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CONTAMINATION OF AN OFFICE BUILOING IN BINGHAMTON, NEW YORK BY PCBS, DIOXINS, FURANS AND BIPHENYLENES AFTER AN ELECTRICAL PANEL AND ELECTRICAL TRANSFORMER INCIDENT

Arnold Schecter, M D , M P H., Professor and Coordinator, Department of Preventive Medicine, Clinical Campus, Upstate Medical Center, State University of New York at Binghamton, Binghamton, New York, 13901, USA, formerly Director, Broome County Health Department, Binghamton, New York

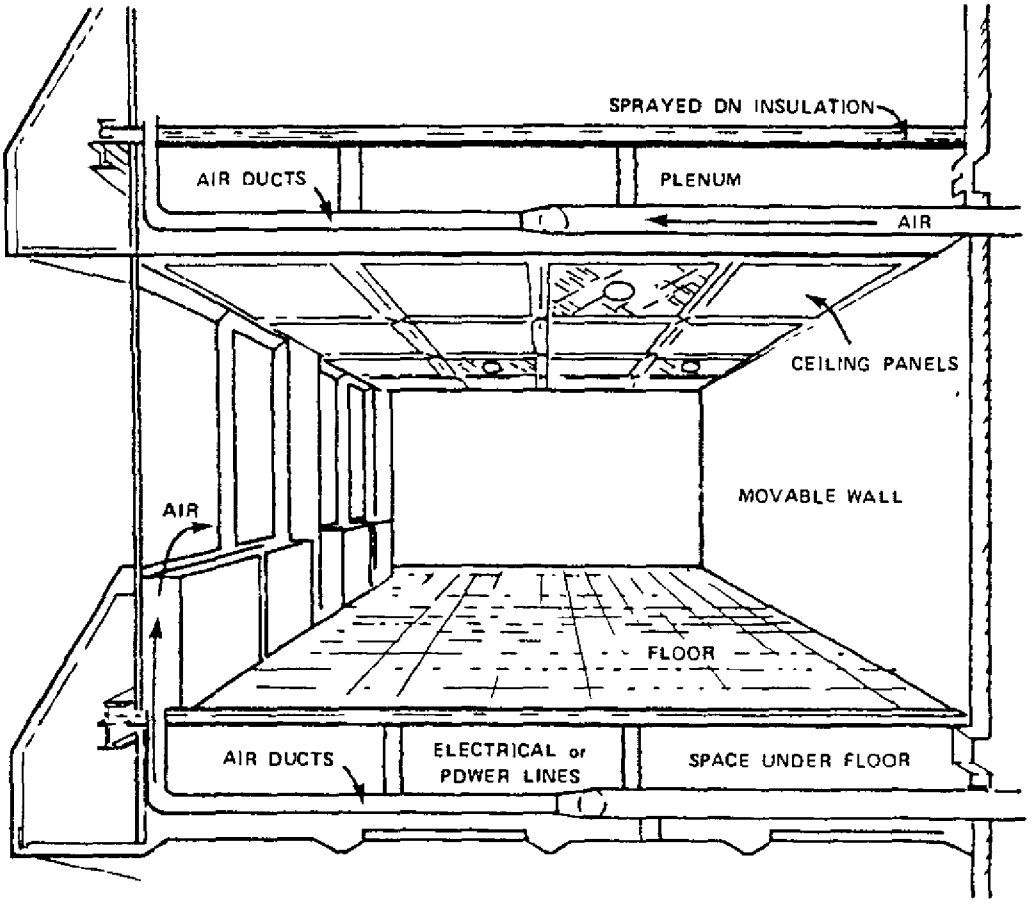
INTRODUCTION

Binghamton, New York is located approximately 200 miles north northwest of New York City in Broome County The city population is approximately 53,000 persons, the tri city area 154,000, and the county population is about 213,000 On Thursday morning, February 5, 1981, at approximately 5:30 AM a malfunction occurred causing overheating of an electrical panel and a nearby electrical transformer within the State of New York's Office building in Binghamton. This overheating led to the release of between 180 to 200 gallons of transformer fluid originally containing 65% PCBs (Arochlor 1254), and 35% tri and tetra chlorinated benzenes Pyrolytic conversion of these compounds led to the formation of numerous furan and dioxin isomers, which, along with the PCBs contaminated every floor of the office building. Biphenylenes were also produced during this event Twenty-one months later the building has still not been reoccupied. Cleaning with water and detergent continues as do efforts to set standards for the presence of PCBs, furans, dioxins, and biphenylenes in soot and also in air. It is believed that this incident is the first to document formation and contamination of a non industrial building with these chemicals after an otherwise somewhat prosaic electrical system malfunction Because electrical system fires, explosions, overheating with the involvement of PCBs and in some cases the chlorinated benzenes is probably relatively common, what has been learned in Binghamton may have general public health relevance elsewhere in both a prospective as well as retrospective fashion.

