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POLYCHLORINATED BIPHENYLS (PCBs)

MANUFACTURE, PROCESSING, DISTRIBUTION IN COMMERCE AND USE PROHIBITIONS: USE IN ELECTRICAL TRANSFORMERS

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EXPOSURE ASSESSMENT:

FIRES INVOLVING PCB TRANSFORMERS

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1. INTRODUCTION

Electrical transformers containing PCB-based collant liquids were manufactured in the United States from the early 1930's until 1978. More than 100,000 such units may still be in service. Although transformers filled with PCBs were more expensive than transformers filled with mineral oil, the PCB units were used in those locations where the flammability of mineral oil would present a significant fire hazard to adjacent equipment or structures. In many applications, such as in underground electrical vaults, the decision as to whether the transformers should contain PCBs was a matter of policy which varied significantly among the various electrical utilities in the United States.

Although normally operating PCB transformers are totally enclosed units, there have been a few documented incidents where physical damage to a transformer or electrical failure within the unit has resulted in the loss of PCBs with significant exposure to people or the environment. The most serious consequence of physical damage may have been the transformer leak that occurred when a transformer being stored for eventual reuse by Pierce Packing Corporation in Billings, Montana, was struck by a truck and leaked into a water recovery sump in a meat packing plant (Anonymous 1979). The resulting contamination of animal feed resulted in a FDA recall of food products in 17 states, and led directly to the EPA ban on the use of PCB transformers in locations where food or feed could be contaminated (EPA 1982).

PCB transformers can also lose PCBs to the environment by venting through the safety valve. The transformers are equipped with pressure relief valves set at about 15 psi which are designed to prevent rupture of the casing if the transformer becomes pressurized due to the generation of gas or vapors due to internal arcing. However, the release of hot pressurized PCB vapors can entrain considerable quantities of

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liquid PCBs as a fine mist. Documented safety valve releases from transformers in Washington, D.C. (Lees and Breysse 1983) and Frankfurt, Germany (Folx 1983) demonstrate that such incidents can release hundreds of pounds of PCBs and, depending on the wind conditions, distribute the aerosol for several hundred feet. However, the arcing conditions are usually of fairly short duration, and the resulting pyrolysis of PCBs does not result in the formation of more than a few parts per million of pyrolysis products in the oil remaining in the transformer (Lees and Breysse 1983, pp. 29-35.).

Greater pyrolysis of PCBs has occurred in several recent incidents where PCB coolant fluid has leaked from transformers into an externally fueled fire. The formation of polychlorinated biphenylenes (PCBPs), dibenzofurans (PCDFs), and dibenzo-p-dioxins (PCDDs) and their wide dispersion in the smoke generated by the fires may present a significantly greater risk to human health and the environment than results from the previously identified transformer failure mechanisms.

2. PYROLYSIS OF PCBS BY FIRE

Laboratory experiments have demonstrated that PCBs are converted into polychlorinated dibenzofurans when heated for two weeks in the presence of oxygen at temperatures between 270°C and 330°C, but that the furans decompose at temperatures above 330°C (Morita et al. 1978). Experimental pyrolysis of PCBs held at elevated temperatures for less than one minute in the presence of air demonstrated that PCBs were completely destroyed at temperatures above 700°C, but that measurable amounts of PCDFs were formed by exposure to temperatures as high as 650°C (Buser et al. 1978). A comparison of the pyrolysis products from two capacitor fires in Sweden suggests that exposure of PCBs to high temperatures in the presence of oxygen can form PCDFs, but that exposure of PCBs to these temperatures in the absence of oxygen can lead to the formation of PCBPs and other chlorinated polynuclear aromatic chemicals (Rappe et al. 1982). PCBs

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apparently do not degrade to PCDDs, but PCDDs can be formed by the pyrolysis of the tri- and tetrachlorobenzenes that are mixed with the PCBs in many transformers (Webber 1982). The chemical reactions leading to the generation of PCDDs and PCDFs are discussed in detail in a recent review article by Choudhry and Hutzinger (1982).

The formation of planar chlorinated compounds, such as PCDFs, PCDDs, and PCBPs, is of concern following the pyrolysis of electrical fluids as some of the congeners of these compounds are much more toxic than PCBs (Vuceta 1983). An assessment of the data from recent fires in the United States that involved the loss of PCBs from transformers indicates that the formation of these compounds by pyrolysis of PCBs is a common occurrence that does not depend on a peculiar set of conditions, and that the normal air convection caused by a fire may spread these chemicals far beyond the confines of a transformer vault.

3. SUMMARY OF FIRES INVOLVING PCB TRANSFORMERS

State Office Building, Binghamton, New York

At 5:30 a.m. on February 5, 1981, a fire occurred in the switchgear adjacent to a PCB transformer in the basement mechanical room of the Binghamton State Office Building. This building is an 18-story office tower that was completed in 1973 (OGS 1982). Power to the building was supplied by two transformers which contained a coolant fluid consisting of 65% Aroclor 1254 and 35% mixed tri- and tetrachlorinated benzenes (Schecter 1983).

