Building experienced a transformer malfunction on June 17, 1985.)

	PCBs	TCDD Equivalents
Surface	50 ug/m^2	1 ng/m^2
Air	0.5 ug/m^3	2 pg/m^3

The surface contamination levels of PCBs and TCDD equivalents are presented below: (The reporting units for the values are ug/m^2 for PCBs and ng/m^2 for TCDD equivalents.)

Area of the Building	No. of Samples	Mean	Geometric Mean	Range
HVAC System**				
PCBs	78	62	37	2.0-332
Basement-to-4th Floor				
PCBs	207	4.9	1.9	(0.32)*-92
TCDD Equivalents	9	0.63	0.21	-0.06-4.9
Chiller/Boiler Rooms				
PCBs	22	5292	102	(5.0)-110000
TCDD Equivalents	2	2.1	1.6	0.80-3.4
Pipe Chases**				
PCBs	5	34	30	14-64
B-2 Tunnel**				
PCBs	6	44	14	2.5-200
B-1 and N Tunnels**				
PCBs	7	12	6.2	(0.32)-28
Loading Docks**				
West - PCBs	8	136	17	1.0-780
North - PCBs	2	18	18	17-19

*Value in parentheses is the limit of detection.
** Samples for TCDD equivalents were not collected.

The surface concentrations of PCBs and TCDD Equivalents measured in the primary occupancy areas of the Building (basement through floors four) were below the respective surface guidelines for all samples, except two. These samples (92 ug/m^2 PCBs and 4.9 ng/m^2 TCDD Equivalents) were obtained on elevated horizontal surfaces (height above floor >6 feet) on the second floor. A statistical relationship between PCB and TCDD Equivalents was determined by linear regression of the logarithmic transformed data ($r = 0.96$). The predicted concentrations of TCDD Equivalents from the geometric means for the PCB concentrations measured in the areas ranged from 0.02 to 0.23 ng/m^2 ($n = 7$, mean = 0.09 ng/m^2). Overall, the surface levels of PCBs and TCDD Equivalents were below the respective guidelines in these areas. The surface concentrations of these contaminants measured in the other areas (chiller/boiler rooms, pipe chases, B-2 conveyor tunnels and west loading dock) exceeded the PCB and/or TCDD Equivalents surface guidelines.

The Building's HVAC system consists of 27 air handling units (AHUs). Seven of the 27 AHUs obtain their fresh make-up air through outside grilles located on the west side of the Building directly above the transformer vault's exterior exhaust vent. The PCB surface concentrations in these seven air-handling systems (range = 14 to 332 ug/m^2, geometric mean = 82) were significantly higher than those in the other systems (range = 2 to 264 ug/m^2, geometric mean = 23) ($t = -5.8$, $p = 0.0001$). The PCB concentrations on workplace surfaces in areas serviced by these seven systems (range <0.32 to 92 ug/m^2, geometric mean 5.5) were significantly higher than those on surfaces in areas serviced by the other systems (range <0.32 to 31 ug/m^2, geometric mean = 1.5) ($t = -5.2$, $p = 0.0001$). The data indicate that the smoke released through the vault's exhaust vent re-entered the Building through the fresh air intake grilles located on its west wall.

The PCB air concentrations measured throughout the Building in April 1985 ranged from 0.11 to 0.49 ug/m^3 ($n = 30$, geometric mean = 0.23 ug/m^3) and those in February 1986 ranged from 0.11 to 0.37 ug/m^3 ($n = 44$, geometric mean = 0.21 ug/m^3). Thus, the air concentrations of PCBs did not change significantly between April 1985 and February 1986 ($t = 1.48$, $p = 0.14$). The PCB air concentrations did not vary significantly with area of the Building in 1985 ($F = 1.64$, $p = 0.18$) nor in 1986 ($F = 1.44$, $p = 0.21$) demonstrating that the air is in a steady-state or equilibrium condition with PCB.

The airborne concentrations of PCDF/PCDDs (tetra-through octa-chloro isomer groups and 2,3,7,8-tetra isomers) measured in April 1985 ($n = 6$) and February 1986 ($n = 5$) were not present above the detection limit, except for low concentrations of hepta-CDDs in two samples and octa-CDDs in seven samples. Since these compounds are not included in the hazard assessment calculation of TCDD Equivalents, they do not affect the calculation that shows that the Building air does not contain detectable concentrations of TCDD Equivalents.

Based upon results of the environmental samples collected by NIOSH researchers, it is concluded that there are workers in the Page Belcher Federal Building who are being exposed to potentially toxic concentrations of PCBs. Recommendations are offered in Section 9.0 of this Report concerning decontamination of certain areas of the Building and its HVAC system; and a medical surveillance program for the Building occupants.

KEYWORDS: SIC 9199 (Office Building), SIC 4911 (Electrical Services), transformer fire, PCBs, Polychlorinated dibenzofurans, PCDFs, polychlorinated dibenzo-p-dioxins, PCDDs, office workers.

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2.0 INTRODUCTION

On March 29, 1985, the National Institute for Occupational Safety and Health (NIOSH) received a request from the United States Postal Service for technical assistance in conducting an assessment of potential contamination associated with an April 16, 1982, soot-producing electrical transformer malfunction at the Page Belcher Federal Building in Tulsa, Oklahoma. The request was prompted by environmental measurements made by representatives of the U.S. Postal Service indicating that the sub-basement chiller and boiler rooms, and west loading dock area were contaminated with polychlorinated biphenyls.

An assessment of potential contamination was conducted by NIOSH during April 13-19, 1985, and January 28 - February 4, 1986. The contamination assessment involved measurement of both surface and airborne concentrations of polychlorinated biphenyls, polychlorinated dibenzofurans and polychlorinated dibenzo-p-dioxins throughout the entire Building (sub-basement through floors four inclusive).

The results of the April 13-19, 1985, survey were presented to the United States Postal Service and the American Postal Workers Union in a letter report dated June 11, 1985. This report presents the final results of the overall contamination assessment and resulting recommendations.

3.0 BACKGROUND

3.1 Transformer Incident

On April 16, 1982, a fire occurred in an electrical transformer located in a vault in the sub-basement of the Page Belcher Federal Building in Tulsa, Oklahoma. Although the fire was contained within the vault, heavy black smoke issued from the vault's exhaust vent/grate in the west mail handling dock area. The size of transformer or length of time the transformer remained energized is not known.

The transformer contained a polychlorinated biphenyl (PCB) dielectric fluid; the exact composition of the fluid is not known. Analysis of a sample of soot obtained from the transformer vault in 1982 contained 3201 micrograms of Aroclor 1260 per gram of soot [1]. (Aroclor 1260 is a commercial mixture of PCBs with approximately 60 weight percent chlorine.) No analyses were reported for polychlorinated dibenzofurans (PCDFs) or polychlorinated dibenzo-p-dioxins (PCDDs). The PCDFs and, to a lesser extent, PCDDs are likely to be present in soot resulting from fires involving PCB-containing electrical equipment [2,3].

The owner of the transformer, Public Service Company of Oklahoma, immediately cleaned the vault and affected areas of the sub-basement [4]. It is not known whether any testing was conducted to verify the effectiveness of the cleaning effort.

3.2 The Building

3.2.1 Structure

The Page Belcher Federal Building is a four story structure containing approximately 375,000 square feet of space with a half sub-basement, a full basement, two mezzanines, and a roof penthouse. Layout drawings of the Building are contained in Figures 1 through 8.

The sub-basement area consists of a boiler room and chiller room, and within the latter are the air handling equipment control and lunch rooms. The transformer vault also is located in the sub-basement beneath the west mail handling dock. The vault is interconnected with the sub-basement by a tunnel that passes under the west dock and into the boiler room.

The basement level consists of offices, mail handling areas and work shops. In addition, there are six passenger elevators which commence at this level, and conveyor tunnels used for transport of the mail from the west and north dock areas to the work room floors.

The first floor constructed at street level consists of two public lobbies and the main mail handling area with two exterior loading docks on the north and west sides. The first floor mezzanine located on the perimeter of the Building contains a snack room, lounges, locker rooms, and mechanical air handling unit rooms.

The second floor consists of offices, mail handling areas, and a maintenance shop. The second floor mezzanine consists of offices along the south side of the Building. The third floor is used primarily as miscellaneous office space. The fourth floor consists of judge's courtrooms, meeting rooms and offices. The roof penthouse level contains mechanical rooms for air handling units and elevator equipment rooms.

3.2.2 HVAC System

The Building has 27 separate air handing units located in the sub-basement, first and second floor mezzanines, third floor, and penthouse mechanical rooms. These units comprise the Building's heating, ventilation, and air-conditioning (HVAC) system. The individual air handling units supply air to specific zones on each floor. There are a total of 77 interior air supply zones in the Building plus one to three perimeter air supply zones for each of four floors and two mezzanines. An air handling unit may serve from one to nine distribution zones.

A summary of the air handling units and zones served by area of the Building is contained in Table 1. The approximate locations of the air handling units and zones are shown on a plan drawing for each floor contained in Figures 1 through 8.

The air handling units located on the first floor mezzanine (AHUs 74, 75 and 76) and on the second floor mezzanine (AHUs 83, 84, 88 and 89) obtain their fresh make-up air from the outside air grilles located on the west side of the Building. These outside air grilles are located directly above the transformer vault s exhaust vent/grate in the west mail handling dock area. The other air handling units obtain their fresh make-up air from outside air grilles located on the north or south walls, or the roof of the Building.

4.0 STUDY DESIGN AND SAMPLING METHODOLOGY

4.1 Study Design

A contamination assessment study was conducted by NIOSH researchers during April 13-19, 1985, and January 28 - February 4, 1986. The primary objective of the study was to measure the concentration levels of PCBs and PCDFs/PCDDs in air and on surfaces throughout the Building (sub-basement through floors four inclusive). To achieve this objective air and surface samples were collected at locations to yield the most representative concentration distribution of these contaminants throughout the Building. The selection of the sampling locations was directly keyed to the 27 air handling systems and the associated 77 air handling distributions zones, with the exception of the samples collected in the following areas: boiler and chiller rooms, west and north tunnels, pipe chases and mail handling docks.

The secondary, though parallel objective, was to determine if the smoke generated by the April 1982 transformer malfunction contaminated the Building. To achieve this objective, a sampling strategy was designed based on the probable path of dispersion and mechanisms of transport (mechanical or natural ventilation) of the contaminants. It was hypothesized that the smoke released through the vault's exhaust vent at the west dock area re-entered the Building through the fresh air intake grilles located on the west wall of the Building. These outside air intake grilles serve the seven air handling units on the first and second floor mezzanines (AHU's 74, 75, 76, 83, 84, 88 and 89, respectively). The hypothesis was that if the smoke re-entered the Building through these outside air grilles, the concentration level of surface contamination present in the seven air handling systems would be significantly greater than that present in the other 20 systems. The other 20 air handling systems obtain their outside make-up air from grilles located on north and south walls of the Building, and at the roof level.

In addition to the smoke venting to the outside of the Building, it was also hypothesized that the smoke exited the vault into the adjacent chiller and boiler room through openings in the vault's structure. Included are two ventilation louvers and an electrical bus tray on the north wall, a door on the south wall, or through any other penetrations (eg, along electrical conduit) in the vault's structure. The resultant smoke in the chiller room and boiler room would have exited the rooms by convective transfer through two pipe chases in the southwest quadrant of the boiler room, and at the air grating through the tunnel adjacent (south) to the vault. Exiting through the tunnel air grating also would have permitted the potential for re-entry through the air intake grilles located on the west wall of the Building.

4.2 Air Sampling - PCDFs/PCDDs and PCBs

Air samples for PCDFs and PCDDs were collected using a high volume sampling device developed by the New York State Health Department (NYSDH) and previously used in evaluating the Binghamton State Office Building [5].

The high volume sampler is a two-stage sampling device (Figure 9). The first stage is a 47-mm diameter, 0.3 u pore size glass fiber filter. The second stage is a cartridge of 8 gms of silica gel adsorbent. The silica gel cartridge was spiked with a 2.5 ng each of 2,3,7,8 - tetrachlorodibenzo-p-dioxin $-^{13}C_{12}$ and 2,3,7,8 - tetrachlorodibenzofuran - $^{13}C_{12}$ before sampling for quantification and to account for any retention losses during sampling. The sampler was attached to a 1.5 cubic feet per minute (cfm) rotary vane vacuum pump operated on 110 VAC line power. The air sample was collected for approximately a 48-hour period at a flow rate of 20 liters per minute (L/min) to achieve an air volume of approximately 57.6 cubic meters (m^3). The air flow rate through the sampler was regulated to 20 L/min using an "in-line" calibrated rotameter and a precision flow control valve. The samplers were inspected approximately every four hours and flow rates recorded and adjusted as necessary.

Air samples for PCBs were collected using NIOSH method 5503 [6] during both the April 1985 and February 1986 surveys. The method involves a two-stage sampling device consisting of a 13-mm glass fiber particulate filter preceeded by 150 mg of florisil adsorbent (100 mg front and 50 mg back sections). The samples were collected using constant flow vacuum pumps at a flow rate of 0.60 L/min for approximately 10-hours (April 1985) and 12-hours (February 1986).

The February 1986 survey also included collecting PCB air samples using a modification of a florisil stick procedure developed by the New York State Department of Health. The New York State Florisil (NYSF) stick procedure was modified by trapping airborne particulates on a 47-mm, 0.3 um pore size glass fiber filter before collecting the vapor phase or the Florisil. This modification is consistent with NIOSH method 5503.

The NYSF stick is a glass tube 9.5 inches long by 0.375 inches outside diameter. The tube contains two sections (front and back) of 400 mg of 30/60 mesh florisil adsorbent. The front and back are separated by two plugs of glass wool. The front section of each tube is spiked with 0.1 ug p,p'-DDE as an internal standard for measurement of recovery. The two-stage sampling device was attached to a 1.5 cfm rotary vane vacuum pump operating at 110 VAC line power. The air samples were collected for approximately a 48-hour period at a flow rate of 1.0 L/min using an "in-line" calibrated rotameter and a precision flow control valve. The samplers were inspected approximately every four hours and flow rates recorded and adjusted as necessary.

4.2.1 Sampling Locations - PCDFs/PCDDs and PCBs

The frequency of air samples collected by area of the Building in April 1985 and February 1986 is summarized in Table 2. A total of 11 PCDF/PCDD and 74 PCB air samples were collected. (These totals do not include field blanks.) A larger number of PCB samples were collected to determine the degree of homogeneity of the air in the Building. This data would support the use of the smaller number of PCDF/PCDD samples as representative of conditions throughout the Building. Ten of the PCDF/PCDD samples were collected at paired locations with PCBs. The approximate sampling locations for the PCB and PCDF/PCDD samples are shown in Figures 10 through 16.

4.3 Surface Sampling - PCDFs/PCDDs and PCBs

A wet-wipe protocol was used to assess the surface concentrations of PCBs, PCDFs and PCDDs.

The surface wipe samples were collected using 3" x 3" soxhlet extracted cotton gauze pads. The sampling procedure consisted of marking off a surface into 0.25 m^2 areas using a galvanized steel template or a metal tape measure. Each 0.25 m^2 area was wiped with a 3" X 3" gauze pad which had been wetted with 8-ml of pesticide grade hexane. The wet wipe sample pad was held with a glove hand; a non-linear polyethylene, unplasticized type glove was changed with each sample. The surface was wiped in two directions (the second direction was performed at a 90° angle to the first direction). Each gauze pad was used to wipe only one 0.25 m^2 area. The gauze pad sample was then placed in glass sample container equipped with a Teflon-lined lid.

Each PCB wipe sample consisted of a single sample from an area of 0.25 m^2. Each PCDF/PCDD wipe sample consisted of a composite of four 0.25 m^2 wipe samples for a total area of 1.0 m^2. The four PCDF/PCDD gauze pads were composited and treated as a single sample to attain as acceptable detection limit.

The same technique was used to collect the samples during the April 1985 survey, except that the sample media was a 2" X 2" cotton gauze pad wetted with 4-ml hexane, and the PCB wipe sample area was 100 cm^2 (0.01 m^2).

4.3.1 Sampling Locations - PCDF/PCDD and PCBs

The frequency of surface samples collected by area of the Building in April 1985 and February 1986 is summarized in Table 2. A total of 11 PCDF/PCDD and 428 PCB surface samples were collected. (These totals do not include field blanks.) It should be noted that in April 1985 (Table 2) 120 PCB surface wipe samples were collected. However, due to the presence of a chemical interference, 51 of the 120 samples could not be analyzed.

As with the air samples, a larger number of PCB surface samples were collected to demonstrate the range of cleanliness of surfaces throughout the Building in order to support the use of a smaller number of PCDF/PCDD samples as being representative. The PCDF/PCDD samples were collected side-by-side with the PCB samples to determine if a statistical relationship existed. The existence of a statistical relationship between PCB and PCDF/PCDD would permit the use of a PCB concentration to predict the corresponding PCDF/PCDD concentration.

The approximate sampling locations for the PCB and PCDF/PCDD samples (excluding the 84 PCB samples obtained interior to the heating, ventilation, and air-conditioning (HVAC) system) are shown in Figures 17 -23. Location of these 84 PCB samples is described in Tables 7 and 8.

4.4 Statistical Treatment of Data

4.4.1 Treatment of None Detected Values

In the statistical analysis of the data, none detected values were treated using the L/2 approximation method [7,8]. This approach assumes that all none detected (ND) values are equal to half the detection limit, L, i.e., ND = L/2. This approach was used for air and surface samples reported as none detected, except for the PCB surfaces samples collected in April 1985. The detection limit reported for these samples was equivalent to 5.0 ug PCB per square meter area (ug/m^2) with an L/2 value of 2.5 ug/m^2. These results were excluded from the statistical analysis of the grouped data for the following reason: Samples collected from the same areas of the Building in February 1986 showed detectable concentrations based on a lower limit of detection (0.6 ug/m^2). Approximately 95 samples collected in February in the basements and floors one through four showed detectable concentrations ranging from 0.6 to 2.5 ug/m^2. Therefore, inclusion of these data (April 1985) would have misrepresented the distribution of the PCB concentration actually present.

4.4.2 Tests for Normality [9,10]

The PCB surface and air sampling data were tested for normality, i.e., tested to determine if the data followed a normal or log normal distribution. The Shapiro-Wilk statistic, W, was used to test for normality if the sample size was less than 51. The Kolmogorov D statistic was used if the sample size was greater that 50. These tests showed the data to be log normally distributed. Therefore, the geometric mean was used as the primary measure of central tendency.

4.4.3 Tests of Significance [9,10]

A t-test was used to answer the following questions:

1. Are the PCB surface concentrations in Air Handling Units (AHUs) 74-76, 83, 84, 88 and 89 significantly different than the concentrations in AHUs 49, 77, 78, 80, 85-87, 93-95 and 100-108?

2. Are the PCB surface concentrations in the work spaces serviced by AHU's 74-76, 83, 84, 88 and 89 significantly different than the concentrations in the work spaces serviced by AHU's 49, 77, 78, 80, 85-87, 93-95 and 100-105?

A paired t-test was used to answer the following questions:

1. Are the PCB air concentrations measured in April 1985 significantly different than those measured in February 1986, i.e., did the PCB air concentration change with time? The test pairs did not include the first and second floor mezzanines as these areas were only tested in February 1986.

2. Are the PCB air concentrations measured in February 1986 using the NIOSH method significantly different from the concentrations measured at the same time using the NYSDH method?

A F-test (one-way analysis of variance) was used to answer the following questions:

1. Does the PCB air concentration vary with area of the Building - April 1985 test data?

2. Does the PCB air concentration vary with area of the Building - February 1986 test data?

4.4.4 Evaluation of Relationship Between PCBs to PCDF/PCDDs [9,10]

To evaluate the relationship between PCB and PCDF/PCDD concentrations on surfaces, the logarithms (base 10) of both data sets were used in linear regression analysis.

4.5 Sample Chain-of-Custody

Sample Chain-of-Custody procedures were an integral activity of both sampling and analytical activities. Chain-of-Custody procedures provided documentation of samples through all phases of activities from the time the sampling devices were prepared to be sent to the field through reporting of the analytical results. Sample Chain-of-Custody was initiated by the sampling personnel upon receipt of the sampling devices. Each sampling device was assigned a unique identification number.

The Chain-of-Custody procedures were in accordance with those specified in NIOSH's manual of Standard Operating Procedures for Industrial Hygiene Sampling and Chemical Analyses, SOP No. 019, December 19, 1984.

5.0 ANALYTICAL METHODOLOGY

The surface wipe and air samples for PCDF/PCDD analysis, and the air samples (NYSF Method) for PCB analysis was completed by Battelle-Columbus Laboratories in Columbus, Ohio. The surface wipe samples and air samples (NIOSH Method) for PCB analysis was completed by Deseret Research Company in Salt Lake City, Utah. (The latter laboratory has NIOSH's Comprehensive Analytical Services Contract.)

5.1 PCDF/PCDD Analysis - Surface and Air

5.1.1 Sample Extraction and Analyte Enrichment

The silica gel cartridge and the particulate filter from each PCDD/PCDF air sampler were Soxhlet extracted for 18 hours using approximately 250 mL of benzene and concentrated to 10 mL using a 3-stage Snyder column. The silica cartridges had been spiked with 2.5 ng each of 2,3,7,8-tetrachlorodibenzo-p-dioxin-$^{13}C_{12}$ (2,3,7,8-TCDD-$^{13}C_{12}$) and 2,3,7,8-tetrachlorofuran-$^{13}C_{12}$ (2,3,7,8-TCDF-$^{13}C_{12}$) prior to sampling. Before extracting 5 ng of octachlorodibenzo-p-dioxin-$^{13}C_{12}$ (OCDD-$^{13}C_{12}$) were spiked into each sample. The benzene extracts were concentrated to approximately 10 mL using a 3-stage Snyder column.

The wipe samples were transferred to Soxhlet thimbles and spiked with 10 ng each of 2,3,7,8-TCDD-$^{13}C_{12}$, 2,3,7,8-TCDF-$^{13}C_{12}$ and OCDD-$^{13}C_{12}$. All samples were Soxhlet extracted for 18 hours using benzene and concentrated to approximately 10 mL using a 3 stage Snyder column.

The benzene extracts from the air and wipe samples were transferred to multilayered columns containing activated silica gel, 44 percent concentrated sulfuric acid on silica gel, and 33 percent 1M sodium hydroxide on silica gel. The columns were rinsed with 70 mL of hexane and the entire eluates were collected. The purpose of these columns was to remove acidic and basic compounds from the extracts as well as oxidizable materials.

The benzene/hexane eluates were concentrated using a gentle stream of nitrogen gas and solvent exchanged into hexane. The hexane solutions were chromatographed through columns containing approximately 5 gm of activated basic alumina using hexane/methylene chloride (97:3, v/v), and hexane/methylene chloride (1:1, v/v) as elution solvents. The 1:1 hexane/methylene chloride eluates were collected, concentrated to near dryness, and dissolved in 20 uL of n-decane containing 5 ng of an absolute recovery standard, 1,2,3,4-TCDD-$^{13}C_{12}$. All solutions were stored at 0°C and protected from light until analyzed.

5.1.2 Analysis

The extracts were analyzed and quantified for PCDD/PCDF using combined capillary column gas chromatography/high resolution mass spectrometry (HRGC/HRMS). The HRGC/HRMS consisted of a Carlo Erba Model 4160 gas chromatograph interfaced directly into the ion source of a VG Model 7070 mass spectrometer. The chromatographic column was a 60 M DB- fused silica column using helium carrier gas at a flow velocity of 25 cm/sec. The mass spectrometer was operated in the electron impact (EI) ionization mode at a mass resolution of 9000-12000 (M/ΔM, 10% valley definition). The operating parameters of the HRGC/HRMS are summarized in Table 3. All HRGC/HRMS data were acquired by multiple-ion-detection using a VG Model 2035 Data System. The exact masses that were monitored are shown in Table 4.

5.1.3 Quality Assurance

The operation of the HRGC/HRMS was evaluated each day by analyzing standard mixtures of PCDD/PCDF isomers. These consisted of 2,3,7,8-TCDF, 2,3,7,8-TCDD, 2,3,7,8-TCDF-$^{13}C_{12}$, and 2,3,7,8-TCDD-$^{13}C_{12}$ mixtures to evaluate accuracy of quantification, mixtures of selected PCDD/PCDF isomers to evaluate the stability of the chromatographic elution windows, and TCDD isomer mixtures to evaluate isomer resolution. The mass accuracy of the MID unit was evaluated at least every four hours by focusing selected ion masses from perfluorokerosene (PFK) and correcting the slope to account for minor variations. Mass focus stability was assured by the use of a reference PFK "lock mass" to correct for any mass focus drift.

Native spike, field blank, and lab blank samples were processed during the extraction and cleanup of the samples. All method blank analyses were free of PCDD/PCDF contamination. The native spike sample quantifications were within ±50% of the correct value with exception of the penta-CDD in one of the air spike samples. The recovery for this isomer is anomalous and could have resulted fram a temporary change in the HRGC/HRMS instrument sensitivity.

5.1.4 Recovery of Internal Standards

The recoveries of the internal standards, 2,3,7,8,-TCDF-$^{13}C_{12}$, 2,3,7,8-TCDD-$^{13}C_{12}$, and OCDD-$^{13}C_{12}$ were calculated by comparison to the external standard, 1,2,3,4-TCDD-$^{13}C_{12}$, which was added following extraction. Relative response factors were calculated from triplicate analysis of a standard mixture containing the four labelled internal standards.

5.1.5 Quantification

The PCDF/PCDD isomers were quantified by comparing the sum of the two ions monitored for each class to the sum of the two ions monitored for the corresponding internal standard. The 2,3,7,8-TCDF-$^{13}C_{12}$ was used to quantify the TCDF isomers, while the 2,3,7,8-TCDD-$^{13}C_{12}$ was used to quantify the TCDD isomers and the pentachloro and hexachloro PCDD/PCDF isomers. The OCDD-$^{13}C_{12}$ was used to quantify the heptachloro and octachloro PCDD/PCDF isomers. Experimental relative response factors were calculated from analysis of a mixture which contained representatives of the tetrachloro- through octachloro-PCDD/PCDF congener classes. Since the mixture did not contain a heptachloro-CDD isomer, the heptachloro-CDF was used for calculating the relative response factor for the heptachloro PCDD/PCDF isomers. The response factors were included in all calculations used to quantify the data. The response factors were calculated using the sum of the two ions monitored for each class of isomers compared to the sum of the two ions monitored for the corresponding internal standard. The experimental response factors were:

Tetra-CDD	1.06	Tetra-CDF	1.04
Penta-CDD	0.425	Penta-CDD	1.02
Hexa-CDD	0.571	Hexa-CDF	1.02
Hepta-CDD	4.29	Hepta-CDF	4.29
Octa-CDD	1.25	Octa-CDF	1.31

The formula used for quantifying the PCDD/PCDF isomers was:

$$\text{Quantity/sample} = \frac{\text{Areas of Quant. Masses x Quantity of Internal Standard}}{\text{Areas of Int. Std. Masses x Response Factor}}$$

The criteria that were used to identify PCDD and PCDF isomers were:

(1) Simultaneous responses at both ion masses

(2) Chlorine isotope ratio within ± 15% of the theoretical value

(3) Retention times within windows determined from analyses of standard mixtures

(4) Signal to noise ratio equal to or greater than 2.5 to 1.

The 2,3,7,8-TCDF/TCDD and OCDD isomers included the additional criterion that they coeluted within ± 2 seconds their isotopically labelled analogs. A limit of detection was calculated for samples in which a particular chlorination class was not detected. The formula used was:

$$\text{Limit of Detection/sample} = \frac{\text{Hts. of Quant. Masses x Quant. Int. Std. x 2.5}}{\text{Hts. of Int. Std. Masses x Response Factor}}$$

5.2 PCB Air Sample Analysis - Battelle-Columbus

5.2.1 Sample Extraction

The filters and the florisil sticks from each PCB air sampler were extracted separately. The filters were Soxhlet extracted for 4 hours using hexane and concentrated to 10 mL using 3 stage Snyder columns. Each half of the florisil stick eluates were combined with the corresponding filter extracts, acid washed with concentrated sulfuric acid and dried using sodium sulfate. All extrats were concentrated to 1 mL. Prior to sampling, the front half of each florisil stick had been spiked with 0.1 ug of a recovery standard, p,p'-DDE.

5.2.2 Analysis

The PCB sample extracts were analyzed using capillary column gas chromatography/electron capture detection (GC/ECD). The PCB analysis conditions are listed in Table 5.

5.2.3 Quality Assurance

Native spikes, lab blanks, field blanks, and second half florisil stick extracts were processed and analyzed with the PCB samples. No DDE or PCB was detected in the analyses of any of the second half florisil sticks; however, very low levels of Aroclor 1242 and 1254, 0.03-0.07 ug/M^3, were detected in two of the four field blanks. (All field samples were blank corrected.) The recoveries of the native spike samples ranged from 67-91%, which is within the expected range of variation.

