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I. SUMMARY

On January 15, 1986, the National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance from the Director, Air and Toxics Division, U.S. Environmental Protection Agency (EPA), Region VII, Kansas City, Missouri. The EPA requested NIOSH assistance in reveiwing the health and safety aspects of the applications to operate a polychlorinated biphenyl (PCB) destruction facility at National Electric (Aptus), Incorporated, Coffeyville, Kansas. On October 1, 1986, NIOSH also received a request from the regulatory compliance officer at National Electric (Aptus) to perform a health hazard evaluation.

The initial environmental and medical evaluation was conducted on January 28-29, 1987. The medical survey included (a) a personal interview, (b) a physical examination, and (c) measurement of serum PCB concentration. Air samples were collected for PCBs and hydrocarbons. Surface samples were collected for PCBs, polychlorinated dibenzo-p-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs). On October 5, 1988, a follow-up environmental survey involved collection of air samples for PCBs and PCDDs/PCDFs. All of the PCB/PCDD/PCDF compounds are suspected human carcinogens.

Results of 39 air samples for PCBs ranged from non-detected (ND) to 10.3 micrograms per cubic meter (ug/m^3) during the initial survey, and between 0.9 to 98.1 ug/m^3 from those collected during the follow-up visit. Thirty-six (92%) of the samples exceeded the NIOSH recommended exposure limit of 1.0 ug/m^3. Thirty-two (76%) of the 42 surface samples for PCBs were above our "guideline" criteria of 100 micrograms per square meter (ug/m^2), while 20 (48%) were above the EPA 1000 ug/m^2 clean-up criteria.

Five air samples collected for PCDDs/PCDFs ranged from ND to 0.33 picograms per cubic meter (pg/m^3), all of which were below the National Research Council (NRC) evaluation criteria (10 pg/m^3). The four surface samples for PCDDs/PCDFs ranged from 0.95 to 191 nanograms per square meter (ng/m^2). One of the samples was above the NRC guideline of 25 ng/m^2. Of particular concern was the presence of the 2,3,7,8-TCDD isomer, the most toxic dioxin isomer, in the Drain/Flush area at a concentration of 1.56 ng/m^2.

Trace levels of benzene, toluene, and xylene were found in the drain/flush, barrel flushing, and solvent recovery areas, but all were well below the NIOSH recommended evaluation criteria. Detectable levels of 1,1,1-trichloroethane [23-83 parts per million (ppm)] and methylene chloride (0.06-1.94 ppm) were found in all the samples. NIOSH currently recommends that methylene chloride exposure be controlled to the lowest feasible level and that 1,1,1-trichloroethane be treated in the workplace with caution because of its similar chemical structure to other chloroethanes, which have been shown to be carcinogenic in laboratory animals.

The serum PCB concentrations (reported as Aroclor 1260) for the 60 participating employees ranged from 1 to 23 parts per billion (ppb), with a mean of 6 ppb. Persons without occupational exposure generally have serum PCB levels less than 20 ppb. Fifty-nine participants (98%) had PCB levels of 20 ppb or less. None of the sixty participants had skin findings suggestive of chloracne.

At the time of this evaluation, worker exposures to PCBs exceeded the NIOSH REL. Surface concentrations of PCBs and PCDDs/PCDFs also exceeded the guideline criteria. Surface concentrations of PCBs were also measured which exceeded the EPA Standard. These results suggest that current work practices and environmental controls do not prevent excessive exposures to workers. Recommendations are made to control environmental exposures.

KEYWORDS: SIC 9999 (nonclassifiable establishments, polychlorinated biphenyl disposal), polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs)

II. INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance on January 15, 1986, from the Director, Air and Toxics Division, U.S. Environmental Protection Agency (EPA), Region VII, Kansas City, Missouri. The EPA requested NIOSH assistance in reviewing the health and safety aspects of the applications to operate a polychlorinated biphenyl (PCB) destruction facility at National Electric (Aptus), Incorporated, Coffeyville, Kansas. On October 1, 1986, NIOSH received a request from the regulatory compliance officer at National Electric (Aptus) to perform a health hazard evaluation. The potential exposures included polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs), and hydrocarbons.

Medical and environmental evaluations were conducted on January 28-29, 1987. The medical evaluation included brief medical interviews, physical examinations, and the collection of blood samples to determine serum PCB levels. The environmental evaluation included the collection of air samples for PCBs, and surface wipe samples for PCBs, PCDDs, and PCDFs. Results from this survey were issued in July 1987 (environmental) and March 1988 (medical).

A follow-up environmental survey was conducted on October 5, 1988. Air samples were taken for PCBs, PCDDs, and PCDFs. Results for this survey were issued in March 1989.

The results of all environmental and medical evaluations will be discussed in this report.

III. BACKGROUND

The National Electric (Aptus) facility in Coffeyville, Kansas, provides turnkey environmental services in PCB management.

Transformers, capacitors, bulk oil, and PCB contaminated materials arriving at the facility are first checked in through the security department (check manifest and weigh trucks). They are then transferred to a receiving area, inventoried, and eventually stored based on their physical characteristics and containers.

All bulk oil shipments are analyzed for PCB content and then pumped into the proper holding tanks. As required, the oil is shipped for incineration.
Transformers are drained on the drain and flush table, then flushed with 1,1,1-trichloroethane and dried. When dried, they are resealed and shipped to an authorized landfill.

Capacitors and debris are segregated and recontainerized as required, shipped for incineration, or taken to an authorized landfill.

Low part oil (<500 ppm) may be chemically detoxified to eliminate PCB content.

