HETA 87-122-1881
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GENERAL DYNAMICS, AIRFORCE PLANT #19
SAN DIEGO, CALIFORNIA

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I. SUMMARY

On January 12, 1987, the National Institute for Occupational Safety and Health (NIOSH) received a request from Local 3723 of the American Federation of Government Employees, to evaluate exposure to "...any and all possible toxic substances with particular emphasis on PCBs (polychlorinated biphenyls)" among workers at the General Dynamics Convair Division, Air Force Plant No. 19, building #1, in San Diego, California.

NIOSH investigators visited the facility on February 25 and May 19-20, 1987. Eleven PCB environmental air samples collected for PCBs at various areas within Building #1 had no detectable PCB (less than approximately 0.1 microgram PCB/cubic meter of air - ug/m^3). The NIOSH Recommended Exposure Limit for PCBs is 1.0 ug/m^3. PCB surface concentrations on high and low contact surfaces in the occupied areas ranged from non-detectable to 11 ug/square meter (ug/m^2). These were all below the guideline used by NIOSH investigators for evaluation of PCB contaminated surfaces (50 - 100 ug/m^2). PCB surface concentrations obtained below a leaking transformer (in a non-occupied area) were 1500 and 1600 ug/m^2.

PCB concentrations in 30 blood samples collected from NAVELEX employees for PCB determination were within a range expected for populations not exposed to PCBs. Serum concentrations ranged from 1.10 to 9.66 parts per billion (ppb) PCB, averaging 3.91 ppb.

On the basis of the environmental and biological data collected at this facility, the NIOSH investigators determined that a health hazard from exposure to PCB does not currently exist. However, recommendations to clean areas contaminated with PCBs to reduce the potential for employee contact with PCB-contaminated surfaces near the electrical transformer(s) are made in section VII of this report.

KEYWORDS: SIC 3679 (Electronic Components, not elsewhere classified) Polychlorinated Biphenyl, PCB, Blood-PCB, biological monitoring

II. INTRODUCTION

On January 12, 1987, NIOSH received a request for health hazard evaluation from the business agent for AFGE local 3723. The request was for an investigation of potential occupational exposures among employees represented by the Local at the General Dynamics Convair Division, Air Force Plant No. 19, in San Diego, California. The request was prompted by a CAL/OSHA environmental survey report which indicated PCB surface concentrations as high as 1500 ug/m^2. Also mentioned in the request were an unspecified number of heat treating tanks which were reportedly emitting contaminants into the work environment. Another concern was a civil suit by the U.S. EPA against General Dynamics for improper maintenance and inspection of PCB transformers, including eleven leaks. In summary, the request was for "...any and all possible toxic substances with particular emphasis on PCBs."

An initial site visit was made on February 25, 1987 for observation of the affected areas and employee interviews. A follow-up evaluation was conducted on May 18-19, 1987. Environmental results were distributed in a letter dated July 15, 1987. Biological monitoring results were distributed to participants in December, 1987.

III. BACKGROUND

Air Force Plant No. 19 is located on a 71 acre parcel near the San Diego Airport. It is comprised of three major buildings, plus one smaller, primarily administration building. The three major buildings are large, hangar-type facilities (Figure 1) constructed during the 1940's to support the defense effort during World War II. The facility is occupied by three government organizations and one civilian defense contractor (Convair Division of General Dynamics). One of the government organizations, NAVELEX (Naval Electronics Systems Engineer Center), sub-leases its space from General Dynamics, who in turn rents its space from the Air Force. NAVELEX employs approximately 650 people to provide technical support to the naval fleet by maintaining computer systems, hardware and software configuration control, and installation of various Navy projects at bases or ships.

The primary area of concern identified by the requestor was building #1, which is occupied primarily by NAVELEX. As indicated in Figure 1, this building is extremely large. Observations made during the walk through survey of building #1 on our initial visit revealed:

1. The building was constructed with two upper mezzanine levels.

2. Office space occupies the south end of the building.
3. Several "inner" buildings were constructed on the ground floor to support the NAVELEX technical group (identified as the "SEA NYMPH" laboratory, this area was designated as secret, with limited access).