Although the city fire department responded within minutes, they did not enter the mechanical room until the power was disconnected to the transformers approximately fifty minutes after the fire started (Geimann 1983). During this period, there was repeated electrical arcing and reports of loud explosions occurring in the mechanical room. Smoke generated by the fire was distributed by convection throughout the

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building through an open vertical chase that started in the mechanical room and ran to the penthouse. This concrete block chase contained the sheet metal duct for the exhaust air from the men's restrooms on all the floors. The chase was not air tight, and allowed smoke to escape into the space between the structural ceiling and the suspended ceiling on each floor of the building. As a result, the entire inside of the building was coated with black soot. Air and wipe samples were taken one to two weeks after the fire occurred to define the levels of PCBs prior to cleaning. The results are summarized in Table 1.

The probable source of the soot was combustion of the materials in the switch gear. The heat of the fire apparently caused a ceramic bushing to crack on one of the transformers, allowing approximately 180 gallons of insulating liquid to drain onto the floor in the vicinity of the fire. Photographs taken shortly after the fire was extinguished showed that the switchgear was completely destroyed, but that there was little damage to the transformers. The mechanical room was heavily coated with soot, and puddles of liquid remained on the floor. The heat from the fire was sufficient to slightly damage a structural steel beam that was directly over the switch gear. However, the fire apparently did not spread to any material other than the switchgear itself.

Elevated levels of PCDFs in the soot were reported within a week after the fire. Initial analyses of soot samples were performed by the New York State Department of Health, U.S. Department of Fish and Wildlife, and the University of Umea. Each of these labs analyzed for those constituents for which they had standards available. The results of these analyses are summarized in Table 2. The New York State Department of Health subsequently did a more thorough investigation of the PCB and PCDF levels in soot taken from the top of the suspended ceiling in each of the floors of the building and of a large composite sample of soot that was collected by vacuum cleaner from the third and

Table 1. PCB Levels in the Binghamton State Office Building Before Cleaning

Type of sample	Date of sampling	Location-floor	Type of surface	n	Range*	Geometric Mean*
Air	2/11-2/13, 1981	1,2,4,7,10,13,15,18		14	0.21→8.7	1.48
Dry wipe**	2/10,2/12,2/13	8,1,2	Open areas, horizontal surfaces	9	<.1→140	2.63****
Dry wipe**	2/10,2/13	1,2	Open areas, vertical surfaces	3	0.3→64	6.76
Dry wipe**	2/10,2/11,2/13	3,5,6,17	Open areas, horizontal surfaces	6	57→930	162.18
Dry wipe**	2/11	17	Open areas, vertical surface	1	7.8	7.8
Dry wipe**	2/12,2/13	5,10,13	Enclosed areas,*** horizontal surfaces	6	12.6→480	74.47
Dry wipe**	2/12	10	Enclosed areas,*** vertical surfaces	3	.42→14	4.62
Dry wipe**	2/11-2/13	5,10,13	Above suspended ceiling, horizontal surfaces	6	600→16,000	1995
Dry wipe**	2/11-2/12	10,17	Above suspended ceiling, vertical surfaces	3	1.5→3.6	2.42
Dry wipe**	2/12	6,14	HV rooms, louvers, and fan blades	8	9.4→820	131.83

*All air samples are $\mu g/m^3$; all wipes are $\mu g/m^2$ of Aroclor 1254.
**Wipe samples taken by wiping one square meter with dry filter paper.
***Inside closed desk and file cabinet drawers.
****ND assumed to be 1/2 of detection limit.

Source: DOH 1981.

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Table 2. Composition of Soot Samples From the Binghamton State Office Building - µg/g

	Smith 1981a		Smith 1981b	Rappe 1981	Stalling 1981
Polychlorinated Biphenyls					
Polychlorinated Dibenzofurans					
2,3,7,8-tetra	273	124	48	12	
Total tetra			597	28	5.4
Total penta				670	105
Total hexa				515	512
Total hepta					101
Total octa					30
Polychlorinated Dibenzo-p-dioxins					
2,3,7,8-tetra	2.8	2.9	1.2	0.6	5
Total tetra			1.8	1.2	5
Total penta				5	
Total hexa				4.7	
Total hepta				7	
Total octa				2	
Polychlorinated biphenylenes					
2,3,6,7-tetra					50
Total tetra					
Notes			Sample 811711965-soot used in animal feeding studies		

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fourth floor of the building and subsequently used for animal feeding studies. The results of these analyses are summarized in Table 3. The variation in the concentration of PCDFs from floor to floor is thought to be a function of the extent to which the various soot samples were contaminated (and thereby diluted) with normal building dirt that had accumulated on the ceilings. Animal feeding studies indicated that the homogenized material from Floors 3 and 4 had an acute toxicity in guinea pigs equal to that expected for an inert material containing 58 ppm 2,3,7,8-TCDD (Eadon et al. 1982).