Thursday, February 5, 1982

At 5:30 in the morning Binghamton firemen and police responded to a fire alarm at the Binghamton State Office Building (BSOB), a 22 story modern office building, located in downtown Binghamton, which was and is part of a one block governmental complex. This consists of Binghamton City Hall, the Broome County Office Building, the BSOB and a common plaza as well as two levels (basement and subbasement) of common parking garage An electrical panel, one of two in the basement, was found to have overheated. This overheating which created loud noises, like explosions, was estimated to have lasted 5-30 minutes The nearby transformer, which had originally contained approximately 1,060 gallons of transformer fluid, leaked an estimated 180 to 200 gallons of fluid onto the floor. Dense smoke was present in the area around the transformer Smoke had been previously vented from the building through two safety doors on the roof at the top of each of two staircases which had opened in response to the smoke or heat Doors leading to the outside and into the basement level of the parking garage, were opened and large fans used to remove smoke It was later noted that there were two air shafts beginning in the ceiling of the area housing the two panels and transformers which vented the men's and women's rooms located on each floor and which terminated at the top of the building. Smoke was later found to have passed through these shafts, through metal

TYPICAL ROOM
STATE OFFICE BUILDING
BINGHAMTON, NEW YORK



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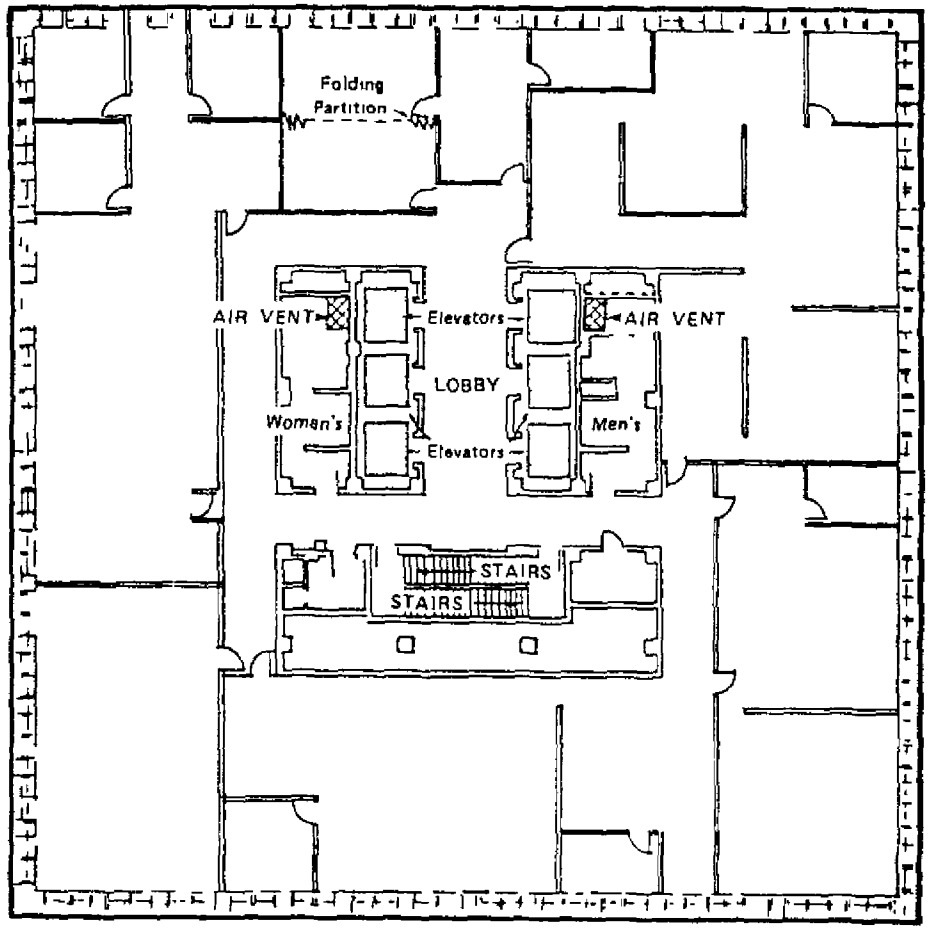
TYPICAL FLOOR PLAN*
STATE OFFICE BUILDING
BINGHAMTON, NEW YORK



*Most inner walls are movable.