4. Several electrical transformers were located at the roof level, aligned with the upper mezzanine (two had the wooden floor below them replaced in remediation of leaks; however, oil spots on the new floor indicated a continuing problem).

5. The greatest use of the building (estimated at greater than 95%) was for storage. This included office furniture, fiberous glass molds, various electrical parts, and surplus (vintage) war materials.

6. The metal heat-treating operation was no longer in use, nor had it been used for several months - possibly years. Its primary function was to serve as a backup to a heat-treat operation at another facility.

IV. EVALUATION DESIGN AND METHODS

Discussions with employees and management and observations during the initial site visit indicated a heightened concern for exposures to PCBs, both current and historically. We therefore elected to concentrate our follow-up efforts on determining current PCB exposures through environmental monitoring of workplace air and surfaces for PCBs, plus collection of biological specimens (blood samples) for PCB determination in estimation of historic exposures, which would have occurred prior to the remedial efforts initiated by the EPA.

To determine the potential for dermal exposure to PCBs, 25 "wipe" samples were obtained from various working surfaces and from unoccupied areas near the electrical transformers. These samples were collected using 3" x 3" gauze swatches wetted with 8 milliliters (ml) of hexane, and wiping a 0.25 square meter (m^2) area. Environmental air samples were collected by drawing air through 150 milligram (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 work shift.

For analysis, the florisil tubes were separated into their primary and backup sections. Each section was desorbed in one ml of toluene with sonication of 1/2 hour. The gas chromatographic analysis was performed on a Hewlett-Packard Model 5730A equipped with an electron capture detector and accessories for capillary column capabilities. A 30 meter x 0.31 millimeter fused silica WCOT capillary column coated internally with DB-5 was used with temperature programming from 210ºC (held for two minutes) to 310ºC at a rate of 8ºC/minute. Five percent methane in argon was used as the carrier gas. The injector was operated in the splitless mode of operation. The presence of an Aroclor was determined by comparison with standard samples of Aroclors 1016, 1221, 1232, 1242, 1248, and 1260 obtained from the EPA. Quantitation was performed by summing the peak heights of the five major peaks of the standards and comparing those sums to the same peaks in the sample. Except for differing desorption techniques, analysis of the wipe samples was identical to that of the florisil tubes.[1]

The serum specimens collected from the employees were submitted to the Center for Environmental Health (CEH), Centers for Disease Control (CDC) for serum PCB analyses. All samples were analyzed in July, 1987. The results were reported as Aroclor 1260 due to the match of the gas chromatographic pattern of the sample serum with serum from an animal fed this Aroclor. The analytical method used was essentially that of Burse et al.[2]

V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace 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 workplace 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 workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various

industries where the agents are used; the NIOSH-recommended standards, 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 standard.

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.

POLYCHLORINATED BIPHENYLS

A. Toxicological

Polychlorinated biphenyls (PCBs) are chlorinated aromatic hydrocarbons that were manufactured in the United States from 1929 to 1977 and marketed under the tradename Aroclor[3]. PCBs have been used commercially for a wide variety of purposes, including insulating fluids for electrical equipment, hydraulic fluids, heat transfer fluids, lubricants, plasticizers, and components of surface coatings and inks[4]. Transformer PCBs are designated "Askarel," and typically are mixed with tri- and tetrachlorobenzenes[4,5]. Since the manufacture and use of PCBs in the United States was banned by the Toxic Substances Control Act (P.L. 94-469), occupational exposure has been limited almost exclusively to the servicing and repair of transformers and mining machinery that contain PCBs, and to activities relating to the disposal of PCB-contaminated equipment and waste material.