IV. METHODS AND MATERIALS

A. Environmental Evaluation

The environmental evaluations consisted of determining potential inhalation exposures by collecting full-shift personal exposure and general area air samples for PCBs, PCDDs/PCDFs, and hydrocarbons. Also, to determine the potential for dermal exposure to PCBs, PCDDs and PCDFs, a number of wipe samples were obtained from various working surfaces.

1. Polychorinated Biphenyls (PCBs)

a. Air Samples

General area and breathing zone (personal) air samples were collected by drawing air through 150-mg florisil tubes attached to battery-operated sampling pumps at a pre-calibrated flow rate of one liter per minute for the duration of the shift.

For analysis (NIOSH Method 5503[1]), the florisil tubes were separated into their primary and backup sections. Each section, along with the glass wool plug which precedes the front section, was desorbed in one ml of hexane with sonication for 1/2 hour. The gas chromatographic analysis was performed on a Hewlett-Packard Model 5730A gas chromatograph (GC) equipped with an electron capture detector and accessories for capillary column capabilities. A 30-m x 0.31-mm 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 8°C/minute. Five percent methane in argon was used as the carrier gas. The injector was operated in the splitless mode. 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 those of the same peaks on the sample.

Two Aroclors (1242, 1254) were found during the evaluation. The analytical limit of detection (LOD) was 0.007-0.14 micrograms per sample (ug/sample) for Aroclor 1242 and 0.003-0.07 ug/sample for Aroclor 1254. The limit of quantitation (LOQ) was 0.02-0.47 ug/sample for Aroclor 1242 and 0.01-0.25 ug/sample for Aroclor 1254.

b. Surface Wipe Samples

A wet-wipe protocol was used to assess the surface concentrations of PCBs. The surface wipe samples were collected using 3" x 3" Soxhlet-extracted cotton gauze pads which had been wetted with 8 ml of pesticide-grade hexane. The sampling procedure consisted of marking the boundaries of a 0.25-m^2 area on the desired surface and wiping this area with the gauze pad. The sample pad was held with a gloved hand; a fresh non-linear polyethylene, unplasticized glove was used for each sample. The surface was wiped in two directions (the second direction was at a 90° angle to the first direction). Each gauze pad was used to wipe only one area. The gauze pad sample was then placed in a glass sample container equipped with a Teflon-lined lid.

The gauze samples were prepared for analysis by extraction in 40 ml of hexane with shaking for 30 minutes. The hexane was transferred to a concentrator tube, and the gauze was rinsed twice with 10 ml of hexane. The concentrated hexane eluent was cleaned on a florisil column, and the sample was brought to a final volume of 3 ml. GC analysis was the same as previously described for the florisil tubes, except that when both Aroclors 1248 and 1260 were present, only three peaks were used to quantitate Aroclor 1248.

The LOD was 0.21 ug/sample for Aroclor 1248, 0.15 ug/sample for Aroclor 1254, and 0.26 ug/sample for Aroclor 1260.
The LOQ was 0.70 ug/sample for Aroclor 1248, 0.52 ug/sample for Aroclor 1254, and 0.87 ug/sample for Aroclor 1260.

2. Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs)

a. Air Samples

The air sampling device for PCDD/PCDF compounds consists of two stages. The first stage is a 47-mm glass microfiber filter (EM 2000, 0.3-um) for collecting particulates. The second stage is a glass cartridge containing eight grams of 140°C activated 30/70 mesh silica gel absorbent. The silica gel cartridge is generally spiked with 2,3,7,8-tetrechlorodipenzo-p-dioxin -$^{13}C_{12}$ and 2,3,7,8-tetrachlorodibenzo furan -$^{13}C_{12}$ before sampling for quantification and to account for any retention losses during sampling. The glass cartridge containing the spiked silica gel absorbent is sealed in a rugged Teflon housing with fluorelastomer Viton "O" rings.

For sample collection the sampler is placed in a vertical position and attached via Tygon tubing to a 20 liter/minute rotary vane vacuum pump. Flow rates are regulated using precision control valves and appropriate flow measurement devices.

b. Surface Wipe Samples

To attain an acceptable detection limit, each PCDD/PCDF wipe sample consisted of a composite of four 0.25-m^2 wipe samples, for a total area of 1.0 m^2. These are collected using the same technique as the PCB wipe samples. The wipe samples are extracted with toluene for 16 hours using a Soxhlet apparatus to dissolve the PCDD and

PCDF from the samples. The resulting toluene solution is concentrated to near dryness on a rotary evaporator. An extensive purification process is then used to prepare the samples for analysis.

The air and surface samples are analyzed by a gas chromatograph/mass spectrometer equipped with a DB-5 (screening) column and by DB-17 and SP 2331 columns in tandem (for isomer confirmation). Selected ^{13}C and ^{37}Cl labeled PCDD and PCDF isomers are included as internal standards and recovery (surrogate) standards.

Analyses are performed to measure total tetra-, penta-, hexa-, hepta-, and octachlorinated dibenzofurans; total tetra-, penta-, hexa-, hepta-, and octachlorinated dibenzodioxins; and specific PCDD and PCDF isomers containing chlorine substitution in the 2, 3, 7, and 8 positions. The analytical limits of detection were variable and ranged between 0.0001 and 1.778 nanograms per sample.