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gratings on the wall of each bathroom, into the bathrooms, and was then distributed in a non homogeneous fashion throughout the usual working areas as well as hidden spaces, including air ducts, elevator shafts, plenums above the ceilings, desk drawers, inside file cabinets, as well as in typewriters and other office equipment

For reasons which are not clear at this time the usual circuit breakers and other safety devices designed to prevent overheating did not prevent the overheating which occurred. The transformer room, as previously mentioned, was not sealed off from the rest of the building. There was probably also a significant pressure and temperature differential which assisted the distribution of chemical contaminants. At the time of the accident the temperature outside was below zero fahrenheit and the building temperature in the sixties except for the overheated transformer and electrical panel which was estimated to have been overheated to up to several thousand degrees fahrenheit.

A strong chemical odor was immediately noticed by firemen and policemen a security guard and an engineer involved in the incident. This same odor was also easily noticed in the basement and first floor of the nearby City Hall, including the basement jail area as well as the police headquarters located in the first floor and basement. The fire department in a portion of City Hall also had a chemical odor. Outside of the BSOB a strong odor consistent with the presence of PCBs or polychlorinated benezenes persisted for several days.

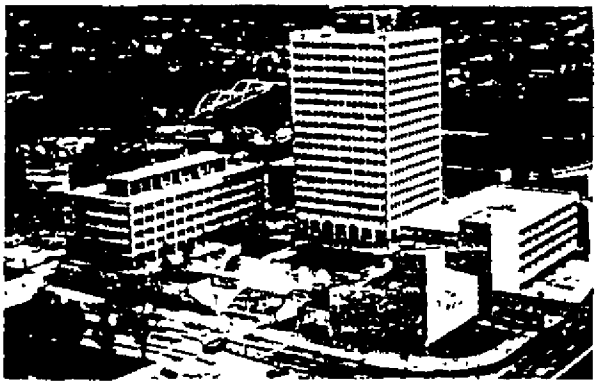
The firemen and policemen went to Binghanton City Hospital for emergency department evaluation of their chemical exposure Within hours a representative of the General Electric Company, the manufacturer of the damaged transformer, informed medical personnel of the composition of the transformer fluid A health emergency was declared and all personnel except for emergency workers, including fire and police personnel, evacuated the entire governmental complex This ban on the use of the City and County Buildings continued for a total of 4 days, through the weekend. The State Office building could not be used because of loss of electrical power The parking garage under the governmental complex was contaminated with levels of PCBs, as high as 2,000 to 4,000 micrograms per square meter, employing hexane soaked wet wipes on the concrete floor. After its contamination was appreciated, it was closed, steam and detergent cleaned twice, tested for PCBs, dioxins, and furan levels, and then reopened several months later

A command post was set up on the fourth floor of the adjacent City Hall which was used for the next few weeks by workers involved in the incident until the recognition of toxic chemicals lead to the use of a trailer and portable toilets nearer the building and geographically removed from non involved workers

Within days cleanup work began on the BSOB to remove the soot covered material found throughout the building. Both experts in toxic chemical removal were employed as well as janitorial workers of the State of New York who began washing and vacuuming the building. Electrical system repair was begun during the first week after the incident. The goal initially set by the State of New York, the owner of the polluted building, was to open the building within days or, if necessary, weeks. This goal was set on day two of the incident. This initial goal assumed that contamination of the air with PCBs and chlorinated benzenes constituted the totality of the chemical contamination. Because of the electrical failure venting of the building to the outside air was not possible. The windows of the building do not open.