The different PCB mixtures marketed under the Aroclor trade name are often characterized by a four-digit number (e.g., Aroclor 1242). The first two digits denote the type of compound, with "12" indicating biphenyl, and the latter two digits giving the weight percentage of chlorine, with the exception of Aroclor 1016, which contains 42% chlorine.

Dietary PCB ingestion, the major source of exposure for the general population occurs primarily through eating contaminated 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[6]. 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[7].

The toxicity of PCBs is complicated by the presence of highly toxic impurities, especially the polychlorinated dibenzofurans (PCDFs)[8], which vary in amount between PCBs from different manufacturers[9], and PCBs of different percent chlorination[10], and which are found in increased concentration when PCBs undergo incomplete pyrolysis [11,12]. Also, different animal species, including man, vary in their pattern of biologic response to PCB exposure[13].

Experimental animal studies have shown that PCB exposure may affect the liver, kidney, immune system, reproductive system, and skin. Liver injury was commonly found in the experimental studies[14]. PCB exposures also produced liver cancer in experimental animals[14,15].

Numerous adverse effects on the reproductive system were observed in animal experiments. PCB exposure produced irregular menstrual cycles. Exposure of pregnant animals to PCBs produced reduced fertility, stillbirths, miscarriages, and resorption of fetuses. PCBs were also detected in the milk of nursing mothers. Effects on the fetus from maternal exposures included reduced viability of offspring and lower birth weights[16].

PCBs may be absorbed into the human body by inhalation or through the skin and gastrointestinal system. PCBs may be metablolized in the body to more polar compounds such as hydroxylated derivatives, which may be excreted in bile, urine, and milk. Unmetabolized PCBs may also be excreted in feces and milk. However, excretion is slow, and PCBs may be stored for years in fat tissue, in which they are very soluble. The primary effects that were reported in early studies of exposed workers were chloracne, liver injury, and irritation of the face, eyes, and skin[17].

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[18,19]. Although PCBs were initially regarded as the etiologic agent of Yusho, analyses of the offending cooking oil demonstrated high levels of polychlorinated dibenzofurans and polychlorinated quarterphenyls, as well as other unidentified chlorinated hydrocarbons, in addition to PCBs[20].

The results of various studies of PCB-exposed workers are remarkably consistent[21]. Among the cross-sectional studies of the occupational exposure, a lack of apparent illness in workers with high PCB exposure seems to be the rule. Chloracne was observed among recent studies of workers in Italy[21], but not among workers in Australia[22], Finland[23], or the United States[7,24-26]. Weak positive correlations of PCB exposure or serum PCB levels and serum or plasma levels of aspartate aminotransferase (SGOT)[21,23-25], glutamyltranspeptidase (GGTP)[7,21,25,26], and triglycerides[7,27,28] have been reported. Correlations with plasma triglycerides[29] and with GGTP[30] are also found among community residents with low level PCB exposures. Causality cannot necessarily be imputed to PCBs in these cross-sectional studies.

The International Agency for Research on Cancer (IARC) has concluded that the evidence for PCBs° carcinogenicity to animals and to humans is limited. "Certain polychlorinated biphenyls are carcinogenic to mice and rats after their oral administration, producing benign and malignant liver neoplasms. Oral administration of polychlorinated biphenyls increased the incidence of liver neoplasms in rats previously exposed to N-nitrosodiethylamine"[15].

In a mortality study among workers at capacitor manufacturing plants in the United States[31], a greater than expected number of observed deaths from cancer of the liver and cancer of the rectum were noted. Neither increase was statistically significant for both study sites combined. However, in a subsequent update of this study[32], with follow-up through 1982, the excess in liver/biliary tract cancer was statistically significant (5 observed vs. 1.9 expected), whereas the excess in cancer of the rectum was still elevated but not significantly. In a mortality study among workers at a capacitor manufacturing plant in Italy[33], males had a statistically significant increased number of deaths from all neoplasms. When analyzed separately by organ system, deaths from neoplasms of the digestive organs and peritoneum (3 observed vs. 0.88 expected) and from lymphatic and hematopoietic tissues (2 observed vs. 0.46 expected) were elevated. This study was later expanded to include all workers with one week or more of employment with vital status follow-up through 1982[34]. In the updated results, there was a statistically significant excess in cancer among both females (12 observed vs. 5.3 expected) and males (14 observed vs. 7.6 expected). In both groups there were non-significant excesses in lymphatic/hematopoietic cancer and statistically significant excess in digestive cancer among males (6 observed vs. 2.2 expected).