The building has been extensively cleaned by vacuuming and washing to remove the soot. The effectiveness of the cleaning has been monitored by wipe samples taken both with dry filter paper and with hexane saturated gauze pads. The results of a study to compare the effect of the sampling procedure on the measured levels of PCBs on surfaces after completion of the preliminary cleanup are summarized in Table 4. A number of dry wipe samples from vinyl walls were analyzed for PCDDs and PCDFs. The results of these analyses are presented in Table 5. Analysis of air samples (Smith et al. 1983a, 1983b), wipe samples from vinyl walls, and bulk samples of sprayed-on ceiling insulation (Versar New York Inc. 1983a, 1983b) have demonstrated that the ratio of the various toxic constituents is not constant from one matrix to another. The relative concentrations of PCDFs having various degrees of chlorination in different media are summarized in Figure 1. These data suggest that vaporization and redeposition processes are causing a gradual redistribution of the material within the building.

The Binghamton State Office Building is still closed to normal use awaiting the establishment of a reoccupancy criteria which will specify the residual levels of PCBs, PCDFs, and PCDDs that will be considered to be safe. The most recent draft risk assessment for re-entry to the Binghamton State Office Building would require that the air contain no

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Table 3. Concentrations (μg/g) of Polychlorinated Biphenyls and Polychlorinated Dibenzofurans in Soot Samples Taken From the Binghamton State Office Building

Floor #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Ave	3-4[f]
PCBs[a]	28		1300	840	220	2800	6600	1800	23000	9600	21000	11000	3400	930	10000	9200	6500	7200	5000
PCDFs[b]																			
Tetra CDF	0.2		<8[g]	16	220	23	190	70	320	140	250	[d]	[d]	32	300	[h]	220	145	100
Penta CDF	<0.2[g]		<9[g]	21	280	36	180	79	440	170	360	[d]	[d]	31	310	150[h]	260	165	120
Hexa CDF	<0.3[g]		<11[g]	13	180	14	35	32	290	84	260	[d]	[d]	[e]	56	89[h]	140	86	70
Hepta CDF	<0.3[g]		<12[g]	1.2	62	3	3.7	14	100	6.5	97	[d]	[d]	5.8	71	33[h]	32	31	20
Octa CDF	<0.3[g]		<14[g]	<1.2	21	0.5	-	3	35	2	31	[d]	[d]	2.8	17	11[h]	15	11	4
Total PCDF	-		-	51	760	76	410	200	1200	400	1000	-	-	87	750		670	438	310
Ratio Total PCDF conc. / PCB conc.				.061		.027	.062	.11	.052	.042	.048			.094	.075		.103	.066	.062

[a]Quantitated as Aroclor 1254; data uncorrected for recovery.
[b]Correction for recovery incorporated.
[c]Not sampled because of dissimilar ceiling construction.
[d]Data not used because of poor recovery of internal ^{37}Cl-Tetra CDF standard (<10%).
[e]Data lost because of instrumental malfunction; for purposes of calculation of total PCDF, it is assumed that hexa CDF is 1/2 the concentration of penta.
[f]Soot collected by vacuum cleaner and used in animal toxicology studies.
[g]Detection limits are per congener, not per chlorination number.
[h]Data not corrected for recovery. Instrument malfunction caused loss of data on ^{37}Cl-Tetra CDF recovery.

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Source: Eadon 1982.

Table 4. PCB Levels in the Binghamton State Office Building After Preliminary Cleanup

Type of sample	Date of sampling	Location-floor	Type of surface	n	Range µg/m²	Geometric Mean µg/m²
Dry wipe*	5/5/82	9	Vinyl floor	12	3.2÷19.6	8.65
Wet wipe**	5/5/82	9	Vinyl floor	12	76÷480	214
Dry wipe	5/5/82	9	Vinyl wall	12	<0.8÷12.4	3.64***
Wet wipe	5/5/82	9	Vinyl wall	12	3.9÷240	46.5
Dry wipe	5/5/82	9	Plaster wall	3	1.4÷1.6	1.5
Wet wipe	5/5/82	9	Plaster wall	3	1.2÷19.6	4.2
Dry wipe	5/5/82	9	Quarry tile floor	3	16÷27.6	20.1
Wet wipe	5/5/82	9	Quarry tile floor	3	880÷960	920
Dry wipe	5/5/82	9	Window glass	6	<0.8÷4.0	.72***
Wet wipe	5/5/82	9	Window glass	6	<0.8÷2.7	1.1***

*Dry wipe - 0.25 m² area wiped with dry filter paper.
**Wet wipe - 0.25 m² area wiped with a cotton gauze pad wetted with 8 ml of hexane.
***GD assumed to be 0.4.

