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NIOSH INVESTIGATORS:
Richard W. Hartle, CIH
Fred D. Richardson, M.D., MSPH
Michael S. Crandall, CIH

I. SUMMARY

On July 16, 1986, the National Institute for Occupational Safety and Health (NIOSH) received a request from employees at the Aluminum Company of America (ALCOA) facility in Lafayette, Indiana, for evaluation of potential occupational exposures to polychlorinated biphenyls (PCBs) in the Unit II extrusion area. In the past, ALCOA used PCB-containing hydraulic fluids in their aluminum extrusion presses.

NIOSH conducted an initial site visit in September, 1986, to identify specific health complaints and to obtain limited environmental data toward development of a follow-up survey protocol. A return visit was made in February, 1987, to conduct further environmental monitoring and to collect biological specimens for serum PCB determinations. Environmental air samples collected during this second visit (both breathing zone and general area; N = 14) ranged from 1.1 to 2.0 micrograms per cubic meter of air (ug/m^3). The NIOSH Recommended Exposure Limit (REL) is 1.0 ug/m^3. PCB contamination on "high-contact" surfaces ranged from "trace" concentrations to 900 ug per square meter (ug/m^2). NIOSH investigators have suggested a 50-100 ug/m^2 guideline for PCB surface contamination based upon background levels found in various locations in the U.S. Results of the medical monitoring indicated that serum PCB levels measured in the ALCOA population (0 - 15.9 nanograms/milliliter (ng/ml)) do not exceed those of the normal (non-occupationally exposed) population (0 - 24 ng/ml).[1]

Although results of the biological samples indicate serum PCB levels of extrusion area workers comparable to the normal population, environmental monitoring indicates exposures to airborne PCBs above the NIOSH REL. Recommendations for reducing unnecessary exposures to PCBs in this work environment are made in Section VII of this report. These include appropriate personal protective clothing, and cleanup of the contaminated areas.

KEYWORDS: SIC 3354 (Aluminum Extruded Products) polychlorinated biphenyls, PCBs, serum PCBs.

II. INTRODUCTION

On July 16, 1986, NIOSH received a request for a health hazard evaluation from employees of the Aluminum Company of America, Lafayette, Indiana. The request was for evaluation of exposures to PCBs and a determination of the potential for related chronic health effects among mechanics, electricians, operators, and mill help.

An initial site visit was conducted on September 3-4, 1986, to meet with ALCOA management and employees to better define the areas of concern, identify any specific health complaints, and acquire limited environmental data toward development of an appropriate follow-up survey protocol. A summary of results of the medical interviews and the PCB bulk and surface sampling data collected during the initial visit were reported in letters dated October 2, 1986, and October 27, 1986. A follow-up evaluation was conducted on February 3-5, 1987, which included surface and air sampling for PCBs, employee interviews, and acquisition of blood samples for serum PCB determinations. Results of the environmental and medical monitoring conducted during the follow-up evaluation were distributed in letters dated June 18, 1987.

III. BACKGROUND

ALCOA, at its Lafayette, Indiana, facility produces extruded tubular aluminum. These parts are designed primarily for structural support in a variety of applications, ranging in size from small, thin tubes, to long, angled parts used for the internal structure of aircraft wings. The area under study (Extrusion Unit #II) contained the three largest presses in the facility, requiring a number of employees for operation and maintenance. Other areas of the facility contained smaller presses, generally operated by a single individual.

Extrusion Unit #II consists of three presses; #s 21-23. The process involves pre-heating of aluminum ingots in induction heaters, placement of the ingot into the hydraulically operated presses and application of pressure.

As was common in the 1950s and 1960s, ALCOA introduced a synthetic fire resistant hydraulic fluid which contained PCBs, to minimize the potential hazard of employee burns from spewing, flaming fluid. All hydraulic systems within 50 feet of an open flame or another source of high temperature were supplied with this fluid. A typical press in the Unit II extrusion area (#23) contains (uses) 3500 gallons of hydraulic fluid. Since the late 1970s, ALCOA has undergone a systematic clean and flush of the hydraulic systems and reported that current PCB levels in the hydraulic fluids and coolants are down to 3-4 parts per million (ppm). Levels of less than 1 ppm PCBs were measured in samples of the hydraulic and coolant fluids obtained by NIOSH during the evaluation. However, as determined from our conversations with management representatives and Unit II employees, a history of chronic leakage, malfunctions, and repairs during the time the fluid contained PCBs apparently created a condition of widespread contamination within the facility.