5.2.4 Recovery of Internal Standards

The DDE recoveries for the PCB air samples were calculated by comparison to a 100% solution of a DDE spiking solution.

5.2.5 Quantification

The PCB levels were quantified by comparison to standard curves which were generated from analysis of external Aroclor standards. Prior to analyzing the sample extracts, standard curves were generated for Aroclor 1242, 1254, and 1260. The standard curves covered the concentration range of 0.25 to 1.0 ug/ml. Each standard solution was analyzed in triplicate and the data were plotted using linear regression equations. The summed areas from approximately 8-10 chromatographic peaks were used for the quantifications. These peaks were selected so that there was a minimum of cross Aroclor interference in samples which contained multiple Aroclors.

5.3 PCB Analysis - Surface and Air

5.3.1 Sample Extraction

The gauze samples were prepared for analysis by extraction in 40 milliliters of hexane with shaking for 30 minutes. The hexane was transferred to a concentrator tube and the gauze was rinsed twice with 10 milliliters of hexane. The concentrated hexane eluant was cleaned on a silanized, prerinsed glass wool column then a florisil column and the sample was brought to a final volume of 3 milliliters.

The florisil tubes were separated into A and B sections. Each section was desorbed in 1 mL of iso-octane and sonicated for 1 hour. Each glass fiber was desorbed in 1 mL of iso-octane and sonicated for 1 hour.

5.3.2 Analysis

The gas chromatographic analysis was performed on a Hewlett-Packard Model 5731A gas chromatograph equipped with an electron capture detector and accessories for capillary column capabilities. A 25m X 0.31mm fused silica WCOT capillary column coated internally with DB-5 was used with temperature programming from 210 C (held for two minutes) to 310 C at a rate of 8C per minute. Five percent methane in argon was used as the carrier gas. The capillary injector was operated in the splitless mode.

5.3.3 Quantification

The presence of an Aroclor was determined by comparison with standard samples of Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260 obtained from the EPA. Quantitation was performed by summing the peak heights of the five major peaks of the standards and comparing those sums to the sums of the same peaks in the sample.

5.3.4 Quality Assurance

The laboratory quality assurance included (a) 10% duplicate analysis; (b) 15% spiked audit samples; and (c) 8% and 10% field blanks for surface and air samples, respectively.

6.0 EVALUATION CRITERIA

6.1 Toxicology - PCBs

Polychlorinated biphenyls (PCBs) are a class of compounds that have various combinations of chlorine atoms attached to a biphenyl molecule [11]. Since commercial introduction in the late 1920s, over 1.25 billion pounds of PCBs have been manufactured and used in the United States, primarily in mixtures with chlorobenzenes known as askarels which are used as dielectric fluids for electrical transformers and capacitors, heat transfer systems, and hydraulic systems [12]. PCBs also have been used as lubricants, plasticizers, pesticide extenders, and components of inks and surface coatings [13]. The main uses of PCBs are summarized in Table 6.

Commercial PCBs are mixtures of isomers of chlorinated biphenyls. The basic structure of PCBs is a biphenyl backbone to which is attached up to ten chlorine atoms. Although there are 209 possible positional chlorobiphenyl isomers, only 100 individual isomers are likely to occur at significant concentrations in commercial PCB mixtures [14]. PCBs were manufactured in the United States and marketed under the "Trade name Aroclor" according to the average percent chlorine content of the mixture. The Aroclor products were designated by numbers such as 1221, 1242, 1248, 1254, and 1260, with the last two digits representing the approximate percent by weight of chlorine in the mixtures. Aroclor 1016, however, contained 41% chlorine [11].

PCB residues are detectable in various tissues of persons without known occupational exposure to PCBs. Mean whole blood PCB levels have been found to range from 1.1 to 8.3 parts per billion (ppb), while mean serum PCB levels range from 2.1 to 24.2 ppb [15]. Mean serum PCB levels among workers in one capacitor manufacturing plant studied by NIOSH ranged from 111 to 546 ppb, or approximately 5 to 22 times the background level in the community. Mean serum PCB levels among workers in transformer maintenance and repair have been found to range from 12 to 51 ppb, considerably lower than among workers at capacitor manufacturing plants [16].

Chlorobiphenyl toxicity is complicated by the presence of highly toxic impurities, especially the polychlorinated dibenzofurans (PCDFs) [17], which vary in amount between PCBs of manufacturers [18], and PCBs of different percent chlorination [19], and which are found in increased concentration when PCBs undergo incomplete pyrolysis [20,21]. As well, different animal species, including man, vary in their pattern of biologic response to PCB exposure [22].

Two human epidemics of chloracne, "Yusho" and "Yu-cheng," from ingestion of cooking oil accidentally contaminated by a PCB heat-exchange fluid used in the oil's pasteurization, have been described in detail [23,24]. Although PCBs were initially regarded as the etiologic agent of Yusho, analyses of the offending cooking oil demonstrated high levels of polychlorinated dibenzofurans and polychlorinated quarterphenyls, as well as other unidentified chlorinated hydrocarbons, in addition to PCBs [25].

The results of individual studies of PCB-exposed workers are remarkably consistent. Among the cross-sectional studies of the occupationally exposed, a lack of clinically apparent illness in situations with high PCB exposure seems to be the rule. Chloracne was observed in recent studies of workers in Italy, [26] but not among workers in Australia, [27], Finland [28], or in the United States [16,29-31]. Weak positive correlations of PCB exposure or serum PCB levels have been reported with SGOT [26,28-30], GGTP [16,26,30,31], and plasma triglycerides [16,32,33]. Correlations with plasma triglycerides [34] and with GGTP [35] are also found among community residents with low level PCB exposures. Causality cannot necessarily be imputed to PCBs in these cross-sectional studies.

The International Agency for Research on Cancer has concluded that the evidence for PCBs'carcinogenicity to animals and to humans is limited. "Certain polychlorinated biphenyls are carcinogenic to mice and rats after their oral administration, producing benign and malignant liver neoplasms. Oral administration of polychlorinated biphenyls increased the incidence of liver neoplasms in rats previously exposed to N-nitrosodiethylamine"[36].

In a mortality study among workers at two capacitor manufacturing plants in the United States [37] a greater than expected number of observed deaths from cancer of the liver and cancer of the rectum were noted. Neither increase was statistically significant for both study sites combined. However, in a recent update of this study (in press), with follow-up through 1982, the excess in liver/biliary tract cancer was statistically significant (5 observed vs. 1.9 expected)/ whereas, the excess in cancer of the rectum was still elevated but not statistically significant. In a mortality study among workers at a capacitor manufacturing plant in Italy [38] males had a statistically significant increased number of deaths from all neoplasms. When analyzed separately by organ system, death from neoplasms of the digestive organs and peritoneum (3 observed vs. 0.88 expected) and from lymphatic and hematopoietic tissues (2 observed vs. 0.46 expected) were elevated. This study was recently expanded to include all workers with one week or more of employment with vital status follow-up through 1982. In the updated results, there was a statistically significant excess in cancer among both females (12 observed vs. 5.3 expected) and males (14 observed vs. 7.6 expected). In both groups there were non-significant excesses in lymphatic/hematopoietic cancer and a statistically significant excess in digestive cancer among males (6 observed vs. 2.2 expected). Unfortunately, not enough information is provided to determine the risk specifically for liver cancer.

The National Institute for Occupational Safety and Health (NIOSH) recommends that exposure to PCB's in the workplace be limited at or below the minimum reliable detectable concentration of 1 ug/m^3 determined as a time-weighted average for up to a 10-hour workday, 40-hour workweek. The NIOSH recommended exposure limit (REL) was based on the findings of adverse reproductive effects in experimental animals, on the conclusion that PCB's are carcinogens in rats and mice and, therefore, potential human carcinogens in the workplace, and on the conclusion that human and animal studies have not demonstrated a level of exposure to PCB's that will not subject the worker to possible liver injury [70,3].

6.2 Toxicology - PCDFs and PCDDs

Polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzo-p-dioxins (PCDDs) are two series of tricyclic aromatic compounds. The general structural formulas are shown in Figure 24. The number of chlorine atoms can vary between 1 and 8 (mono- through octa-chloro isomer groups) resulting in 75 PCDDs and 135 PCDF positional isomers.

The toxic effects of these compounds are associated with the number and specific placement in the chlorine atoms on the molecule. The tetra-, penta- and hexa-chlorinated isomer groups exhibit greater toxicity than the other chlorinated forms [39-41]. PCDDs and PCDFs with chlorine at positions 2,3,7, and 8 are particularly toxic [42-44]. PCDDs and PCDFs are highly toxic in experimental animals when administered acutely subchronically, or chronically [44-49, 50-52]. Toxic effects include severe weight loss, liver necrosis and hypertrophy, skin lesions, immunosuppression, reproductive toxicity, teratogenesis and death. Of the 75 PCDD and 135 PCDF isomers, only 2,3,7,8-TCDD and a mixture of hexachlorinated dibenzo-p-dioxins with four of the six chlorines in positions 2,3,7, and 8 have been tested for carcinogenicity. Two independent studies of 2,3,7,8,-TCDD resulted in significant increases in the incident of liver and/or lung tumors in treated rodents [53,54]. A mixture of two 2,3,7,8-substituted hexa chlorinated dibenzodioxins were found to produce an increased incidence of liver tumors or neoplastic modules in exposed rats and mice [55]. Exposure of humans to PCDDs had caused chloracne (a skin lesion which resembles mild to very severe acne and which may last many years); and liver toxicity [50, 56]. There is suggestive evidence of associations between increased incidences of cancer in humans and exposure to PCBs containing significant PCDFs [57,58], and to phenoxyacetic herbicides contaminated with PCDDs including TCDD [59,60]. However definite causal relationships between exposure and carcinogenic effects in humans remain unclear due to the inadequately defined population studies and the influences of mixed exposures.

6.3 Guidelines - Air and Surface

On July 16, 1985, the Governor of New Mexico appointed Expert Advisory Panel convened to develop air and surface cleanup guidelines for the New Mexico State Highway Department General Office Building in Santa Fe; the Building experienced a transformer malfunction on June 17, 1985 [61].

The Panel consisted of representatives of the National Institute for Occupational Safety and Health (NIOSH), U.S. Environmental Protection Agency (EPA), Workers Institute for Safety and Health (WISH), and four members of New Mexico's scientific community.

The PCB, PCDF and PCDD test data obtained in the Page Belcher Federal Building were compared to the guidelines recommended by this Panel. The guidelines were based on the potential risk of cancer resulting from exposure to polychlorinated biphenyls (PCBs), polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzo-p-dioxins (PCDDs). The guidelines for PCDFs and PCDDs are intended to maintain the risk of developing cancer below one in one million for a person spending the rest of his/her working lifetime (30 years) in the building. Animal studies on the carcinogenicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) were used to estimate the potential cancer risks. It was also necessary to make certain judgements and assumptions regarding the toxicity of the related compounds and the potential for exposure to occupants of the building. The guidelines for PCBs take into account the usual presence of detectable background levels of PCBs in air and on surfaces [61], and are intended to guide the cleanup within a safe margin of this background level.

The surface and air guidelines recommended by the Panel are shown below:

	AIR	SURFACE
PCBs*	0.5 ug/m^3**	50 ug/m^2
2,3,7,8-TCDD Equivalents*	2 pg/m^3	1 ng/m^2

*Units: ug/m^3 = micrograms of PCB per cubic meter of air.
pg/m^3 = picograms of TCDD Equivalents per cubic meter of air.
ug/m^2 = micrograms of PCB per square meter of surface.
ng/m^2 = nanograms of TCDD Equivalents per square meters of surface.

**This is a cleanup criteria and not a health guideline.

The observed surface and airborne concentrations of PCDF/PCDD (including penta through hepta chloro isomer groups and 2,3,7,8-tetra isomers) were converted to 2,3,7,8-tetrachlorodibenzo-p-dioxin equivalents (TCDD Equivalents). TCDD Equivalents are defined as the concentration of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) which by itself would be believed to exhibit the same biological potency as a mixture of structurally-related compounds (PCDF/PCDD) actually present in a sample.

Overall, the concentrations ranged from 2.0 to 332 ug/m^2 (geometric mean = 37 ug/m^2) with a 5-95 percentile range of 5.6 to 210 ug/m^2. (The 5-95 percentile range encompasses 90% of the observations.) Thirty-four of the 78 samples (44%) showed contamination levels above 50 ug/m^2 (range 52 to 332 ug/m^2; geometric mean = 100) (Table 13). Twenty-two of the 34 samples (65%) were collected from the seven air handling units (74-76, 83, 84, 88 and 89) that obtain their fresh make-up air through air intake grilles located on the west wall of the Building. These 22 samples showed contamination levels ranging from 56 to 332 ug/m^2 (geometric mean = 114 ug/m^2). The PCB in all 78 samples was identified as Aroclor 1260; the other six Aroclors were not present at a limit of detection of 0.28 ug/m^2.

A summary of these data (78 samples) is presented according to the individual 26 air handling units in Table 9. The seven air handling units, that obtain their fresh make up air at the west side of the Building, showed contamination levels ranging from 14 to 332 ug/m^2 (n = 29; geometric mean = 82). The other 19 air handling units, which obtain their fresh make-up air through air intake grilles located on the south and north walls and roof of the Building, showed contamination levels ranging from 2.0 to 264 ug/m^2 (n = 49; geometric mean = 23 ug/m^2). Comparison of these two data sets shows that there is a statistically significant difference between the contamination levels present in the seven versus 19 air handling units ($p = 0.0001$, $t = -5.8$). These data indicate that soot released from the vault's exhaust vent re-entered the Building through the air intake grilles located on the Building's west wall.

A summary of the PCB concentrations on workplace surfaces (eg., floors, walls, furniture) serviced by the air handling units is presented in Table 10. Overall, the concentrations ranged from none detected (0.32 ug/m^2) to 92 ug/m^2 (n = 203; geometric mean 1.9 ug/m^2) with a 5 - 95 percentile range of none detected (0.32 ug/m^2) to 23 ug/m^2. One of the 203 samples showed a contamination level (92 ug/m^2) above 50 ug/m^2. This sample was collected on top of a storage cabinet in the mechanical maintenance shop. The area is serviced by air handling unit 89. AHU 89 showed the highest average surface concentration of PCBs (152 ug/M^2). The PCB in all 203 samples was identified as Aroclor 1254; the other six Aroclors were not present at a detection limit of 0.32 ug/m^2.

The PCB concentrations on workplace surfaces serviced by the seven air handling units that obtain their fresh make-up air from the west side of the Building ranged from none detected (0.32 ug/m^2) to 92 ug/m^2 (n = 40; geometric mean = 5.5 ug/m^2). The concentrations on workplace surfaces serviced by the other air handling units ranged from none detected (0.32 ug/m^2) to 31 ug/m^2 (n = 163; geometric mean = 1.5 ug/m^2). Comparison of these two data sets shows that there is a statistically significant difference in the PCB concentrations present on the workplace surfaces in areas of Building serviced the seven air handling units versus those present on surfaces in area serviced by the other units ($p = 0.0001$, $t = - 5.15$).

This finding is consistent with that found for the contamination levels interior to the HVAC system which shows a relationship between location of outside air intake grilles (west versus other) and surface contamination levels.

7.1.2 Building Surfaces - PCBs

The analyses of the PCB surface wipe samples collected from various surfaces throughout the Building in April 1985 and February 1986 are presented in Tables 11 and 12, respectively. The analyses of 257 samples are summarized in Table 14 by area of the Building (sub-basement through floors four, first and second floor mezzanines, pipe chases, tunnels and mail handling docks) and location within the area (floors, vertical, elevated horizontal and high skin contact surfaces). Vertical surfaces include walls, structural columns and sides of equipment; elevated horizontal surfaces are those surfaces at a height of greater than six-feet above the floor (eg., pipes, tops of storage shelves and cabinets); and high skin contact surfaces include desks, tables, counters, file cabinets, etc.)

Overall, the surface concentrations measured in the basement, floors one through four, and first and second floor mezzanines ranged from none detected (0.32 ug/m^2) to 92 ug/m^2 (n = 207; geometric mean = 1.9 ug/m^2) with a 5-95 percentile range of none detected 0.32 ug/m^2 to 22 ug/m^2. The highest concentration levels were measured on the second floor. The surface concentrations measured on this floor ranged from none detected (0.60 ug/m^2) to 92 ug/m^2 (n = 33; geometric mean = 5.6 ug/m^2). One of the 33 samples exceeded the 50 ug/m^2 surface guideline. This sample (92 ug/m^2) was collected from the top of a metal storage cabinet in room 220 of the mechanical maintenance area. In all of the 207 samples, the PCB was identified as Aroclor 1254; other Aroclors (1016, 1221, 1232, 1242, 1248, and 1260) were not present at a detection limit of 0.60 ug/m^2.

Overall, the surface concentrations measured in the sub-basement chiller room ranged from none detected (5.0 ug/m^2) to 1900 ug/m^2 (n = 9; geometric mean = 105 ug/m^2) which exceeds the 50 ug/m^2 guideline. The two highest concentrations (690 ug/m^2 and 1900 ug/m^2) were measured on the transformer's vault ventilation louvers (numbers 5 and 6) located on the vault's north wall.

These samples indicate that the smoke did vent from the vault structure through these louvers into the chiller room. Since the chiller room was found to be at positive pressure with respect to the boiler room, there would have been a net flow of air from the chiller room to boiler room [64]. In all samples, the PCB was identified as Aroclor 1260; the other six Aroclors stated above were not present at a detection limit of 5.0 ug/m^2.

Overall, the surface concentrations in the sub-basement boiler room ranged from none detected (5.0 ug/m^2) to 110,000 ug/m^2 (n = 13; geometric mean = 141 ug/m^2). The geometric mean exceeds the 50 ug/m^2 surface guideline. The sample (WP 030) showing the concentration of 110,000 ug/m^2 was collected on the floor along the trough or floor drain, which extends from the tunnel area outside of the vault to the sump pump in the boiler room. This sample most probably represents contamination due to a contaminated liquid from the vault versus particulate deposition. In the absence of this sample, the concentrations range from none detected (5.0 ug/m^2) to 910 ug/m^2 (n = 12, geometric mean = 81 ug/m^2), which more likely represents the contamination distribution in boiler room due to particulate deposition. In all samples, the PCB was identified as Aroclor 1260; the other six Aroclors stated above were not present at a detection limit of 5.0 ug/m^2.

The east and west pipe chases located in the southwest quadrant of the boiler room would have been one path by which the smoke would have exited the sub-basement areas. A sample (WP 025) collected on the ventilation louver of the west pipe chase showed a concentration of 220 ug/m^2, thus, indicating that the contaminated smoke probably exited through the pipe chases. Surface concentrations made interior to the pipe chases ranged from 14 to 64 ug/m^2 (n = 5; geometric mean = 30 ug/m^2). In all samples, the PCB was identified as Aroclor 1260; the other six Aroclors stated above were not present at a detection limit of 0.60 ug/m^2.

Overall, the surface concentrations measured in the basement tunnel areas (north and B-1 and B-2 conveyor tunnels) ranged from none detected (0.32 ug/m^2) to 200 ug/m^2 (n = 13, geometric mean = 9.0 ug/m^2). The highest concentration (200 ug/m^2) was measured from a sample (WP 025) collected on an overhead sprinkler pipe in the B-2 conveyor tunnel. The other five samples (Table 11) collected in the B-2 conveyor tunnel showed concentrations ranging from 2.5 to 25 ug/m^2 (geometric mean = 12 ug/m^2). The PCB present in 12 of the 13 samples was identified as Aroclor 1254; the PCB present in the thirteenth sample (WP 025, 200 ug/m^2) was identified as Aroclor 1260. The other Aroclors were not present at a detection limit of 0.32 ug/m^2.

Overall, the surface concentrations measured on the west and north loading docks ranged from 1.0 to 780 ug/m^2 (n = 10; geometric mean = 17 ug/m^2). Eight of the ten samples were collected on the west loading dock. Three of the eight samples collected from elevated surfaces showed concentrations (range 59 to 780 ug/m^2) above 50 ug/m^2. The contamination of the west loading dock appears to be limited to elevated surfaces, where there is low potential for frequent skin contact. In all samples, the PCB was identified as Aroclor 1260; the other six Aroclors stated above were not present at a detection limit of 0.60 ug/m^2.

7.1.3 Settled Dust - PCDFs/PCDDs and PCBs

Table 15 presents the results of the analysis of a settled dust sample for tetra - through octa-chloro dibenzofurans (PCDFs) and dibenzo-p-dioxins (PCDDs) including the respective 2,3,7,8-tetra isomers. The settled dust sample was obtained from on top of the electrical switchgear in the sub-basement chiller room. The results are reported in terms of nanograms of chemical per gram of dust (ng/g), which is equivalent to parts per billion (ppb, wt./wt.).

The sample contained approximately 107 ng/g total PCDFs including 6.6 ng/g 2,3,7,8-TCDF and 156 ng/g total PCDDs; 2,3,7,8-TCDD was not present at a detection limit of 0.24 ng/g. The calculated 2,3,7,8-TCDD equivalent toxicity of the sample equaled 6.3 ng/g.

A sample of settled dust also obtained on the switchgear at an immediately adjacent area contained 11,000 ng/g PCB; the PCB was identified as Aroclor 1260. The corresponding of PCBs-to-TCDD equivalents is ratio approximately 1,746:1.

7.1.4 Building Surfaces - PCDFs and PCDDs

Surface wipe samples were collected from eleven locations throughout the Building for analysis of tetra-through octa-chloro PCDFs/PCDDs and the respective 2,3,7,8-tetra isomers. The sampling locations and results from the analysis of these samples are presented in Table 16. (Two quality control "field blank" samples also are included.) The PCDDs (tetra-through hexa-chloro isomer groups) were all undetected, except for low concentrations of hexa CDDs in three samples; the 2,3,7,8-TCDD isomer was not present above the detection limit in any of the samples. The PCDFs (tetra-through hepta-chloro isomer groups) were present above the detection limit in three of the eleven samples; the 2,3,7,8-TCDF isomer was present above the detection limit in six samples.

The calculated contamination levels for the 11 PCDF/PCDD samples in terms of 2,3,7,8-TCDD equivalents are presented in Table 17. The TCDD-equivalents ranged from 0.01 to 4.9 ng/m^2 where two samples showed concentrations (4.9 ng/m^2 and 3.4 ng/m^2) above 1 ng/m^2. The highest concentration was found on the top of a storage cabinet in OCR/CS area on the second floor. The other sample was obtained from the surface of a boiler vent pipe in the sub-basement boiler room. Both samples were collected on elevated horizontal surfaces, where there is low potential for frequent and continued skin contact. However, these areas should be cleaned.

7.1.5 Relationship Between PCBs and TCDD-Equivalents on Surfaces

Surface wipe samples were collected for both PCB analysis and PCDF/PCDD analysis at eleven paired locations to determine if a direct statistical relationship existed. There were six locations where both the calculated TCDD-Equivalents and the PCB concentrations were above the detection limit. The surface concentrations of PCBs and TCDD-equivalents for these six locations are presented in Table 18. These data were used to determine the existence of a statistical relationship.

To determine the relationship between PCBs and TCDD equivalents concentrations, the logarithms (base 10) of both data sets (Table 18) were used in a linear regression. The model was a straight line fit of the log of the TCDD equivalents as a function of the log the PCB concentration. The Pearson Correlation coefficient was 0.963, demonstrating a strong linear relationship between these parameters.

The results of the linear fit are presented below:

<u>Analysis of Variance</u>

Source	df	Sum of Squares	Mean Square	F
Regression	1	3.71	3.71	51.7
Error	4	0.29	0.07	
Total	5	4.0		

$p = 0.02$, $F = 51.7$
and

<u>Estimates of Parameters</u>

Parameter	Estimate	Variance	t
Intercept	-1.868	0.172	-10.8
Slope	1.643	0.228	7.2

The linear relationship between the log TCDD equivalents and log PCB surface concentrations is shown in Figure 25. The upper and lower 95% confidence limits for the predicted values of TCDD equivalents is also shown. The linear regression equation for predicting a surface concentration of TCDD-equivalents for a given PCB value is listed below:

$$\text{Log TCDD-Equivalents} = -1.87 + 1.64 \log_{10} \text{PCB}$$

The predicted concentrations of TCDD-equivalents from the geometric means for the PCB concentrations measured on floors one through four, first and second floor mezzanines, and the basement are presented below:

Area	PCB Geometric Mean ug/m2	Predicted TCDD-Equivalents ng/m2
4th Floor	1.1	0.02
3rd Floor	1.2	0.02
2nd Floor Mez.	1.6	0.03
2nd Floor	5.6	0.23
1st Floor Mez	1.9	0.04
1st Floor	2.7	0.07
Basement	5.2	0.20

The predicted surface concentrations of TCDD-equivalents for all of the areas are below the 1 ng/m^2 guideline value.

7.2 Assessment of Airborne Contamination

7.2.1 Airborne PCBs

The analyses of the PCB air samples collected in April 1985 and February 1986 are presented in Table 19 and Tables 20-21, respectively. A total of 74 samples were collected throughout the Building to measure the levels of PCBs to which the occupants would normally be exposed. Samples were not collected in areas such as pipe chases and elevator shafts.

The PCB air concentrations measured in April 1985 are summarized by area of the Building in Table 22. Overall, the air concentrations ranged from 0.11 to 0.49 ug/m^3 ($n = 30$; geometric mean = 0.23 ug/m^3) with a 5-95 percentile range of 0.13 to 0.49 ug/m^3. Comparison of the log transformed mean concentrations for the seven areas tested revealed no significant difference in concentration ($F = 1.64$, $p = 0.18$), i.e., the concentration of airborne PCB does not vary significantly with area of the Building. This data indicates that the Building air is in a steady-state or an equilibrium condition with PCB.

The PCB air concentrations measured in February 1986 using NIOSH Method 5503 and the modified New York State Florisil (NYSF) stick method are presented in Tables 20 and 21, respectively. Comparison of the log transformed PCB concentrations at 18 paired sampling locations throughout the Building showed that there was no statistically significant difference ($t = 0.71$, $p = 0.48$) between the test methods. Therefore, the test results were combined as a single data set.

The air concentrations measured in February 1986 are summarized by area of the Building in Table 23. Overall, the concentrations ranged from 0.11 to 0.37 ug/m^3 (n = 44; geometric mean = 0.21 ug/m^3) with a 5-95 percentile range of 0.13 to 0.33 $ug/^3$. Comparison of log transformed mean concentrations for the nine areas tested showed that there was no statistically significant difference in PCB concentration (F = 1.44; p = 0.21). This data shows that the PCB air concentrations between April 1985 and February 1986 remained in a steady-state condition.

The log transformed PCB air concentrations measured in April 1985 (n = 30; mean = 0.23 ug/m^3) were compared with those measured in February 1986 (n = 40; mean = 0.21 ug/m^3), excluding the four measurements made on the first and second floor mezzanines in February 1986. These two areas were excluded because they were not tested in April 1985. A paired t-test of the means showed that there was no statistically significant difference (t = 1.48, p = 0.14). Therefore, it is concluded that the air concentration has not changed significantly between April 1985 and February 1986.

The PCBs present in the samples collected using NIOSH method 5503 in April 1985 and February 1986 did not conform to any specific Aroclor pattern, i.e., each sample had a non-standard chromatogram. Since the chromatographic pattern most closely resembled Aroclor 1242, the samples were selectively quantitated against Aroclor 1242. However, there were several other PCB peaks present. The PCBs in the samples collected in February 1986 using the NYSF method most closely resembled Aroclor 1242 and 1254. Aroclor 1242 represented on average 78% (std. dev = 7%, range 60 - 88%) of the total PCBs present in the 24 samples. The average concentration of Aroclor 1254 (0.05 ug/m^2, range 0.02 to 0.10 ug/m^3) was below the limit of detection (0.10 ug/m^3) for the NIOSH method.

7.2.1.1 PCB Enrichment Phenomena

The PCB on surfaces in the HVAC system and that on the Building surfaces was identified as Aroclor 1260 and Aroclors 1254/1260, respectively, whereas, the PCB in the air most closely resembled Aroclor 1242. The difference in the PCB content in air versus that on solid surfaces is believed to be due to a phenomena known as PCB enrichment, i.e., the vapor phase is enriched with lower chlorinated isomers relative to a standard or source mixture on a surface. This enrichment results in non-standard chromatograms.

The enrichment phenomena of PCBs in the vapor phase has been demonstrated in laboratory studies [65]. In the vapor phase, the air samples from Aroclors 1016, 1242 and 1254 were rich in PCBs with four or fewer chlorine atoms per molecule relative to a standard on the surface. Similarly, an Aroclor 1242 standard is predominately rich in three and four chlorine atoms per molecule, i.e., the total weight percent chlorine is predominately represented by the tri- and tetra-chlorobiphenyl isomers.