Source: Versar New York 1982.

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Table 5. Contamination of Vinyl Walls in the Binghamton State office Building After Washing Dry Wipe Samples

Chemical	Units	Location: 7th Floor				11th Floor				Mean	Std. Deviation
PCBs	$\mu g/m^2$	2.4	1.0	1.2	1.3	2.9	1.2	0.7	1.9	1.6	0.78
PCDFs	ng/m^2										
2,3,7,8-tetra		1.13	0.83	0.55	0.53	0.90	0.93	0.55	0.93	0.79	0.22
Total tetra		8.25	4.50	4.25	4.25	6.25	6.75	4.00	9.00	5.91	1.96
Total Penta		5.50	4.00	2.10	2.50	2.75	3.25	3.25	6.50	3.73	1.53
Total Hexa		2.00	1.60	1.13	0.83	2.10	3.67	2.20	3.75	2.19	1.06
Total Hepta		0.63	0.50	0.23	0.13	0.50	0.85	0.50	0.95	0.55	0.28
Total Octa		0.25	0.13	0.10	0.13	0.30	0.28	0.19	0.30	0.22	0.10
PCDDs	ng/m^2										
2,3,7,8-tetra		ND	ND	ND	ND	ND	ND	ND	ND	*	
Total tetra		ND	ND	ND	ND	ND	ND	ND	ND	*	
Total penta		ND	ND	ND	ND	ND	ND	ND	ND	*	
Total hexa		ND	ND	ND	ND	ND	ND	ND	ND	*	
Total hepta		ND	0.14	ND	ND	ND	0.14	ND	0.19	**	
Total octa		0.50	0.55	ND	ND	0.53	0.48	ND	0.95	**	

*ND - average detection limit = 0.01 ng/m^2
**ND - average detection limit = 0.1 ng/m^2

Source: Versar New York 1983b.

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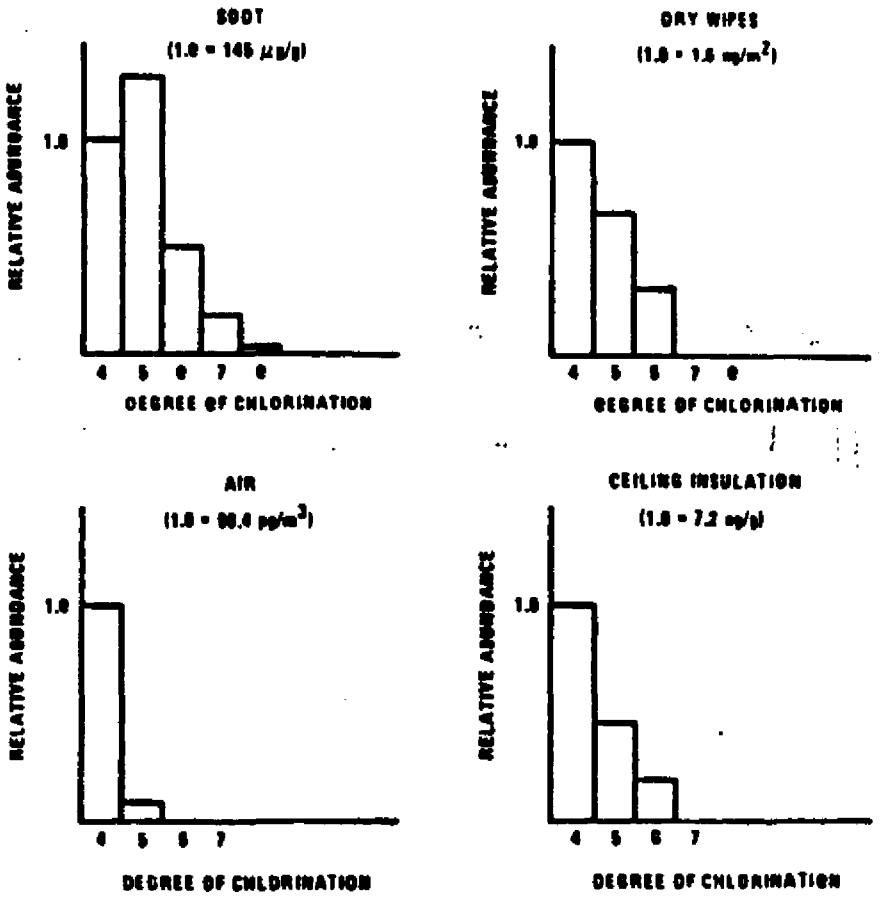

Figure 1. Relative Abundance of Chlorodibenzofuran Congeners in Various Media in the Binghamton State Office Building

Source: Eadon 1982; Smith 1983a, 1983b; Versar New York Inc. 1983a, 1983b.