Job titles typical of press work include press operator, assistant operator, press heater (responsible for pre-heating of ingots), lubricator, run out table operator (management of extruded parts), and coiler. These jobs are typically conducted at the floor level surrounding the presses.

The presses are maintained by a pool of approximately 15 maintenance workers, made up of general mechanics, electricians, and laborers. The hydraulic and coolant lines and pumps require maintenance activities both internal to, and below the presses. Below each press is a series of catacombs containing the hydraulic and electrical equipment. These areas are typically soaked with the hydraulic and coolant fluids.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

To determine the potential for dermal exposure to PCBs, a number of wipe samples were obtained from various working surfaces and tools during the initial and follow-up site visits. These samples were collected by using 3" x 3" gauze swatches wetted with 8 milliliters (ml) of hexane, and wiping a 0.25 m^2 area. "Bulk" samples of floor and wall scrapings and hydraulic and coolant fluids were also obtained.

During the follow-up evaluation, environmental air monitoring was conducted during the day shifts of February 4-5, 1987. General area and breathing zone (personal) 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 shift.

For analysis, the florisil tubes were separated into their primary and backup sections. Each 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 equipped with an electron capture detector and accessories for capillary column capabilities. A 30m x 0.31mm fused silica WCOT capillary column coated internally with DB-5 was used with temperature programming from 210° C (held for two minutes) to 310° C at a rate of 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. The NIOSH calculated limit of detection was 0.13 ug/sample, while the calculated limit of quantitation was 0.44 ug/sample.

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 three ml. GC analysis was the same as previously described for the florisil tube samples.

B. Medical

The Unit II extrusion area was considered by ALCOA to be the most heavily PCB-residual contaminated area. Twenty-two persons were identified by ALCOA management as being press workers or having press maintenance responsibilities during the morning (7AM-3PM) shift. Sixteen of these persons (eight operators, five mechanics, two laborers, one electrician) were randomly selected for clinical interviews during the initial visit. There were no visible dermal signs of toxic exposure nor symptoms in this group. The follow-up survey was intended to biologically evaluate employees in terms of serum PCB levels.

To assist in the follow-up evaluation, ALCOA provided a list of personnel that were designated as having work histories primarily associated with either Unit I or Unit II. Personnel from these units were matched to each other by type of work and length of employment in their designated area (Unit). Unit I personnel had an average of 147.7 months of work exposure to the Unit I area. Unit II personnel had an average of 166.6 months of work exposure to the Unit II area. These durations of exposure are statistically equivalent. Seven matched pairs were randomly selected from the above mentioned list. A single volunteer from management was included to represent a "no exposure" category. Each of the fifteen participants completed a brief work history questionnaire and had a sample of blood drawn for serum PCB analysis.

V. EVALUATION CRITERIA

A. Toxicology

PCBs are chlorinated aromatic hydrocarbons that were manufactured in the United States from 1929 to 1977 and primarily marketed under the trade name Aroclor.[2] PCBs 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, have low solubility in water, low flammability and favorable dielectric properties. Additionally, they have low vapor pressure at ambient temperatures and viscosity-temperature relationships which were suitable for a wide variety of industrial applications. PCBs have been used commercially for insulating fluids for electrical equipment, hydraulic fluids, heat transfer fluids, lubricants, plasticizers, and components of surface coatings and inks.[3]

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).