3. Hydrocarbons

The air samples for hydrocarbons were collected by drawing air through a glass tube containing 150 mg of activated charcoal at a flowrate of 0.2 liters per minute using calibrated, battery-operated sampling pumps. The samples were desorbed with carbon disulfide and analyzed by gas chromatography with a flame ionization detector. Identities of analytes were confirmed by mass spectrometry. The limits of detection for the various analytes are reported below:

Analytes	LOD (milligrams/sample)
l,l,l-trichloroethane	0.23
Methylene Chloride	0.01
Benzene	0.01
Toluene	0.01
Xylene	0.03

B. Medical

The medical survey included, for each participant, (a) an examination of the skin of the head and neck for signs of chloracne, and (b) measurement of serum PCB concentration. All employees working on the main production floor the days of our visit were invited to participate. Office workers and truck drivers were not included. Venous blood was obtained using a multiple draw Vacutainer system. The blood was allowed to clot, and serum was separated, frozen, and sent to the Center for Environmental Health and Injury Control (CEHIC), Centers for Disease Control, Atlanta, Georgia, for analysis. To prevent contamination of the blood samples with PCB from the skin, the first tube of blood was discarded, and the second tube was used for PCB analysis.

The analytical method used by the CEHIC laboratory involves gas chromatography with electron capture detection, using the Webb-McCall factors to quantify PCB.[2] The results were reported as Aroclor 1260, in parts per billion (ppb) of serum.

V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by work place exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other work place exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the work place are: 1) NIOSH Criteria Documents and Recommended Exposure Limits (RELs), 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor (OSHA) Permissible Exposure Limits (PELs). Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA PELs. The NIOSH RELs and ACGIH TLVs are usually based on more recent information than are the OSHA standards. The OSHA PELs may also be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended exposure limits, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA PEL.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures.

A. PCBs

PCBs are chlorinated aromatic hydrocarbons that were manufactured in the United States from 1929 to 1977 and primarily marketed under the trade name Aroclor.[3] They found wide use because they are heat stable; resistant to chemical oxidation, acids, bases and other chemical agents;

stable to oxidation and hydrolysis in industrial use; and have low solubility in water, low flammability, and favorable dielectric properties. Additionally, they have low vapor pressure at ambient temperatures and viscosity-temperature relationships that were suitable for a wide variety of industrial applications. PCBs have been used commercially in insulating fluids for electrical equipment, hydraulic fluids, heat transfer fluids, lubricants, plasticizers, and components of surface coatings and inks.[4]

The different PCB mixtures marketed under different trade names are often characterized by a four-digit number. The first two digits denote the type of compound ("12" indicating biphenyl), and the latter two digits giving the weight percentage of chlorine, with the exception of Aroclor 1016. In other commercial preparations the number code may indicate the approximate mean number of chlorine atoms per PCB molecule (Phenoclor, Clophen, Kanechlor) or the weight percentage of chlorine (Fenclor).

Dietary PCB ingestion, the major source of population exposure, occurs especially through eating fish, but PCB residues are also found in milk, eggs, cheese, and meat. PCB residues are detectable in various tissues of persons without known occupational exposure to PCBs. Mean whole blood PCB levels range from 1.1 to 8.3 parts per billion (ppb), while mean serum PCB levels range from 2.1 to 24.2 ppb for persons without known occupational exposure.[5] 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 typically range from 12 to 51 ppb, considerably lower than among workers at capacitor manufacturing plants.[6]
PCB toxicity is complicated by the presence of highly toxic impurities, especially the polychlorinated dibenzofurans (PCDFs)[7], which vary in amount depending on the manufacturer,[8] and percent chlorination,[9] and which are found in increased concentrations when PCBs undergo incomplete pyrolysis.[10,11] As well, different animal species, including man, vary in their pattern of biologic response to PCB exposure.[12]

Two human epidemics of chloracne, "Yusho" and "Yu-cheng," resulted from ingestion of cooking oil accidentally contaminated by a PCB heat-exchange fluid used in the oil's pasteurization.[13,14] Although PCBs were initially regarded as the etiologic agent in the Yusho study, analyses of the offending cooking oil demonstrated high levels of PCDFs and polychlorinated quarterphenyls, as well as other unidentified chlorinated hydrocarbons, in addition to PCBs.[15]

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,[16] but not among workers in Australia,[17] Finland,[18] or the United States.[6,19-21] Weak positive correlations between PCB exposure, or serum PCB levels, and SGOT [16,18-20], GGTP[6,16,20,21], and plasma triglycerides have been reported.[6,22,23] Correlations between plasma triglycerides[24] and GGTP[25] have also been found among community residents with low level PCB exposures. Causality has not been imputed to PCBs in these cross-sectional studies.

The International Agency for Research on Cancer has concluded that the evidence for PCB carcinogenicity in animals and 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".[26]

In a mortality study among workers at two capacitor manufacturing plants in the United States[27] 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. In a recent update of this study[28], however, with follow-up through 1982, an excess in liver/biliary tract cancer was statistically significant (5 observed vs. 1.9 expected). The excess in cancer of the rectum was still elevated but not statistically significantly so. In this mortality study, the personal time-weighted average exposures in 1976 ranged from 24 to 393 ug/m^3 at one plant, and from 170 to 1 NIOSH recommends that occupational exposures to carcinogens be reduced to the lowest feasible level. Results of several investigations of PCB surface contamination in office buildings indicate that there is a "background" level of surface contamination in the range of 50 to 100 micrograms per square meter (ug/m^2).[34-37] Therefore, for surfaces in the occupational environment that may be routinely contacted by the unprotected skin, NIOSH investigators have recommended that PCB contamination not exceed 100 ug/m^2 (the lowest feasible level considering background contamination).