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more than 8.4 pg/m^2 2,3,7,8-TCDF and that surface contamination be no more than 2.5 ng/m^2 2,3,7,8-TCDF (Kim 1983). This criteria assumes that the ratio of 2,3,7,8-TCDF to other toxic chemicals remains the same as in the soot and that the level of contamination remains constant for 30 years following the reopening of the building. The draft risk assessment is being reviewed by a panel of experts and the calculated re-entry criteria are subject to revision.

One Market Plaza, San Francisco, California

Shortly after 11 a.m. on May 15, 1983, a fire started in the sub-basement transformer vault of the One Market Plaza office building at the corner of Steuart and Mission streets in San Francisco. The vault contained three transformers that were filled with Aroclor 1242 coolant liquid. Heavy black smoke issued from the sidewalk grating adjacent to the building for about three hours until the high voltage power to the transformer was interrupted by the utility (Burks 1983). During this three-hour period, there was considerable vibration and loud noises occurring in the vault that were described by reporters as explosions (Smith and Soiffer 1983). No information is available on the size of the transformers, but it was reported that only one transformer leaked, and that after the fire there was 50 to 60 gallons of liquid in the vault, with the floor and walls of the vault caked with black soot and liquids dripping from the vault ceiling (Bartlett and Soiffer 1983). The liquid remaining in the transformer contained 127 ng/g TCDFs and no detectable TCDDs (detection limit = 7.4 ng/g) (Anonymous 1983a). Contributing to the seriousness of the fire was the failure of a protector in the vault (Melnick 1983).

Smoke and soot from the transformer vault contaminated the adjacent switch gear room through the bus duct, and small areas of the adjacent parking garage and work shop areas through small cracks in the concrete block vault walls. Some of the heavy smoke issuing from the sidewalk

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grating was apparently pulled in through the street level air makeup louvers on Steuart Street and into the ventilating fans that supply air through the sub-basement, basement, plaza level, and floors 2 through 6 of the Steuart Street office tower. Tests later indicated that the contamination was limited to the second basement, the air handling system through floor 6, and the exterior of the building. The upper floors of the Steuart Street Tower receive air from ventilating fans mounted in a penthouse above the 28th floor.

Air samples taken in the vault starting a week after the fire measured 320 to 1500 $\mu g/m^3$ PCBs, depending on the rate of ventilation through the vault. The switch gear room adjacent to the vault had air concentrations as high as 98 $\mu g/m^3$ PCBs before ventilation was started. Air levels in the sub-basement fan room (outside the fan housings) found a peak level of 2.7 $\mu g/m^3$ PCBs (Anonymous 1983b). The San Francisco Department of Public Health restricted access to any area having a level of PCBs in the air in excess of 1 $\mu g/m^3$ or surface contamination in excess of 100 μg $PCBs/m^2$ when sampled by wiping with a cloth wetted with octane. Although no samples collected in the offices on floors 2 through 6 were contaminated above these levels, the city requested that the ventilation system not be operated because of the possibility of spreading contamination to these clean areas; without ventilation, the floors could not be occupied.

Analysis of the soot collected in the transformer vault and in the sub-basement adjacent to the wall of the transformer vault showed the presence of PCBs, TCDFs, and TCDDs as shown in Table 6.

Only one sample was completely characterized for polychlorinated dibenzofurans. This was a wipe sample taken August 9 from the floor of the HVAC fan room in the second basement that had the following amounts of CDFs (Anonymous 1983b):

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Table 6. PCBs, PCDFs, and PCDDs in Samples from One Market Plaza Before Cleaning

Type of sample	Location	Dated Sample	PCBs µg/g	Total TCDFs µg/g	2,3,7,8-TCDF µg/g	Total TCDDs µg/g	2,3,7,8-TCDD µg/g
Soot	adjacent to vault	—	86,000	28.9	6.3	.324	.059
Soot	inside of vault	—	--	15.6	7.3	.400	--
			$\mu g/m^2$	ng/m^2	ng/m^2	ng/m^2	ng/m^2
Wipe**	fan room	—	—	.016	.0045	.001*	--
Wipe**	switch gear room - fan	—	7.3	1.05	.93	.017	.017
Wipe**	switch gear room - floor	—	—	7.3	2.9	--	--
Wipe**	28th floor	—	.006	<0.05*	--	--	--
Wipe**	vault floor	7/17	--	2.3	.065	-	-
Wipe**	from room top of fan	8/9	—	7.9	2.4	--	--
			$\mu g/m^3$	ng/m^3	ng/m^3	ng/m^3	ng/m^3
Air	inside vault	—	390	9.2	1.65	<.003*	--
Air	21st floor	—	.6	.006	<.001*	--	--
Air	vault	7/17	490	.99	.15	--	--
Air	vault	8/12	560	2.8	1.0	--	--
Air	switch gear room	8/20-21	2.8	.07	.022	--	--
Air	fan room	8/6-7	.84	.013	.004	--	-

*None detected at detection limit indicated.
**Wipe sample collected using Kim-wipe paper wetted with octane.