CHEMICAL ANALYSIS

Initial chemical sampling and analysis performed by Mr. Charles Garner, an industrial hygienist on loan from the nearby IBM Corporation factory confirmed the presence of chemicals consistent with those in the transformer in the air of the basement and first floor of City Hall. Later study revealed air ducts running from the BSOB into the basement area of the immediately adjacent City Hall. Air and soot samples collected several days after the incident and analyzed by Galson Laboratory and separately by Dr James Carnahan of the General Electric Company revealed PCBs present within soot as well as air levels as high as 80 micrograms per cubic meter within the BSOB and many floors above the transformer several days after the incident. Air levels of PCBs fell to a level of 1-3 micrograms per cubic meter, and these levels persisted for over a year when



Photographs of the Governmental Complex in Binghamton New York, from top left, clockwise: The Governmental Complex with the County Building of the left, then the State Office Building, followed by City Hall and the City Council Chambers A desk with soot on it and a window, photographically darkened, in the State Office Building. A worker in the polluted building apparently wearing an asbestos protective mask rather than a NIOSH approved mask protective against organic vapors and particulate matter The damaged electrical panel (left), the damaged transformer and an apparently undamaged electrical panel Soot is apparent. A cleanup worker in February, 1981, in the contaminated building, not wearing his gloves or mask and with an open protective suit exposing his own clothes

measured by standard methods sampling and analyzing PCBs in air Analysis of soot samples collected in a number of floors in the building revealed levels of Arochlor 1254 as high as 10 to 20% by weight. There was not a readily apparent pattern to the soot or PCB distribution. PCBs were measured in elevated amounts even where no visible soot existed, as in the first floor cafeteria Sampling of the fourth through seventh floors, and the corresponding stairwells where soot of a flocular nature as well as heavy despositions of soot were found, revealed PCB contamination in all areas initially sampled. These included, floors, walls, light fixtures, ceiling panels, sprayed on insulation and beams within hidden aspects above the false ceiling (plenums), within file cases and desk drawers, and later, within air ducts and elevator shafts. The area of visibly most obvious soot was in the men's bathrooms especially in the middle floors such as the fourth through seventh floors where soot was noted to have flowed from the air vent areas through the metal grating into the bathrooms and under the bathroom doors into the general office work areas. According to verbal accounts from Binghamton firemen they did not find this distribution of soot remarkable. Sampling for PCBs from other buildings in downtown Binghamton, revealed levels from 0.1 to 0 7 micrograms per square meter in older buildings to non detectable in some newer buildings employing a dry (filter paper) wipe sampling technique on floors, desks and walls. Within seven days after the incident Dr James Carnahan of the General Electric Company Laboratory at Schenectady, New York notified us that furan isomers were present in the BSDB soot in amounts above what might have existed from trace contamination of the original transformer fluid This suggested pyrolytic conversion of the PCBs as previously found under laboratory and industrial conditions. It also raised the possibility of similar pyrolytic conversion of the polychlorinated benzenes to the somewhat more toxic dioxin isomers. An elequent isomer analysis of a sample of soot was performed by Dr David Stalling of the US Fish and Wildlife Bureau which extended the previous furan findings by providing confirmation of specific furan isomers and also described the finding of dioxins and biphenylenes. Thepresence of the dioxins including the highly toxic 2,3, 7,8 tetra chlorinated dioxin isomer was later described by Dr Patrick O'Keefe and colleagues at the New York State Health Department as well as by Dr Christoffer Rappe and Dr. Hans Buser. Each laboratory and each sample led to somewhat different values as would be expected given the non homogeneous nature of the soot and the technical difficulty of the chemical separations and analysis. Later analysis confirmed the differing amount of these various chemicals in various locations within the building.

Later analysis of the concrete parking garage floor after two slow detergent cleanings showed small amounts of total furan and dioxin isomers at levels as high as 127 nanograms total for those isomers measured, with the furans markedly predominating. An adjacent building's parking garage, also less than 12 years old, had essentially non detectable levels of furans and dioxins present; hexane or benzene extraction type wipe technique was employed in the latter instances in order to extract a higher percent of the total amount of chemicals present, usually we found from 1.1 to 10.1 ratios of PCBs on adjacent sections of contaminated floor or concrete by "wet"(solvent) wiping or dry wipe technique, respectively.Analysis performed by Prof. James Spalik of B.C.C.