In field measurements, air has also been shown to contain PCB isomers with lower chlorine content that the original source [66,67], as well as, Aroclors different than that present on the surface [61]. In one study [61], conducted in a Building that had experinced a PCB (Aroclor 1260) transformer malfunction, the post cleanup contamination levels on surfaces ranged from none detected (0.60 ug/m^2) to 32 ug/m^2 (n = 93; arithmetic mean = 5 ug/m^2); the PCB was identified as Aroclor 1260 in all samples. The corresponding air levels ranged from 0.04 to 0.26 ug/m^3 (n = 16; arithmetic mean = 0.15 ug/m^3). None of the samples showed detectable levels of Aroclor 1260 at a detection limit of 0.02 ug/m^3; but contained both Aroclor 1242 and 1254. Aroclor 1242 represented an average of 43% of the total PCBs present; Aroclor 1254 represented 57%.

Electrical burnout of in service flourescent light ballasts can result in elevated concentrations of airborne PCBs (Aroclor 1242) in the incident room [68]. However, the concentrations in comparison rooms were not increased above detectable levels [68]. Ballast burnout is considered to be a minor, if not insignificant, contributor to the ubiquitous PCB presence in this Building.

7.2.2 Airborne PCDFs and PCDDs

Air samples were collected from ten locations throughout the Building and one at the roof fresh air intake for analysis of tetra- through octa-chloro PCDFs/PCDDs and the respective 2,3,7,8-tetra isomers. The sampling locations and analyses of these samples is presented in Table 24. (Two quality control "field blank" samples also are included.) The PCDDs (tetra-through octa-chloro isomer groups) were undetected, except for low concentrations of hepta-CDDs in two samples and octa-CDDs in seven samples; the 2,3,7,8-TCDD isomer was not present above the detection limit in any of the samples. The PCDFs (tetra-through octa-chloro isomer groups) and 2,3,7,8-TCDF isomer were below the limit of detection in all of the samples. The 2,3,7,8-TCDD equivalents, calculated based on these none detected concentrations, are presented in Table 25.

8.0 CONCLUSIONS

The following principal conclusions are founded upon the environmental measurements made by NIOSH researchers:

1. Low levels of airborne PCBs were measured throughout the Building both in April 1985 and February 1986. The airborne concentrations do not vary significantly with area of the Building, thus indicating a steady-state or equilibrium condition. The airborne concentrations measured in April 1985 were not significantly different from those measured in February 1986. The non-standard chromatograms present for each sample are believed to be due to a PCB enrichment phenomena, i.e., the vapor phase is enriched with lower chlorinated isomers relative to a source mixture on a surface. This enrichment results in a non-standard chromatogram, which in this instance, most closely resembled Aroclor 1242 versus Aroclor 1260. The airborne concentrations present in all of the samples were below the guideline value.

2. The Building air did not contain detectable concentrations of TCDD Equivalents.

3. The surface concentrations of PCBs and TCDD Equivalents measured in the sub-basement chiller and boiler rooms exceeded the skin contact guidelines.

4. The surface concentrations of PCBs measured on the west loading dock exceeded the skin contact guideline. The contamination appears to be limited to elevated surfaces (such as structural beam ledges and pipes), where there is low potential for skin contact.

5. Overall, the surface concentrations of PCBs and TCDD Equivalents measured in the primary occupancy areas of the Building (basement, floors one through four, and first and second floor mezzanines) were below the respective skin contact guidelines. The highest overall surface contamination levels were present on the second floor. This area is serviced by seven primary air handling units (AHUs) where four of the AHUs contained the highest contamination levels of PCBs. These four AHUs obtain their fresh make-up air at the west side of the Building.

6. Although the overall PCB surface concentrations measured in the pipe chases and B-2 conveyor tunnel are below the skin contact guideline, the statistical relationship established between PCBs and TCDD equivalents suggests that there could be concentrations of TCDD Equivalents above the skin contact guideline.

7. The surface concentrations of PCBs measured in the seven air handling units (AHUs), that obtain their fresh make-up air through outside grilles on the west side of the Building, were significantly higher than those measured in the other AHUs. The PCB in all samples was identified as Aroclor 1260, which is the same Aroclor identified in a sample of soot obtained in the vault [1]. The data demonstrate that the contamination released from the vault's exterior exhaust vent re-entered the Building through the outside air grilles located on its west wall.

8. The PCB concentrations on workplace surfaces in areas of the Building serviced by the seven AHUs, that obtain their fresh make-up air on the west side of the Building, were significantly higher than on workplace surfaces in areas serviced by the other AHUs.

9.0 RECOMMENDATIONS

1. The following areas of the Building should be decontaminated to levels according to the guidelines contained in Section 6.3 of this Report: (a) chiller room including the lunch and control rooms, and ventilation louvers on the transformer vault's south-wall; (b) boiler room including the ventilation tunnel, and east/west pipe chases including their entire vertical extension to

the upper floors of the Building; (c) B-2 conveyor tunnel; and (d) west loading dock. Every surface in these areas, including but not limited to floors, walls, ceilings, equipment, pipes, furniture, and all other objects located in these areas should be cleaned. However, there are certain surfaces such as ceilings in these areas that may not be contaminated. If such surfaces are not cleaned, adequate testing should be done to establish the degree of surface cleanliness.

Upon completion of the clean-up, testing should be conducted to certify that the areas have been cleaned according to the guidelines specified in Section 6.3 of this Report.

2. The contamination deposited in the heating, ventilation, and air-conditioning (HVAC) system is serving as a continous source of airborne PCBs throughout the Building. Based on the known toxicity of PCBs [70,3] and because the surface levels in the HVAC system are above the guideline, it is recommended that the HVAC system be cleaned.

3. Limited testing conducted by NIOSH and Public Service Company of Oklahoma's consultant [64] indicates that the mechanical maintenance shop may be contaminated with PCBs above the skin contact guideline value. Further testing should be conducted to more completely determine the contamination levels in this area. The testing also should include the maintenance supervisors office area.

4. There are workers in the Building (primarily, postal employees in the sub-basement area) who have had exposure to concentrations of PCBs above background levels [61] over the last several years while working in the Building. In order to address possible concern about the effects of their exposure, these workers should undergo specific medical testing relevant to this exposure. This testing should include assessment of serum PCB levels, medical questionnaires, physical examinations, and other laboratory testing as appropriate. This testing protocol should also consider the amount of time a worker may have spent in contaminated areas. A preliminary protocol for this surveillance has been developed at a meeting of physicians representing NIOSH, American Postal Workers Union, and the Public Service Company of Oklahoma. Followup medical surveillance must also be considered, but will to some extent be dependent on the results of the initial examination.

10.0 REFERENCES

1. Public Service Company of Oklahoma. Report of Analysis. Memorandum dated May 6, 1982, from Stephen Davenport to Bobby Piersall titled Solid Samples from the Federal Building Vault.

2. Kominsky, J.R., and Melius, J.M. (1985) PCB, PCDF and PCDD Contamination of Structures Resulting from Electrical Equipment Fires and Failures, Proceedings of the 7th Annual RMCOEH Conference "Harazardous Waste Management and Control: Weighing the Risks", Park City, UT, in print.

3. Current intelligence bulletin no. 45 Polychlorinated Biphenyls (PCBs): Potential Health Hazards from Electrical Equipment Fires or Failures. Cincinnati: U.S. Department of Health and Human Services, Public Health SErvice, Centers for Disease Control, National Institute for Occupational Safety and Health, 1986;DHHS (NIOSH) publication no. 86-111.

4. Memorandum to the File dated April 19, 1982, from Tom Drake, Tulsa City County Health Department, Tulsa, Oklahoma.

5. O'Keefe PW, Silkworth JB, Gierthy JF, et al. Chemical and biological investigations of a transformer accident at Binghamton, NY. Environ Health Perspect 1985;60:201-9.

6. Eller, PM. NIOSH manual of analytical methods. 3rd ed. Cincinnati: U.S. Department of Health and Human Services. Public Health Service, Centers for Disease Control, National Institute for OCCupational Safety and Health, 1984;DHHS (NIOSH) publication no. 84-100:5503-1 to 5503-5.

7. Kushner, E.J. On Determining the Statistical Parameters for Pollution Concentration From A Truncated Data Set. Atmospheric Environment Volume 10, pgs. 975-979 (1976).

8. Nehls, G.H. and Akland G.G. Procedures for Handling Aerometric Data. J. Air Pollution Control Assoc. Volume 23, pgs. 180-184 (1973).

9. SAS Institute Inc., SAS User's Guide: Statistics, Version 5 Edition. Cary, N.C.: SAS Institute Inc., 1985.

10. SAS Institute Inc. SAS User's Guise: Basics, Version 5 Edition. Cary, N.C.: SAS Institute Inc., 1985.

11. Hutzinger O, Safe S, Zitko V. The chemistry of PCB's. Florida: CRC Press, Inc., 1974:3,7,13,17,120.

12. EPA. PCBs in the United States: Industrial Use and Environmental Distribution Task 1. Final Report. EPA 560/6-76-005. Prepared by Versar, Inc. February 25, 1976.

13. Lloyd JW, Moore RM, Woolf BS, Stein HP. Polychlorinated biphenyls. J Occup Med 1976;18:109.

14. Pomerantz L, Burke J, Firestone D, McKinney J, Roach J, Trotter W. Chemistry of PCBs and PBBs. Environ Health Perspect 1978;24:133-46.

15. Landrigan PJ. General population exposure to halogenated biphenyls. In: Kimbrough RD, ed. Halogenated biphenyls, terphenyls, naphthalenes, dibenzodioxins, and related products. Amsterdam: Elsevier/North-holland Biomedical Press, 1980:267.

16. Smith AB, Schloemer J, Lowry LK, et al. Metabolic and health consequences of occupational exposure to polychlorinated biphenyls (PCBs). Br J Ind Med 1982;39:361.

17. Vos JG, Koeman JG. Comparative toxicologic study with polychlorinated biphenyls in chickens, with special reference to porphyria, edema formation, liver necrosis, and tissue residues. Tox Appl Pharm 1970;17:656.

18. Vos JG, Koeman JH, van der Mass HL, ten Noever de Brauw MC, de vos RH. Identification and toxicological evaluation of chlorinated dibenzofuran and chlorinated naphthalene in two commercial polychlorinated biphenyls. Fd Cosmet Toxicol 1970;8:625.

19. Bowes GW, Mulvihill MJ, Simoneit BRT, Burlingame AL, Risebrough RW. Identification of chlorinated dibenzofurans in American polychlorinated biphenyls. Nature 1975;94:125.

20. Buser HR, Bosshardt HP, Rappe C. Formation of polychlorinated dibenzofurans (PCDFs) from the pyrolysis of PCBs. Chemosphere 1978;7:109.

21. Buser HR, Rappe C. Formation of of polychlorinated dibenzofurans (PCDFs) from the pyrolysis of PCBs. Chemosphere 1977;8:157.

22. Vos JG. Toxicology of PCBS for mammals and for birds. Env Health perspect 1969;21:29.

23. Kuratsune M, Yoshimura T, Matsuzaka J, Yamaguchi A. Epidemiologic study on Yousho, a poisoning caused by ingestion of rice oil contaminated with a commercial brand of polychlorinated biphenyl. Environ Health Perspect 1972;1:119.

24. Wong CK. PCB poisoning special issue. Clinical Medicine (Taipel). Volume 7, no. 1, 1981.

25. Masuda Y, Kuroki H. Polychlorinated dibenzofurans and related compunds in patients with "Yusho." In: Hutzinger O, Frei R W, Merian E, Pocchiari F, eds. Chlorinated dioxins and related compounds. Oxford: Pergamon Press, 1982:561.

26. Maroni M, Colombi A, Arbosti G, Cantoni S, Foa V. Occupational exposure to polychlorinated biphenyls in electrical workers, II. Health effects. Br J Ind Med 1981;38:55.

27. Ouw KH, Simpson GR, Siyali DS. The use and health effects of Aroclor 1242, a polychlorinated biphenyl in the electrical industry. Arch Environ Health 1976;31:189.

28. Karppanen E, Kolho L. The concentration of PCB in human blood and adipose tissue in three different research groups. In: PCB Conference II, Stockholm, 1972. National Swedish Environmental Protection Board. 1973, 124

29. Fischbein A, Woolf MS, Lillis R, Thornton J, Selikoff IJ. Clinical findings among PCB-exposed capacitor manufacturing workers. Ann NY Acad Sci 1979;320:703.

30. Chase KH, Wong O, Thomas D, Berney BW, Simon RK. Clinical and metabolic abnormalities associated with occupational exposure to polychlorinated biphenyls (PCBs). J Occup Med 1982;24:109.

31. Emmett EA, Agnew J, Bleeker ML, Ferrara JM, Levin BK, Jeffreys J, Maroni M. Health effects of PCB Exposure of GSA Switchgear employees. NIOSH Technical Assistance Request #80-7, The Johns Hopkins University School of Hygiene and Public Health, Baltimore, Maryland, 1983.

32. Lawton RW, Sack BT, Ross MR, Feingold J. Studies of employees occupationally exposed to PCBs. General Electric Research and Development Center, Schenectady, 1981.

33. Crow KD. Chloracne: a critical review including a comparison of two series of cases of acne from chloronaphthalene and pitch fumes. Trans St John's hosp Dermatol Soc 1970;56:79.

34. Baker EL Jr, Landrigan PJ, Glueck CJ. Metabolic consequences of exposure to polychlorinated biphenyls in sewage sludge. Am J Epid 1980;112:553.

35. Kreiss K, Zack MM, Kimbrough RD, Needham LL, Smrek AL, Jones BT. Association of blood pressure and polychlorinated biphenyl levels. JAMA 1981;245:2505.

36. International Agency for Research on Cancer. IARC monographs on the evaluation of the carcinogenic risk of chemicals to humans. Chemicals, Industrial Process, and Industries Associated with Cancer in Humans. IARC Monographs, Volumes 1 to 29. Supplement 4, Lyon, france, 1982, p. 218.

37. Brown DP, Jones M. Mortality and industrial hygiene study of workers exposed to polychlorinated biphenyls. Arch Environ Health 1981;36:120.

38. Bertazzi PA, Zocchetti C, Guercilena s, Foglia MD, Pesatori A, Riboldi L. Mortality study of male and female workers exposed to PCBs. Presented at the International Symposium on Prevention of Occupational Cancer, April, 1981, Helsinki, Finland.

39. Goldstein JA. The structure-activity relationships of halogenated biphenyls as enzme inducers. Ann NY Acad Sci 1979;320:164-78.

40. Yoshimura H, Yoshihara S, Ozawa N, Miki M. Possible correlation between industion modes of hepatic enzymes by PCBs and their toxicity in rats. Ann NY Acad Sci 1979;320:179-92.

41. Poland A, Greenlee W, Kende AS. Studies on the mechanism of action of the chlorinated dibenzo-p-dioxins and related compunds. Ann NY Acad Sci 1979;320:214-30.

42. McConnell EE, Moore JA, Haseman JK, Harris MW. The comparative toxicity of chlorinated dibenzo-p-dioxins in mice and guinea pigs. Toxicity Appl Pharmacol 1978;44:335-56.

43. Nagayama J, Kuroki H, Masuda Y, Kuratsune M. A comparative study of polychlorinated dibenzofurans, polychlorinated biphenyls and 2,3,7,8-tetrachlorodibenzo-p-dioxin on aryl hydrocarbon hydroxylase inducing potency in rats. Arch Toxicol 1983;53:177-84.

44. Yoshihara S, Nagata K, Yoshimura H, Kuroki H, Masuda Y. Indusctive effect on hepatic enzymes and acute toxicity of individual polychlorinated dibenzofuran congeners in rats. Toxicol Appl Pharmacol 1981;59:580-8.

45. Moore JA, McConnell EE, Dalgard DW, Harris MW. Comparative toxicity of three halogenated dibenzofurans in guinea pigs, mice, and rhesus monkeys. Ann NY Acad Sci 1979;320:151-63.

46. Schwetz BA, Norris JM, Sparschu GL, et al. Toxicology of chlorinated dibenzo-p-dioxins. Environ Health Perspect 1973;5:87-99.

47. McConnell EE, Moore JA, Dalgard DW. Toxicity of 2,3,7,8-tetrachloro-dibenzo-p-dioxin in rhesu monkeys (macaca mulatta) following a single oral dose. Toxicol Appl Pharmacol 1978;43:175-87.

48. Garthoff LH, Cerra FE, Marks EM. Blood chemistry alterations in rats after single and multiple gavage administration of polychlorinated biphenyl. Toxicol Appl Pharmacol 1981;60:33-44.

49. Moore JA, Gupta BN, Vos JG. Toxicity of 2,3,7,8-tetrachlorodibenzo-furan - preliminary results. In: Proceedings of the National Conference on Polychlorinated Biphenyls, held 1975 November 19-21 in Chicago, EPA-560/6-75-004. Environmental Protection Agency, Office of Toxic Substances, 1976:77-80.

50. Current intelligence bulletin no. 40-2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD, "dioxin"). Cincinnati: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, 1984;DHHS (NIOSH) publication no. 84-104.

51. Hassoun E, d'Argy R, Dencker L. Teratogenicity of 2,3,7,8-tetrachloro-dibenzofuran in the mouse. J Toxicol Environ Health 1984;14:337-51.

52. Kociba RJ, Keyes DG, Beyer JE, et al. Results of a two-year chronic toxicity and oncogenicity study of 2,3,7,8-tetrachlorodibenzo-p-dioxin in rats. Toxicol Appl Pharmacol. 1978;46:279-303.

54. NTP (National Toxicology Program). Bioassay of 2,3,7,8-tetrachlorodibenzo-p-dioxin for possible carcinogenicity (gavage study). DHHS Publ No. (NIH) 82-1765. Carcinogenesis Testing Program, NCI, Bethesda, DM. NIH, and Research Triangle Park, NC, NTP. 1982

55. NTP (National Toxicology Program). Bioassay of 1,2,3,6,7,8- and 1,2,3,7,8,9-hexachlorodibenzo-p-dioxin for possible carcinogenicity (gavage study). DHHS Publ No. (NIH) 80-1758. Carcinogenesis Testing Program, NCI, Bethesda, MD, NIH, and Research Triangle Park, NC, NTP.

56. Ideo G, Bellati G, Bellobuono A, Bissanti L. Urinary D-glucaric acid excretion in the Seveso area, polluted by tetrachlorodibenzo-p-dioxin (TCDD): five years of experience. Environ Health Perspect 1985;60:151-7.

57. Urabe H, Koda H, Asahi M. Present state of Yusho patients. Ann NY Acad Sci 1979;320:273-6.

58. Kuratsune M. Epidemiologic studies on Yusho. In: Higuchi K, ed. PCB poisoning and pollution. Tokyo: Kodansha LTD., 1976:9-23.

59. Hardell L, sandstrom A. Case-control study: soft tissue sarcomas and exposure to phenoxyacetic acids or chlorophenols. Br J Cancer 1979;39:711-7.

60. Hardell L. Malignant Lymphoma of histiocytic type and exposure to phenoxyacetic acids or chlorophenols. Lancet L 1979;(Jan 6):55-6.

61. Kominsky, J.R. and Melius, J.M. Final certification report: New Mexico State Highway Department's General Office Building and Annex, 1120 Cerrillos Road, Santa Fe, Mexico. HETA Report no. 85-414. National Institute for Occupational Safety and Health, Cincinnati, Ohio, September 1986.

62. Eadon, G.; K. Aldous, G. Frenkel, et al. 1982. Comparisons of Chemical and Biological Data on Soot Samples from the Binghamton State Office Building. Albany, NY: Center for Laboratories and Research, New York State Department of Health. March, 1982.

63. Kim NK, Hawley J. Re-entry guidelines Binghamton State Office Building. [Report prepared by New York State Department of Health, Bureau of Toxic Substance Assessmnent,. Division of Health Risk Control, Albany, New York, July 1985].

64. Final Report. PCB Contamernation Assessment Page Belcher Federal Building, Tulsa, Oklahoma. IT Corporation, Knoxville, TN., May 28, 1986.

65. Lin, J.M. Quantitative Perchlorination for Representative PCBs in the Liquid Phase and Vapor Phase. Doctor of Philosophy Thesis, Univeristy of Cincinnati, 1986.

66. Brownlow, C. S., The Evaluation and Development of Solid Sorbent Sampling Techniques for Arocolor 1254, Master's Thesis, University of Cincinnati, 1982.

67. Tatsukawa, R. PCB pollution of the Japanese environment in PCB Poisoning and Pollution, ed: Higuchi, K., Academic Press, New York, 1976. pg 147-149

68. Kominsky, J.R. and Paulozzi, L. Polychlorinated Biphenyl Contamination Resulting from Florescent Light Ballast Burnout. Presented at the American Industrial Hygiene Conference, Dallas, Texas, May 18-23, 1986.

69. Memorandum dated August 1, 1986. Minutes of July 31, 1986, meeting between Dr. Melius (NIOSH), Drs. Tabershaw and Pike (medical consultants to U.S. Postal Workers), and Dr. Milby (medical consultant to Public Service Company of Oklahoma).

70. National Institute for Occupational Safety and Helath. Criteria for a recommended standard: occupational exposure to polychlorinated biphenyls (PCBs). Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. DHEW publication no. (NIOSH) 77-225.

11.0 DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Postmaster, Tulsa, Oklahoma
2. President Tulsa Area Local, American Postal Workers Union, Tulsa, Oklahoma
3. Assistant United States Attorney, Tulsa, Oklahoma
4. Tulsa City County Health Department, Tulsa, Oklahoma
5. Occupational Safety and Health Administration, Region VI.
6. U.S. Environmental Protection Agency, Region VI.

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table 1

Summary of Air Handling Units (AHU)
And Air Handling Zones (AHZ) by Area of the Building Serviced

Page Belcher Federal Building
Tulsa, Oklahoma

Area Serviced	AHU-AHZ	Location of AHU
4th Floor	100-1,2,3,4,5,6,7,8,9	Penthouse
	101-1,2,3,4,5,6,7	Penthouse
	102-1,2,3,4,5,6,7	Penthouse
	103, 104, 105,	Penthouse
	P106, P107, P108,	Penthouse
3rd Floor	93-1,2,3,4	Penthouse
	94-1,2,3,4	Penthouse
	95-1,2,3,4	Penthouse
	P106, P107, P108	Penthouse
2nd Floor Mezzanine	87-2	2nd Floor Mezzanine
	88-1	2nd Floor Mezzanine
	P106, P107, P108	Penthouse
2nd Floor	83-1,2,3	2nd Floor Mezzanine
	84-1,2,3	2nd Floor Mezzanine
	85-1,2,3	2nd Floor Mezzanine
	86-1,2	2nd Floor Mezzanine
	87-1,2	2nd Floor Mezzanine
	88-2,3	2nd Floor Mezzanine
	89-1,2	2nd Floor Mezzanine
	P106, P107, P108	Penthouse
1st Floor Mezzanine	74-2	1st Floor Mezzanine
	76-1	1st Floor Mezzanine
	77-2,3	1st Floor Mezzanine
	P106, P107, P108	Penthouse
1st Floor	73	1st Floor Mezzanine
	74-1,2	1st Floor Mezzanine
	75-1,2	1st Floor Mezzanine
	76-2	1st Floor Mezzanine
	77-1	1st Floor Mezzanine
	78-1,2	1st Floor Mezzanine
	80-1,2	1st Floor Mezzanine
	79	1st Floor Mezzanine
	87-3,4	2nd Floor Mezzanine
Basement	49-1,2,3	Sub-Basement
Sub-Basement (Control/Lunch Rooms	49-4	Sub-Basement

Table 2

Frequency of Air and Surface Samples
Collected by Area of the Building in April 1985 and February 1986

Page Belcher Federal Building
Tulsa, Oklahoma

Area	PCB		PCDF/PCDD	
	Surface	Air	Surface	Air
		April 1985		
4th Floor	8	3	1	-
3rd Floor	8	2	-	-
2nd Floor	4(11)*	6	1	1
1st Floor	6(7)	6	1	1
Basement	8(1)	6	-	-
Sub-Basement Chiller Room[(a)]	9(10)	4	1	1
Sub-Basement Boiler Room	15(1)	3	1	1
Sub-Basement Tunnels	1(1)	-	-	-
Mail Handling Dock	4(2)	-	-	-
Roof Fresh Air Intake	-	-	-	1
Interior of HVAC system	6(18)	-	-	-
Total**	69(51)	30	5	5
		February 1986		
4th Floor	52	7	1	1
3rd Floor	52	7	1	1
2nd Floor Mezzanine	8	2	-	-
2nd Floor	33	5	1	1
1st Floor Mezzanine	10	2	1	-
1st Floor	26	5	1	1
Basement	26	9	1	1
Sub-Basement Chiller Room	-	3	-	-
Sub-Basement Boiler Room	-	4	-	1
Sub-Basement Tunnels	12	-	-	-
Pipe Chases	5	-	-	-
Mail Handling Docks	6	-	-	-
Interior of HVAC System	78	-	-	-
Total**	308	44	6	6

*Value in parentheses represent the samples that could not be analyzed due to the presence of a chemical interference.
**Totals do not include quality assurance samples.

(a) A sample of settled dust was obtained from the top of the electrical switch gear.

Table 3

HRGC/HRMS Operating Parameters

Page Belcher Federal Building

Tulsa, Oklahoma

Mass Resolution	9,000-12000 (M/ΔM, 10% valley definition
Electron Energy	70 eV
Accelerating Voltage	6,000 volts
Source Temperature	200 C
Preamplifier Gain	10^7 volts/amp
Electron Multiplier Gain	$\simeq 10^6$
Transfer Line Temperature	280 C
Column	DB-5 60M
Injector Temperature	300 C
Column Temperature-Initial	160 C hold for 2 minutes
Column Temperature-Program	20 C/min to 240 C hold for 30 minutes
	20 C/min to 320 C hold for 20 minutes
Carrier Gas	Helium
Flow Velocity	~ 25 cm/sec
Injection Mode	Splitless
Injection Volume	2 ul

Table 4

Exact Masses Used for the Determination of PCDFs and PCDDs

Page Belcher Federal Building

Tulsa, Oklahoma

Compound	Accurate Mass Mass 1	Accurate Mass Mass 2	Theoretical Isotope Ratio Mass 1/Mass 2
Tetrachlorodibenzo-p-dioxins	319.8965	321.8936	0.77
Tetrachlorodibenzofurans	303.9016	305.8987	0.77
Pentachlorodibenzo-p-dioxins	355.8546	357.8517	1.54
Pentachlorodibenzofurans	339.8597	341.8567	1.54
Hexachlorodibenzo-p-dioxins	389.8156	391.8127	1.23
Hexachlorodibenzofurans	373.8207	375.8178	1.23
Heptachlorodibenzo-p-dioxins	423.7766	425.7737	1.03
Heptachlorodibenzofurans	407.7817	409.7788	1.03
Octachlorodibenzo-p-dioxins	457.7377	459.7347	0.88
Octachlorodibenzofurans	441.7428	443.7398	0.88
Tetrachlorodibenzo-p-dioxin-$^{13}C12$	331.9367	333.9338	0.77
Tetrachlorodibenzofuran-$^{13}C12$	315.9418	317.9389	0.77
Octachlorodibenzo-p-dioxin-$^{13}C12$	469.7779	471.7749	0.88

Table 5

Instrument Conditions for PCB Analysis

Page Belcher Federal Building
Tulsa, Oklahoma

Instrument	Varian 3700 Gas Chromatograph
Column	DB-5 (30M)
Column Temperature	60 C (hold for 2 min.) 8 C/min. to 300 C (hold 4 min.)
Carrier Gas	Helium at 30 cm/sec
Injector Temperature	250 C
Detector Temperature	300 C
Detector	Ni63 ECD
Injector Volume	2 uL

Table 6

Uses of PCB Classified by Grade of Aroclor

Current use of PCB	Grade of Aroclor used
Electrical capacitors	1016, 1221, 1254
Electrical transformers	1242, 1254, 1260
Vacuum pumps	1248, 1254
Gas-transmission turbines	1221, 1242
Former use of PCB	
Hydraulic fluids	1232, 1242, 1248, 1254, 1260
Plasticizer in synthetic resins	1248, 1254, 1260, 1262, 1268
Adhesives	1221, 1232, 1242, 1248, 1254
Plasticizer in rubbers	1221, 1232, 1242, 1248, 1254, 1268
Heat transfer systems	1242
Wax extenders	1242, 1254, 1268
Dedusting agents	1254, 1260
Pesticide extenders, inks, lubicants, cutting oils	1254
Carbonless reproducing paper	1242

Table 7

PCB Surface Wipe Sample Results
Interior of Heating, Ventilation, and Air-Conditioning System

Page Belcher Federal Building
Tulsa, Oklahoma

April 13-19, 1985

Sample Number	Sample Location/Description	Aroclor 1260 ug/100 cm^2*
	INTERIOR OF HVAC SYSTEM:	
WP095	1M floor: AHU 74 floor of unit	0.60
WP096	1M floor: AHU 76 floor of unit	1.3
WP098	2M floor: AHU 83 floor of unit	ND (0.05)**
WP102	Penthouse: AHU 106 floor of unit	ND (0.05)
WP107	Penthouse: AHU 100 floor of unit	ND (0.05)
WP114	1st floor: AHU 74 supply duct AHZ 74-1	ND (0.05)

* 1 ug/100 cm^2 is equivalent to 100 ug/m^2
** Denotes none detected. The limit of detection is in parentheses.