B. Exposure Criteria

1. Airborne contamination

In February, 1986, NIOSH recommended that exposure to PCBs in the workplace be limited at or below 1 ug/m^3 (based upon the recommended sampling and analytical method in use at the time) determined as a TWA for up to a 10-hour workday, 40-hour workweek. The NIOSH recommended exposure limit (REL) was based on the findings of adverse reproductive effects in experimental animals, on the conclusion that PCBs are carcinogens in rats and mice and, therefore, potential human carcinogens in the workplace, and on the conclusion that human and animal studies have not demonstrated a level of exposure to PCBs that will not subject the worker to possible liver injury[14].

In 1971, the Occupational Safety and Health Administration (OSHA) promulgated its permissible exposure limits (PEL) of 1 mg/m^3 for airborne chlorodiphenyl products (PCBs) containing 42% chlorine and 0.5 mg/m^3 for chlorodiphenyl products containing 54% chlorine, determined as 8-hr TWA concentrations based on the 1968 TLVs of the ACGIH[36]. The TLVs, which have remained unchanged at 1.0 and 0.5 mg/m^3 through 1987, are based on the prevention of liver injury among exposed workers[37]. The OSHA PEL and the ACGIH TLV values include a "skin" notation which refers to the potential contribution to overall exposure by the cutaneous route, including the mucous membranes and eyes, by either airborne or direct skin contact with PCBs.

2. Surface Contamination

NIOSH recommends that occupational exposures to PCBs be minimized to the lowest feasible level. Results of several investigations of PCB surface contamination in office buildings indicate that a "background" level of surface contamination exists, in the range of 50 to 100 micrograms per square meter (ug/m^2)[38-41]. Therefore, for surfaces in the occupational environment that may be routinely contacted with the unprotected skin, NIOSH investigators have recommended that PCB contamination not exceed 100 ug/m^2 (the lowest feasible level considering background contamination).

The risk posed by this level of contamination was assessed by the EPA in its PCB Spill Cleanup policy (40 CFR Part 761)[42]. 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 to 50 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 and 1 in 1,000,000 excess deaths; usually stated in terms of workers with a 30 year work history). Although the EPA document did not provide a risk estimate for the cleanup criteria it established for high-contact indoor surfaces (1000 ug/m^2), it did state, "EPA also believes that the surface standards of 10,000 ug/m^2 for indoor low-contact surfaces (and vaults) and high-contact surfaces in a restricted access industrial facility would not present significant risks to workers or the the general population." However, since there is a considerable degree of uncertainty associated with such a risk assessment calculation, EPA also stated that, "...the results of these [EPA] studies indicate that high-contact surfaces such as manually operated machinery may require surface standards more stringent than the 1000 to 10,000 ug/m^2 standards."

VI. RESULTS AND DISCUSSION

No airborne PCBs were detected on any of the florisil tube samples. Considering the analytical limit of detection (0.05 ug/sample) and the average volume of air per sample (0.460 cubic meters), this corresponds to airborne concentrations of less than approximately 0.1 ug ug/m^3 PCB. Locations of sample acquisition are presented in Table 1.

PCB surface concentrations on "high contact" (i.e. desk tops) items in office areas ranged from non-detectable to 0.6 ug/m^2. Concentrations on low contact items in the office areas (i.e. floors, walls) ranged from non-detectable to 10.7 ug/m^2 (see Table 2). The highest concentrations of surface PCBs, 1500 and 1600 ug/m^2, were obtained in an unoccupied area on the upper mezzanine from an area below a transformer with a history of leaking (column C-16).