A representative finding among the initial chemical analysis is that of Christoffer Rappe and Hans Buser which showed:

A.	PCDD	Total level	20 ppm
	2,3,7,8-Tetra-CDD		0.6 ppm
	4 other isomers		
	(1,3,7,8-, 1,4,7,8-, 1,2,3,7-		
	or 1,2,3,8- and 1,2,7,8- 1,4,6,9-)		0.6 ppm
	Total level tetra-CDDs		1.2 ppm
	1,2,3,7,8-Penta-CDD		2 5 ppm
	7 other penta-CDD isomers		2 5 ppm

	Total level penta-CDDs	5.0	ppm
	1,2,3,4,6,8- + 1,2,4,6,7,9-Hexa-CDD	1.2	ppm
	1,2,3,6,8,9-Hexa-CDD	1.3	ppm
	1,2,3,4,7,8-Hexa-CDD	0.7	ppm
	1,2,3,6,7,8-Hexa-CDD	0.6	ppm
	1,2,3,7,8,9-Hexa-CDD	0.4	ppm
	1,2,3,4,6,7-Hexa-CDD	0.5	ppm
	Total level hexa-CDDs	4.7	ppm
	1,2,3,4,6,7,9-Hepta-CDD	4	ppm
	1,2,3,4,6,7,8-Hepta-CDD	3	ppm
	Total level hepta-CDDs	7	ppm
	Octa-CDD	2	ppm
8.	PCDFs Total level	2160	ppm
	2,3,7,8-Tetra-CDF	12	ppm
	1,3,7,9-Tetra-CDF	1	ppm
	6 other tetra-CDF isomers	15	ppm
	Total level of tetra-CDFs	28	ppm
	1,3,4,7,8-Penta-CDF	65	ppm
	1,2,4,7,8-Penta-CDF	25	ppm
	1,2,4,7,9-Penta-CDF	22	ppm
	1,2,3,7,8-Penta-CDF	310	ppm
	1,2,3,6,7-Penta-CDF	60	ppm
	1,2,6,7,8-Penta-CDF	25	ppm
	2,3,4,7,8-Penta-CDF	48	ppm
	2,3,4,6,7-Penta-CDF	12	ppm
	12 other penta-CDF isomers	110	ppm
	Total level penta-CDFs	670	ppm
	1,2,3,4,6,8-Hexa-CDF	30	ppm
	1,3,4,6,7,8-Hexa-CDF	125	ppm
	1,2,4,6,7,8-Hexa-CDF	50	ppm
	1,2,3,4,7,8-Hexa-CDF	310	ppm
	Total level hexa-CDF	515	ppm

Patrick O'Keefe & Smith New York State Health Department, 1981

2,3,7,8 TCDD & 2,3,7,8 TCDF

Transformer Soot - Binghamton State Office Building

	Analyitical Result (ppm)	
Sample	TCDD[1]	TCDF[2]
Binghamton soot #1	3	273
Binghamton soot #2	4	124
Average Value	3.5	200

Both samples were composite soot taken from floors 3 & 4

(1) 2,3,7,8 TCDD - Tetrachlorodibenzo paradioxin
(2) 2,3,7,8 TCDF - Tetrachlorodibenzo furan

David Stalling, Ph.D., United States Fish and Wildlife Bureau, 1981

Binghamton State Office Building Soot

TCDD 5 ppm	2378 Tetra CDD TCDDS
Tetra - CDFs	5.4 ppm
Penta - CDFs	105 ppm
Hexa - CDFs	512 ppm
Hepta - CDFs	101 ppm
Octa - CDFs	30 ppm
Total Furans	753.4 ppm
Biphenylenes	50 ppm

WRIGHT STATE UNIVERSITY, BREHM LABORATORY, DAYTON, OHIO 45435
RESULTS OF HRGC/LRMS ANALYSIS OF WIPE SAMPLE BRO-4 (BROOME COUNTY NO 4) FOR TETRA- THROUGH OCTA-CHLORINATED DIBENZO-p-DIOXINS AND DIBENZOFURANS.

Government Complex Parking Garage (After Cleaning) Dr. Thomas Tiernan, 1982

CDD/CDF	Apparent Isomers	Quantity of CDD/CDF Detedted (ng/wipe)	Minimum Detectable Quantity (ng per isomer)	%Recovery of Internal stds
TEcdd	N.D.	N.D.	0.10	100
	$^{37}Cl_4$-2,3,7,8	----	----	
PCDD	N D.	N D	D.10	
HxCDD	N.D.	N D.	0 20	
HpCDD	1,2,3,4,6,7,8	0 65	0 20	
	1,2,3,4,6,7,9	0.45	0 20	
	Total	1.1	0 20	
	$^{37}Cl_4$- 1,2.3,4,6,7.8	----	----	100