Source: Anonymous 1983a, 1983b.

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Chemical	Amount	Relative abundance
Total TCDFs	73 ng/ng[a]	1
2,3,7,8-TCDF	29 ng/m[a]	.40
Total penta CDFs	22 ng/m[a]	.30
Total hexa CDFs	4 ng/m[a]	.05
Total hepta CDFs	2.3 ng/m[a]	.03
Total octa CDFs	.2 ng/m[a]	<.01

The available reports on the analytical results from One Market Plaza do not specify the analytical procedures nor, in most cases, the detection limits. However, it is apparent that the conversion of PCBs to PCDFs occurred with about the same efficiency in both Binghamton and San Francisco. Reoccupancy of One Market Plaza depends on whether the cleaning efforts achieve the criteria established by the State of California (Gravitz 1983) and the City of San Francisco (Silverman 1983). The criteria established by the City are summarized in Table 7.

First National Bank Building, Chicago, Illinois

On September 28, 1983, a fire occurred in a bus bar between a transformer and the switchgear in a transformer vault under the plaza on the same block as the First National Bank Building. Although power to the transformer was cut after about 10 minutes, smoke continued to issue from the side walk grating for about 45 minutes. Inspection of the transformers after the fire was extinguished found that one of the four transformers in the vault had leaked approximately 15 gallons of coolant consisting of 65% Aroclor and 35% chlorinated benzenes (Simon 1983a, 1983b). The source of the leak was a small hole in the transformer casing that was perhaps caused by electrical arcing.

Significant PCB contamination was limited to the vault, the exhaust air ducts from the vault, and to the exterior surfaces of a small building that was adjacent to the transformer vent. The highest readings outside the vault and its exhaust system were on a window near the vault (119,000 $\mu g/m^2$) and on an intake air well grille (181,000 $\mu g/m^2$) and window (96,000 $\mu g/m^2$). The transformer vault was

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Table 7. Reoccupancy Criteria for One Market Plaza

GENERAL OFFICE SPACE	
Air	
PCDDs/PCDFs*	10 pg/m³
PCBs	1 µg/m²
Surfaces	
PCDDs/PCDFs*	3 ng/m²
PCBs	100 µg/m²
TRANSFORMER VAULT	
Air	
PCDDs/PCDFs*	80 pg/m³
PCBs	1 µg/m²
Surfaces	
PCDDs/PCDFs*	24 ng/m²
PCBs	1000 µg/m²

*Defined as the sum of all PCDD and PCDF congeners chlorinated at the 2,3,7, and 8 positions.

Source: Silverman 1983.

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adjacent to an underground parking garage and shared a ventilating system with the garage and the small adjacent building; none of the adjacent areas were heavily contaminated.

The tall First National Bank Building was about one half block from the vault and was not contaminated. Although one fiber glass filter on an air intake vent on the fourth floor of the First National Bank was found to contain about 90 μg/g PCBs, the adjacent filters did not show high levels. None of the measurements of PCBs taken in the building indicated unsafe levels of contamination. However, the building was evacuated when smoke was seen coming from a window vent; the source of the smoke was later identified as the exhaust from an auxiliary diesel generator that started when power was shut off at the transformers.

No analyses were reported for PCDFs or PCDDs in the soot. A number of wipe samples were collected in the First National Bank building and from the air supply intake near the transformer, but no PCDFs or PCDDs were found at a detection limit of 250 ng/4 ft^2 (673 ng/m^2) for total PCDFs and PCDDs by full spectrum MS scanning, and a detection limit of from 0.8 to 15 ng/ft^2 (8.6 to 160 ng/m^2) 2,3,7,8-TCDD.

The First National Bank building was evacuated at the time of the fire, but reoccupied the following day. Cleaning was limited to the transformer vault, its exhaust system, and the exterior of the small building next to the vault. The criteria of cleanliness was established by Commonwealth Edison at 400 μg $PCBs/ft^2$ (4300 $\mu g/m^2$) when sampled by wiping with a filter paper wetted with hexane.

4. DISCUSSION

The data that has been developed in the laboratory and from the analysis of samples of combustion products from various fires involving PCBs indicates that the formation of polychlorinated dibenzofurans can be expected in cases where PCBs are exposed to air and elevated temperatures. A fire involving a PCB transformer can generate

considerable smoke and the damage to surrounding property depends on where the smoke goes. Elevated levels of PCBs have been found several hundred feet from the source of the fire; if the smoke gets into a building through ventilating ducts, the elevated levels of PCBs and pyrolysis products will be found in the building.