Table 8

Surface Concentrations of Polychlorinated Biphenyls (PCBs)
Interior of Heating, Ventilation, and Air-Conditioning System

Page Belcher Federal Building
Tulsa, Oklahoma

February 3-4, 1986

Sample Number	Sample Location/Description	Aroclor 1260 ug/m^2
WP752	Penthouse: AHU 102 supply duct AHZ 102-3	[19.2]*
WP753	Penthouse: AHU 102 supply duct AHZ 102-3	[19.2]
WP755	Penthouse: AHU 102 surface of fan housing	2.5
WP764	4th Floor: SW quad supply duct AHZ 102-2	28.4
WP765	4th Floor room 4543: supply duct AHZ 102-3	24.8
WP754	Penthouse: AHU 106 surface of fan housing	[12.4]
WP756	Penthouse: AHU 101 surface of fan housing	8.4
WP757	Penthouse: AHU101 supply duct AHZ 101-7	11.2
WP766	4th floor S quad: supply duct AHZ 101-7	34.8
WP767	4th floor room 4420: supply duct AHZ 101-5	26.0
WP758	Penthouse: AHU 105 supply duct	[8.4]
WP759	Penthouse: AHU 104 supply duct	16.0
WP760	Penthouse: AHU 103 supply duct	11.6

Table 8 - Continued

Sample Number	Sample Location/Description	Aroclor 1260 ug/m^2
WP761	Penthouse: AHU 100 surface of fan housing	[7.6]
WP762	Penthouse: field blank	ND(0.68)**
WP768	4th floor room 4453: supply duct AHZ 100-9	[7.2]
WP769	4th floor room 4462: supply duct AHZ 100-5	[5.6]
WP763	Penthouse: AHU 108 surface of fan housing	[12.4]
WP800	Penthouse: AHU 107 supply duct	[6.0]
WP801	3rd floor: AHU 93 surface of fan housing	[3.3]
WP770	3rd floor room 3089: supply duct AHZ 93-1	29.2
WP771	3rd floor room 3015: supply duct AHZ 93-3	26.8
WP802	3rd floor: AHU 94 surface of fan housing	2.0
WP772	3rd floor room 3475: supply duct AHZ 94-4	[34.8]
WP776	3rd floor room 3447: supply duct AHZ 94-1	92.0
WP803	3rd floor: AHU 95 supply duct AHZ 95-1	[7.2]
WP773	3rd floor room 3397: supply duct AHZ 95-1	[32.0]
WP774	3rd floor room 3353: supply duct AHZ 95-2	48.0
WP774	3rd floor room 3353: field blank	ND(0.53)
WP804	2M floor:AHU 87 supply duct AHZ 87-2	32.4
WP778	2M floor room M223: supply duct AHZ 87-2	32.4
WP780	2M floor room M224: supply duct AHZ 87-1	26.4

Table 8 - Continued

Sample Number	Sample Location/Description	Aroclor 1260 ug/m^2
WP810	1M floor: AHU 75 supply duct AHZ 75-2	64.0
WP828	1st floor: supply duct AHZ 75-1	15.6
WP789	1st floor: supply duct AHZ 75-2	28.4
WP834	1M floor: AHU 75 supply duct AHZ 75-1	68.0
WP811	1M floor: field blank	ND(0.28)
WP793	1M floor: AHU 76 supply duct AHZ 76-2	208.0
WP788	1st floor: supply duct AHZ 76-2	34.8
WP835	1M floor: AHU 76 supply duct AHZ 76-1	116.0
WP836	1M floor: field blank	ND(0.28)
WP794	2M floor: AHU 85 supply duct AHZ 85-2	52.0
WP821	2nd floor: supply duct AHZ 85-2	[8.4]
WP825	2nd floor: supply duct AHZ 85-1	96.0
WP795	2M floor: AHU 86 supply duct AHZ-1	[60.0]
WP829	2M floor: field blank	ND(0.28)
WP822	2nd floor: supply duct AHZ-1	264.0
WP823	2nd floor: supply duct AHZ-1	116.0
WP824	2nd floor: supply duct AHZ-2	84.0
WP796	1M floor: AHU 77 supply duct AHZ-2	60.0
WP781	1M floor: supply duct AHZ 77-2	25.2
WP782	1M floor: supply duct AHZ 77-2	[17.2]
WP799	Sub-basement: AHU 49 supply duct	56.0
WP792	Sub-basement: field blank	ND(0.28)
WP751	Basement room B104: AHU 49 supply duct AHZ 49-3	44.0

Table 8 - Continued

Sample Number	Sample Location/Description	Aroclor 1260 ug/m^2
WP805	2M floor: AHU 88 supply duct AHZ 88-2	132.0
WP777	2M floor room M208: supply duct AHZ 88-1	[132.0]
WP779	2M floor room M210: supply duct AHZ 88-2	[72.0]
WP830	2M floor: AHU 88 supply duct AHZ 88-3	120.0
WP806	2M floor: AHU 83 supply duct AHZ 83-3	148.0
WP812	2nd floor SW quad: supply duct AHZ 83-3	104.0
WP819	2nd floor: supply duct	92.0
WP813	2nd floor SW quad: supply duct AHZ 83-3	[72.0]
WP831	2M floor: AHU83 supply duct AHZ 83-1	332.0
WP807	2M floor:AHU 84 supply duct AHZ 84-3	[64.0]
WP814	2nd floor NW quad: supply duct AHZ 84-3	168.0
WP815	2nd floor NW quad: supply duct AHZ 84-3	136.0
WP817	2nd floor: supply dust AHZ 84-1	38.8
WP832	2M floor: AHU 84 supply duct	39.2
WP808	2M floor: AHU 89 supply duct AHZ 89-1	[76.0]
WP816	2nd floor: supply duct AHZ 89-1	144.0
WP818	2nd floor: supply duct AHZ 89-2	132.0
WP837	2M floor: AHU 89 supply duct AHZ 89-2	256.0
WP809	1M floor: AHU 74 supply duct AHZ 74-1	[44.0]
WP790	1st floor: supply duct AHZ 74-1	56.0
WP791	1st floor: supply duct AHZ 74-2	14.0
WP833	1M floor: AHU 74 supply duct AHZ 74-2	116.0

Table 8 - Continued

Sample Number	Sample Location/Description		Aroclor 1260 ug/m^2
WP783	Basement CFS: AHU 49 supply duct AHZ 49-2		56.0
WP784	Basement CFS: AHU 49 supply duct AHZ 49-2		76.0
WP785	Basement CFS: AHU 49 supply duct AHZ 49-2		44.0
WP786	Basement room B104: AHU 49 supply duct AHZ 49-3		52.0
WP787	Basement room B104: field blank	ND	(0.28)
WP797	1M floor: AHU 78 supply duct AHZ 78-2		27.6
WP826	1st floor: supply duct AHZ 78-2		19.6
WP798	1M floor: AHU 80 supply duct AHZ 80-1		[9.2]
WP827	1st floor: supply duct AHZ 80-1		16.4

* PCB concentration is between the limit of detection and limit of quantitation.

** Denotes none detected. The limit of detection is in parentheses.

Table 9

Summary of Polychlorinated Biphenyl (PCB) Concentrations
Interior of the HVAC System by Air Handling Unit (AHU)

Page Belcher Federal Building
Tulsa, Oklahoma

February 1986

AHU	Sample Size	PCB Concentration - ug/m^2 Mean	Geometric Mean	Geometric Std. Dev.	Range
49	6	55	54	1.2	44-76
74	4	58	47	2.4	14-116
75	4	44	37	2.0	16-68
76	3	120	93	2.5	35-208
77	3	34	30	1.9	17-60
78	2	24	23	1.3	20-28
80	2	13	12	1.5	9-16
83	5	150	126	1.8	72-332
84	5	89	74	2.0	39-168
85	3	52	35	3.5	8.4-96
86	4	131	111	1.9	60-264
87	3	30	30	1.1	26-32
88	4	114	111	1.3	72-132
89	4	152	137	1.6	76-256
93	3	20	14	3.4	3.3-29
94	3	43	19	7.3	2.0-92
95	3	29	22	2.7	7.2-48
100	3	6.8	6.7	1.2	5.6-76
101	3	24	22	1.8	11-35
102	5	19	15	2.7	2.5-28
103	1	12	12	-	-
104	1	16	16	-	-
105	1	8.4	8.4	-	-
106	1	8.4	8.4	-	-
107	1	6.0	6.0	-	-
108	1	12	12	-	-
Overall	78	62	37	3.1	2.0-332*

*5-95 percentile range = 5.6 - 210 ug/m^2.

Table 10

Summary of Polychlorinated Biphenyl (PCB) Concentrations on Workplace Surfaces by Air Handling Zone (AHZ)

Page Belcher Federal Building
Tulsa, Oklahoma

February 1986

AHZ	Sample Size	PCB Concentration - ug/m^2			
		Mean	Geometric Mean	Geometric Std. Dev.	Range
49	22	5.9	3.2	3.3	(0.32)*-23
73	1	14	14	-	-
74	4	15	4.2	11	(0.32)-44
75	6	11	8.1	2.6	2.4-28
76	7	3.1	1.7	3.8	(0.60)-8.4
77	8	1.8	1.4	2.0	(0.60)-6.0
78	4	1.3	1.2	1.5	0.80-1.8
79	1	1.8	1.8	-	-
80	2	2.9	2.7	-	1.8-4.0
83	4	18	12	2.7	5.2-44
84	7	24	19	2.4	2.9-44
85	4	4.2	2.4	4.4	(0.60)-9.2
86	5	9.5	4.7	4.0	0.76-31
87	12	3.1	1.5	3.5	(0.60)-15
88	9	2.9	2.1	2.4	0.76-8.4
89	3	36	17	4.2	6.8-92
93	20	3.7	2.3	2.6	(0.60)-16
94	15	2.7	1.2	3.7	(0.60)-12
95	17	0.88	0.62	2.3	(0.60)-2.7
100	17	1.7	0.97	2.6	(0.60)-12
101	15	1.1	0.73	2.4	(0.60)-4.4
102	14	2.0	1.5	2.2	(0.60)-7.2
103	2	3.9	2.9	-	1.3-6.4
104	2	1.0	0.71	-	(0.60)-1.7
105	2	1.9	1.9	-	1.6-2.2
Overall	203	5.0	1.9	3.7	(0.32)-92**

*None detected. Value in parentheses is the limit of detection
**5-95 percentile range = (0.32) -23 ug/m^2.

Table 11

Surface Concentrations of Polychlorinated Biphenyls (PCBs)

Page Belcher Federal Building
Tulsa, Oklahoma

April 13-19, 1985

Sample Number	Sample Location/Description	Aroclor 1260* ug/100 cm^2
	FOURTH FLOOR:	
WP079	Room 4547 file cabinet	ND (0.05)**
WP080	Room 4562 desk	ND (0.05)
WP081	Room 4527 table	ND (0.05)
WP082	Room 4500 file cabinet	ND (0.05)
WP083	Room 4489 table	ND (0.05)
WP084	Room 4493 table	ND (0.05)
WP085	Room 4411 counter	ND (0.05)
WP086	Room 4447 desk	ND (0.05)
	THIRD FLOOR:	
WP071	Room 3003 desk	ND (0.05)
WP072	Room 3339 file cabinet	ND (0.05)
WP073	Room 3378 book case	ND (0.05)
WP074	Room 3440 desk	ND (0.05)
WP075	Room 3477 table	ND (0.05)
WP076	Room 3103 table	ND (0.05)
WP077	Room 3103 file cabinet	ND (0.05)
WP078	Express mail office table	ND (0.05)

Table 11 - Continued

Sample Number	Sample Location/Description	Aroclor 1260 ug/100 cm^2
	BASEMENT:	
WP037	Top surface vent duct at CFS area	ND (0.05)
WP038	Bag room desk	ND (0.05)
WP039	CFS area desk	ND (0.05)
WP040	Sprinkler pipe CFS area	ND (0.05)
WP042	Wood shop refrigerator	ND (0.05)
WP043	Communications office book case	ND (0.05)
WP044	Parking garage sprinkler pipe	ND (0.05)
WP045	Parking garage sprinkler pipe	ND (0.05)
	SUB-BASEMENT: CHILLER ROOM	
WP002	Floor NE quad	2.0
WP006	Floor SE quad	1.6
WP009	Overhead chiller water pipe	0.91
WP011	Face of door to boiler room	ND (0.05)
WP013	Top of switchgear	4.8
WP016	Overhead chiller water pipe	1.5
WP017	Transformer vault ventilation louver #5	6.9
WP018	Transformer vault ventilation louver #6	19.0
WP120	Metal cabinet at fire alarm Z-5	ND (0.05)
	SUB-BASEMENT: BOILER ROOM	
WP021	Floor NW quad along EW drain trough	8.9
WP022	Concrete column J-3	ND (0.05)
WP024	Overhead cold water pipe	0.66

Table 11 - Continued

Sample Number	Sample Location/Description	Aroclor 1260 ug/100 cm^2
	SECOND FLOOR:	
WP062	Flat case at col H-35	ND (0.05)
WP070	Desk at col H-9	ND (0.05)
WP090	Storage locker	ND (0.05)
WP118	Wall between col L-3 and P-3	ND (0.05)
	FIRST FLOOR:	
WP053	Catwalk at monorail N-end	ND (0.05)
WP054	Sprinkler pipe behind sack central	ND (0.05)
WP055	MOCS area desk	ND (0.05)
WP056	Desk at col P-9	ND (0.05)
WP059	Desk at col L-32	ND (0.05)
WP060	Desk at col E-35	ND (0.05)

Table 11 - Continued

Sample Number	Sample Location/Description	Aroclor 1260 ug/100 cm^2
WP025	S wall vent louver west pipe chase	2.2
WP026	Overhead sprinkler pipe	1.3
WP029	Floor NE quad	0.83
WP030	Floor NE quad along NS drain trough	1100.0
WP032	Storage shelf along N wall at louver	9.1
WP031	Storage shelf between col J-11 and J-9	1.5
WP033	Floor SE quad	0.46
WP034	Overhead input air pipe	1.0
WP035	Overhead sprinkler pipe	1.5
WP121	Overhead boiler vent pipe	ND 0.05)
	SUB-BASEMENT: TUNNEL AREAS	
WP019	Tunnel S of vault: floor at vault entrance	67.0
WP020	Tunnel S of vault: S wall at E end	0.45
WP025	B-2 conveyor tunnel: overhead sprinkler pipe	2.0
	WEST MAIL HANDLING DOCK:	
WP046	Vertical side of 54 conveyor	0.59
WP047	Beam ledge at 54 conveyor	7.8
WP048	Overhead sprinkler pipe at 56 conveyor	2.1
WP050	Face of 53 conveyor vestibile door	ND (0.05)

** Denotes none detected. The detection limit is in parentheses
* 1 ug/100 cm^2 is equivalent to 100 ug/m^2.

Table 12

Surface Concentrations of Polychlorinated Biphenyls (PCBs)

Page Belcher Federal Building
Tulsa, Oklahoma

January 30 - February 2, 1986

Sample Number	Sample Location/Description	Aroclor 1254 ug/m^2
	FOURTH FLOOR:	
WP500	U.S. Congressman Jone's Office wall	[0.80]*
WP501	Men's Restroom floor	2.1
WP502	Room 4545 desk	2.5
WP503	Room 4547 file cabinet	2.2
WP504	Room 4574 desk	[1.1]
WP505	Room 4557 file cabinet	[1.4]
WP506	Room 4557 table	7.2
WP507	Room 4561 table	[1.3]
WP508	Room 4554 coat rack	ND (0.60)**
WP509	Room 4562 table	[1.4]
WP510	Room 4510 table	3.2
WP511	Room 4510 field blank	ND (0.60)
WP512	Room 4569 wall	[0.84]
WP513	Room 4527 table	4.4
WP514	Room 4531 desk	3.4
WP515	Room 4531 desk	[0.68]
WP516	Room 4540 desk	[0.64]
WP517	Room 4528 table	[1.2]
WP518	Judge Ellison's Conference Room table	[0.84]

Table 12 - Continued

Sample Number	Sample Location/Description	Aroclor 1254 ug/m^2
WP519	Room 4426 table	2.4
WP520	Room 4448 desk	2.2
WP521	Room 4448 wall	[1.6]
WP522	Room 4408 desk	[1.7]
WP523	Room 4408 field blank	ND (0.60)
WP524	Room 4408 wall	ND (0.60)
WP525	Room 4436 book case shelf	ND (0.60)
WP526	Room 4432 table	[1.3]
WP527	Room 4422 table	[1.9]
WP528	Room 4420B file cabinet	[0.80]
WP529	Room 4420A table	[1.5]
WP530	Room 4414 desk	ND (0.60)
WP531	Lobby at Room 4448 wall	ND (0.60)
WP532	Room 4447 desk	[1.0]
WP533	Room 4403A table	ND (0.60)
WP534	Room 4411 desk	[0.68]
WP535	Room 4411 field blank	ND (0.60)
WP536	Room 4453A file cabinet	[1.1]
WP537	Room 4530 desk	[1.4]
WP538	Room 4450 file cabinet	[0.60]
WP539	Room 4436 desk	[1.3]
WP540	Room 4436 wall	6.4
WP541	Room 4460 desk	2.0
WP542	Room 4535 table	2.7
WP543	Room 4453Q desk	[1.2]
WP544	Lobby at Room 4462	ND (0.60)

Table 12 - Continued

Sample Number	Sample Location/Description	Aroclor 1254 ug/m^2
WP545	Room 4466 window sill	11.6
WP546	Room 4476A table	ND (0.60)
WP547	Room 4476A field blank	ND (0.60)
WP548	Room 4470 file cabinet	[1.3]
WP549	Room 4480 table	ND (0.60)
WP550	Room 4473 file cabinet	[1.2]
WP551	Room 4484 book case	[0.64]
WP552	Room 4504 wall	ND (0.60)
WP553	Room 4506 file cabinet	ND (0.60)
WP554	Room 4514 file cabinet	ND (0.60)
WP555	Room 4508 table	[1.1]
	THIRD FLOOR:	
WP556	Room 3022B table	[1.7]
WP557	Room 3033 table	[0.80]
WP558	Room 3038B window ledge	6.8
WP559	Room 3038B field blank	ND (0.60)
WP560	Room 3027B table	[1.6]
WP561	Room 3022 table	[0.92]
WP562	Room 3023A table	[1.1]
WP563	Room 3234 table	3.7
WP564	Room 3232 desk	3.6
WP565	Room 3239 desk	[0.96]
WP566	Room 3046 table	2.4
WP567	Room 3046 file cabinet	[1.4]
WP568	Room 3057 file cabinet	3.0

Table 12 - Continued

Sample Number	Sample Location/Description		Aroclor 1254 ug/m^2
WP569	Room 3058	wall	[1.5]
WP570	Room 3062	service counter	2.0
WP571	Room 3062	field blank	ND (0.60)
WP572	Room 3068	table	15.6
WP573	Room 3080	file cabinet	ND (0.60)
WP574	Room 3098	book case	9.2
WP575	Room 3102	desk	[1.7]
WP576	Room 3102	storage cabinet	2.3
WP577	Room 3077	desk	3.2
WP578	Room 3118	table	5.2
WP579	Room 3118	refrigerator	2.1
WP580	Room 3118	cigarette display case	9.6
WP581	Room 3103	desk	[0.76]
WP582	Room 3128	storage cabinet	12.4
WP583	Room 3014D	table	ND (0.60)
WP584	Room 3014D	field blank	ND (0.60)
WP585	Room 3014	desk	ND (0.60)
WP586	Room 3097	wall	[1.4]
WP587	Room 3447	storage cabinet	ND (0.60)
WP588	Room 3447	table	[1.9]
WP589	Room 3471	table	2.5
WP590	Room 3469	file cabinet	[0.48]
WP591	Elevator lobby	window ledge	11.2
WP592	Room 3327	wall	ND (0.60)
WP593	Room 3339	file cabinet	ND (0.60)
WP594	Room 3323	book case	[1.8]

Table 12 - Continued

Sample Number	Sample Location/Description	Aroclor 1254 ug/m^2
WP595	Room 3323 field blank	ND (0.60)
WP596	Room 3364 storage cabinet	[1.7]
WP597	Room 3315 desk	ND (0.60)
WP598	Room 3357 table	[0.88]
WP599	Room 3367A desk	ND (0.60)
WP600	Room 3370 storage cabinet	[1.1]
WP601	Room 3402E wall	[1.8]
WP602	Room 3402C window ledge	2.7
WP603	Room 3408 file cabinet	[0.60]
WP604	Room 3422 file cabinet	ND (0.60)
WP605	Room 3442B table	ND (0.60)
WP606	Room 3484 table	[1.6]
WP607	Room 3484 field blank	ND (0.60)
WP608	Room 3434 table	ND (0.60)
WP609	Room 3386 desk	ND (0.60)
WP610	Room 3382 file cabinet	ND (0.60)
WP611	Room 3392 table	[0.68]
WP612	Room 3437 desk	ND (0.60)
	SECOND FLOOR MEZZANINE:	
WP613	Room M210 window ledge	8.4
WP614	Room M208 desk	[0.92]
WP615	Room M209 storage cabinet	[0.76]
WP616	Room M229 desk	2.6
WP617	Room M224 desk	[1.6]
WP618	Room M220 file cabinet	ND (0.60)
WP619	Room M220 field blank	ND (0.60)
WP620	Room M218 storage cabinet	[1.2]
WP621	Room M216 table	5.6

Table 12 - Continued

Sample Number	Sample Location/Description	Aroclor 1254 ug/m^2
	SECOND FLOOR:	
WP622	City section, top of letter case zone 03	4.8
WP623	City section, top of letter case zone 47	2.8
WP624	City section, top of ventilation duct	ND (0.60)
WP625	City section, top of incoming flat case	2.4
WP626	Letter sorter machine area storage cabinet	31.2
WP627	Incoming flat secondary top of duct	8.4
WP628	Column E-32 desk	[0.76]
WP629	BCS machine area storage cabinet	9.2
WP630	Roof of M/D office	44.0
WP631	M/D office area field blank	ND (0.60)
WP632	OCR/CS storage cabinet	28.0
WP633	LSM #1 power source box	44.0
WP634	Electrical panel box on Col P-18	20.0
WP635	Mech Maintenance room 220 storage cabinet	92.0
WP636	Room 220A supv. of maintenance table	6.8
WP637	Custodial storage top of J-4 flammable cabinet	4.4
WP638	LSM #1 desk	2.9
WP639	Face of col H-13	5.2
WP640	Conveyor metal housing	5.6
WP641	Col L-9 top metal box 26	16.4
WP642	Face of col R-6	8.4
WP643	Col R-6 field blank	ND (0.60)
WP644	Top of flat cases 740	25.6
WP645	Face over hang wall at col 3 between L & P	31.6
WP646	Face over hang wall at col 3 between J & L	16.4
WP647	Room 242 cabinet	[1.3]

Table 12 - Continued

Sample Number	Sample Location/Description	Aroclor 1254 ug/m^2
WP648	Room 243 table	ND (0.60)
WP649	Room 245 perimeter heating unit	4.8
WP650	Room 252 desk	3.1
WP651	Room 207 desk	3.0
WP652	Room 208 storage cabinet	[1.7]
WP653	Room 211 storage cabinet	3.2
WP654	Room 212 table	5.6
WP655	Room 212 field blank	ND (0.60)
WP656	Room 214C storage cabinet	[0.80]
WP657	Room 214 table	2.0
	FIRST FLOOR MEZZANINE:	
WP658	Snack bar table	[1.2]
WP659	Snack bar table	[1.3]
WP660	Snack bar wall	[0.60]
WP661	Room M112 storage locker	6.0
WP662	Room M112C letter cases	[0.72]
WP663	Room M112C file cabinet	[1.6]
WP664	Room M108 storage locker	8.4
WP665	Room M107 desk	[1.1]
WP666	Room M106 field blank	ND (0.60)
WP667	Room M106 table	3.8
WP668	Room M106 storage lockers	3.7

Table 12 - Continued

Sample Number	Sample Location/Description	Aroclor 1254 ug/m^2
	FIRST FLOOR:	
WP669	Room 109A table	4.0
WP670	East lobby wall	[1.8]
WP671	East lobby wall	[0.96]
WP672	Southeast lobby wall	ND (0.60)
WP673	South service lobby display case	14.8
WP674	Main lobby wall at elevator	14.0
WP675	Col 24-E storage cabinet	18.4
WP676	Service lobby wall	[1.8]
WP677	Service lobby wall	[1.8]
WP678	168 box section flat case	[0.80]
WP679	168 box section flat case field blank	ND (0.60)
WP680	168 box section col J-37 storage shelves	[1.0]
WP681	Face of col P-35	[1.2]
WP682	MOCS col P-27 metal cage	[1.9]
WP683	Face of col J-27	[1.6]
WP684	Face of col J-18	3.4
WP685	Express mail area storage shelves	28.0
WP686	Lobby elevator #6 wall	ND (0.60)
WP687	Stairwell #4 wall	ND (0.60)
WP688	Saw tooth area face of H-series conveyor	4.0
WP689	Saw tooth area face of col L-7	2.4
WP690	Roof of interior west dock vestibule	44.0
WP691	West dock field blank	ND (0.60)
WP692	Stairwell #2 wall	ND (0.32)

Table 12 - Continued

Sample Number	Sample Location/Description	Aroclor 1254 ug/m^2
WP693	Flat mail 1st class dist. lockers	14.4
WP694	Flat mail 1st class dist. face col E-11	3.2
WP695	Roof of room 103E	9.2
WP696	Face of J-9 conveyor over saw tooth	7.2
	BASEMENT:	
WP697	Elevator service lobby wall	1.6
WP698	Room B-213 desk	4.8
WP699	Room B213 roof of audio booth	[0.84]
WP700	Room B213 wall	[1.0]
WP701	Room B208 refrigerator	6.0
WP702	Room B217 table	3.0
WP703	Room B217 field blank	ND (0.32)
WP704	Room B217 storage cabinet	1.2
WP705	Room B104 window ledge	4.0
WP706	Room B106 electrical panel box	2.7
WP707	Elevator lobby wall	3.3
WP708	Room B105 storage cabinet	2.2
WP709	Room B110 storage cabinet	22.8
WP710	Room B117 table	6.4
WP711	Room B117 storage cabinet	20.8
WP712	Room CFS face of col J-24	1.7
WP713	Room CFS table at work station 3	[0.84]
WP714	Room CFS table at work station 7	ND (0.32)
WP715	Room CFS field blank	ND (0.32)
WP716	Room CFS ventilation duct	8.4

Table 12 - Continued

Sample Number	Sample Location/Description	Aroclor 1254 ug/m^2
WP717	Room CFS storage cabinet	3.4
WP718	Room CFS storage cabinet	10.4
WP719	Sack room top of ventilation duct	21.6
WP720	Sack room table	2.2
WP725	Supply area office file cabinet	2.9
WP726	Supply area storage cabinet	1.2
WP727	Supply area field blank	ND (0.32)
WP728	Supply area storage cabinet	[0.52]
WP729	Supply area storage cabinet	[0.64]
	BASEMENT TUNNEL AREAS:	
WP721	North tunnel light fixture	16.0
WP722	North tunnel wall	ND (0.32)
WP723	North tunnel storage shelving	3.0
WP724	North tunnel top of LSM vacuum	27.6
WO730	B-1 conveyor tunnel floor	12.8
WP731	B-1 conveyor tunnel light fixture	11.2
WP732	B-1 conveyor tunnel overhead pipe	12.4
WP733	B-2 conveyor tunnel light fixture	25.2
WP734	B-2 conveyor tunnel wall	4.0
WP735	B-2 conveyor tunnel floor	2.5
WP736	B-2 conveyor tunnel light fixture	24.8
WP737	B-2 conveyor tunnel wall	5.6
WP738	B-2 conveyor tunnel field blank	ND (0.32)

Table 12 - Continued

Sample Number	Sample Location/Description	Aroclor 1254 ug/m^2
	BASEMENT PIPE CHASES:	
WP739	West chase sub-basement level wall	36.8[a]
WP740	East chase sub-basement level panel box	32.8[a]
WP741	East chase second level ventilation riser	64.0[a]
WP742	East chase first level ventilation riser	13.6[a]
WP743	West chase sub-basement level face boiler stack	24.8[a]
	MAIL HANDLING DOCKS:	
WP744	North dock light fixture	18.8[a]
WP745	North dock light fixture	16.8[a]
WP746	West dock light fixture	29.4[a]
WP747	West dock undersurface H conveyor Bag 52	4.8[a]
WP748	West dock undersurface H conveyor Bag 53	[1.8][a]
WP749	West dock undersurface H conveyor Bag 53	[1.0][a]
WP750	Bag 53 field blank	ND (0.68)[a]

* PCB concentration is between the limit of detection and limit of quantitation.

** Denotes none detected. The limit of detection is in parentheses.

[a] Reported as Aroclor 1260.