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CDD/CDF	Apparent Isomers	Quantity of CDD/CDF Detected (ng/wipe)	Minimum Detectable Quantity (ng per isomer)	% Recovery of Internal Stds.
OCDD	1,2,3,4,6,7,8,9	1.0	0 20	
	$^{37}Cl_8$OCDD	----	----	100
TCDF	1,2,4,8	2 0	0 10	
	2,3,6,8	3.1	0.10	
	2,3,7,8	9.6	0.10	
	Other isomers (8)	35.8	0.10	
	Total	50.4	0.10	
PCDF	1,2,4,7,8	5.2	0.10	
	Other isomers (13)	11 8	0.10	
	Total	17.0	0.10	
HxCDF	1,2,4,6,7,9	1 6	0.20	
	Other isomers (12)	43.6	0.20	
	Total	45.2	0.20	
HpCDF	1,2,3,4,6,8,9	2 7	0 20	
	Other isomers (4)	4 6	0.20	
	Total	7 3	0 20	
OCDF	1,2,3,4,6,7,8,9	7 3	0.20	

MEDICAL ASPECTS OF THE INCIDENT

Toxic chemicals including those found in the Binghamton electrical panel transformer incident have been implicated in an increasing variety of medical disorders especially in a variety of annual species. These include skin lesions, cancers, adverse reproductive outcomes, central and peripheral nervous system as well as gastrointestinal disorders, immunologic deficiencies, and other pathologic conditions.

Initially, some of those exposed to the Binghamton chemical complex complained of skin rashes, headaches, irritability, anxiety, difficulty sleeping, sexual difficulties, and tingling of the extremities. A collaborative medical surveillance was established which accepted all persons exposed or who thought they were exposed to the toxic chemicals involved. The results of this activity, which includes about 500 persons, are still far from complete at this time. Evaluation included a medical history and physical examination, hematologic tests of blood, blood chemistries for 22 substances including liver enzymes and triglyceride and cholesterol levels from fasting patients. Urine was sometimes taken. Blood PCB tests were ordered but are not yet completely analyzed and available. Special fat analysis for PCBs, furans and dioxin isomers was performed. Lymphocyte function studies and urine porphorin analysis was performed on one patient.

Elevated liver enzymes and triglyceride and cholesterol levels were found in some of the 500 patients without etiology being well characterized. The percent of abnormal laboratory examinations may or may not be above that expected from a matched control population. Estimates of exposure to the chemicals in question proved a problem. Ideally, serum PCB, furan and dioxin levels as well as cytochrome P 450 & 448, liver enzymes, cholesterol triglycerides, liver levels before and immediately after exposure might have proved helpful but were not available Workers in the building after the initial cleanup effort do in fact have preentry as well as exit medical evaluations including blood PCB levels.

As would be expected from such a large group of persons exposed in this incident a number of medical conditions have arisen, as diverse as malignant melanoma of the skin and transient erythema of the face to fetal damage and wastage where the husband was the exposed partner, to serious psychiatric disorders including an obsession with the exposure to these toxic chemicals followed by a suicide attempt with the patient still comatose months after the attempt. Establishing etiology regarding causation of any of

these medical abnormalities with respect to the toxic chemicals remains as elusive at the present time as establishing exposure levels of individual patients.

It is not the purpose of this paper to review medical aspects of the diagnostic pathologic, and possible treatment options which confront physicians or health officials faced with problems of patients who may have been exposed to toxic chemicals in combinations produced by electrical system incidents such as the one documented in this paper. Likewise, I will not review the various animal toxicologic tests, including rabbit skin, guinea pig LD 50, electron microscopic examinations of guinea pig liver tissue, chick embryo tests and others performed or under way at this time in an attempt to characterize the toxicity of the Binghamton soot. It is important to note that the soot has not inactivated these chemicals as shown by chick embryo fetotoxicity and terotogenicity demonstrated in pilot tests with the Binghamton soot but not with fireplace soot or activated charcoal as well as guinea pig LD 50 testing.

At the present time over one billion dollars in law suits or the intention to file law suits have been filed primarily against the State of New York as the owner of the polluted building. Under New York State Law it is necessary to file an "Intention to Sue" within a given time frame in order not to lose the right at some future date to sue the State of New York for damages recognized at a later date. Such damage derived from an incident might include cancer or other conditions not apparent initially. Damages awarded under the American judicial system might take into account punitive as well as compensatory damages, and include loss of income, medical costs, and other items.