The U.S. Environmental Protection Agency has published a spill cleanup policy (April 2, 1987 - 52 FR 10688) which includes discussions of industrial surfaces contaminated from PCB spills.[38] In the "Development" section of the policy (Risks Posed by Leaks and Spills of PCBs), the EPA states that the estimated level of oncogenic risk associated with dermal exposures of 1.0 ug/100cm^2 (100 ug/m^2) of PCBs on hard, indoor, high-contact surfaces is between 1 x $10^{-5}$and 1 x 10^{-6} (between 1 in 100,000 an 1 in 1,000,000 cancer deaths). A high-contact industrial surface was defined as "a surface which is repeatedly touched, often for long periods of time." Manned machinery and control panels were given as examples of high-contact surfaces. The policy also states, "Residual PCB levels of 10 ug/100 cm^2 (1000 ug/m^2) on indoor low-contact surfaces in industrial areas would not be expected to result in significant exposures." Examples of low-contact industrial surfaces included ceiling, walls, floors, roofs, roadways and sidewalks, utility poles, unmanned machinery, concrete pads beneath electrical equipment, curbing, exterior structural building components, indoor vaults, and pipes.

However in EPA's consideration of the costs/benefits, and a general lack of data on the incremental costs of decontamination to various levels of PCB contamination, the EPA spill cleanup Final Rule requires that high-contact and low-contact industrial surfaces be cleaned only to 1000 ug/m^2, or 10,000 ug/m^2 for low contact, non-impervious surfaces, with encapsulation.

B. PCDDs/PCDFs

PCDDs and PCDFs are two series of tricyclic aromatic compounds. The number of chlorine atoms can vary between 1 and 8 (mono- through octa-chloro homologs), resulting in 75 PCDDs and 135 PCDF positional isomers.

The toxic effects of these compounds are associated with the number and specific placement of the chlorine atoms in the molecule. The tetra-, penta- and hexachlorinated 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.[44-52] 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 showed significant increases in the incidece of liver and/or lung tumors in exposed rodents.[52,53] A mixture of two 2,3,7,8-substituted hexachlorinated dibenzodioxins was found to produce an increased incidence of liver tumors or neoplastic nodules in exposed rats and mice.[54] Exposure to PCDD can cause chloracne and liver toxicity in humans.[50,55] There is suggestive evidence of an association between increased incidence of cancer in people exposed to PCB containing substantial amounts of PCDF[56,57] and in people exposed to phenoxyacetic herbicides contaminated with PCDD, including TCDD.[58,59] Definite causal relationships between exposure and carcinogenic effects in humans remain unclear, however, due to the inadequately defined study populations and the influences of mixed exposures.

NIOSH recommends that 2,3,7,8-TCDD be regarded as a potential occupational carcinogen, that occupational exposure to 2,3,7,8-TCDD be controlled to the lowest feasible level, and that decontamination measures be used for 2,3,7,8-TCDD-contaminated work environments. This recommendation is based on a number of reliable studies demonstrating carcinogenicity in rats and mice.[50]

Air and surface guideline criteria or PCDDs/PCDFs are expressed as 2,3,7,8-TCDD equivalents. 2,3,7,8-TCDD equivalents are defined as the concentration of 2,3,7,8-TCDD which, by itself, would exhibit the same biological potency as the mixture of structurally-related compounds, PCDDs and PCDFs, actually present in a sample. The structually-related PCDDs and PCDFs that are considered in the calculation of 2,3,7,8-TCDD equivalents include the tetra- through octachloro homologs and 2,3,7,8-substituted isomers.[60]
This procedure, initially developed by the New York State Department of Health, estimates the amount of 2,3,7,8-TCDD that would have to be present to exhibit a similar toxicity as the measured amounts of all of the other PCDDs and PCDFs. The procedure assumes certain weighting factors (ratios of toxicities) between 2,3,7,8-TCDD and the other PCDDs and PCDFs.[61] The weighting factors (called toxicity equivalency factors by EPA) are those currently proposed by EPA [Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Dibenzo-p-Dioxins and Dibenzofurans (CDDs and CDFs), Risk Assessment Forum, EPA 625/3-87/012, 1987].

PCDFs	Factor	PCDDs	Factor
2,3,7,8-TCDFs	0.1	2,3,7,8-TCDD	1.0
other TCDFs	0.001	other TCDDs	0.01
2,3,7,8-PeCDFs	0.1	2,3,7,8-PeCDDs	0.5
other PeCDFs	0.001	other PeCDDs	0.005
2,3,7,8-HxCDFs	0.01	2,3,7,8-HxCDDs	0.04
other HxCDFs	0.0001	other HxCDDs	0.0004
2,3,7,8-HpCDFs	0.001	2,3,7,8-HpCDDs	0.001
other HpCDDs	0.00001	other HpCDDs	0.00001
OCDFs	0.0	OCDDs	0.0

The concentrations of the PCDD and PCDF compounds are converted to TCDD equivalents by multiplying measured values by the appropriate factor. The TCDD equivalents are then summed and compared to the guideline value.

The dioxin subcommittee of the National Research Council recently released a report on acceptable levels of dioxin contamination in office buildings following transformer fires.[62] The exposure guidelines adopted by the subcommittee were 10 pg/m^3 for air and 25 ng/m^2 for surfaces expressed as 2,3,7,8,-TCDD equivalents. Reported lifetime cancer risk estimates were 9×10^{-8} to 2×10^{-4} at the recommended guideline. Risks correspond to a single source contamination, either air or surface. Risks and exposures for simultaneous exposure are additive. For example, risks apply for exposure to 10 pg/m^3 of air only, 25 ng/m^2 of surface only, or 5 pg/m^3 of air plus 12.5 ng/m^2 of surface. Simultaneous exposure at 10 pg/m^3 of air and 25 ng/m^2 of surface implies risks twice as large as given values.