Table 13
PCB Surface Concentrations > 50 ug/m^2
Interior of Heating, Ventilation, and Air-Conditioning System

Page Belcher Federal Building
Tulsa, Oklahoma

February 1986

Sample Number	Sample Location/Description	Aroclor 1260 ug/m^2
WP776	3rd Floor room 3447: supply duct AHZ 94-1	92.0
WP805	2M floor: AHU 88 supply duct AHZ 88-2	132.0
WP777	2M floor room M208: supply duct AHZ 88-1	[132.0]
WP779	2M floor room M210: supply duct AHZ 88-2	[72.0]
WP830	2M floor AHU 88 supply duct AHZ 88-3	120.0
WP806	2M floor: AHU 83 supply duct AHZ 83-3	148.0
WP812	2nd floor SW quad: supply duct AHZ 83-3	104.0
WP819	2nd floor: supply duct	92.0
WP813	2nd floor SW quad: supply duct AHZ 83-3	[72.0]
WP831	2M floor: AHU 83 supply duct AHZ 83-1	332.0
WP807	2M floor: AHU 84 supply duct AHZ 84-3	[64.0]
WP814	2nd floor NW quad: supply duct AHZ 84-3	168.0
WP815	2nd floor NW quad: supply duct AHZ 84-3	136.0
WP808	2M floor: AHU 89 supply duct AHZ 89-1	[76.0]
WP816	2nd floor: supply duct AHZ 89-1	144.0
WP818	2nd floor: supply duct AHZ 89-2	132.0
WP837	2M floor: AHU 89 supply duct AHZ 89-2	256.0
WP790	1st floor: supply duct AHZ 74-1	56.0
WP833	1M floor: AHU 74 supply duct AHZ 74-2	116.0
WP810	1M floor: AHU 75 supply duct AHZ 75-2	64.0
WP793	1M floor: AHU 76 supply duct AHZ 76-2	208.0
WP835	1M floor: AHU 76 supply duct AHZ 76-1	116.0

Table 13 continued

Sample Number	Sample Location/Description	Aroclor 1260 ug/m^2
WP794	2M floor: AHU 85 supply duct AHZ 85-2	52.0
WP825	2nd floor: supply duct AHZ 85-1	96.0
WP795	2M floor: AHU 86 supply duct AHZ-1	[60.0]
WP822	2nd floor: supply duct AHZ-1	264.0
WP823	2nd floor: supply duct AHZ-1	116.0
WP824	2nd floor: supply duct AHZ-2	84.0
WP796	1M floor: AHU 77 supply duct AHZ-2	60.0
WP799	Sub-basement: AHU 49 supply duct	56.0
WP783	Basement CFS: AHU 49 supply duct AHZ 49-2	56.0
WP784	Basement CFS: AHU 49 supply duct AHZ 49-2	76.0
WP785	Basement CFS: AHU 49 supply duct AHZ 49-2	44.0
WP786	Basement room B104: AHU 49 supply duct AHZ 49-3	52.0

*PCB concentration is between the limit of detection and limit of quantitation.
**Denotes none detected. The limit of detection is in parentheses.

Table 14

Summary of Polychlorinated Biphenyl (PCB) Concentrations on Workplace Surfaces by Area and Location

Page Belcher Federal Building
Tulsa, Oklahoma

April 1985 and February 1986

Area	Location of Surface	Sample Size	PCB Concentration - ug/m² Mean	Geometric Mean	Geometric Std Dev.	Range	5% - 95%
4th Floor[2]	Floor	1	2.1	2.1	-	-	-
	Vertical	8	1.4	0.70	2.9	(0.60)*-6.4	-
	High Skin Contact	41	1.8	1.2	2.4	(0.60) -12	-
	Elevated Horizontal	2	0.47	0.43	-	(0.60) -0.64	-
	Overall	52	1.7	1.1	2.5	(0.60) -12	(0.60)-6.7
3rd Floor[2]	Floor	-	-	-	-	-	-
	Vertical	4	1.3	1.0	2.3	(0.60)-1.8	-
	High Skin Contact	40	2.1	1.1	3.1	(0.60)-16	-
	Elevated Horizontal	8	4.8	2.7	3.5	(0.60)-12	-
	Overall	52	2.5	1.2	3.2	(0.60)-18	(0.60)-12
2nd Floor Mezzanine[2]	Floor	-	-	-	-	-	-
	Vertical	-	-	-	-	-	-
	High Skin Contact	6	3.2	1.9	3.4	(0.60)-8.4	-
	Elevated Horizontal	2	0.98	0.95	-	0.76-1.2	-
	Overall	8	2.7	1.6	2.9	(0.60)-8.4	(0.60)-8.4

Table 14 Continued

Area	Location of Surface	Sample Size	PCB Concentration - ug/m² Mean	Geometric Mean	Geometric Std Dev.	Range	5% - 95%
2nd Floor[2]	Floor	-	-	-	-	-	-
	Vertical	4	15	12	2.2	5.2-32	-
	High Skin Contact	10	3.5	2.6	2.7	(0.60)-6.8	-
	Elevated Horizontal	19	18	7.3	4.7	(0.60)-92	
	Overall	33	13	5.6	4.1	(0.60)-92	(0.60)-58
1st Floor Mezzaine[2]	Floor	-	-	-	-	-	-
	Vertical	1	0.60	0.60	-	-	-
	High Skin Contact	5	1.8	1.6	1.7	1.1-3.8	-
	Elevated Horizontal	4	4.7	3.4	2.9	0.72-8.4	-
	Overall	10	2.8	1.9	2.5	0.6-8.4	0.6-8.4
1st Floor[2]	Floor	-	-	-	-	-	-
	Vertical	14	2.4	1.2	3.3	(0.32)-14	-
	High Skin Contact	1	4.0	4.0	-	-	-
	Elevated Horizontal	11	13	7.0	3.8	(0.80)-44	-
	Overall	26	7.0	2.7	4.4	(0.32)-44	(0.32)-38

Table 14 Continued

Area	Location of Surface	Sample Size	PCB Concentration - ug/m² Mean	Geometric Mean	Geometric Std Dev.	Range	5% - 95%
Sub-Basement Chiller Room[1]	Floor	2	180	170	1.2	160-200	-
	Vertical;	1	(5.0)	(5.0)	-	-	-
	High Skin Contact	2	1295	1143	2.0	690-1900	-
	Elevated Horizontal	4	181	63	9.6	(5.0)-480	-
	Overall	9	408	105	10	(5.0)-1900	(5.0)-1900
Sub-Basement Boiler Room[1]	Floor	4	27754	776	34	46-110000	46-110000
	Vertical	1	(5.0)	(5.0)	-	-	-
	High Skin Contact	-	-	-	-	-	-
	Elevated Horizontal	8	216	100	5.3	5.0-910	5.0-910
	Overall	13	8673	141	1.4	-110000	-110000
Mail Handling Dock[1/2]	Floor	-	-	-	-	-	-
	Vertical	1	(5.0)	(5.0)	-	-	-
	High Skin Contact	-	-	-	-	-	-
	Elevated Horizontal	9	125	21	8.7	1.0-780	-
	Overall	10	112	17	8.5	1.0-780	1.0-780

*None detected. Value in parentheses is the limit of detection.
[1]April 1985 test data.
[2] February 1986 test data.

Table 14 Continued

Area	Location of Surface	Sample Size	PCB Concentration - ug/m² Mean	Geometric Mean	Geometric Std Dev.	Range	5% - 95%
Basement[2]	Floor	-	-	-	-	-	-
	Vertical	4	1.9	1.7	1.6	1.0-3.3	-
	High Skin Contact	9	3.4	2.3	3.2	(0.32)-6.4	-
	Elevated Horizontal	13	7.4	3.4	4.0	(0.52)-23	-
	Overall	26	5.2	2.7	3.3	(0.32)-23	(0.32)-23
Sub-Basement Tunnels[1/2]	Floor	1	2.5	2.5	-	-	-
	Vertical	3	3.3	1.5	7.1	(0.32)-5.6	-
	High Skin Contact	-	-	-	-	-	-
	Elevated Horizontal	9	37	19	3.0	3.0-200	-
	Overall	13	27	9.0	5.3	(0.32)-200	(0.32)-200
Sub-Basement Pipe Chase[1/2]	Floor	-	-	-	-	-	-
	Vertical	4	35	30	1.9	14-64	-
	High Skin Contact	1	33	33	-	-	-
	Elevated Horizontal	-	-	-	-	-	-
	Overall	5	34	30	1.8	14-64	14-64

Table 15

Polychlorinated Dibenzo-p-dioxins (PCDDs) and Polychlorinated Dibenzofurans in Settled Dust*
Obtained from the Top of the Switchgear in the Chiller Room

Page Belcher Federal Building
Tulsa, Oklahoma

April 16, 1985

PCDFs-ng/g						PCDDs-ng/g						2,3,7,8-TCDD
2,3,7,8-TCDF	TCDF	PeCDF	HxCDF	HpCDF	OCDF	2,3,7,8-TCDD	TCDD	PeCDD	HxCDD	HpCDD	OCDD	Equivalents - ng/g
6.6	18	23	14	40	12	(0.24)**	(0.24)	(0.051)	0.27	16	140	6.3

*Sample of settled dust obtained on same surface contained 11000 ng/g PCB as Aroclor 1260.
** Value in parentheses is the limit of detection.

Table 16

Surface Concentrations of Polychlorinated Dibenzofurans (PCDFs)
and Polychlorinated Dibenzo-p-dioxins (PCDDs)

Page Belcher Federal Building
Tulsa, Oklahoma

April 1985 - February 1986

Sample Date	Sample Number	Sample Location	PCDFs - ng/m^2						PCDDs-ng/m^2					
			2,3,7,8-TCDF	TCDF	PeCDF	HxCDF	HpCDF	OCDF	2,3,7,8-TCDD	TCDD	PeCDD	HxCDD	HpCDD	OCDD
4-85	CR001	Chiller room	2.3	4.2	(0.29)*	(0.2)	(1.3)	8.4	(0.91)	(0.91)	(0.17)	(0.26)	25	1400
4-85	BR005	Boiler room	8.5	17	(0.24)	3.6	22	39	(1.0)	(1.0)	(0.39)	(0.28)	7.5	1400
4-85	F1009	Floor 1 col J-9	0.056	0.056	(0.008)	(0.006)	(0.051)	(0.081)	(0.072)	(0.072)	(0.009)	(0.009)	1.2	67
4-85	F2013	Floor 2 col L-3	0.068	0.98	0.18	0.027	(0.083)	(0.13)	(0.12)	(0.12)	(0.030)	(0.009)	1.8	410
4-85	F4017	Floor 4 Lobby	(0.009)	(0.009)	(0.006)	(0.009)	(0.01)	(0.032)	(0.019)	(0.19)	(0.007)	(0.010)	0.33	4.6
4-85	C021	Field blank	(0.086)	(0.086)	(0.045)	(0.054)	(0.039)	(0.34)	(0.098)	(0.098)	(0.028)	(0.076)	(0.25)	2.1
2-86	DF906	Bsmt. CFS	(0.030)	(0.030)	(0.018)	(0.013)	0.17	(0.27)	(0.056)	(0.056)	(0.046)	0.097	0.54	7.0
2-86	DF904	Floor col J-9	0.46	0.82	0.76	1.8	34	66	(0.042)	(0.042)	(0.059)	3.3	80	990
2-86	DF903	Floor 1M	(0.061)	(0.061)	(0.011)	(0.017)	0.25	0.50	(0.051)	(0.051)	(0.032)	(0.068)	0.90	11
2-86	DF902	Floor 2 OCR	1.5	8.6	24	24	22	23	(0.069)	(0.069)	(0.17)	6.6	65	630
2-86	DF901	Floor 3 Rm 3118	(0.083)	(0.083)	(0.015)	0.073	(0.17)	0.34	(0.098)	(0.098)	(0.079)	0.081	0.51	5.8
2-86	DF900	Floor 4 Rm 4562	(0.037)	(0.037)	(0.014)	(0.012)	(0.020)	(0.11)	(0.055)	(0.055)	(0.049)	(0.024)	(0.016)	0.53
2-86	DF905	Field blank	(0.010)	(0.010)	(0.009)	(0.009)	(0.013)	(0.034)	(0.029)	(0.029)	(0.020)	(0.016)	(0.010)	(0.13)

*Value in parentheses is the limit of detection.

Table 17

Surface Concentrations of 2,3,7,8 - Tetrachlorodibenzo-p-dioxin Equivalents

Page Belcher Federal Building
Tulsa, Oklahoma

April 1985 and Feburary 1986

Sample Date	Sample Number	Sample Location	2,3,7,8,-TCDD Equivale ng/m^2
		SUB-BASEMENT:	
4-85	CR001	Chiller room top of cabinet SW quad	0.80
4-85	BR005	Boiler room boiler vent pipe SW quad	3.4
		BASEMENT:	
2-86	DF906	CFS area face of col J-24	0.03
		FLOOR 1:	
4-85	F1009	Face of col J-9	-0.01*
2-86	DF904	Face of conveyor over saw-tooth at col J-9	0.39
		FLOOR 1 MEZZANINE:	
2-86	DF903	Snack bar table	0.03
		FLOOR 2:	
4-85	F2013	Wall between columns L-3 and P-3	0.26
2-86	DF902	OCR/CS area top of cabinet	4.9
		FLOOR 3:	
2-86	DF901	Room 3118 snack bar	0.07
		FLOOR 4:	
4-85	F4017	Lobby S wall	-0.06
2-86	DF900	Room 4562 file cabinet	0.03

*Negative value resulted when the field blank had a concentration greater than the fie sample.

Table 18
Surface Concentrations of PCBs and TCDD-Equivalents
at Paired Sampling Sites

Page Belcher Federal Building
Tulsa, Oklahoma

February 1986

Sampling Site		PCB ug/m^2	TCDD-Equivalents ng/m^2
Floor 1:	Face of conveyor over saw-tooth at column J-9	7.2	0.39
Floor 1:	Mezzanine: Table Snack Bar	1.3	0.03
Floor 2:	Top of cabinet OCR/CS area	28	4.9
Floor 3:	Table Snack Bar	5.2	0.07
Floor 4:	File cabinet Room 4562	1.4	0.03
Basement:	Face column J-24 CFS area	1.7	0.03

Table 19

Airborne Concentrations of Polychlorinated Biphenyls (PCBs)

Page Belcher Federal Building
Tulsa, Oklahoma

April 14-15, 1985

Sample Number	Sample Location	Sample Volume Liters	Aroclor 1242* ug/m^3
	FOURTH FLOOR:		
AP226	Room 4453	366	0.27
AP212	Room 4547	366	0.22
AP227	Judge Seymour's Office	366	0.11
	THIRD FLOOR:		
AP211	Corridor SE quad	366	0.25
AP225	Snack bar	366	0.49
	SECOND FLOOR:		
AP210	SE quad	366	0.25
AP222	NE quad	366	0.27
AP229	NW quad	366	0.16
AP209	NW quad	366	0.16
AP228	SW quad	366	0.19
AP223	SW quad	366	0.27
	FIRST FLOOR:		
AP208	SE quad	366	0.19
AP221	NE quad	366	0.36
AP207	NW quad	366	0.16

Table 19 – Continued

Sample Number	Sample Location	Sample Volume Liters	Aroclor 1242* ug/m^3
AP230	NW quad	366	0.25
AP231	SW quad	366	0.30
AP220	SW quad	366	0.22
	BASEMENT:		
AP203	Room B118	366	0.25
AP218	Room B118	366	0.16
AP202	Room B117	366	0.19
AP204	Room B217	366	0.19
AP219	Room B217	366	0.30
AP206	Room B115	366	0.14
	SUB-BASEMENT:		
AP200	Chiller room	366	0.27
AP214	Chiller room	366	0.31
AP215	Chiller room	366	0.25
AP213	Lunch room	366	0.36
AP216	Boiler room	366	0.31
AP201	Boiler room	366	0.16
AP217	Boiler room	366	0.25

* The PCBs present did not conform to any specific Aroclor pattern. The samples were selectively quantitated against Aroclor 1242.

Table 20

Airborne Concentrations of Polychlorinated Biphenyls (PCBs)

Page Belcher Federal Building
Tulsa, Oklahoma

February 2, 1986

Sample Number	Sample Location	Sample Volume Liters	Aroclor 1242* ug/m^3
	FOURTH FLOOR:		
AP432	Judge Seymour's Library	543	0.24
AP433	Room 4533	434	0.19
AP430	File room	515	0.19
	THIRD FLOOR:		
AP434	Storage room	399	0.20
AP436	Room 3447	516	0.14
AP437	SWPA office	435	0.21
	SECOND FLOOR:		
AP440	Room 208	430	0.23
AP443	Column H-18	439	0.15
AP435	Room 223	434	0.25
	FIRST FLOOR:		
AP447	Column J-11	438	0.25
AP445	Column L-37	437	0.22
AP444	Snack bar	435	0.23

Table 20 - Continued

Sample Number	Sample Location	Sample Volume Liters	Aroclor 1242* ug/m^3
	BASEMENT:		
AP438	CFS Column J-24	442	0.21
AP439	Room B217	440	0.23
AP442	Medical clinic	440	0.20
AP450	Supply office	380	0.26
AP452	Supply office storage area	378	0.13
	SUB-BASEMENT:		
AP429	Chiller room	420	0.24
AP441	Boiler room	444	0.23
AP431	Boiler room	386	0.24

* The chromatograms for these samples most closely resembled Aroclor 1242, however, there were several other PCB peaks present. The samples were selectively quantitated against Aroclor 1242.

Table 21

Airborne Concentrations of Polychlorinated Biphenyls (PCBs)

Page Belcher Federal Building
Tulsa, Oklahoma

January 31 - February 2, 1986

Sample Number	Sample Location	Sample Volume Liters	Aroclor ug/m^3 1242	1254	1260	Total
	FOURTH FLOOR:					
AP402	Judge Seymour's Office	2959	0.15	0.04	ND*	0.19
AP413	Room 4533	2918	0.09	0.04	ND	0.13
AP412	File room	2901	0.16	0.06	ND	0.22
AP416	Room 4422	2797	0.29	0.04	ND	0.33
	THIRD FLOOR:					
AP401	Storage room	3057	0.12	0.04	ND	0.16
AP414	Room 3447	2880	0.12	0.03	ND	0.15
AP403	SWPA office	3091	0.12	0.05	ND	0.17
AP400	Room 3350	2880	0.09	0.02	ND	0.11
	SECOND FLOOR:					
AP408	Room 208	3088	0.23	0.06	ND	0.29
AP417	Column H-18	3052	0.21	0.06	ND	0.27
AP405	Column J-35	3091	0.10	0.04	ND	0.14
AP404	Room 223	3114	0.18	0.07	ND	0.25
	FIRST FLOOR:					
AP410	Column J-11	3014	0.16	0.07	ND	0.23
AP420	Column E-11	3001	0.21	0.03	ND	0.24
AP418	Column L-37	3036	0.19	0.05	ND	0.24
AP415	Snack bar	3049	0.15	0.03	ND	0.18

Table 21 - Continued

Sample Number	Sample Location	Sample Volume Liters	Aroclor ug/m³ 1242	1254	1260	Total
	BASEMENT:					
AP419	Woodworking shop	2965	0.30	0.07	ND	0.37
AP423	CFS Column J-24	2953	0.12	0.02	ND	0.14
AP406	Room B217	2967	0.29	0.04	ND	0.33
AP411	Medical clinic	2936	0.14	0.03	ND	0.17
	SUB-BASEMENT:					
AP409	Chiller room	3005	0.21	0.03	ND	0.24
AP407	Chiller room	3093	0.19	0.06	ND	0.25
AP421	Boiler room	2956	0.15	0.10	ND	0.25
AP422	Boiler room	2959	0.14	0.06	ND	0.20

* Denotes none detected. The limit of detection is 0.02 ug/m^3.

Table 22

Summary of Polychlorinated Biphenyl (PCB) Air Concentrations by Area of the Building for April 1985

Page Belcher Federal Building
Tulsa, Oklahoma

Area	Sample Size	PCB Concentration - ug/m^3 Mean	Geometric Mean	Range
4th Floor	3	0.20	0.19	0.11-0.27
3rd Floor	2	0.37	0.35	0.25-0.49
2nd Floor	6	0.22	0.21	0.16-0.27
1st Floor	6	0.25	0.24	0.16-0.36
Basement	6	0.21	0.20	0.14-0.30
Sub-Basement				
Chiller Room	4	0.30	0.29	0.25-0.36
Boiler Room	3	0.24	0.23	0.16-0.31
Overall	30	0.24	0.23	0.11-0.49*

*5-95 percentile range = 0.13 - 0.41 ug/m^3.

Table 23

Summary of Polychlorinated Biphenyl (PCB) Air Concentrations by Area of the Building for February 1986

Page Belcher Federal Building
Tulsa, Oklahoma

Area	Sample Size	PCB Concentration - ug/m^3 Mean	Geometric Mean	Range
4th Floor	7	0.21	0.20	0.13-0.33
3rd Floor	7	0.16	0.16	0.11-0.21
2nd Floor Mezzanine	2	0.25	0.25	0.25-0.25
2nd Floor	5	0.22	0.21	0.14-0.29
1st Floor Mezzanine	2	0.21	0.20	0.18-0.23
1st Floor	5	0.24	0.24	0.22-0.25
Basement	9	0.23	0.21	0.13-0.37
Sub-Basement				
Chiller Room	3	0.24	0.24	0.24-0.25
Boiler Room	4	0.23	0.22	0.20-0.25
Overall	44	0.22	0.21	0.11-0.37*

*5-95 percentile range = 0.13 - 0.33 ug/m^3.

Table 24

Airborne Concentrations of Polychlorinated Dibenzofurans (PCDFs) and Polychlorinated Dibenzo-p-dioxins (PCDDs)

Page Belcher Federal Building
Tulsa, Oklahoma

April 1985 and February 1986

Sample Date	Sample Number	Sample Location	PCDFs - pg/m^3						PCDDs-pg/m^3					
			2,3,7,8-TCDF	TCDF	PeCDF	HxCDF	HpCDF	OCDF	2,3,7,8-TCDD	TCDD	PeCDD	HxCDD	HpCDD	OCDD
4-85	V003	Chiller room	(0.18)*	(0.18)	(0.84)	(0.64)	(0.30)	(0.35)	(0.41)	(0.41)	(0.10)	(0.065)	(0.25	2.6
4-85	V004	Boiler room	(2.3)	(2.3)	(0.35)	(0.16)	(4.9)	(4.9)	(6.4)	(6.4)	(0.44)	(0.18)	(4.5)	(2.3)
4-85	V020	Floor 1 col J-11	(2.8)	(2.8)	(7.2)	(3.4)	(7.3)	(14)	(4.1)	(4.1)	(6.7)	(3.6)	(9.1)	18
4-85	V013	Floor 2 col J-7	(0.53)	(0.53)	(0.15)	(0.16)	(1.8)	(4.0)	(1.3)	(1.3)	(0.18)	(0.35)	(1.8)	(2.1)
4-85	V009	Roof air intake	(0.36)	(0.36)	(0.14)	(0.27)	(0.48)	(0.94)	(0.31)	(0.31)	(0.13)	(0.30)	(0.4)	1.1
4-85	V005	Field blank	(0.12)	(0.12)	(0.21)	(0.14)	(0.18)	(0.35)	(0.24)	(0.24)	(0.14)	(0.17)	(0.1)	(0.18)
2-86	DF480	Boiler room	(0.60)	(0.60)	(0.081)	(0.078)	(0.64)	(2.4)	(0.21)	(0.21)	(0.21)	(0.19)	1.1	1.1
2-86	DF479	CFS col J-24	(0.42)	(0.42)	(0.28)	(0.13)	(0.20)	(0.67)	(0.24)	(0.24)	(0.40)	(0.43)	(0.35)	6.4
2-86	DF475	Floor 1 col J-11	(0.54)	(0.54)	(0.081)	(0.074)	(1.1)	(3.2)	(0.32)	(0.32)	(0.20)	(0.12)	3.6	37
2-86	DF477	Floor 2 col H-18	(0.77)	(0.77)	(0.13)	(0.075)	(0.21)	(0.88)	(0.19)	(0.19)	(0.22)	(0.26)	(0.21)	2.7
2-86	DF478	Floor 3 Rm 3447	(0.61)	(0.61)	(0.30)	(0.23)	(0.69)	(1.2)	(0.62)	(0.62)	(0.54)	(0.21)	(0.47)	(1.5)
2-86	DF476	Floor 4 Library	(0.33)	(0.33)	(0.10)	(0.065)	(0.12)	(0.82)	(0.66)	(0.66)	(0.28)	(0.16)	(0.12)	(1.6)
2-86	DF481	Field blank	(0.31)	(0.31)	(0.19)	(0.19)	(0.12)	(0.44)	(0.19)	(0.19)	(0.42)	(0.40)	(0.078)	(1.5)

*The value in parentheses is the limit of detection.

Table 25

Air Concentrations of 2,3,7,8-Tetrachlorodibenzo-p-dioxin Equivalents

Page Belcher Federal Building
Tulsa, Oklahoma

April 1985 and Feburary 1986

Sample Date	Sample Number	Sample Location	2,3,7,8,-TCDD Equivalent pg/m^3
		SUB-BASEMENT:	
4-85	V003	Chiller room	(0.04)*
4-85	V004	Boiler Room	(3.5)
2-86	DF480	Boiler room	(0.08)
		BASEMENT:	
2-86	DF479	CFS area	(0.03)
		FLOOR 1:	
4-85	V020	Col J-11 SW quad	(4.6)
2-86	DF475	Col J-11 SW quad	(0.03)
		FLOOR 2:	
4-85	V013	Col J-7 SW quad	(0.58)
2-86	DF477	Col H-18 SW quad	(0.01)
		FLOOR 3:	
2-86	DF478	Room 3447	(0.29)
		FLOOR 4:	
2-86	DF476	Judge Seymour's Library	(0.18)
		ROOF:	
4-85	V009	Ambient fresh air intake	(0.04)

*The 2,3,7,8-TCDD equivalents were calculated with all samples showing levels of the PCDF and PCDD compounds below the limit of detection.