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.[4] 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.[5]

PCBs' toxicity is complicated by the presence of highly toxic impurities, especially the polychlorinated dibenzofurans (PCDFs)[6], which vary in amount between PCBs from different manufacturers,[7] and PCBs of different percent chlorination,[7] and which are found in increased concentration when PCBs undergo incomplete pyrolysis.[9,10] As well, different animal species, including man, vary in their pattern of biologic response to PCB exposure.[11] Two human epidemics of chloracne, "Yusho" and "Yu-cheng," from ingestion of cooking oil accidentally contaminated by a PCB heat-exchange fluid used in the oil's pasteurization, have been described in detail.[12,13] 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.[14]

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,[15] but not among workers in Australia,[16] Finland,[16] or the United States.[5,18-20] Weak positive correlations between PCB exposure, or serum PCB levels, and SGOT [15,17-19], GGTP(5,15,19,20), and plasma triglycerides have been reported.[5,21,22] Correlations between plasma triglycerides[23] and GGTP[24] 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 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"[25].

In a mortality study among workers at two capacitor manufacturing plants in the United States[26] a greater than expected number of observed deaths from hepatobiliary cancer and cancer of the rectum were noted. Neither increase was statistically significant for both study sites combined.

However, in a recent unpublished update of this study, with follow-up through 1982, the excess in liver/biliary tract cancer was statistically significantly elevated (5 observed vs. 1.9 expected), whereas an excess in cancer of the rectum was still elevated but not statistically significant. In a mortality study among workers at a capacitor manufacturing plant in Italy,[27] males had a statistically significant increase in number of deaths from all neoplasms. When analyzed separately by organ system, death from neoplasms of the digestive organs and peritoneum (3 observed vs. 0.88 expected) and from lymphatic and hematopoietic tissues (2 observed vs. 0.46 expected) were elevated. This study was recently expanded to include all workers with one week or more of employment with vital status follow-up through 1982. In the updated results, there was a statistically significant excess in cancer among both females (12 observed vs. 5.3 expected) and males (14 observed vs. 7.6 expected). In both groups there were non-significant excesses in lymphatic/hematopoietic cancer and a statistically significant excess in digestive cancer among males (6 observed vs. 2.2 expected).

B. Occupational Criteria

1. Airborne contamination

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.

NIOSH recommends that airborne exposure to PCBs in the work place be limited to at or below the minimum reliable detectable concentration of 1 microgram of PCB per cubic meter of air (ug/m^3) (using the recommended, published NIOSH sampling methods) determined as a TWA for up to a 10-hr workday, 40-hr workweek. The NIOSH REL was based upon the findings of adverse reproductive effects in experimental animals, on the conclusion that PCBs are carcinogenic in rats and mice and, therefore, potential human carcinogens in the work place, and on the conclusion that human and animal studies have not demonstrated a level of exposure to PCBs that will not subject workers to possible liver injury.[28]

OSHA promulgated its 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 ACGIH TLVs.[29] The TLVs, which have remained unchanged at 1 mg/m^3 and 0.5 mg/m^3 through 1986, are based on the prevention of liver injury in exposed workers. The ACGIH Short Term Exposure Limits (STEL) for airborne chlorodiphenyls are 2 mg/m^3 and 1 mg/m^3 for 42% and 54% chlorine products, respectively. The OSHA PEL and the ACGIH TLV and STEL 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

In July of 1985, an advisory panel was convened to provide guideline recommendations for air and surface cleanup for PCBs, dioxins, and furans for the State Highway Department Building in Santa Fe, New Mexico. Both NIOSH and the EPA were represented on this panel. These guidelines included specifications for PCB concentrations in office areas not to exceed 50 ug/m^2 on "working" surfaces. Examples of working surfaces included "high contact" items such as desk tops and chairs. Although application of these guidelines to the industrial environment is difficult, recommendations by a NIOSH investigator (June 1986) for surfacecleanup of PCBs in an aircraft rework facility proposed 250 ug/m^2 for low-contact surfaces, and 100 ug/m^2 for actual aircraft parts. These criteria were based upon the background levels found in several areas of the country in office environments, and the potential for vaporization/aerosolization of PCBs from contaminated surfaces.