C. 1,1,1-Trichloroethane[63-65]

1,1,1-Trichloroethane (methyl chloroform) is a degreaser and solvent of relatively low toxicity. Vapor may be mildly irritating to eyes. At a vapor concentration over 1000 ppm, anesthetic effects including lightheadedness, dizziness, and incoordination have been reported. As is the case with other halogenated hydrocarbons, cardiac arrhythmias resulting from excessive exposure have been reported. No physiological effects have been reported when vapor concentrations are below the TLV of 350 ppm. Repeated skin contact can lead to dermatitis secondary to defatting. NIOSH recommends that 1,1,1-trichloroethane be treated in the workplace with caution because of its similar chemical structure to four other chloroethanes which have been shown to be carcinogenic in laboratory animals.[66] The current OSHA PEL is 350 ppm.

D. Methylene Chloride[67]

NIOSH estimates that 1 million workers are potentially exposed to methylene chloride during its manufacture and uses as a solvent, aerosol propellant, fumigant, and blowing agent in flexible urethane foams. In 1976, NIOSH published a document entitled Criteria for a Recommended Standard . . . Occupational Exposure to Methylene Chloride. In that criteria document, NIOSH recommended a 10-hour TWA occupational exposure limit of 75 parts per million (ppm) in order to prevent interference by methylene chloride with delivery of oxygen to tissues and impairment in functions of the central nervous system (CNS). Since 1976, the carcinogenicity of methylene chloride has been documented in several studies in animals. On the basis of carcinogenic and tumorigenic responses in rats and mice, and in accordance with the Cancer Policy of the Occupational Safety and Health Administration (OSHA) ("Identification, Classification, and Regulation of Potential Occupational Carcinogens," 29 CRF 1990), NIOSH recommends that methylene chloride be regarded as a "potential occupational carcinogen." Although the potential for methylene chloride-induced cancer in humans has not been determined, the probability of a population of exposed workers developing cancer could be decreased by reducing exposure. Therefore, NIOSH recommends that occupational exposure to methylene chloride be controlled to the lowest feasible limit.

E. Benzene[68]

Exposure to benzene can result in central nervous system depression and skin irritation. The data on benzene also leaves no doubt regarding the human carcinogenic potential of this chemical. NIOSH recommends that occupational exposure to benzene be controlled so that no worker is exposed to more than 0.1 ppm as an 8-hour TWA and that short-term exposure be controlled so as not to exceed 1 ppm as determined in any 15-minute sampling period. Furthermore, since there is the potential for significant amounts of benzene to enter a worker°s body by dermal absorption, NIOSH urges workers to use care when handling benzene and benzene-contaminated solvents.

F. Toluene

The major toxicity of toluene in the occupational setting is its neurologic effects: muscular weakness, incoordination, and mental confusion. NIOSH recommends that no worker be exposed to a concentration greater than 100 ppm determined as a TWA exposure for up to a 10-hour workday, 40-hour workweek.[69] The OSHA standard is 200 ppm.[70]

G. Xylene

The major toxicity of xylene in the occupational setting is its neurologic effects: muscular weakness, incoordination, and mental confusion. NIOSH recommends that no worker be exposed to a concentration greater than 100 ppm determined as a TWA exposure for up to 10-hour workday, 40-hour workweek.[71] The OSHA standard is 100 ppm.[70]

VI. RESULTS

A. Environmental Evaluation

A total of 39 air samples (32 breathing zone and 7 area) were collected for analysis of PCBs (Tables I-V, and VIII). Thirty-six (92%) of the samples exceeded the NIOSH recommended exposure limit of 1.0 ug/m^3, suggested as the lowest feasible limit. The PCBs were identified as Aroclors 1242 and 1254.

The PCB analyses of 42 samples collected on various surfaces are summarized in Tables I-IV and VI.

Thirty-two (76%) of the samples were above the guideline evaluation criterion of 100 ug/m^2, while 20 (48%) of the samples were above the 1000 ug/m^2 EPA clean-up criterion. The PCBs were identified as Aroclors 1248 and 1260.

Five air samples (Table VIII) were collected for tetra through octa-chlorinated PCDD and PCDF homologs and the 2,3,7,8-tetra isomers. The calculated concentrations of TCDD-equivalents ranged from non-detected to 0.33 pg/m^3, all of which were well below the evaluation criteria of 10 pg/m^3.

Four surface samples (Tables I-IV) were collected for tetra through octa-chlorinated PCDD and PCDF homologs and the 2,3,7,8-tetra isomers. The calculated concentrations of TCDD-equivalents ranged from 0.95 to 191 ng/m^2, with one of the samples above the NRC guideline of 25 ng/m^2. Of particular concern was the presence of 2,3,7,8-TCDD , the most toxic dioxin isomer, in the Drain/Flush sample (Table I) at a concentration of 1.56 ng/m^2.

Nine organic vapor samples were taken in the Drain/Flush, Barrel Flushing, and Solvent Recovery areas. Results of the samples are shown in Table VII. Trace levels of benzene, toluene, and xylene were found, but were well below the NIOSH recommended evaluation criteria. Detectable levels of 1,1,1-trichloroethane (23-83 ppm) and methylene chloride (0.06-1.94 ppm) were found in all the samples. NIOSH currently recommends that methylene chloride exposure be controlled to the lowest feasible level and that 1,1,1-trichloroethane be treated in the workplace with caution because of its similar chemical structure to other chloroethanes, which have been shown to be carcinogenic in laboratory animals.