The environmental air sampling data indicate that there are no current airborne exposures to PCBs within building #1. The surface data also indicate a low potential for exposure in occupied areas. This assessment included the enclosed "Sea Nymph" laboratory, where concern was expressed for the placement of the fresh air intakes near the roof mounted transformers. Surface sampling inside the fresh air duct and within the laboratory did not reveal PCB contamination.

Thirty individuals with a history of employment in the same areas as the transformers were selected for measurement of serum PCB levels. All thirty had serum PCB values in the range of non-occupationally exposed individuals (less than 20 ppb)[6]. Serum PCB levels among the 30 volunteers ranged from 1.10 to 9.66 ppb, averaging 3.91 ppb.

Results of the biological monitoring showed serum PCB levels within the range expected for the general population, indicating no more than low or non-existent historical exposures within the building.Observation of the areas below the transformers on the upper mezzanine indicate a continued leakage of transformer oil. A review of U.S. EPA reports of investigations of the leaking transformers indicated that all PCB-containing transformers are to be removed or retrofilled. However, in the interim, areas showing visible signs of transformer leakage should be considered controlled areas, requiring limited access and use of appropriate protective equipment when access is required.

As previously discussed, the heat treat operation was not functioning during our evaluation, nor had it been for some time. Therefore, we are unable to comment on either the extent or type of exposures experienced by employees working in other areas of the building during operation. However, based upon CAL/OSHA investigative reports and review of the material safety data sheets from substances used in the process, we would not expect any long-term or chronic health effects as a result of these exposures.

VII. RECOMMENDATIONS

1. Areas visibly contaminated with leaking transformer fluid should be re-evaluated for effectiveness of the previous remediation efforts, and re-cleaned to reduce contamination to acceptable levels. Of particular concern is the area on the upper mezzanine near column C-16, where PCB surface contamination levels of 1500 and 1600 ug/m^2 were measured. In the interim, (although the potential for significant dermal contact with these contaminated surfaces is minimal) it would be prudent to limit access to this area to essential personnel and to require appropriate personal protective articles when access is required, such as monitoring the roof mounted antenna. Disposable Tyvek shoe coverings and disposable gloves should provide adequate protection to the individual and protect against spread or "tracking" of the contamination.

2. If the heat treat operation is restarted, effluents should be directed to the outside through local exhaust ventilation. Based upon employee complaints, passive ventilation (i.e. escape of effluents through the roof mounted louvers) does not appear to be adequate.

VIII. REFERENCES

1. National Institute for Occupational Safety and Health. NIOSH manual of analytical methods. Vol 1, 3rd ed. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1984. (DHHS (NIOSH) publication no. 84-100).

2. Burse VW, Needham LL, Lapeza CR, Korver MP, Liddle JA, Bayse DD. Evaluation of Potential Analytical Approach for Determination of Polychlorinated Biphenyls in Serum: Interlaboratory Study. J. Assoc. Off. Anal. Chem. 1983; Vol.66, No.4.

3. Lloyd JW, Moore RM, Woolf BS, Stein HP. Polychlorinated biphenyls. J Occup Med 1976;18:1O9.

4. Hutzinger O, Safe S, Zitko V. The chemistry of PCBs. Cleveland: The Chemical Rubber Company Press, 1974.

5. Durfee RL. Production and usage of PCBs in the United States. In: Proceedings of the National Conference on Polychlorinated Biphenyls. November 19-21, 1975. Chicago, EPA 56O/6-75-OO4/ United States Environmental Protection Agency, 1976, 1O3.

6. Landrigan PJ. General population exposure to halogenated biphenyls. In: Kimbrough RD, ed. Halogenated biphenyls, terphenyls, naphthalenes, dibenzodioxins, and related products. Amsterdam: Elsevier/North-Holland Biomedical Press, 198O:267.