Figure 1

Layout drawing of sub-basement and basement with approximate locations of air handling units and zones

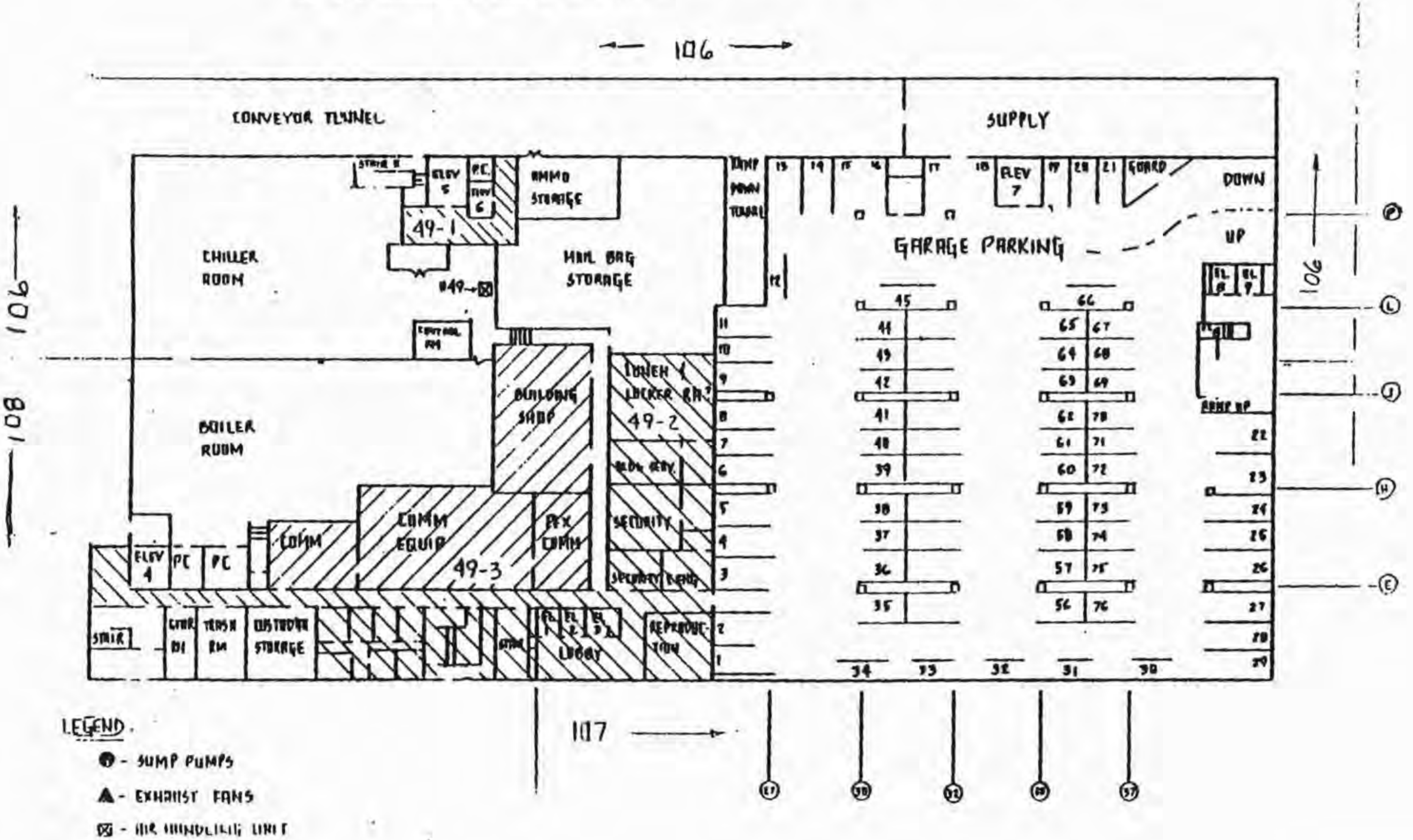

Figure 2

Layout drawing of first floor with approximate locations of air handling zones

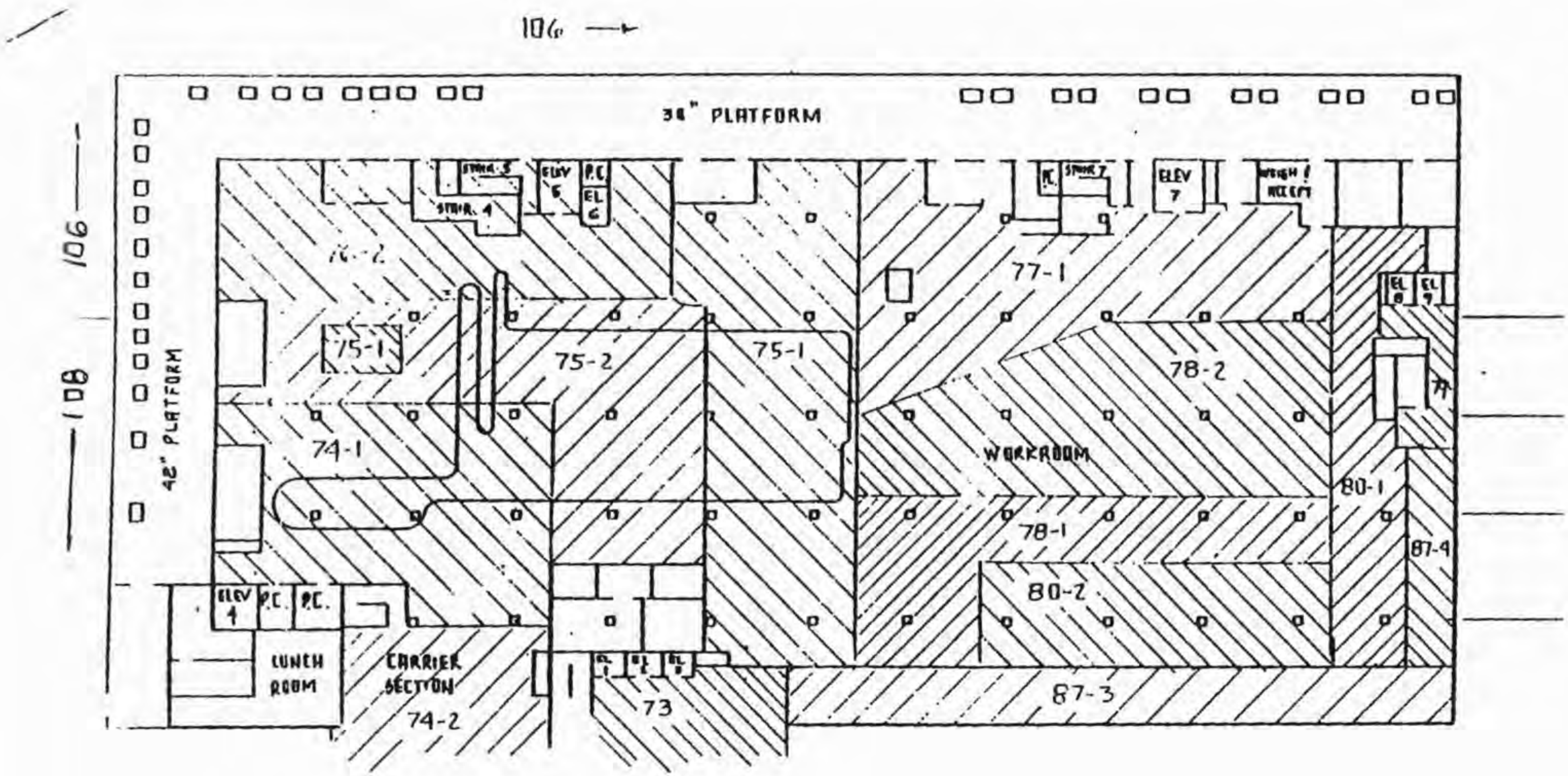

Figure 3

Layout drawing of first floor mezzanine with approximate locations of air handling zones

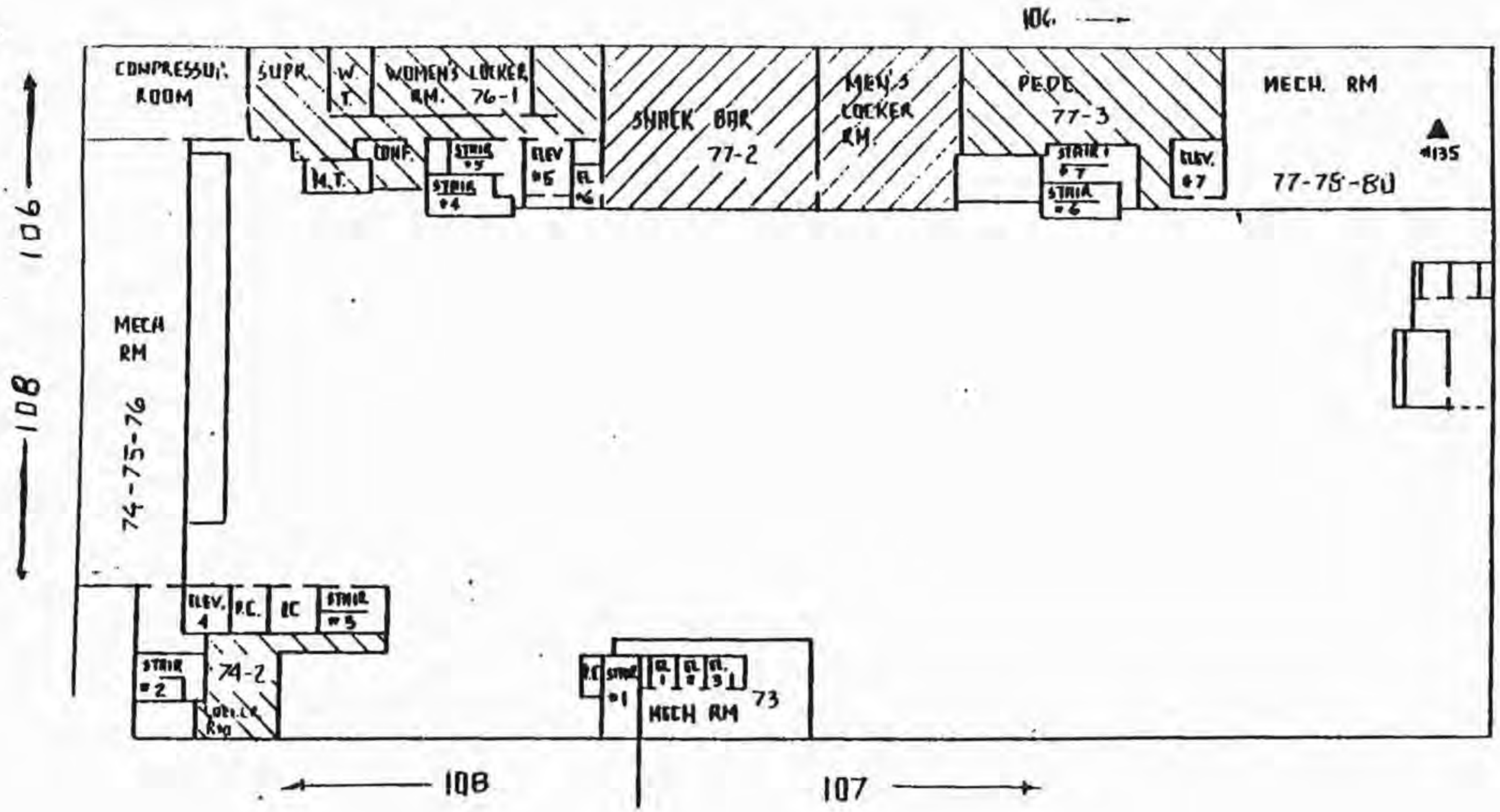

Figure 4

Layout drawing of second floor with approximate locations of air handling units and zones

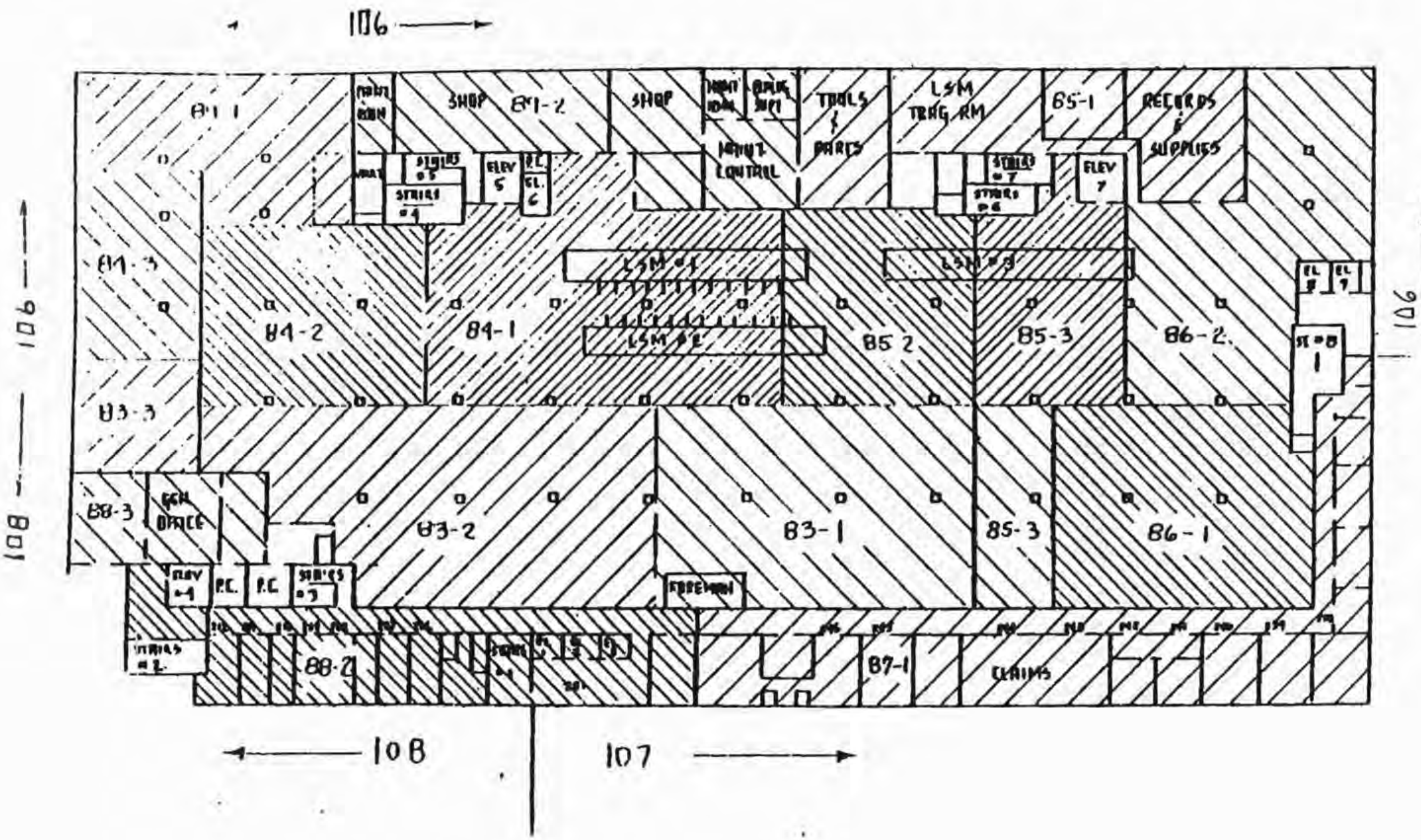

Figure 5

Layout drawing of second floor mezzanine with approximate locations of air handling units and zones

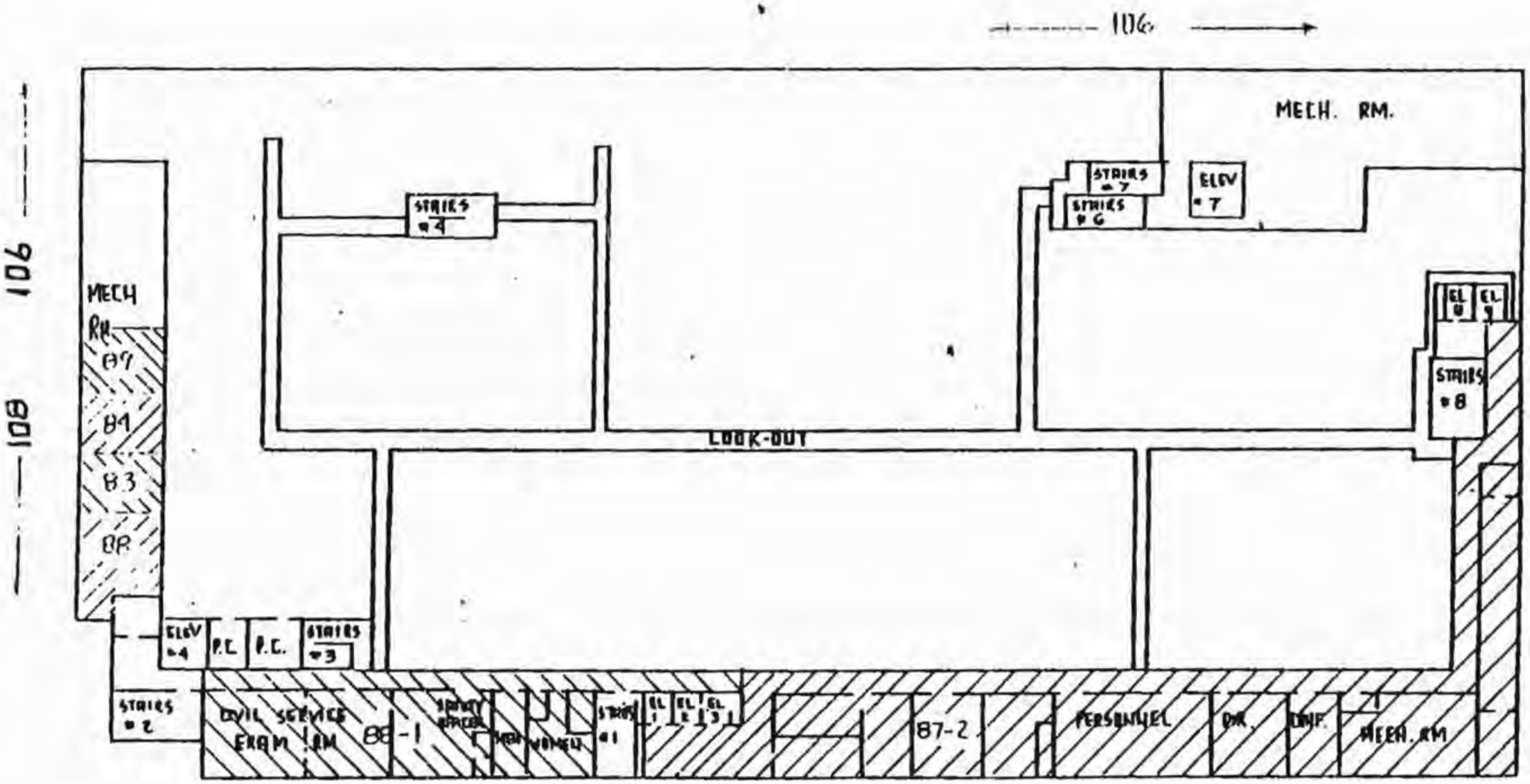

Figure 6

Layout drawing of third floor with approximate locations of air handling units and zones

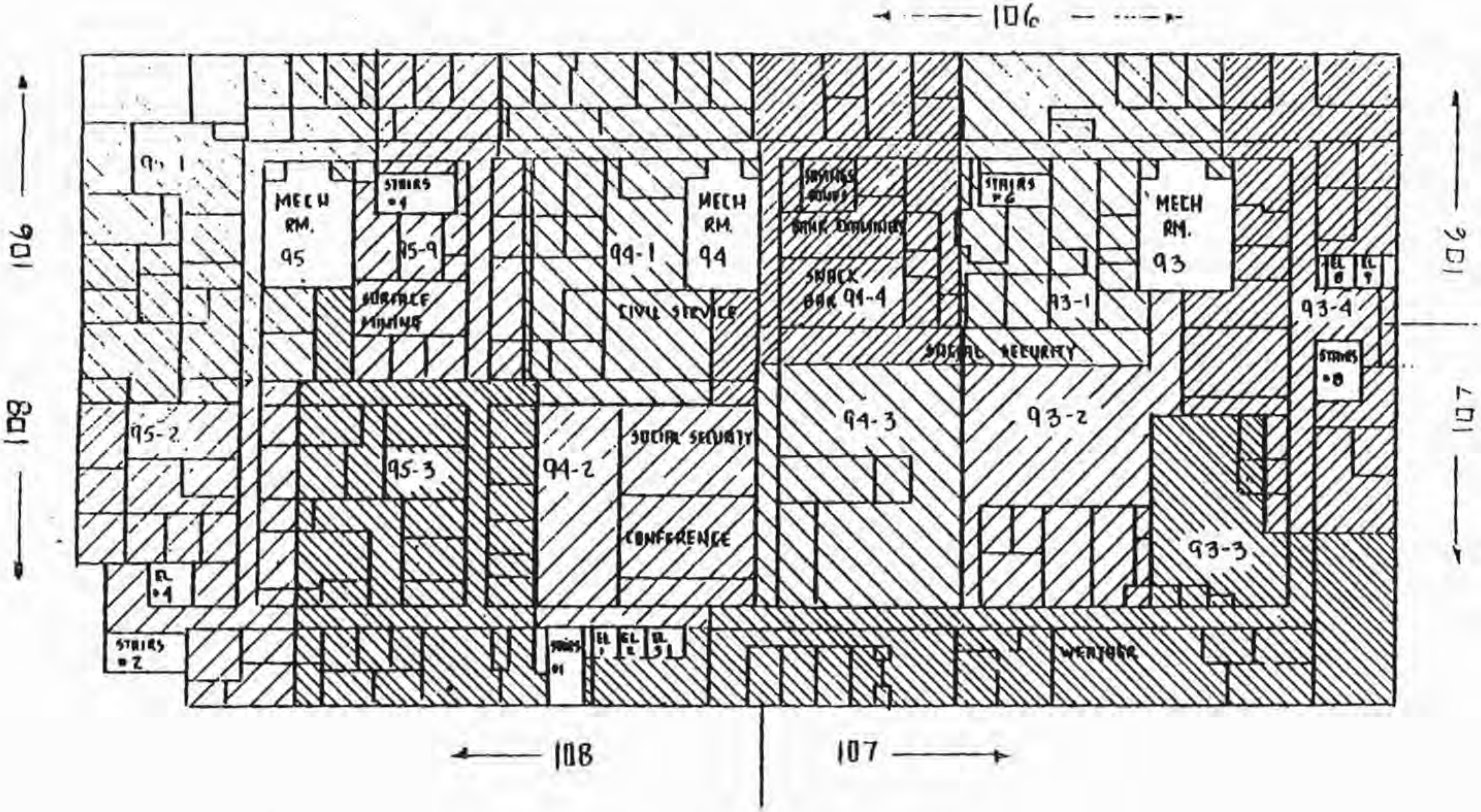

Figure 7

Layout drawing of fourth floor with approximate locations of air handling units and zones

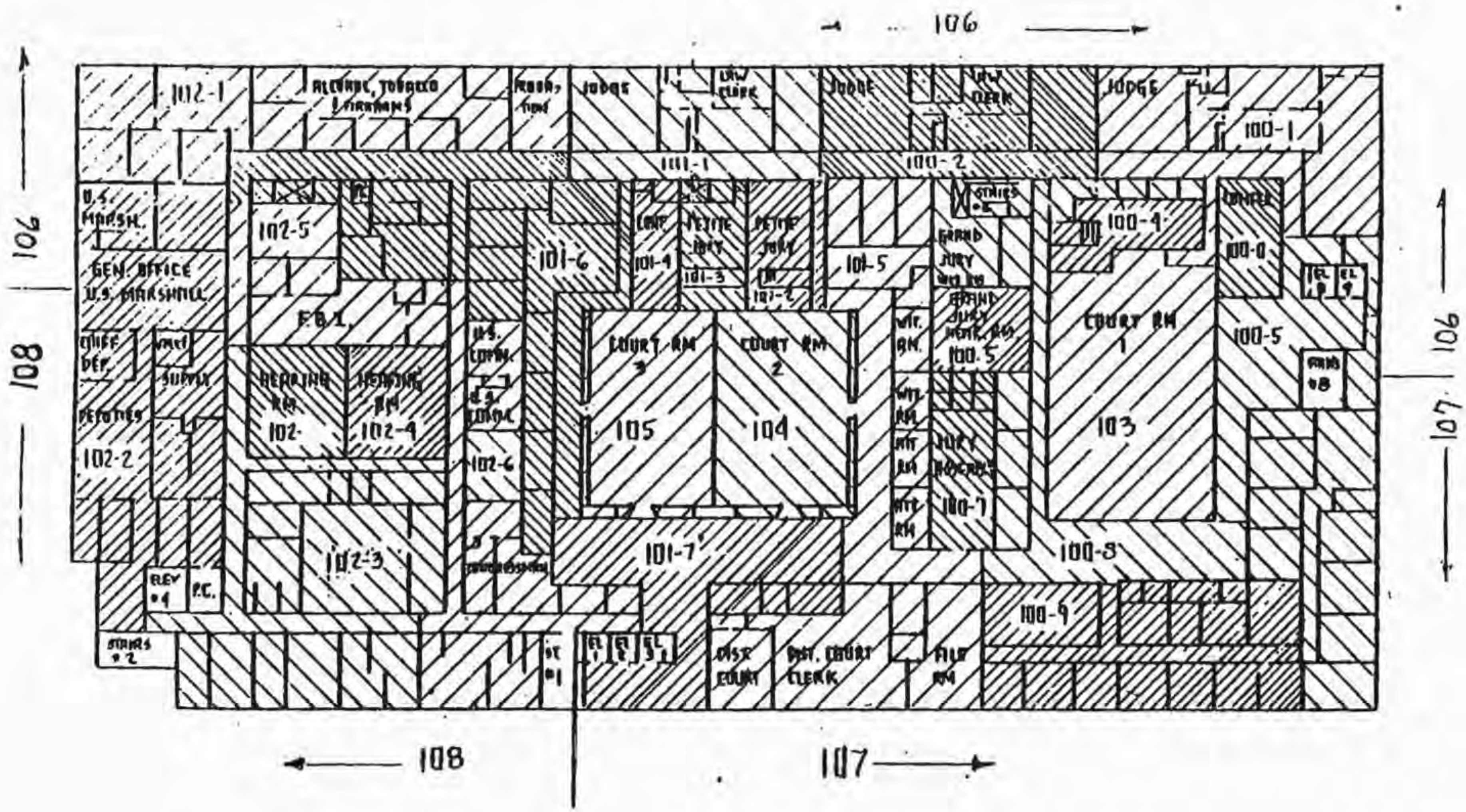

Figure 8

Layout drawing of penthouse/roof with approximate locations of air handling units