B. Medical Evaluation

Sixty employees had the skin examination and provided a blood sample. The sixty participants included 57 men and 3 women. They ranged in age from 20 to 59 years, with a median of 32. All employees (excluding office personnel and truck drivers) working on the day of the study participated.

None of the 60 participants had skin findings suggestive of chloracne.

Among the 60 participants, serum PCB levels ranged from 1 to 23 ppb, with a mean of 6. Persons without occupational exposure generally have serum PCB levels less than 20 ppb. Fifty-nine participants had PCB levels of 20 ppb or less

VII. DISCUSSION

Air concentratons of PCBs exceeded the NIOSH REL (1.0 ug/m^3) in all areas of the plant. Since the workers are exposed to a suspected human carcinogens, the half-mask respirators in use do not meet the NIOSH recommended level of protection.[72] When respiratory protection is required to achieve the lowest exposure concentration, then only the most effective respirators should be used. Supplied-air respiratory protection is recommended in such situations. However, due to the layout of the plant and the mobility needed in certain jobs (forklift drivers, etc.) this may not be possible in all situations. General area air concentrations of PCDDs/PCDFs were all below evaluation criteria.

Surface contamination with PCBs inside the containment areas is much greater than the existing EPA cleanup standard (1,000 ug/m^2). Surface PCB levels in some areas outside of the containment areas are not being controlled to near background levels (100 ug/m^2 or less). This indicates that policies and procedures in place for containing the PCBs inside the controlled areas are not effective. The physical separation of the protection and non-protection areas is too easily compromised. One of the surface samples for 2,3,7,8-TCDD equivalents inside the containment area was also above the evaluation criteria.

The medical data did not document excessive absorption of PCB among workers. The lack of elevated serum PCB concentrations accompanying the widespread PCB contamination documented in our environmental study may have several explanations. The facility has been operating for only 3 years. This duration of exposure may not be sufficiently long to result in elevation of serum PCB levels if exposures were relatively low. Personal protective equipment, although seemingly inadequate at the time of this survey, may have protected workers to some extent from absorption of PCBs. Based on this study, it is impossible to evaluate the relative contributions of personal protective equipment and short duration of exposure to the apparent lack of substantial absorption of PCBs.

VIII. Recommendations

l. Access to the facility should be on a restricted and controlled basis. A clean/dirty changing room and shower facility should be used by anyone entering or leaving the plant. The dressing area for entry should be separate from the re-dressing/shower area for exit. This type of procedure is necessary to prevent PCBs/PCDFs/PCDDs from being transferred out of the plant. It will also prevent the contamination of street clothing.

2. Engineering and administrative contols should be utilized to reduce PCB/PCDD/PCDF levels to the lowest extent possible. In the interim, since all of the samples taken within the plant for airborne PCB levels were above the NIOSH evaluation criteria, it is recommended that the entire plant be made a mandatory respirator area. Anyone entering the plant should wear a Type C supplied-air respirator. A respiratory protection program should be implemented that complies with OSHA regulations 1910.134.

3. Due to the high levels of PCB, PCDF, and PCDD contamination, the Drain/Flush area should be isolated (utilizing enclosures, ventilation systems, etc.) from the rest of the plant. Access to this area should be restricted to control cross-contamination of other areas of the plant. All protective clothing and equipment utilized in this area should not be taken to other areas of the plant. All disposable clothing should be placed in marked and approved containers and disposed of appropriately. Until the levels of airborne PCDFs/PCDDs can be established, it is recommended that the workers in this area wear a combination Type C supplied-air respirator, with full facepiece, operated in pressure-demand mode, and equipped with an auxiliary positive-pressure self-contained air supply.

4. Low-contamination areas (areas that do not handle PCBs, such as the lunchroom and maintenance areas) should be isolated from the high contamination areas. Surfaces in these areas should be cleaned below the PCB/PCDF/PCDD evaluation criteria, which is to the lowest feasible level (background or limit of detection). Airborne levels

of PCBs should be reduced below the 1 ug/m^3 evaluation criterion utilizing proper engineering controls. Anyone entering these areas from a high-contamination area should undergo a decontamination process.

5. At a minimum, high-contact surfaces (as defined by the EPA[38]) in the restricted access areas should be cleaned, using EPA-described methods, to below the EPA standard of 1,000 ug/m^2 (10 ug/100 cm^2).

6. The possibility that truck traffic into and out of the plant could be actively transferring PCBs, PCDFs, and PCDDs out of the plant should be evaluated. If these substances are being carried out of the plant, modifications in loading and unloading procedures may be necessary.

7. It is recommended that an air and surface sampling program for PCBs/PCDFs/PCDDs be implemented to establish contamination levels in all areas of the plant. An ongoing program will be necessary to determine if contamination levels are increasing or decreasing. It is highly recommended that the services of a certified industrial hygienist, who has experience with PCBs, PCDFs, and PCDDs, be utilized in establishing a comprehensive industrial hygiene program.

8. It is recommended that use of methylene chloride be discontinued as a means for removing labels from barrels.

9. Periodic blood PCB testing should be continued. If a worker is found to have an elevated PCB blood level, an individual exposure assessment should be conducted, and appropriate modifications should be made to reduce exposure. The exposure assessment should concentrate on evaluating all factors which could be leading to excessive PCB absorption, such as inadequate respiratory protection, skin contact, work practices, personal hygiene, equipment, skin decontamination, and process control measures.