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

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

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

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

11. Buser HR, Bosshardt HP, Rappe C. Formation of polychlorinated dibenzofurans (PCDFs) from the pyrolysis of PCBs. Chemosphere 1978;7:1O9.

12. Buser HR, Rappe C. Formation of polychlorinated dibenzofurans (PCDFs) from the pyrolysis of individual PCB isomers. Chemosphere 1977;8:157.

13. Vos JG. Toxicology of PCBs for mammals and for birds. Env Health Perspect 1969;21:29.

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

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

16. Kimbrough RD. Laboratory and human studies on polychlorinated biphenyls (PCBs) and related compounds. Environ. Health Perspect. 1985; 59:99-106.

17. Smith AB, Brown, DP. Polychlorinated biphenyls in the workplace. In J.S. Waid (ed.) PCBs and the Environment. Volume 3. CRC Press, 1987, pp 63-82.

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

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

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

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

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

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

24. Fischbein A, Woolf MS, Lilis R, Thornton J, Selikoff IJ. Clinical findings among PCB-exposed capacitor manufacturing workers. Ann NY Acad Sci 1979;32O:7O3.

25. Chase KH, Wong O, Thomas D, Berney BW, Simon RK. Clinical and metabolic abnormalities associated with occupational exposure to polychlorinated biphenyls (PCBs). J Occup Med 1982;24:1O9.
26. Emmett EA, Agnew J, Bleeker ML, Ferrara JM, Levin BK, Jeffreys J, Maroni M. Health effects of PCB exposure of GSA switchgear employees. NIOSH Technical Assistance Request #8O-7, The Johns Hopkins University School of Hygiene and Public Health, Baltimore, Maryland, 1983.

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

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

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

30. Kreiss K, Zack MM, Kimbrough RD, Needham LL, Smrek AL, Jones BT. Association of blood pressure and polychlorinated biphenyl levels. JAMA 1981;245:25O5.

31. Brown DP, Jones M. Mortality and industrial hygiene study of workers exposed to polychlorinated biphenyls. Arch Environ Health 1981;36:12O.

32. Brown DP. Mortality of workers exposed to PCBs. Arch. Environ. Health 1987 (in press).

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

34. Bertazzi PA, Riboldi L, Pesatori A, Radice L, Zocchetti C. Cancer Mortality of Capacitor Workers. Am. J. Ind. Med. 1987; 11: 165-176.

35. National Institute for Occupational Safety and Health. Current Intelligence Bulletin 46-Polychlorinated Biphenyls (PCBs): Potential Health Hazards from Electrical Equipment Fires or Failures. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1986. (DHHS(NIOSH) Publication No,, 86-111).
36. Occupational Safety and Health Administration. OSHA safety and health standards. 29 CFR 1910.1000. Occupational Safety and Health Administration, revised 1980.

37. American Conference of Governmental Industrial Hygienists. Threshold Limit Values and Biological Exposure Indices for 1987-1988 (and supporting documentation). American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio, 1987.

38. National Institute for Occupational Safety and Health. PCB exposures following fluorescent light ballast burnout. Applied Industrial Hygiene 1987; (2)3: p. R-24.

39. National Institute for Occupational Safety and Health (NIOSH). Health Hazard Evaluation Report HETA 86-112-1819, (Commercial Office Building, Santa Fe, New Mexico). Dept. of Health and Human Services, Public Health Service, Centers for Disease Control, NIOSH, Cincinnati, Ohio, 1987.

40. National Institute for Occupational Safety and Health (NIOSH). Health Hazard Evaluation Report HETA 86-472-1832, (Commercial Office Buildings, Boston, Massachusetts). Dept. of Health and Human Services, Public Health Service, Centers for Disease Control, NIOSH, Cincinnati, Ohio, 1987.