A review of transformer incidents suggests several precautions that would limit the threat to human health and the environment resulting from the continued use of PCB transformers. First, the possibility of fire should be minimized by preventive maintenance of the various electrical components used in conjunction with the transformers (switchgear, breakers, cables, etc.) and the area around the transformers should be kept clear of flammable materials. Second, there should be a method or procedure for quickly disconnecting the power to the transformers if a fire should occur in the vault. The installatidn of circuit breakers on the high voltage side, perhaps activated by temperature, infrared, or smoke alarms in the vault, would do much to reduce the duration of the fire and the generation of smoke and the installation of network protector on the secondary side would prevent current from being fed back into a failed transformer. The apparent advantage of the protective equipment should, however, be carefully balanced against the increased likelihood of failure of a more complex installation, bearing in mind that the failure of a protector contributed to the severity of the incident in San Francisco and the failure of a primary switch filled with PCBs resulted in the contamination of an office building recently in Syracuse, New York (Heath 1983). Third, design features to seal off the vault from the adjacent buildings, and perhaps to seal off the normal vault ventilating ducts in the event of a fire, would decrease the dispersion of smoke and the resulting contamination. Fourth, since continued operation of the building HVAC system can contribute to the spread of smoke, the HVAC controls could be tied to a fire or smoke sensor in the vault to allow for automatic shut down in the case of a fire.

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5. REFERENCES

Anonymous. 1979. Case study of contamination: PCB's in feed. Science News, Vol. 116, No. 14 (Oct. 6, 1979), p. 228.

Anonymous. 1983a. Summary of PCB air sampling results - One Market Plaza. August 15, 1983.

Anonymous. 1983b. Summary of air sampling results for PCB's and TCDF's - One Market Plaza. September 12, 1983.

Bartlett R, Soiffer B. 1983. Cleanup after S.F. explosion. San Franscisco Chronicle, May 17, 1983, p. 1.

Burks J. 1983. Downtown dioxin danger. Firehouse, November 1983, pp. 71-72, 114.

Buser HR, Bosshardt H-P, Rappe C. 1978. Formation of polychlorinated dibenzofurans (PCDFs) from the pyrolysis of PCBs. Chemosphere, No. 1, pp. 109-119.

Choudhry GG, Hutzinger O. 1982. Mechanistic aspects of the thermal formation of halogenated organic compounds including polychlorinated dibenzo-p-dioxins. Toxicology and Environmental Chemistry, Vol. 5, No. 1, pp. 67-93.

DOH. 1981. Background. (Attachment to agenda sent to the members of the Expert Panel for the Binghamton State Office Building prior to a meeting of the panel in New York City on April 3, 1981.) Albany, NY: New York State Department of Health.

Eadon G, Aldous K, Frenkel G, et al. 1982. Comparisons of chemical and biological data on soot samples from the Binghamton State Office Building. Albany, NY: New York State Department of Health. March 1982.

EPA. 1982. Polychlorinated biphenyls (PCBs) manufacturing, processing, distribution in commerce and use prohibitions; use in electrical equipment. Federal Register, Vol. 47, No. 165 (August 25, 1982), pp. 37342-37360.

Folx R. 1983. Hochgiftiges Clophen spritzte aus den Trafos. Frankfurter Rundschau, May 9, 1983, pp. 13-14.

Geimann S. 1983. City crisis began after fire ended. (Series of articles on the fire in the Binghamton State Office Building). Binghamton (N.Y.) Sunday Press, Binghamton (N.Y.) Evening Press. Jan. 30 - Feb. 5, 1983.

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5. REFERENCES (continued)

Gravitz N, Fan A, Neutra RR. 1983. Interim guidelines for acceptable exposure levels in office settings contaminated with PCB and PCB combustion products. Berkeley, CA: California Department of Health Services. November 1, 1983.

Heath T. 1983. Tests show PCB danger unlikely at Chimes Building. The Post Standard (Syracuse, NY), Vol. 155, No. 98 (December 23, 1983), p. A-1.

Jansson B, Sundström G. 1982. Formation of polychlorinated dibenzofurans (PCDF) during a fire accident in capacitors containing polychlorinated biphenyls (PCBs). In: Chlorinated dioxins and related compounds - impact on the environment. O. Hutzinger, ed. New York: Pergamon Press, pp. 201-208.

Kim NK, Hawley J. 1983. Revised risk assessment Binghamton State Office Building. Draft Report submitted to the expert panel on the Binghamton State Office Building. Albany, NY: New York State Department of Health. June 7, 1983.

Lees PSJ, Breysse PN. 1983. Final report on industrial hygiene assessment: PCB exposure of GSA switchgear operators. Report submitted to Accident and Fire Branch, General Services Administration. Baltimore, MD: Center for Occupational and Environmental Health, The Johns Hopkins University. Jan. 20, 1983.

Melnick N. 1983. 100 PCBs leaks reported in downtown S.F. San Francisco Examiner, September 21, 1983, pp. A1, A12.