More recently, the Environmental Protection Agency published a spill cleanup policy (April 2, 1987 - 52 FR 10688) which includes discussions of industrial surfaces contaminated from PCB spills occurring after May, 1987 (Appendix A). 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 50 ug/m^2 of PCBs on hard, indoor, high-contact surfaces is between 1×10^{-5} and 1×10^{-6} (between 1 in 100,000 and 1 in 1,000,000; usually stated in terms of workers with a 30 year work history). 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 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 ceilings, 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, the spill cleanup policy Final Rule requires that high-contact and low-contact industrial surfaces be cleaned to only 1000 ug/m^2, or 10,000 ug/m^2 for low-contact, non-impervious surfaces, with encapsulation. The policy does state, however, that high-contact surfaces such as manually operated machinery may require surface standards more stringent than 1000 ug/m^2, based upon results of EPA-sponsored studies.

VI. RESULTS AND DISCUSSION

A. Environmental

During the follow-up evaluation on February 4-5, 1987, one of the three presses in the Unit II extrusion area was not operating due to a scheduled rework (#23 press). Several mechanical difficulties were experienced with the remaining two presses in the area (#s 21 and 22) which resulted in a substantial amount of "down time" during the environmental evaluation. Although this resulted in our inability to collect personal, breathing zone samples from the press operators, we were able to collect breathing zone samples from maintenance workers during repairs of the #22 press. Also, we were able to collect general area samples from stationary locations near press control panels, which represent locations where the press operators would spend the majority of their time.

Four personal, breathing zone samples were collected from maintenance employees during repairs of the #22 press. Time-weighted average exposures ranged from 1.1 to 1.6 ug/m^3, averaging 1.4 ug/m^3 (Table I). Four general area samples collected at the control panels of the #21 and 22 presses ranged from 1.5 to 2.0 ug/m^3, averaging 1.8 ug/m^3. Six full-shift area samples collected from the maintenance pits below the two presses ranged from 1.3 to 2.0 ug/m^3, averaging 1.6 ug/m^3.

Surface samples were collected near the presses, in the break/lunch areas, from personal items of the employees, and from other plant areas including the Unit I extrusion area, the locker room, and the administrative offices (Table II). Of 16 surface samples collected within the Unit II area from "high-contact" surfaces (surfaces which can be repeatedly touched with unprotected skin), contamination levels ranged from "trace" quantities (detectable, yet below the amount required for accurate quantitation) to 900 ug/m^2. Three samples collected from tools used on/near the presses (hammer, wrench, and scraper handles) ranged from 829 to 2590 ug/m^2. Two samples collected from the floor in the lunch/locker room for the maintenance mechanics were reported at 636 and 2632 ug/m^2. Samples from floors near the presses were reported at 39,000 and 58,000 ug/m^2.

Bulk samples of several materials were collected in September 1986 for PCB determinations, including surface sludge from various locations, hydraulic and cooling fluids, and operator's gloves (Table III). The hydraulic and cooling fluids were reported at less than 1 ppm. Six samples of surface sludge from floors near the presses and on items in the press pits ranged from 19 to 640 ppm. Two samples of cotton gloves used by press operators were reported at 36 and 160 ppm.

B. Medical

All 15 participants had measured serum PCB values in the range of non-occupationally exposed (0-24 ng/ml). The Unit I and Unit II personnel had an average of 147.7 months and 166.6 months of work exposure respectively, per person, in these distinct work areas. These durations of exposure are statistically equivalent. Serum PCB levels for persons included in the clinical survey are listed in Table IV, excluding the data for the single management representative. Pursuit of the answer to the pre-survey concern about a possible difference in PCB exposure between Unit I and Unit II personnel (in terms of serum PCB levels) was still pursued despite the aforementioned serum PCB results. It was still possible to have high-normal PCB levels among some of the employees versus low-normal levels in others, the difference potentially accounted for by a difference in work exposure. In comparing Unit I versus Unit II personnel serum PCB levels:

1. Unit I personnel had a mean Aroclor 1242 serum level of 4.43 nanograms /milliliter (ng/ml), and the Unit II personnel had a mean Aroclor 1242 serum level of 5.50 ng/ml.

2. Unit I personnel had a mean Aroclor 1260 serum level of 10.12 ng/ml, Unit II personnel had a mean Aroclor 1260 serum level of 6.86 ng/ml.