41. National Institute for Occupational Safety and Health (NIOSH). Health Hazard Evaluation Report HETA 87-166-1835, (U.S. Post Office Building, Oklahoma City, Oklahoma). Dept. of Health and Human Services, Public Health Service, Centers for Disease Control, NIOSH, Cincinnati, Ohio, 1987.

42. U.S. Environmental Protection Agency. Polychlorinated Biphenyls Spill Cleanup Policy. Title 40, Code of Federal Regulations, Part 761, Subpart G, Sect. 761.120. Federal Register, Vol. 52, No. 63, p. 10688, April 2, 1987

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

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1.	AFGE Local 3723
2.	NAVELEX
3.	NIOSH, Denver Region
4.	OSHA, Region VIII

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

Table 1

AIRBORNE PCB CONCENTRATIONS

NAVELEX
San Diego, California
18-19 May, 1987
HETA 87-122

Sample Number	Location	Concentration
F-1 & 2	TSEE Maintenance Office (Area 2)	ND*
F-2 & 13	4341 System Programmer (Area 4)	ND
F-3 & 15	Guard Station (post 1 in 106 Area); behind Desk	ND
F-4 & 21	Sea Nymph Room; Near Entry Door	ND
F-5 & 14	07 Office Space; West End in Main Aisle	ND
F-6 & 16	07 Office Space; East End in Office	ND
F-7 & 20	06 Office Space; Main Aisle Outside Office 416	ND
F-8 & 17	Upper Mezzanine; Column C-4	ND
F-9 & 19	Upper Mezzanine; Column C-16	ND
F-10	Outside of Building	ND
F-11 & 18	Upper Mezzanine; Column B-19	ND

* ND = Non Detectable Concentration (less than 0.1 ug/m^3)

Table 2

PCB SURFACE CONCENTRATIONS

NAVELEX
San Diego, California
18-19 May, 1987
HETA 87-122

Location	Concentration (ug/m^2)
TSSE Maintenance Office (Area 2); unused desk top	ND*
Debris Surrounding Supply Air Grille for Maintenance Office	0.55**
4341 System Programmer's Office (Area 4); programmer's desk top	ND
Security Post #1; Guard's desk top	Trace***
Security Post #1; floor in front of guard's desk	4.4
Sea Nymph Area; desk top in center of main room	ND
Sea Nymph Area; top surface of antenna chamber	ND
S/7 Computer Operations (Rm 100); desk top near entrance	0.60
07 Office Area; desk top at BG-PHES, Code 71	0.52
07 Office Area; Wang table top at Code 73	Trace
07 Office Area; upper edge of mobile wall partition at Code 73	10.7
07 Office Area; desk top in north area	ND
06 Office Area; desk top in hallway outside office 417	Trace
06 Office Area; desk top in room 405 (Code 65)	Trace
06 Office Area; wall in hallway outside room 405 (Code 65)	ND
Upper Mezzanine; top of aluminum duct above 106 area	120
Upper Mezzanine; top of women's rest room at column C-16	1500

*ND = None Detected
**Not m^2 area; qualitative sample
***Trace = an insufficient amount of PCB was in the sample to meet prescribed limits for accurate quantitation

Cont.

Table 2 (Cont.)

PCB SURFACE CONCENTRATIONS

NAVELEX
San Diego, California
18-19 May, 1987
HETA 87-122

Location	Concentration (ug/m^2)
Upper Mezzanine; floor at column C-16 with visible transformer oil	1600
Upper Mezzanine; inside supply air duct to 106 area	ND
07 Office Area; at bottom of stairs to upper mezzanine (west)	9.2
Upper Mezzanine; access way to roof mounted antenna	100
07 Office Area; wall outside conference room	ND
Upper Mezzanine; hand rail at stairs (west)	1.7
Near 106 area; floor outside guard post #1 office near transformer	5.2
Upper Mezzanine; floor 100' from stairway to 07 office area (west)	24
Administration Building; table top in conference room	1.2


FIGURE 1
AIR FORCE PLANT #19
BUILDING #1