Morita M, Nakagawa J, Rappe C. 1978. Polychlorinated dibenzofuran (PCDF) formation from PCB mixture by heat and oxygen. Bull. Environm. Contam. Toxicol., Vol. 19, pp. 665-670.

OGS. 1983. The Binghamton State Office Building clean-up: a progress report update. Albany, NY: New York State Office of General Services. January 1983.

Rappe. 1981.

Rappe C, Marklund S, Bergqvist P-A, et al. 1982. Polychlorinated dioxins (PCDDs), dibenzofurans (PCDFs) and other polynuclear aromatics (PCPNAs) formed during PCB fires. Chemica Scripta, Vol. 20, pp. 56-61.

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5. REFERENCES (continued)

Rappe C, Marklund S, Bergqvist P-A, et. al. 1983. Polychlorinated dioxins, dibenzofurans and other polychlorinated polynuclear aromatics formed during incineration and polychlorinated biphenyl fires. In: Chlorinated dioxins and dibenzofurans in the total environment. Boston, MA: Butterworth Publishers. pp. 99-124.

Schecter A. 1983. Contamination of an office building in Binghamton, New York by PCBs, dioxins, furans and biphenylenes after an electrical panel and transformer fire. Chemosphere, Vol. 12, No. 4/5, pp. 669-680.

Silverman MF. 1983. Letter to Mr. Wynn Oliver, Tishman West Building Management Corporation [sic] from Mervyn F. Silverman, Director of Health, City and County of San Francisco. November 17, 1983.

Simon S. 1983a. Summary of October 3, 1983, meeting on clean-up of PCB transformer fire at First National Bank Building.

Simon S. 1983b. Untitled ms memo dated 12/13/83, with summary of sampling results from First National Bank, Chicago.

Smith R, Soiffer B. 1983. Big PG & E explosion - S.F. highrise shut. San Francisco Chronicle, May 16, 1983, p. 1.

Smith RM, O'Keefe PW, Hilker DL, et al. 1981a. Analysis of 2,3,7,8 tetrachlorobenzofuran and 2,3,7,8 tetrachlorodibenzo-p-dioxin in a soot sample from a transformer explosion in Binghampton [sic], New York Albany, NY: New York State Department of Health. Feb. 20, 1981.

Smith RM, Hilker DL, O'Keefe PW, et. al. 1981b. Analysis of a Binghamton soot sample for tetrachlorodibenzofurans and tetrachlorodibenzo-p-dioxins. Albany, NY: New York State Department of Health. Oct. 1, 1981.

Smith RM, O'Keefe PW, Hilker DR, et. al. 1982a. Analysis for 2,3,7,8-tatrachlorodibenzofuran and 2,3,7,8-tetrachlorodibenzo-p-dioxin in a soot sample from a transformer explosion in Binghamton, New York. Chemosphere, Vol. 11, No. 8, pp. 715-720.

Smith RM, Hilker DR, O'Keefe PW, et. al. 1982b. Determination of polychlorinated dibenzofurans in soot samples from a contaminated office building. Albany, NY: New York State Department of Health. March 1982.

Smith RM, Hilker D, O'Keefe P, et al. 1983a. Determination of TCDFs and TCDDs in air samples from the sixteenth floor of the Binghamton State Office Building. Albany, NY: New York State Department of Health. March 16, 1983.

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5. REFERENCES (continued)

Smith RM, Hilker D, O'Keefe P, et al. 1983b. Determination of tetra-hexa CDFs and tetra-CDDs in air samples from the 11, 14, 16 and 17th floors of the Binghamton State Office Building. Albany, NY: New York State Department of Health. May 16, 1983.

Stalling. 1981.

versar New York Inc. 1982. Investigation of the contamination remaining in the Binghamton State Office Building following completion of the preliminary cleanup. Report submitted to New York Office of General Services. Springfield, VA: Versar New York Inc., October 20, 1982.

Versar New York Inc. 1983a. Determination of toxic compounds in sprayed-on ceiling insulation: sampling and analysis (PCBs, PCDDs, and PCDFs). Report submitted to New York State Office of General Services. Springfield, VA: Versar New York Inc., July 18, 1983.

Versar New York Inc. 1983b. Determination of the ratios of various toxic chemicals on vinyl wall surfaces in the Binghamton State Office Building. Report submitted to New York State Office of General Services. Springfield, VA: Versar New York Inc., September 26, 1983.

Vuceta J, Marsh JR, Kennedy S, et al. 1983. State-of-the-art review: PCDDs and PCDFs in utility fluid. Palo Alto, CA: Electric Power Research Institute.

Webber I. 1982. The degradation of polychlorinated benzenes in electrical equipment. Paper delivered at the IEEE/PES Conference, New York, NY. Feb. 1-5, 1982.

Wegars D. 1983. Workers returning to PCB skyscraper. San Francisco Chronicle, May 26, 1983, p. 4.

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