Neither of the above listed differences in mean PCB levels is statistically significant. A possible explanation for the lack of difference in measurable serum PCB levels between the two groups is that Unit I and Unit II personnel are statistically indistinguishable in terms of duration of exposure to Unit II by self-reported work history. Therefore, mean PCB levels (mPCB) ((Aroclor 1242 + 1260)/2) for all participants were compared against each other. In this comparison we found no association between duration of Unit II exposure and serum PCB (r=.1).

The mPCB for each type of employee designation represented in the sample group (press operators, laborers, electricians, maintenance/general mechanics) is listed in Table V, excluding the single individual from management. There are no significant differences in mPCB between any of the groups, for either Aroclor.

C. Discussion

Experimental work in laboratory animals suggests that aerosolized PCBs are rapidly absorbed in the lung, with little alveolar deposition, followed by hepatic uptake. A plateau in hepatic absorption can be reached in the case of high air concentrations with subsequent redistribution to high fat content tissues and excretion with solid waste. There is very little urinary loss of unmetabolized PCBs.[29] Measured serum level is subject to variability due to PCB dose on the date of measurement, individual metabolic rate, and systematic (laboratory) variation. Serum samples drawn on February 4, 1987, were obtained in the morning and as such may not reflect peak PCB circulatory levels for that particular day.

All full-shift air samples (both breathing zone and general area) collected in the Unit #II extrusion area (N=14) were above the NIOSH REL for PCBs of 1 ug/m^3. The small range of airborne concentrations (between 1.1 and 2.0 ug/m^3) and the relatively large distances between sample locations, suggest no single point source of exposure;

vaporization/aerosolization from the wide-spread surface contamination is the most likely source. Although bulk sample analysis of the current coolant and hydraulic fluids revealed less than 1 ppm PCB content, historic leakage of the PCB-containing hydraulic fluid apparently resulted in significant surface contamination. Although PCBs have relatively low vapor pressures and tend not to volatilize, the large size of the contaminated surfaces undoubtedly contributes to airborne PCBs. Also, PCB-contaminated press surfaces which become hot during operation will also result in PCB vaporization.

Air samples collected in the Maintenance Mechanic's lunch/locker room were reported as "trace" quantities (quantities above the analytical limit of detection, yet of insufficient amounts for accurate quantitation).

Surfaces which receive repeated contact are of particular concern. Wipe samples collected from these types of surfaces in the Unit II area (i.e., work bench, control panel, stair rail, etc.) had considerable variation in surface PCB contamination (29 - 900 ug/m^2). As presented earlier, the EPA has estimated the risk of developing cancer from repeated exposure to 50 - 100 ug/m^2 on high-contact industrial surfaces to be between 1 in 100,000 and 1 in 1,000,000.[30] Although NIOSH offers no judgement as to whether this is an acceptable risk (i.e. the NIOSH policy for suspect occupational carcinogens such as PCBs is to control exposures to the fullest possible extent) 50 - 100 ug/m^2 does appear to be close to "background" PCB-contamination levels found in several areas of the United States, using the same surface wipe procedures as used within the ALCOA facility[31,32]. Therefore, reducing contamination levels on the high-contact surfaces to 50-100 ug/m^2 would essentially control exposures from this route (skin contact) to the "fullest possible extent." As discussed earlier, vaporization from contaminated surfaces (including low-contact) is undoubtedly contributing to airborne exposures. Decontamination of these surfaces, particularly surfaces which become heated during the extrusion process, should result in lowered airborne exposures. Surface sampling of the # 23 press, which was recently cleaned and repainted during the scheduled rework, should indicate the degree of decontamination afforded by this type of procedure.

The efficiency of the PCB wipe methods used during this evaluation is not known. Because of the use of a solvent, it is obvious that this method does not represent the actual amount of PCB available to, or absorbed by, skin contact of contaminated surfaces. Rather, this wipe procedure is used to determine relative levels of contamination. It should be noted that considerable variation can be expected between investigators (using the same procedure), and where variations to the procedure are used (i.e. use of Whatman smear tabs rather that gauze, or use of dry vs. wet wipes). Therefore, surface contamination data should be interpreted in terms of relative concentrations, and used as a guide toward identifying areas which should receive remedial efforts.