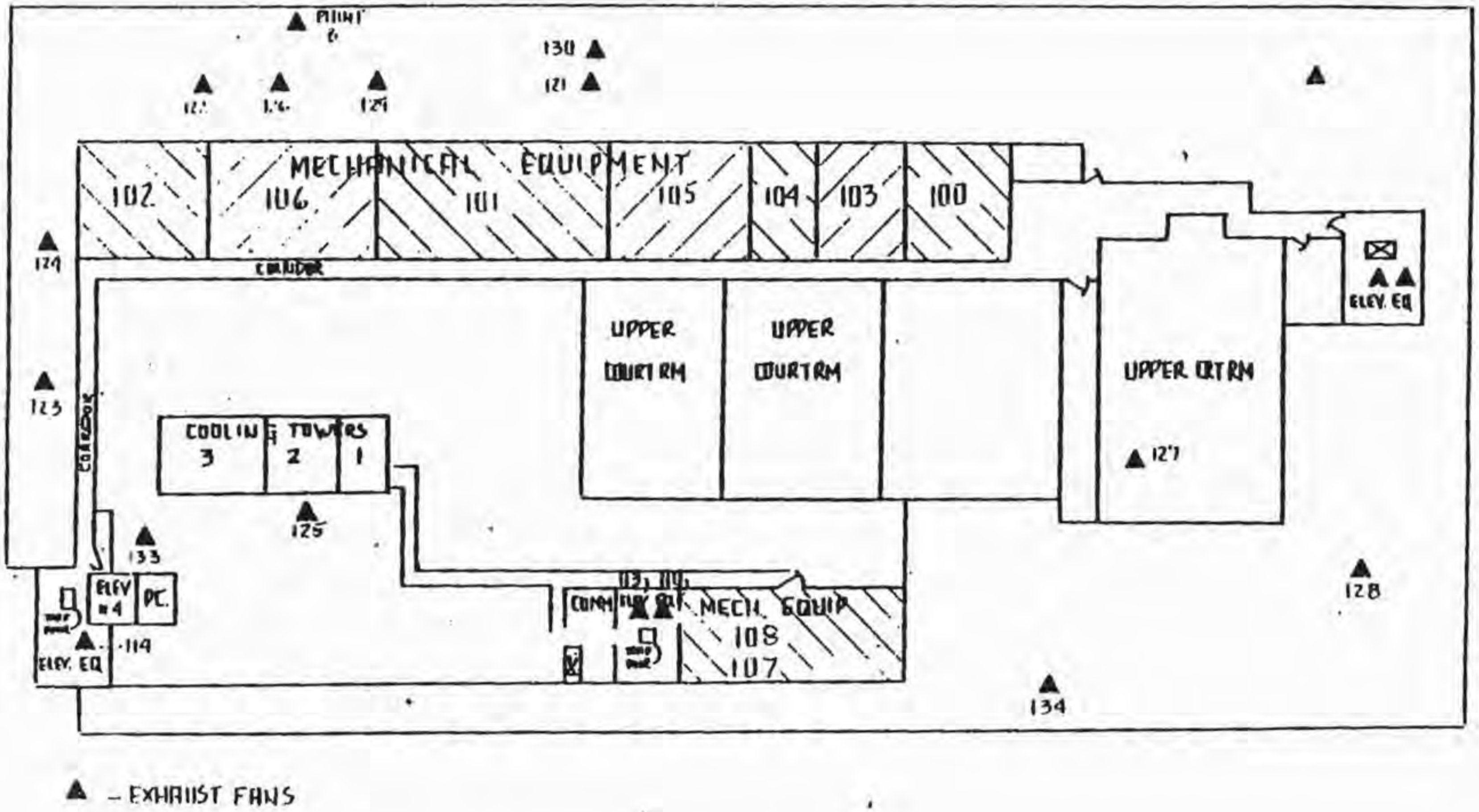

Figure 9

Two-stage air sampling device for PCDFs/PCDDs

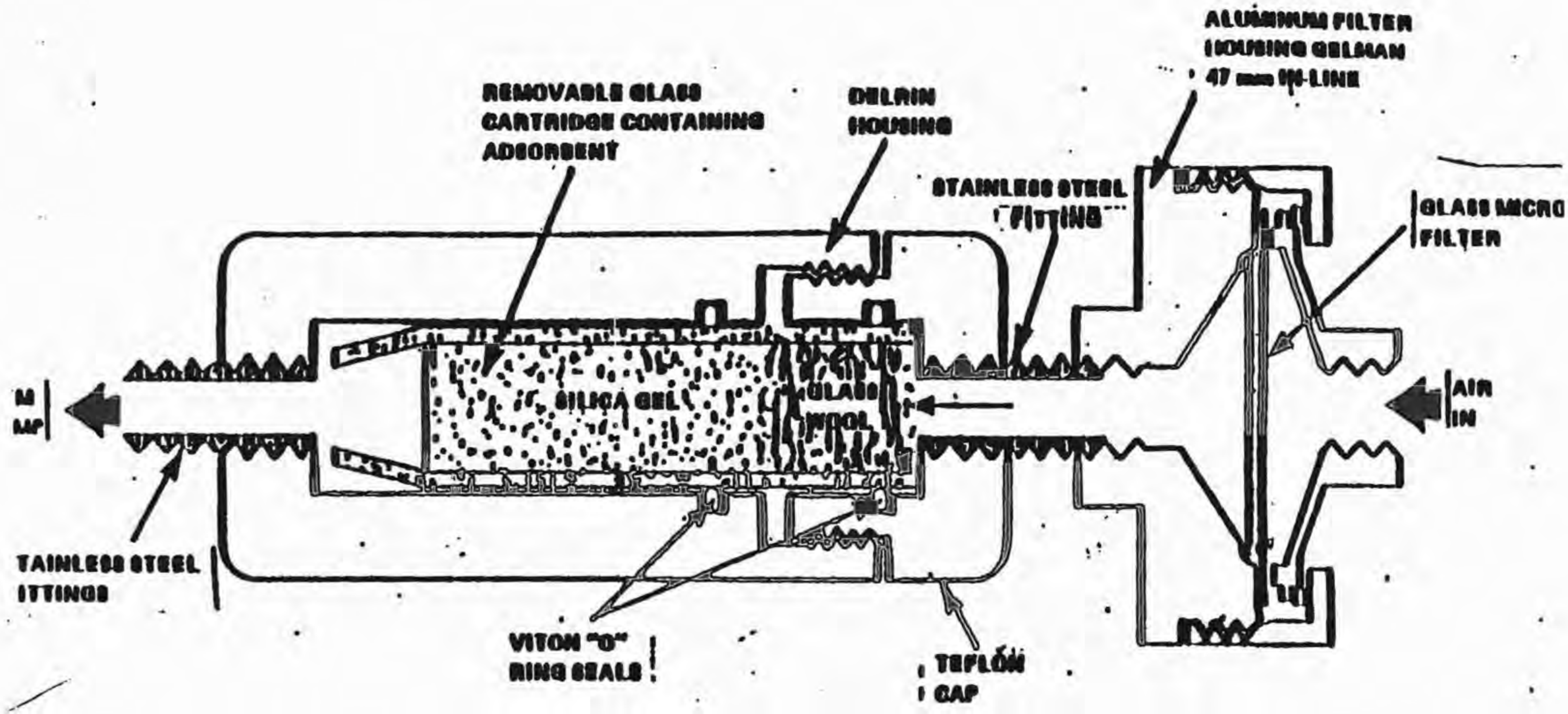

Figure 10

Locations of PCB and PCDF.PCDD air samples - Sub-basement and basement

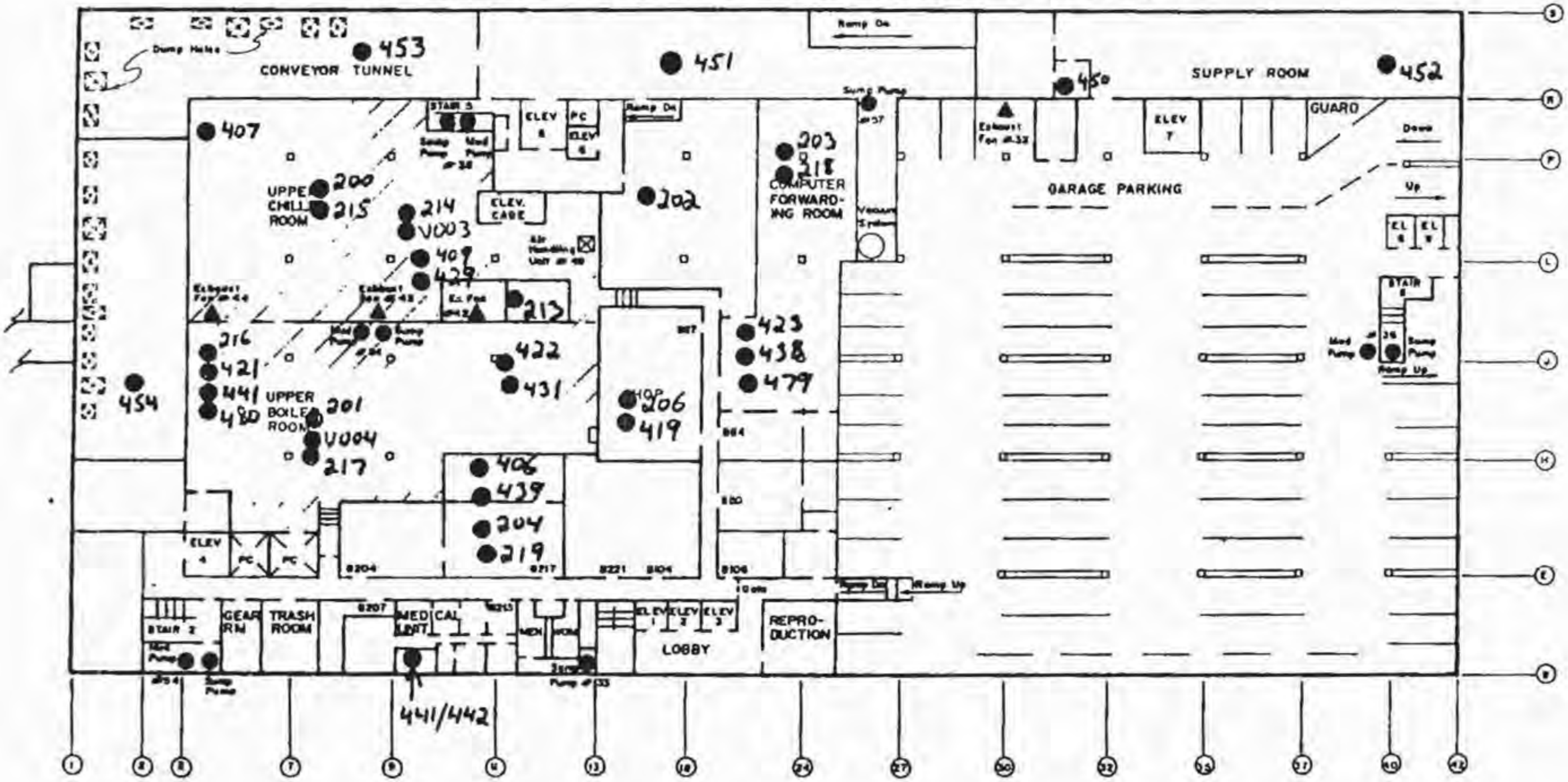

Figure 11

Locations of PCB and PCDF.PCDD air samples - first floor

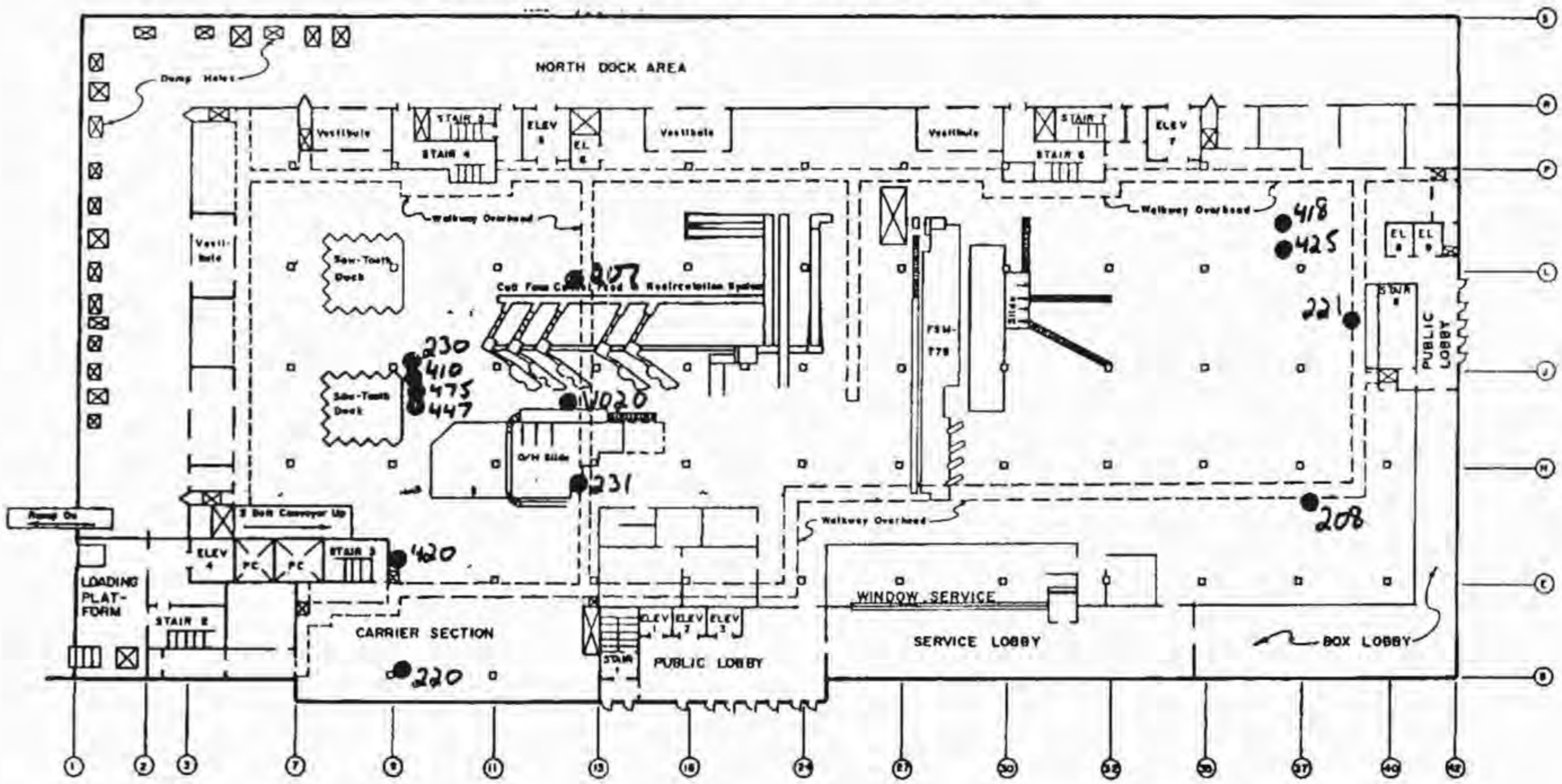

Figure 12

Locations of PCB air samples - First floor mezzanine

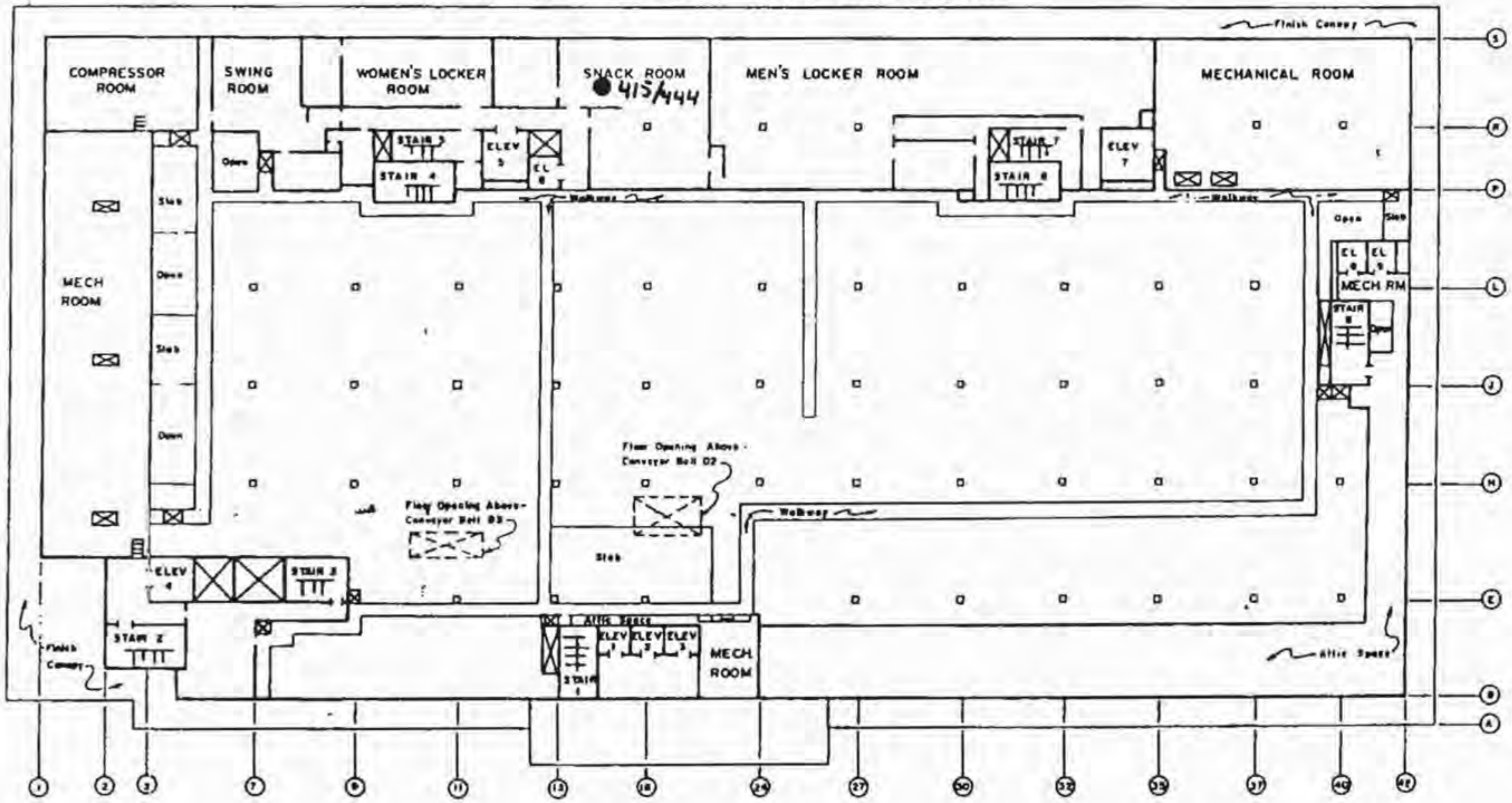

Figure 13

Locations of PCB and PCDF/PCDD air samples - second floor

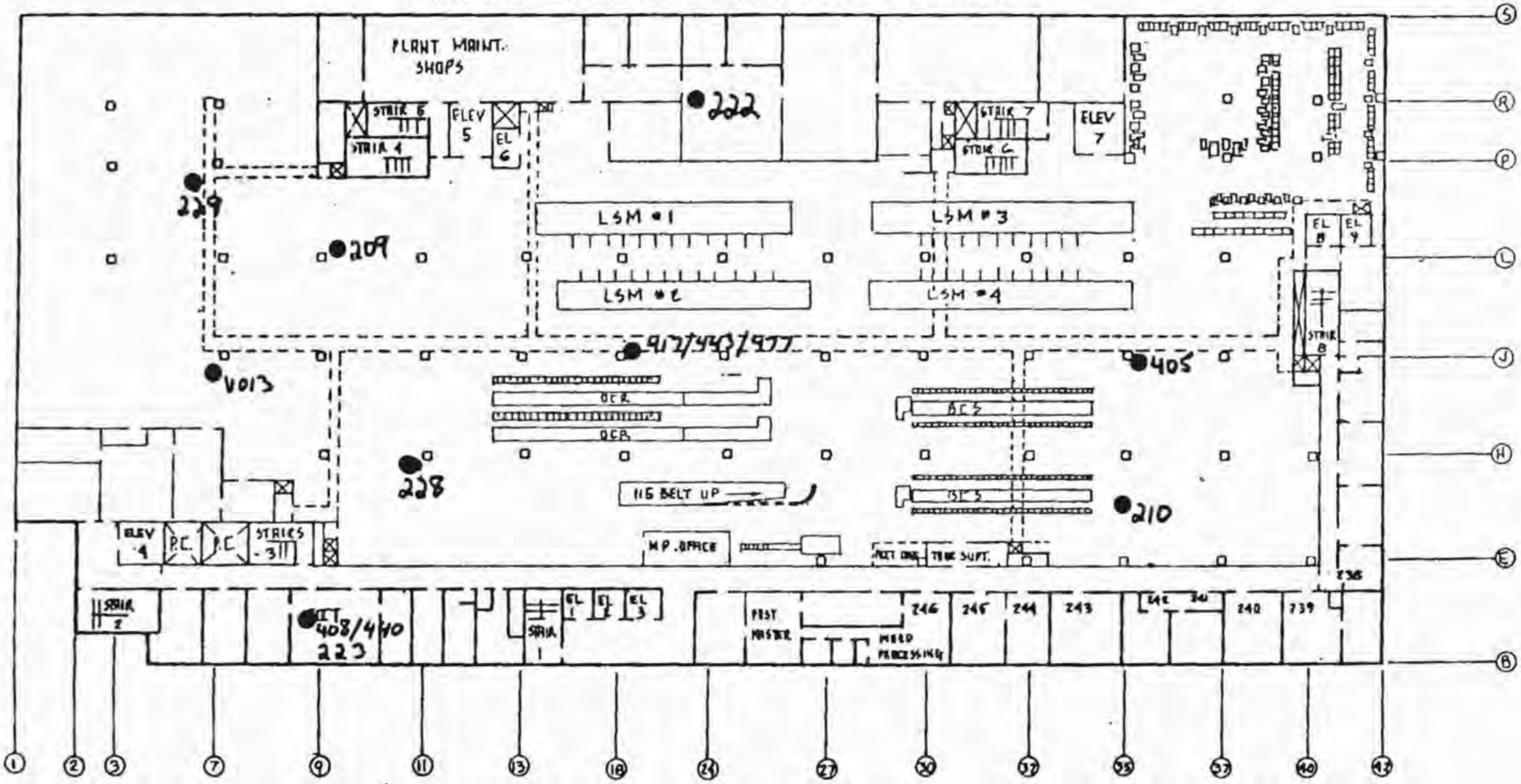

Figure 14

Locations of PCB air samples - second floor mezzanine

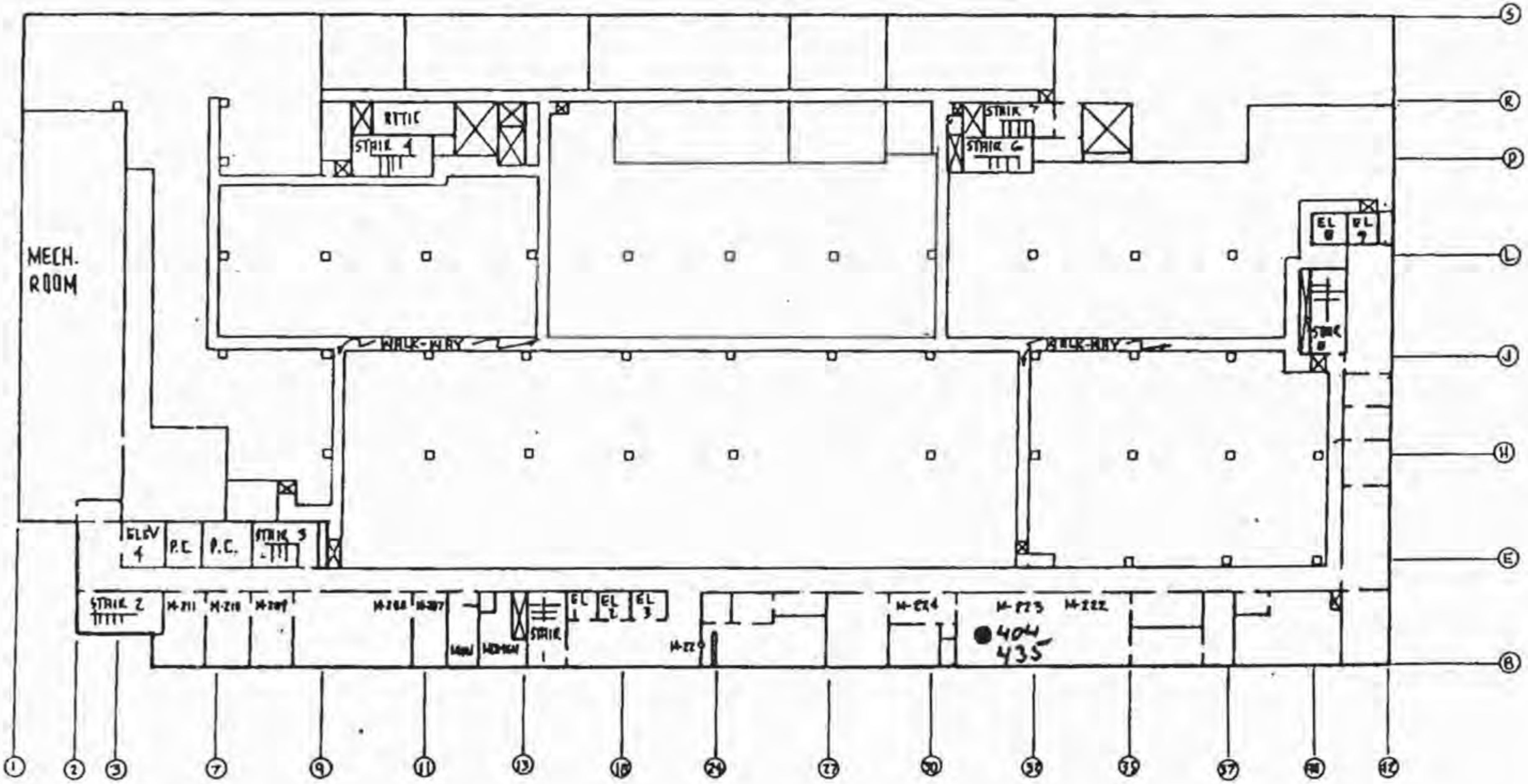

Figure 15

Locations of PCB and PCDF/PCDD air samples - third floor

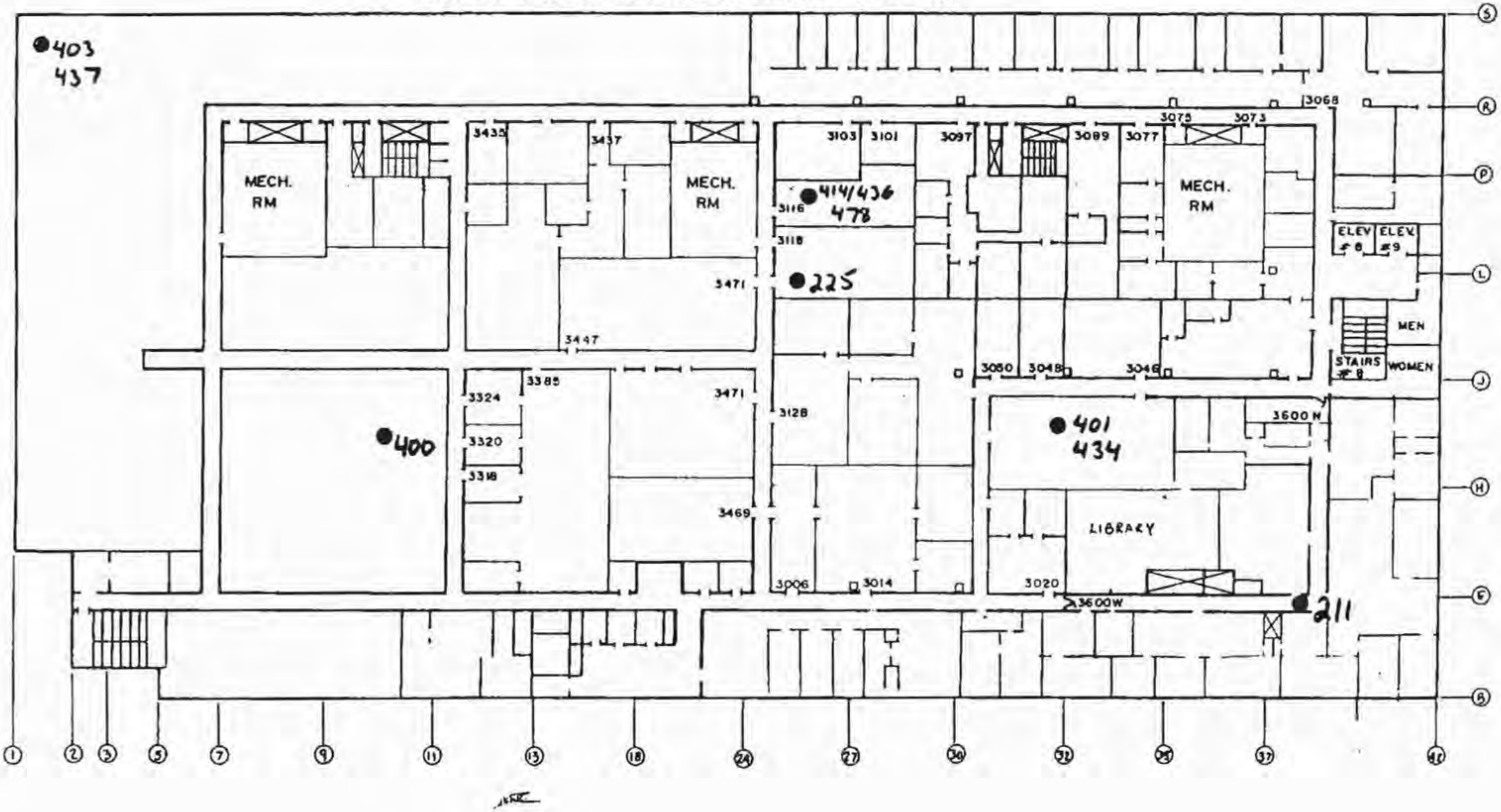

Figure 16

Locations of PCB and PCDF/PCDD air samples - fourth floor

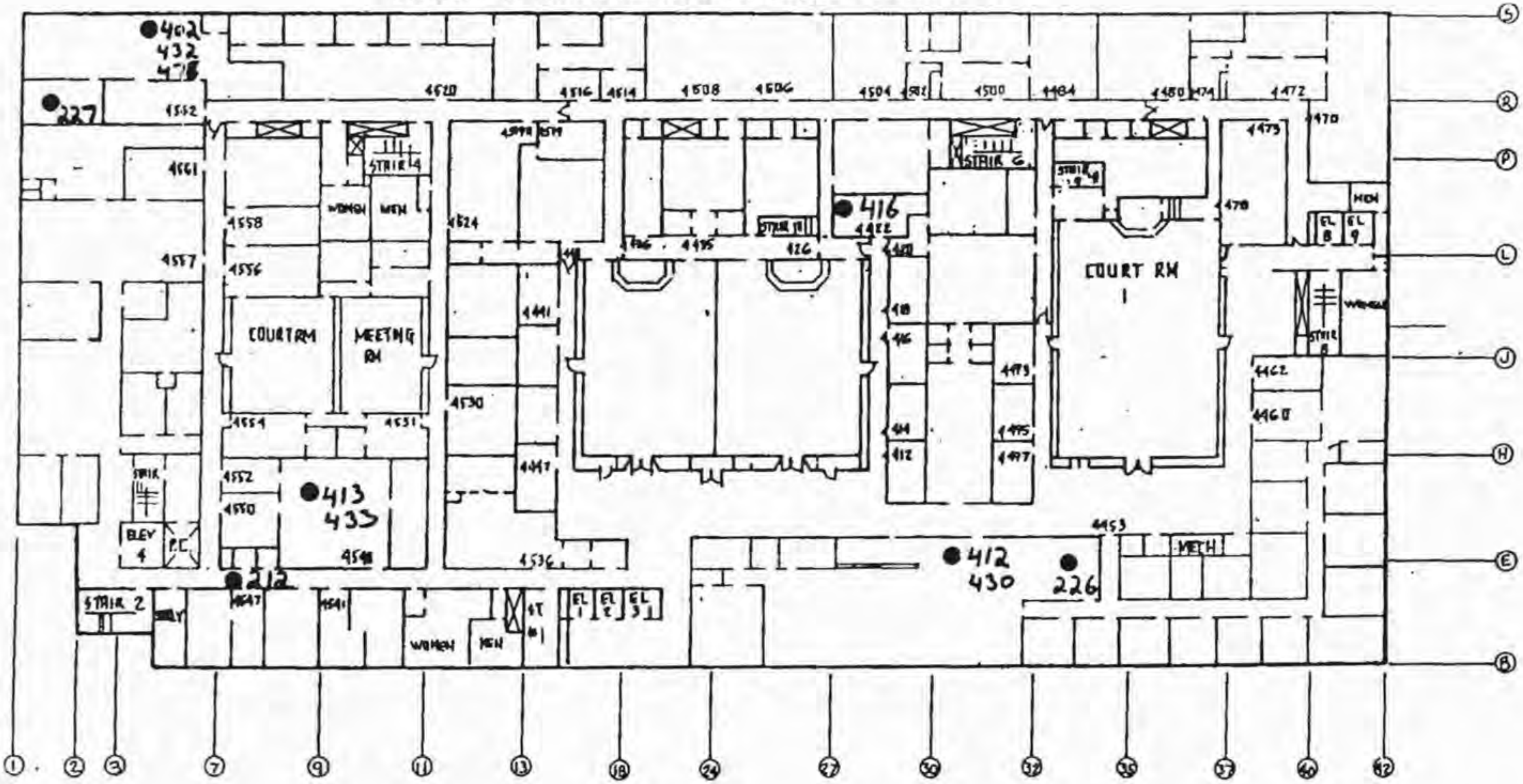

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Figure 17