In addition the question of jurisdiction arises. Usually a city or county would declare a potential health hazard through its health department, acting partly under legal powers granted by State Government. The Federal Government has standing in certain instances, through the Environmental Protection Agency (E.P.A.), the Occupational Safety and Health Administration (OSHA) or the National Institute on Occupational Safety and Health (NIOSH) as well as other agencies on certain occasions Here the State of New York found itself the inadvertant owner of a polluted building. Instead of its customary role in acting as a regulator, the State found itself in the role of pollutor Questions defining which agency regulates a given governmental agency which becomes a pollutor is an aspect of law and public policy which has not been previously addressed to the best of our knowledge in circumstances similar to the Binghamton incident.

It is however, worthy of note that in the United States at this time a Federal Agency such as the EPA will not enter such disasters without the approval of the State authorities Because of this entry of the E.P A. was delayed several months until their aid was sought and obtained by the Senior Senator from the State of New York, Senator Patrick Moynihan.

CONCLUSIONS and DISCUSSION

At this early time less than two years after the Binghamton (State Office Building) incident there are some tentative conclusions which may be made:

1. Electrical incidents involving PCB and polychlorinated benzene containing transformers, capacitators, ballasts etc. constitute a previously unrecognized health hazard by exposing persons in non industrial sites including offices and schools to such toxic chemicals as PCB's, furans, dioxins, biphenylenes, and other related compounds Several similar incidents including a Binghamton City Hall capacitor incident producing air levels of 80 micrograms per cubic meter were noted in Binghamton during the year after the incident.

2. The presence of these chemicals has not been previously documented in similar circumstances so that long term exposure to small or other than small amounts of a combination of toxic chemicals of this kind has probably been occurring in industrial countries since 1929 when widespread use of PCB's began. These incidents may be contributing to environmentally induced or promoted cancers, reproductive abnormalities, immunologic deficiency, and possibly premature death from infection, neurologic and gastrointestinal system pathology and possibly, by elevating serum triolyceride and cholesterol levels, excess or avoidable cardiovascular and cerebrovascular pathology

3 Prevention of some of these incidents is relatively easily and economically achieved by redesigning and enclosing PCB containing transformers and other PCB containing elect-

rical systems. Many transformers are already in contained areas Others, like the Binghamton transformer, are placed in a fashion which easily may lead to significant contamination of the building. Future buildings must be constructed with this newly described potential health hazard in mind and preexisting buildings must be evaluated carefully and, if necessary, appropriate safety features added. Improved circuit breakers or fuses are certainly desirable. Adequate fire safety and temoerature decreasing devices can be installed to prevent incidents similar to the Binghamton incident.

4 Removal and replacement of PCB and polychlorinated benzene containing transformers, capacitors, ballasts, etc. must clearly be considered if health risks warrant such measures. Refilling transformers as with silicon may diminish the risk. "Dry" transformers, with no fluid, may offer improved safety, at least with respect to toxic chemical exposure. Mineral oil containing transformers, while posino a fire hazard, appear to be less of a toxic chemical threat.

5. There is no unanimity regarding standards for PCB's in oaseous ohase even in industry at this time. The current United States OSHA standard for PCB's in air for industry is 500 or 1000 micrograms per cubic meter, depending on the isomer mix. However a National Institute on Occupational Safety and Health (NIOSH) Criteria Document has taken the position, that no exposure to PCB's should be considered safe or desirable. To implement that point of view it was suogested in that document that one microgram per cubic meter, the minimum level of detection at that time, be used as a value to replace the 500 or 1000 micrograms per cubic meter standard Different values may well have to be established for young children, pregnant women, and other special cases to adequately satisfy conditions as demanding as those found in Binghamton and doubtlessly elsewhere, simply awaiting confirmatory chemical analysis. Standards for PCB's in soot, or for dioxins, furans and biphenylenes in soot or air need to be established.

6 National and international levels for those chemicals must be established not only for buildings and various portions of these buildings, such elevator shafts, air ducts, and elsewhere, but also for human body fluids and organs. At present, serum and fat determinations of PCB, dioxin, and furan isomer levels are in early stages of beino used to attempt to document levels of exposure Individual isomer analysis of body tissues may prove useful. As clinicians we have values to consider for lead, arsenic and other chemicals in body fluids, but we do not currently have clinically meaningful values for dioxins, furans, biphenylenes or PCB's Determination of metabolic pathways and usefulness of blood, fat, urine or fecal levels of these compounds and their metabolities will doubtlessly lead to data useful to clinicians evaluatino and treating patients after related incidents.