The feasibility of cleaning the high-contact, hard, smooth surfaces near the extrusion area (i.e. control panels, work benches) to a level of 50 - 100 ug/m^2 is demonstrated by the PCB-surface concentrations on the lunch/break tables adjacent to the presses ("trace" to 52 ug/m^2). These tables reportedly receive routine cleaning with typical janitorial cleaners. However, any decontamination effort should involve a surface sampling program, to determine effectiveness.

Surface samples obtained from four tools used in the extrusion area ranged from 308 ug/m^2 on a small wrench, to 2590 ug/m^2 on the wooden handle of a scraper used to clean sludge in a press pit. Although this is a quite limited set of data from hand tools in the extrusion area, it does indicate the potential for substantial surface contamination on these instruments.

Two surface samples from floors in the extrusion area were reported at 39,000 and 58,000 ug/m^2, indicating a relatively high level of surface contamination on the walkways surrounding the presses. The floors are constructed of pitch impregnated wooden blocks. In areas directly adjacent to the presses, they are covered with corrugated aluminum. In most areas near the presses, a layer of grease/sludge is present on the floor surfaces, as is the case on most all surfaces in the pit areas. Although the degree of success resulting from encapsulation has not been well documented, nor have encapsulant materials been evaluated, this option may prove useful in areas surrounding the presses.

The PCBs on surfaces in the press areas were identified as Aroclor 1248 and 1254, whereas the airborne PCBs were reported as Aroclor 1260. The difference in the PCB content in air versus that on surfaces is believed to be due to a phenomena known as PCB enrichment, where the vapor phase is enriched with lower chlorinated homologues (exhibiting relatively higher vapor pressures) relative to the mixture on the surface.

Although the biological monitoring indicates that blood-PCB levels are within the range of those found in non-occupationally exposed persons, environmental monitoring has indicated airborne PCB concentrations above the NIOSH REL. This occupational exposure presents an unnecessary risk, and in the opinion of the NIOSH investigators it should be eliminated.

VII. RECOMMENDATIONS

1. The only long-term solution for reduction of PCB exposures experience by Unit II extrusion area employees is decontamination of the area.

    a. Due to the various types of surfaces present in the areas, pilot studies will be necessary to demonstrate effective cleanup/decontamination techniques. Although little data are available on the use of encapsulants for contamination control, this option may prove useful in some areas of the facility.

    b. A post-decontamination sampling protocol (both surface and air) will be required to ensure effectiveness.

    c. Stringent controls should be implemented to protect against recontamination of cleaned areas during the cleanup effort, particularly through tracking of PCB contaminated materials.

2. Cleanup of the contaminated surfaces should reduce airborne contamination to acceptable levels. However, a monitoring program should be instituted to assure that airborne exposures are below acceptable levels (NIOSH REL for PCBs = 1.0 ug/m^3). If a decontamination program is not successful in reducing airborne exposures and PCB concentrations remain above 1.0 ug/m^3, the Unit II extrusion area should be made a mandatory respirator area, and employees provided organic vapor cartridge respirators with a dust prefilter. Considering the airborne concentrations measured during our investigation, it is the opinion of the NIOSH investigator that this type of respirator, if properly worn, will reduce worker exposure to or below the NIOSH REL. If it is determined that respirators are required, the program must comply with OSHA regulations 29 CFR 1910.134.

3. Two glove samples (portions of the index finger) were obtained from press operators and analyzed for PCB content. Results were reported at 36 and 160 ppm. Cotton gloves do not provide protection against permeation of PCB laden materials. Absorption of the PCB-laden oils through the cotton material and retention of the oils against the skin is perhaps worse than no protection. Studies on PCB-breakthrough times of selected materials indicate that vitrile, viton, viton SF, butyl, nitrile, and neoprene materials afford the highest level of protection. Reference to this study is recommended.[35] Selection of gloves should include consideration of the job, durability of the material, and type of PCB-laden material encountered

4. Access to the Unit II extrusion area should be limited to essential personnel. In addition to other protective items mentioned, these employees should be provided with company laundered coveralls, and a "clean side/dirty side" locker room concept (including shower facilities) should be instituted upon arrival and upon leaving the facility.