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are temporarily available upon request from NIOSH, Hazard Evaluations and Technical Assistance Branch, 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. U.S. Environmental Protection Agency, Region VII
2. National Electric (Aptus), Incorporated
3. NIOSH, Cincinnati Region
4. OSHA, Region VII

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 I

Surface Concentrations of 2,3,7,8 - Tetrachlorodibenzo-p-dioxin Equivalents
Surface and Airborne Concentrations of Polychlorinated Biphenyls (PCBs)

National Electric, Inc./Drain and Flush Area
Coffeyville, Kansas
HETA 86-510
January 28-29, 1987

Location	2,3,7,8-TCDD Equivalents (ng/m^2)	Job	Type of Sample	PCB Air Levels (ug/m^3)	Location	PCB Surface Levels (ug/m^2)
Drain and Flush Pad	190.5*	Drain & Flush	Breathing Zone	7.6	Drain and Flush/Top/Corrugated Metal	832,000
		"	"	6.7	Personal Protective Equipment Locker/ Outside Drain and Flush Berm	2,316
		"	"	7.8	Epoxy Painted Floor/Outside Drain and Flush Berm/Changing Area for Clothes and boots	10,080
		"	"	3.9	Unpainted Floor/Inside Drain and Flush Berm Changing Area	141,120
		"	"	4.6	PCB Correlation (Taken beside PCDD/ PCDF Sample)	1,560,000
Evaluation Criteria	1.0 (NIOSH) 25.0 (MRC)			1.0 (NIOSH)		100 (NIOSH) 1000 (EPA)

* = This sample contained 1.56 ng of 2,3,7,8-TCDD
ng/m^2 = nanograms of TCDD equivalents per square meter of surface
ug/m^3 = micrograms of PCB per cubic meter of air
ug/m^2 = micrograms of PCB per square meter of surface

Table II

Surface Concentrations of 2,3,7,8 - Tetrachlorodibenzo-p-dioxin Equivalents
Surface and Airborne Concentrations of Polychlorinated Biphenyls (PCBs)

National Electric, Inc./Berm No. 9
Coffeyville, Kansas
HETA 86-510
January 28-29, 1987

Location	2,3,7,8-TCDD Equivalents (ng/m²)	Job	Type of Sample	PCB Air Levels (ug/m³)	Location	PCB Surface Levels (ug/m²)
Floor Berm No. 9 (unpainted cement)	1.7	Berm No. 9*	Breathing Zone	7.6	Unpainted Cement/10 ft. from Safety Shower	72,000
		"	"	6.7	Rampway/between Berms # 9 and #3(clean area)	12,160
		"	"	7.8	PCB Correlation (taken beside Dioxin/Furan sample)	11,280
		"	"	3.9		
		"	"	4.6		
Evaluation Criteria	1.0 (NIOSH) 25.0 (NRC)			1.0 (NIOSH)		100 (NIOSH) 1000 (EPA)

ng/m² = nanograms of TCDD equivalents per square meter of surface
ug/m³ = micrograms of PCB per cubic meter of air
ug/m² = micrograms of PCB per square meter of surface
* = Drain and Flush Workers

Table III

Surface Concentrations of 2,3,7,8 - Tetrachlorodibenzo-p-dioxin Equivalents
Surface and Airborne Concentrations of Polychlorinated Biphenyls (PCBs)

National Electric, Inc./Oil Transfer Area
Coffeyville, Kansas
HETA 86-510
January 28-29, 1987

Location	2,3,7,8-TCDD Equivalents (ng/m^2)	Job	Type of Sample	PCB Air Levels (ug/m^3)	Location	PCB Surface Levels (ug/m^2)
Floor/Major Aisle Intersection (Unpainted Cement)	2.2	Oil Transfer	Breathing Zone	5.4	Unpainted Cement Floor/ Center of Area	25,600
		Oil Transfer Coordinator	"	2.9	Floor Ramp(Center)/Outside of Oil Transfer	3,360
		Oil Transfer	"	5.1	Stair Rail/Going to Oil Transfer Office	656
		Oil Transfer Coordinator	"	4.0	Rampway/Between Berms #9 and #3 (Clean Area)	12,160
		Oil Transfer	"	4.4		
Evaluation Criteria	1.0 (NIOSH) 25.0 (NRC)			1.0 (NIOSH)		100 (NIOSH) 1000 (EPA)

ng/m^2 = nanograms of TCDD equivalents per square meter of surface
ug/m^3 = micrograms of PCB per cubic meter of air
ug/m^2 = micrograms of PCB per square meter of surface

Table IV

Surface Concentrations of 2,3,7,8 - Tetrachlorodibenzo-p-dioxin Equivalents
Surface and Airborne Concentrations of Polychlorinated Biphenyls (PCBs)

National Electric, Inc./Oil Transfer Area
Coffeyville, Kansas
HETA 86-510
January 28-29, 1987

Location (ug/m²)	2,3,7,8-TCDD Equivalents (ng/m²)	Job	Type of Sample	PCB Air Levels (ug/m³)	Location	PCB Surface Levels
Receiving Floor/	0.95	Receiving	Breathing Zone	2.0	Receiving Office/Desk Top	136
Midpoint		Receiving	"	4.5	Receiving Area/Center Floor	12,172
(unpainted Cement)		Receiving	"	3.0	Receiving Forklift/Steering Wheel/Levers/Etc.	220
		Receiving	"	3.4	Receiving Forklift/Brake/Clutch/Accelerator/Etc.	450
		Receiving	"	2.2	Receiving Area/Ramp/Midpoint	8,640
		Receiving	"	6.7	Receiving/Ramp by scales	17,520
		Receiving	"		Receiving/Scale Table Top	7,920
					Receiving Office/Door Surface	81
Evaluation Criteria	1.0 (NIOSH) 25.0 (NRC)			1.0 (NIOSH)		100 (NIOSH) 1000 (EPA)

ng/m² = nanograms of TCDD equivalents per square meter of surface
ug/m³ = micrograms of PCB per cubic meter of air
ug/m² = micrograms of PCB per square meter of surface