7. Because toxic chemical exposure is a rapidly increasing health problem, it may be appropriate that serum be drawn and stored for all willing members of the population at several points in time in order that comparisons be made when indicated to be able to evaluate level of exposure after an individual incident At the very least, none elevated but low levels of a given chemical found after chemical contamination might prove quite reassuring to a patient. In the Binghamton incident persons without previous blood samples available were exposed to various amounts of PCB's, dioxins, furans, biphenylenes and other pyrolytic byproducts. Because of this, blood PCB and furan and dioxin analysis will be very difficult to interpret. Fish from the Hudson River in New York are frequently high in PCB levels and fish from the Great Lakes have been found to contain significant levels (in parts per trillion, P.P.T.) of dioxins, including 2,3,7,8 TCDD. Previous exposure to industrial chemicals or herbicides containing dioxins, PCB's or furans provides further confounding variables. With a presumed relatively low level exposure for most of the original 500 persons under medical surveillance it will be difficult to differentiate origin of postive but low levels of PCB's found in body tissues Isomer analysis and fat biopsy data may be of value but these techniques are still experimental and the amounts present, expecially since some samples were taken long after the incident, may be too low to detect accurately at this time. Frozen samples for future analysis may prove useful

8 Medical surveillance of exposed populations following similar instances from both an occupational medicine standpoint as well as an epidemiologically oriented study is desirable. For the individual patient and his or her physician knowing what to look for, and when, and possibly being able to decrease body burden of these toxic chemicals if present

in elevated levels by pharmacological or other means is certainly medically desirable Although epidemiology provides only a weak tool for dealing with relatively small numbers of persons or subtle events, it certainly may be of some usefulness in events such as this one Certainly, as better physiological indices of exposure become available, whether urinary porphyrin patterns, fat, blood, urine or fecal chemical analysis for the chemicals, cytochrome P450 or P448 alterations, electron microscopic lesions of hepatic parenchymal cells characteristic or pathognomonic of toxic chemical exposure, patterns of elevated liver enzymes or increased serum cholesterol or triglycerides, enhance the usefulness of large scale collaborative studies and registries will come to be of markedly enhanced value. At present, relatively small numbers of patients as well as imprecise estimates of exposure constitute major problems in human studies.

9. Intense multispecialty research into all aspects of such accidents is needed Psychiatric research to understand and prevent psychiatric illness following these environmental incidents is especially needed Medical research considering how patients exposed should best be monitored and eventually treated is urgently indicated Further research to explain why chemicals which seem so toxic in numerous animal species have not been demonstrated to be as toxic in man is essential to differentiate between species differences which might show man relatively impervious to these chemicals or simply to establish better studies demonstrating toxicity in humans. Better, faster, cheaper, readily performed sampling and chemical analysis techniques are certainly needed. Dioxin and furan isomer analysis frequently cost $1,000 to $2,000 each and take months to complete. These are far too costly for most parties involved and almost no organization is willing to shut down entirely for months waiting to learn whether or not a potential health hazard exists

Legal and legislative research is needed in order to consider whether the current adversarial and legal approach to redressing wrongs and hopefully obtaining justice through law suits, now epidemic in the United States, is the most reasonable approach to justice for those injured by incidents of toxic chemical contamination Legislative alternatives to the judicial process are possible, such as workman's compensation, or specialized approaches similar to the black lung coal mining legislative approach which supposes that working in a mine for a given number of years followed by lung diseases of certain kinds are compensable without involving a court of law are also possible. In Australia, Veterans of the Vietnam War who become ill in a fashion which might be attributed to toxic chemical exposure are compensated unless the government can prove that the illness was not caused by Agent Orange containing 2,3,7,8, TCDD. Each of these financial and legal approaches has advantages and disadvantages, but the toxicity of these chemicals in man may remain subject to vigorous research and disagreement for many years While scientists continue the tedious and necessary research to its ultimate but slow course justice will be sought in one way or another by those exposed to toxic chemicals at great cost to all involved.

10. Interdisciplinary communication with scientific colleagues and the general public with frequency as well as maximum clarity is essential. Meetings such as The International Dioxin Conferences with promptly published proceedings, and with maximum participation of numerous views is desirable. Hopefully future meetings will also have scientific presentations from colleagues in sociology, psychology, law, anthropology, political science and case studies from physicians and from affected persons themselves in order that we may communicate most effectively in an interdisciplinary fashion and learn from one another Possibly even panel sessions including responsible and knowledgeable members of the press would contribute to increased understanding and better communication between those involved in past and future incidents involving these toxic chemicals.