Locations of PCB and PCDF/PCDD surface wipe samples - sub-basement and basement

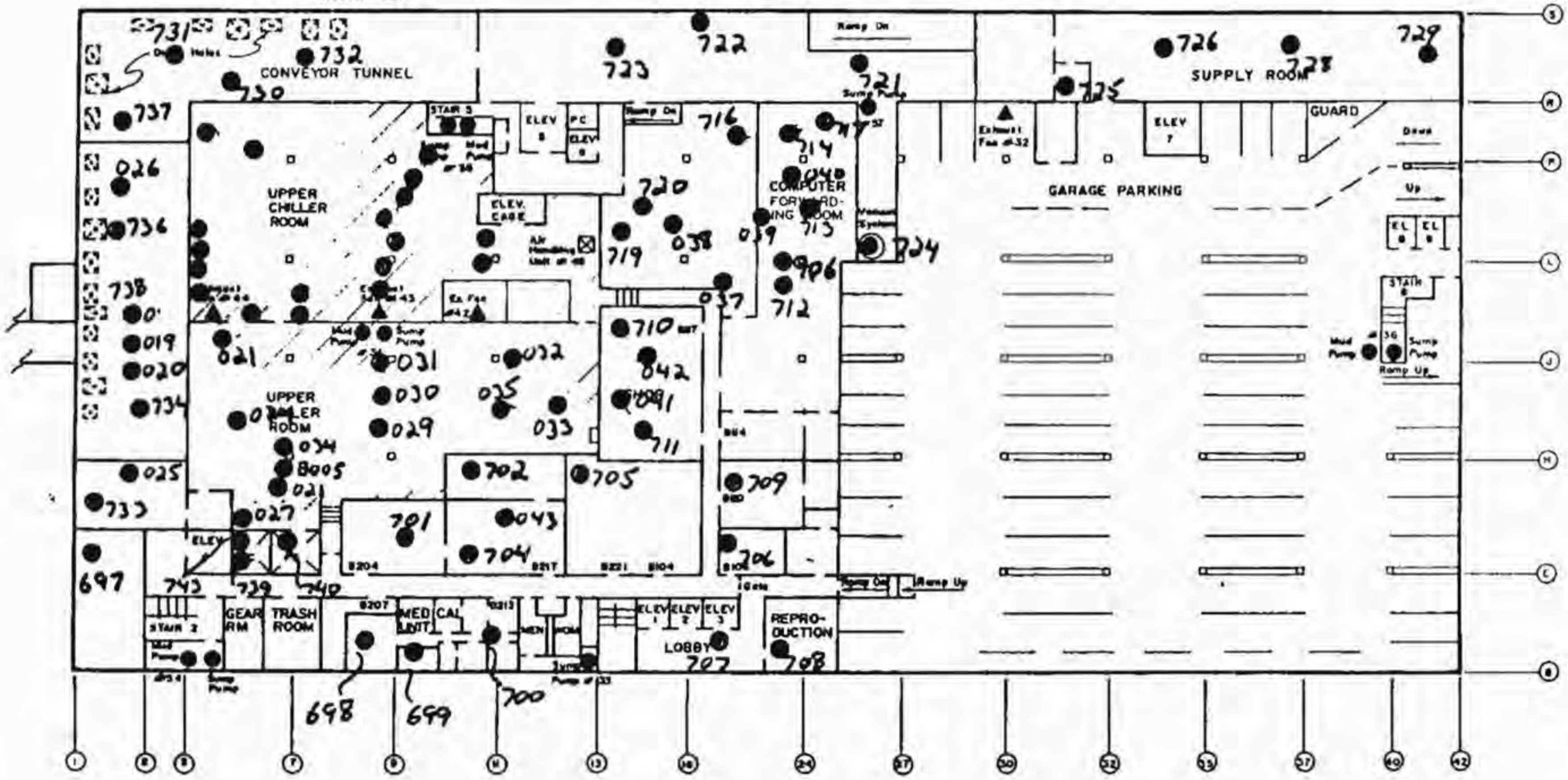

Figure 18

Locations of PCB and PCDF/PCDD surface wipe samples - first floor

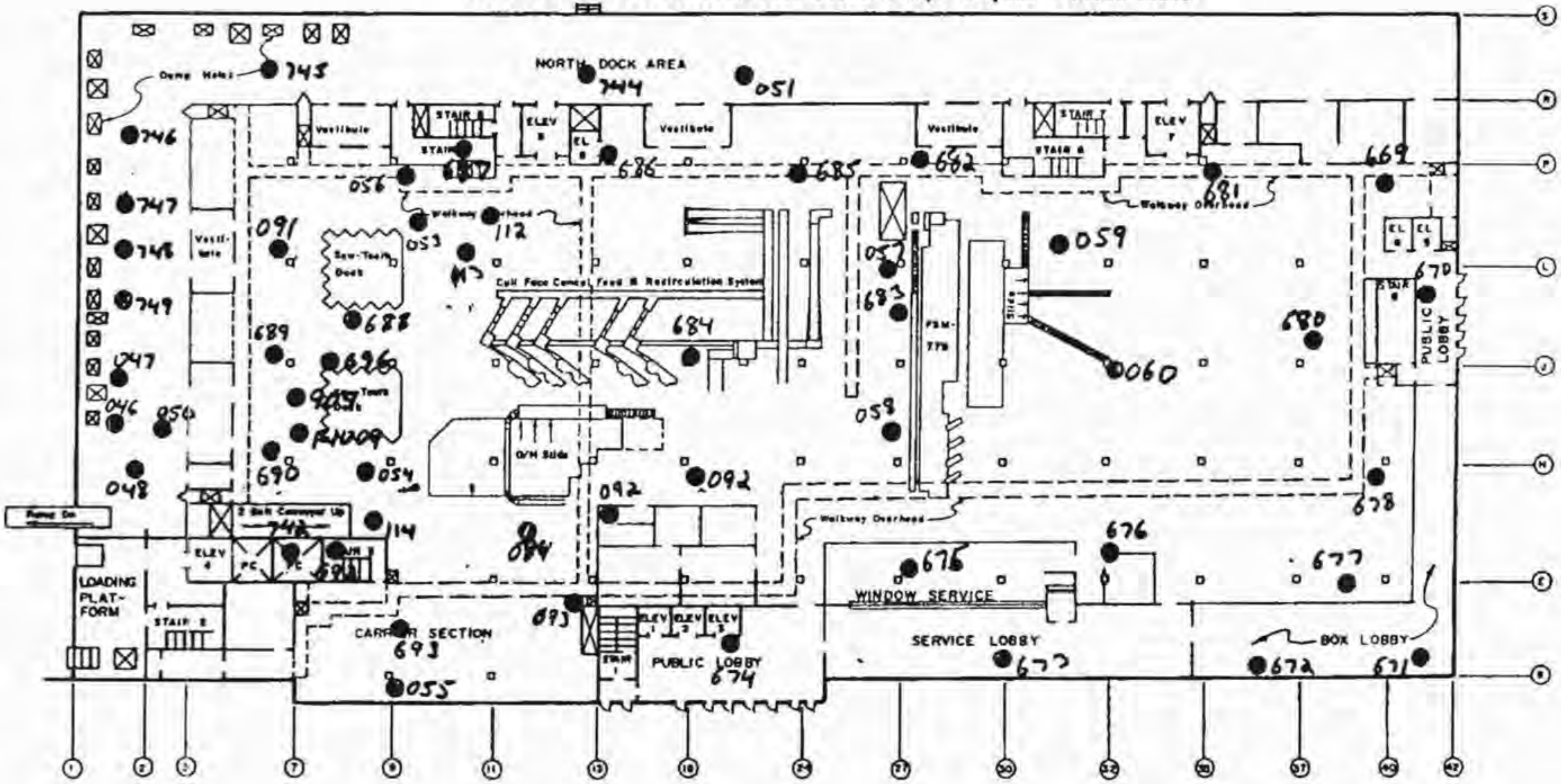

Figure 19

Locations of PCB and PCDF/PCDD surface wipe samples - first floor mezzanine

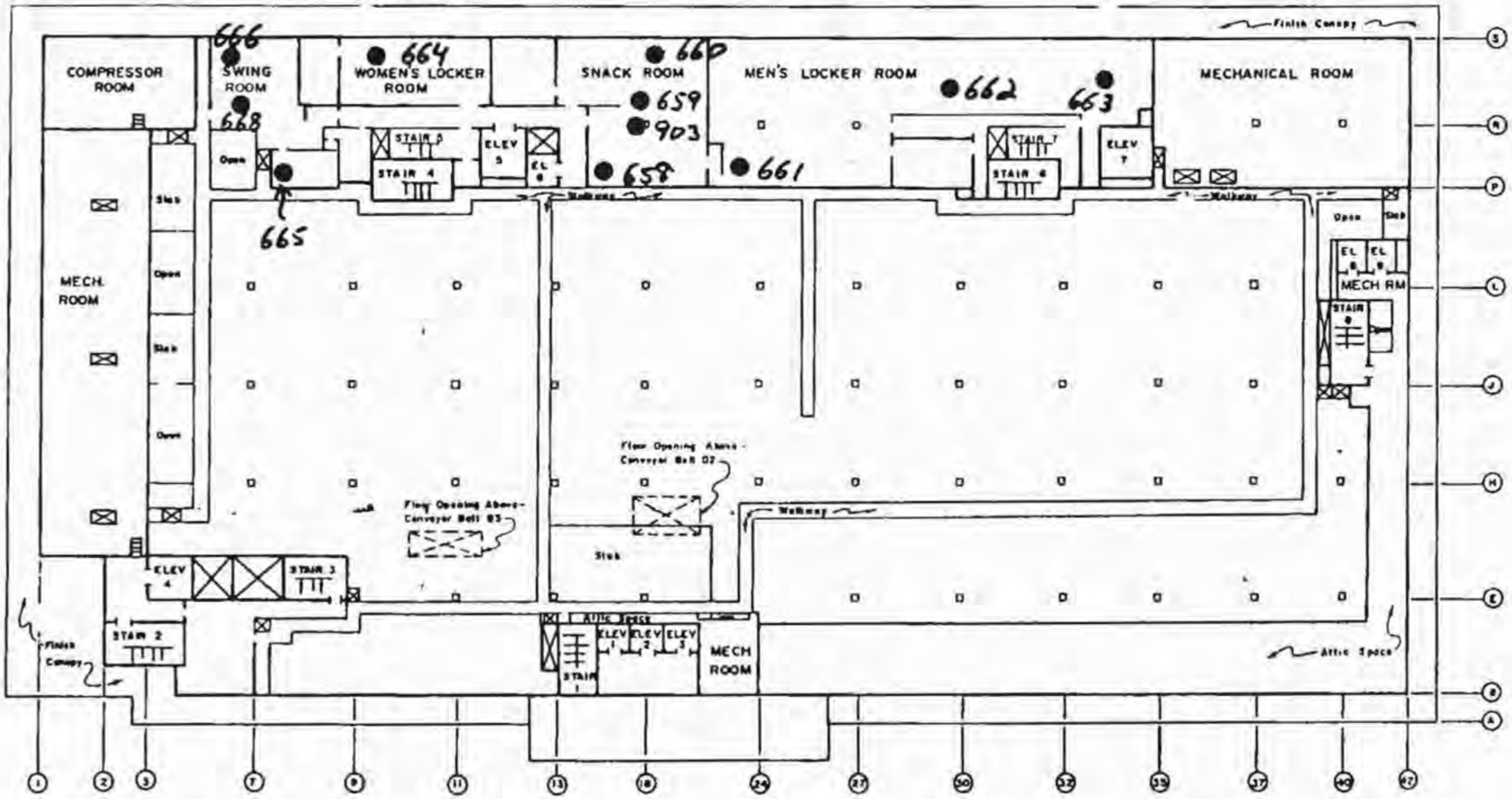

Figure 20

Locations of PCB and PCDF.PCDD surface wipe samples - second floor

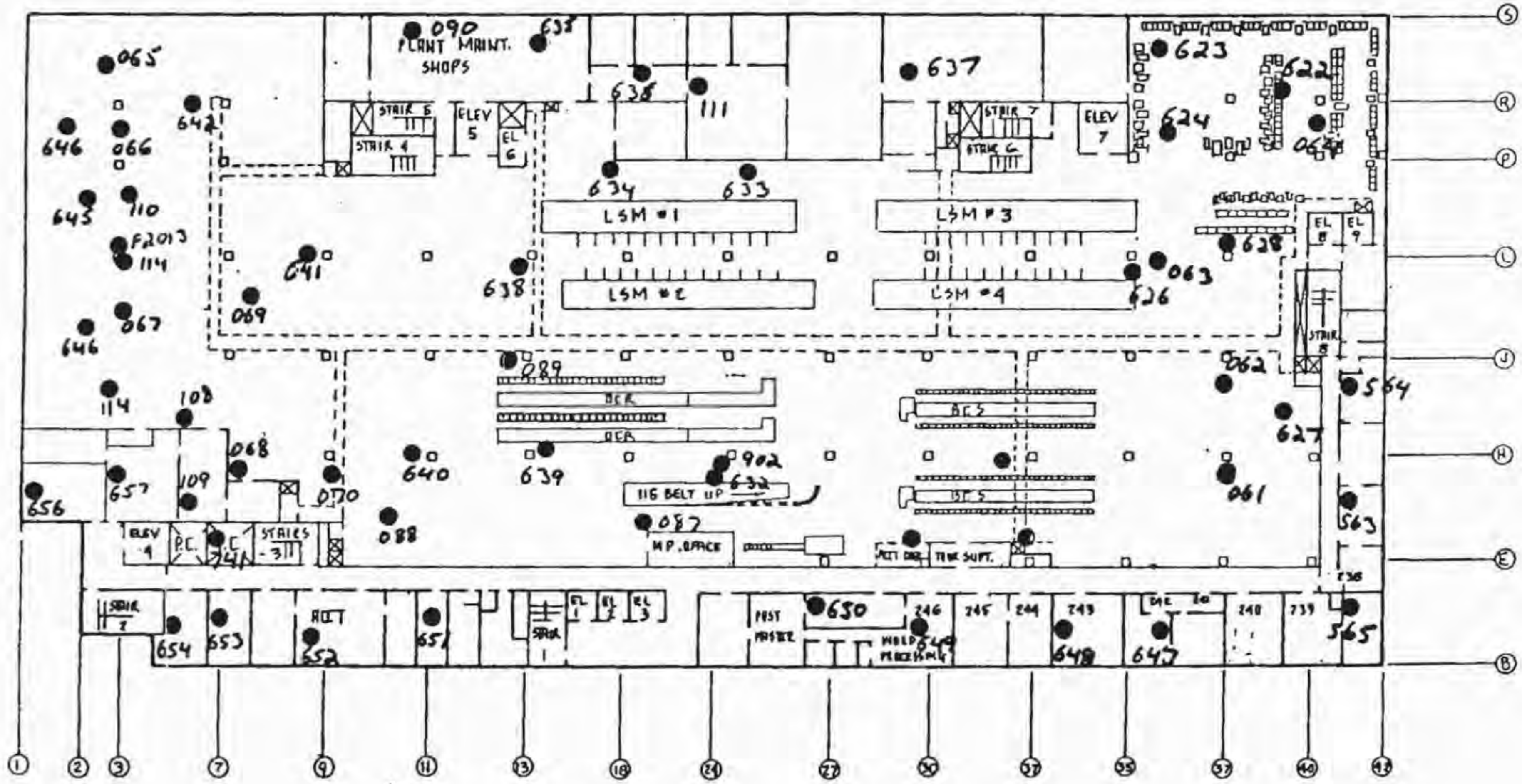

Figure 21

Locations of PCB surface wipe samples - second floor mezzanine

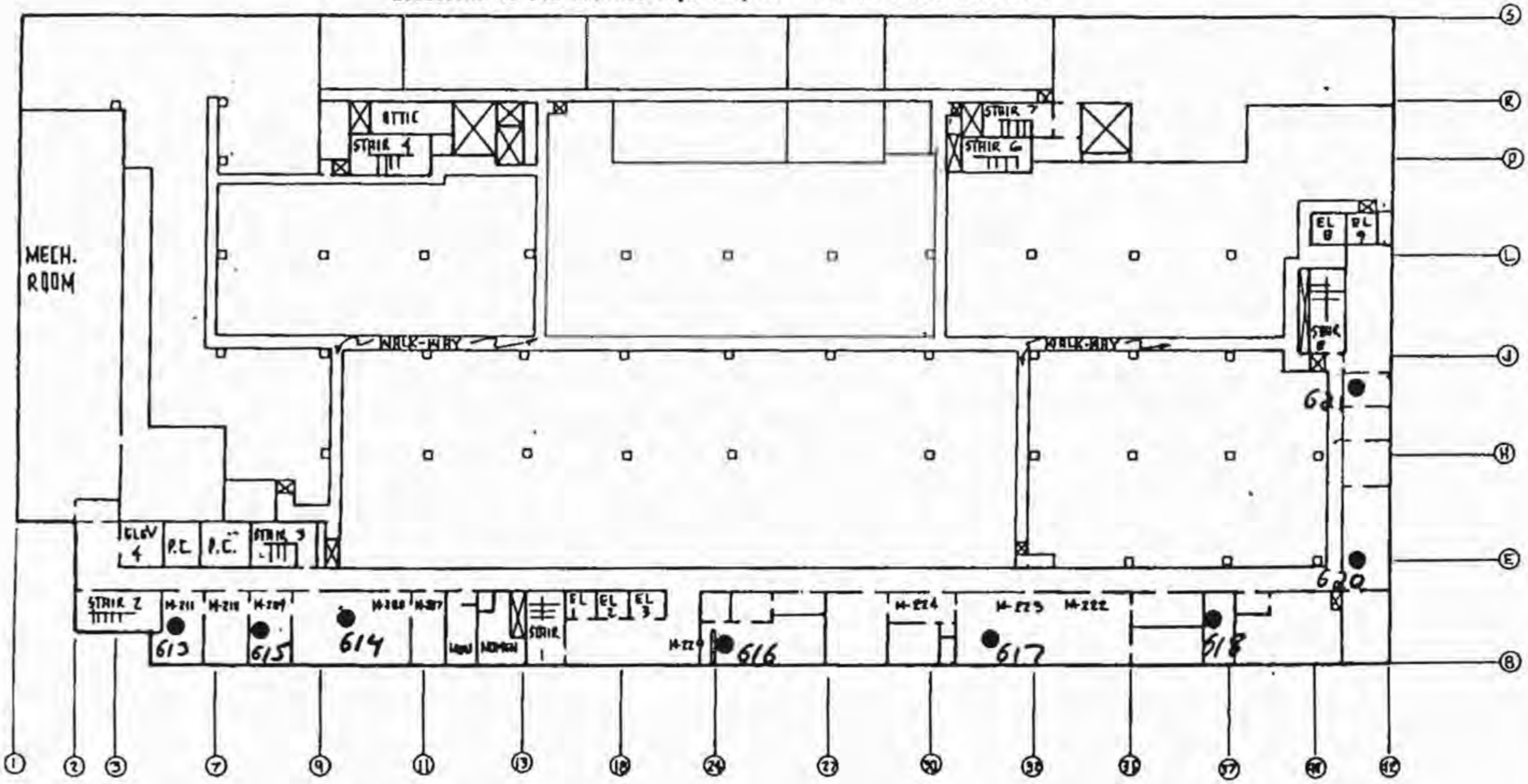

Figure 22

Locations of PCB and PCDF.PCDD surface wipe samples - third floor

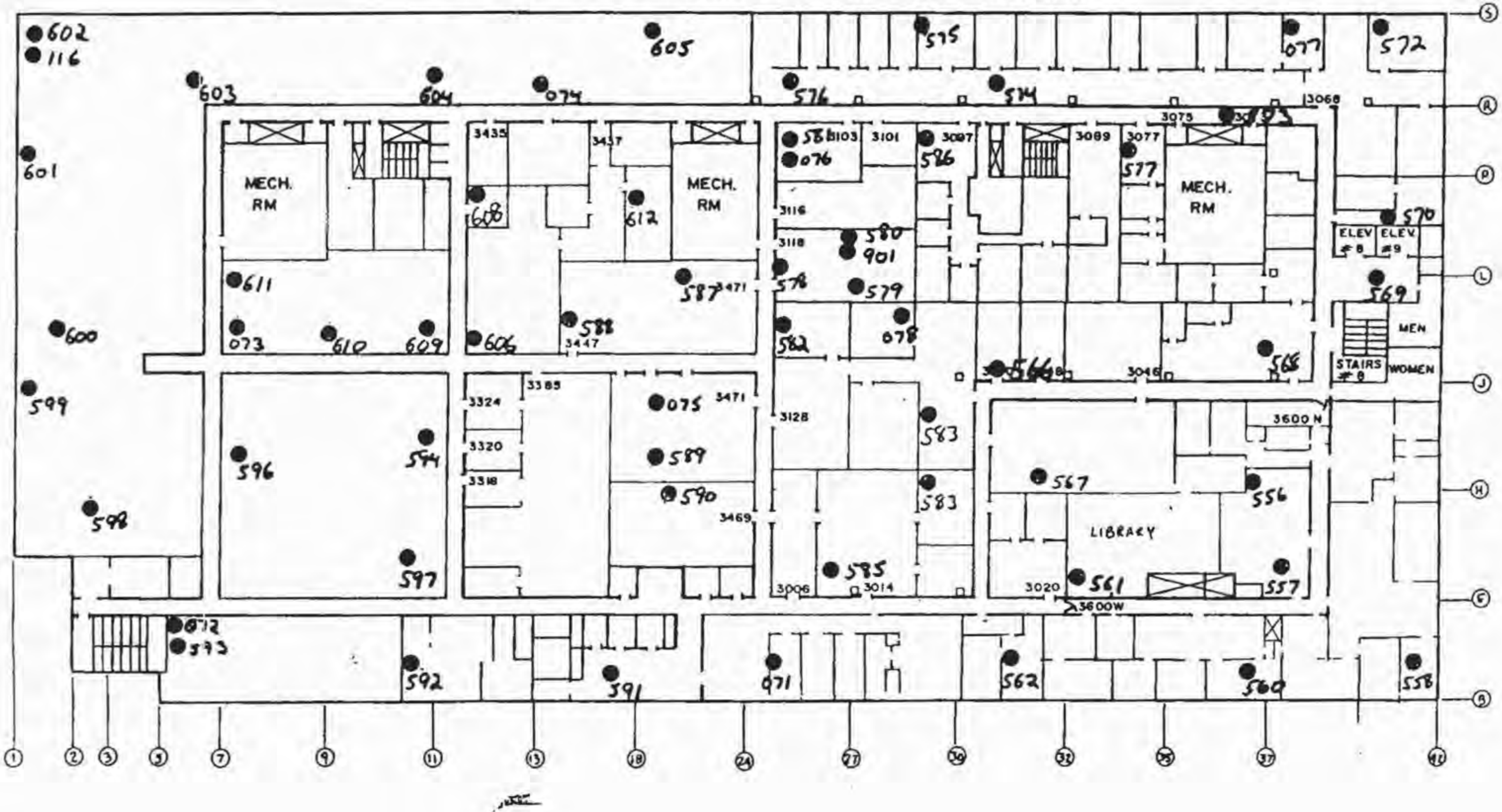

Figure 23

Locations of PCB and PCDF/PCDD surface wipe samples - fourth floor

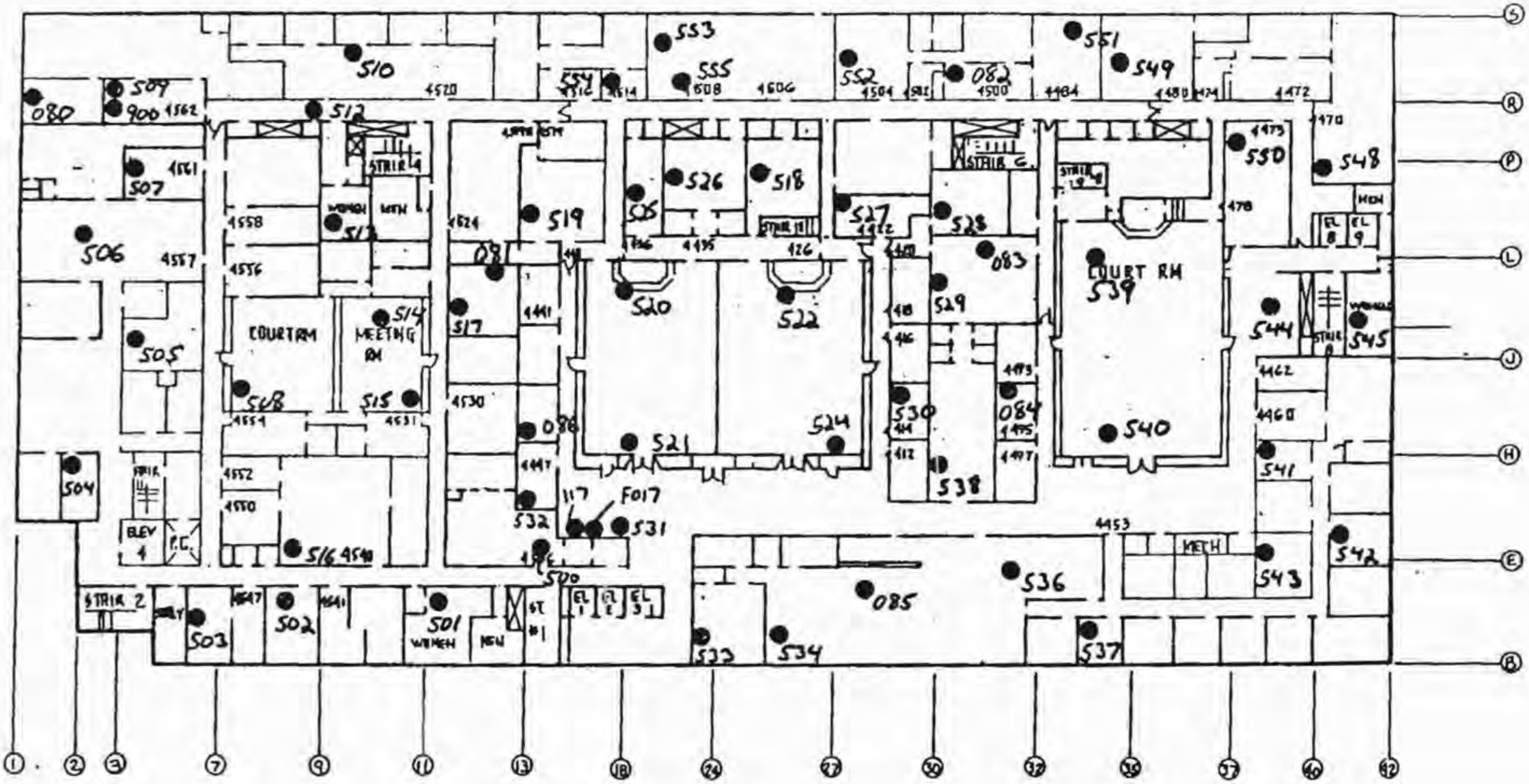

Figure 24

Structual formulas for PCDFs and PCDDs

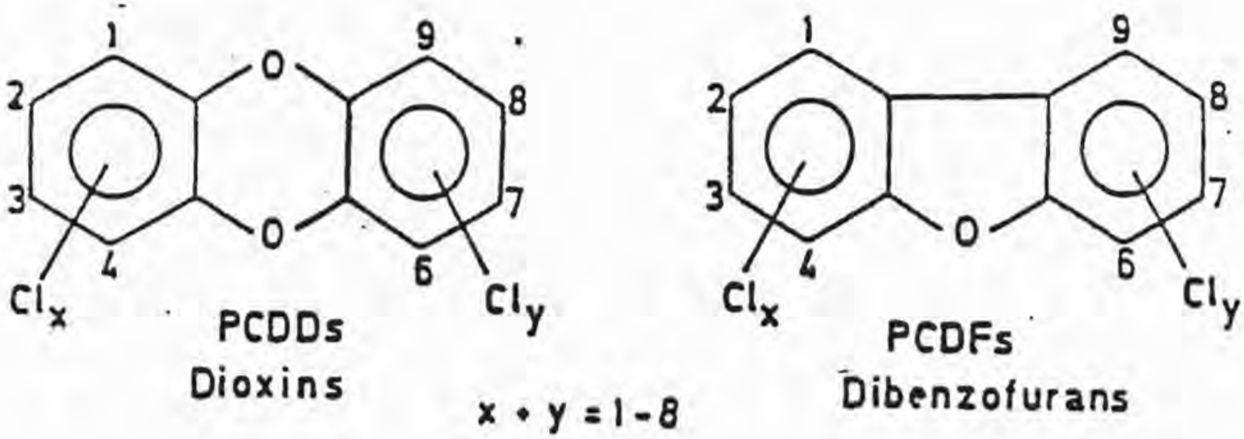

Figure 25

Linear Regression Analysis of Logarithmic Transformed PCB and TCDD Equivalents Concentrations on Surfaces