Table V
Airborne Concentrations of Polychlorinated Biphenyls (PCBs)

National Electric, Inc.
Coffeyville, Kansas
HETA 86-510
January 28-29, 1987

Job/Location	Type Sample	PCB Air Levels (ug/m^3)
Maintenance	Breathing Zone	6.2
Tool Room	"	2.9
Maintenance	"	2.6
Barrel Flushing	Breathing Zone	7.0
"	"	7.4
"	"	11.2
"	"	9.3
Solvent Recovery	Breathing Zone	5.9
"	"	7.0
Barrel Coordinator	Breathing Zone	8.1
" Handling	"	5.1
" "	"	6.3
" Coordinator	"	6.8
" Handling	"	10.0
" "	"	10.3
Top of Pop Machine/ Warehouse Breakroom	Area	2.4
NOP Operator	Breathing Zone	1.6
Solvent Recovery Exhaust	Area	N.D.
Evaluation Criteria		1.0 (NIOSH)

ug/m^3 = micrograms of PCB per cubic meter of air

The limit of detection was 0.14 ug/sample (Aroclor 1242) and 0.07 ug/sample(Aroclor 1254), which would correspond to an atmospheric concentration of less than 0.3 ug/m^3 and less than 0.15 ug/m^3 respectively (sample air volume of approximately 480 liters).

Table VI

Surface Concentrations of Polychlorinated Biphenyls (PCBs)

National Electric, Inc.
Coffeyville, Kansas
HETA 86-510
January 28-29, 1987

Location	PCB Surface Levels (ug/m^2)
Berm #7/Dry Storage/Intersection	19,360
Berm#7/top of Capacitor Assembly	21,850
Barrel Dumping/Epoxy Painted Floor	6,800
Barrel Flusher/Bottom of Leather Boots (Street Shoes)	128
Maintenance Area/Floor/Midpoint	3,680
Tool/Room/Distribution Counter	3,400
Maintenance Hand Cart	148
EA Berm Office/Conference Table	46
" " /Conference Room/Floor	532
" " /Painted Wall	(4)
" " /Stained and Varnished Door	280
Warehouse Breakroom/Lunch-Table Top	152
" " /Top of Sandwich Machine	246
" " /Floor/Unpainted Cement	980
Laboratory/Inside Backdoor/Floor	83
" /Lab Bench/In Front of Bubble Calibrator	24
" /Lab-Desk top/Front of Sample Receiving	180
Main Office/Top of Chris Logelin's Desk	4
" /Chris Logelin's Office Floor	10
" /Reception Area/Center	9
" /Lunchroom/Table top	39
" / " /Top of Pop Machine	134
" / " /Microwave Counter Top	84
Evaluation Criteria	100 (NIOSH) 1000 (EPA)

ug/m^2 = micrograms of PCB per square meter of surface
( ) = Substance was present in trace quantities, between the limit of detection (0.21 ug/sample) and limit of quantitation (0.87 ug/sample).

Table VII
Hydrocarbon Samples/Breathing Zone

National Electric, Inc.
Coffeyville, Kansas
HETA 86-510
January 28-29, 1987

Job	Concentrations (ppm)				
	1,1,1-trichloroethane	Methylene Chloride	Benzene	Toluene	Xylene
Drain and Flush	23.0	0.22	(0.034)	0.06	(0.08)
" "	22.4	0.28	ND	0.09	ND
Barrel Flushing	83.2	1.94	(0.033)	0.39	(0.1)
" "	73.6	0.64	(0.033)	0.51	(0.1)
Solvent Recovery	36.9	0.38	ND	0.06	ND
Drain and Flush	23.8	0.12	ND	ND	ND
" "	25.3	0.06	ND	ND	ND
Barrel Flushing	77.6	0.33	0.072	0.03	ND
" "	71.3	1.15	0.07	0.23	ND
Evaluation Criteria	*350(15 minute ceiling)	LFL	0.1	100	100

ppm = parts per million
LFL = Lowest Feasible Limit. NIOSH recommends that methylene chloride be considered a potential human carcinogen in the workplace.
* = NIOSH recommends that 1,1,1-trichloroethane be treated in the workplace with caution because of its similar chemical structure to other chloroethanes which have been shown to be carcinogenic in laboratory animals.
( ) = Substance was present in trace quantities, between the limit of detection (benzene 0.01 ug/sample, xylene 0.03 ug/sample) and limit of quantitation (benzene 0.02 ug/sample, xylene 0.06 ug/sample).

Table VIII

Airborne Concentrations of PCBs
Airborne Concentrations of 2,3,7,8-TCDD Equivalents

Aptus, Inc.
Coffeyville, Kansas
HETA 86-510
October 5, 1988

Location	PCBs (ug/m^3)	2,3,7,8,-TCDDs (pg/m^3)
Drain and Flush	9.8	0.09
Barrel Flush	6.1	0.02
Shredder	98.1	0.33
A-Damper (Kiln)	0.9	ND
Remediation Building (Ambient Air)	ND	ND
Evaluation Criteria:	(NIOSH) 1.0	(NRC) 10.0

ug/m^3 = micrograms of PCB per cubic meter of air
pg/m^3 = picograms of TCDD equivalents per cubic meter of air
ND = None Detected