5. Any tools used on or near the presses in the Unit II area should not be used in any other area of the facility, including general cleanup equipment such as brooms and mops. Any personal items, including hand tools should be thoroughly cleaned prior to leaving the premises.

6. The medical department should maintain an awareness of trends in industrial hygiene PCB sampling data.

7. Perform annual SMA-12s; evaluation of abnormalities should include PCB exposure in the differential diagnosis.

8. Consumption of food in the extrusion area should be discontinued, and smoking should be discouraged.

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IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by: Richard W. Hartle, CIH
Fred D. Richardson, M.D., MSPH

Acknowledgements: Michael S. Crandall, CIH (environmental)
Joyce Jenkins (Analytical)

Originating Office: Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations, and Field Studies

Report Typed By: Kathy Conway
Clerk-typist
Industrial Hygiene Section

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1. ALCOA
2. ABGWIU, Local 115
3. NIOSH Cincinnati Region
4. OSHA, Region V

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
AIRBORNE PCBs
ALCOA
LAFAYETTE, INDIANA
HETA 86-445
February 4-5, 1987

Operation/Location	Date	Volume (l) (ug/m3)	Concentration
Personal (Breathing Zone) Samples			
Laborer/#22 Press	2/04/87	393	1.35
Maintenance Mechanic/#22 Press	2/04/87	459	1.10
Mechanical Apprentice/#22 Press	2/04/87	406	1.58
Maintenance Mechanic/#22 Press	2/05/87	445	1.42
General Area Samples			
Control table/#22 Press	2/04/87	415	1.61
Control table/#22 Press	2/05/87	436	1.88
Front pit near elec. motors/#22 Press	2/04/87	398	2.04
Front pit near elec. motors/#22 Press	2/05/87	464	1.75
Rear pit near ram/#22 Press	2/04/87	112*	trace**
Rear pit near ram/#22 Press	2/05/87	425	1.55
Control panel/#21 Press	2/04/87	386	1.50
Control panel/#21 Press	2/05/87	446	2.00
Front pit below controls/#21 Press	2/04/87	382	1.28
Front pit below controls/#21 Press	2/05/87	417	1.49
Rear pit near ram/#21 Press	2/04/87	374	1.36
Lunch table/Area for Mechanics	2/04/87	327	trace
Lunch table/Area for Mechanics	2/05/87	448	trace

*Environmental sampling pump malfunction resulted in small sample volume.
**Values in parentheses represent "trace" concentrations which are of an insufficient amount to meet prescribed limits for accurate quantitation .

TABLE II
SURFACE SAMPLE RESULTS FOR PCBs
ALCOA
LAFAYETTE, INDIANA
HETA 86-445
September 3-4, 1986 / February 4-5, 1987

Location (surface type)	Concentration (ug/m^2)
September 1986	
Lunch table near #23 press (smooth aluminum)	16
Table near control panel at #23 press (painted metal)	56
Horizontal surface of #23 press near control panel (painted metal)	184
Work bench aprox. 20' from #22 press (painted metal)	44
Lunch table near #22 press (smooth aluminum)	Trace*
Control panel for butt shear at #22 press (smooth aluminum)	670
Work bench at #21 press (painted metal)	29
External surface of lunch pail stored near #21 press (plastic)	14
Lunch table near #21 press (smooth aluminum)	8
Gear box at #8 press (painted metal)	17
Floor of men's locker room; main isle near locker #803 (concrete)	92
Floor of Administrative offices; entry to plant in stair well (tile)	3
Desk top in Administrative offices; 1st floor (formica)	2
February 1987	
#21 Press lunch table (smooth aluminum)	52
Mobile maintenance cart (smooth aluminum)	168
2" wrench in #21 pit (smooth metal)	308
Hand rail on stairs to #21 pit; rear area near ram (painted metal)	900
Floor near water fountain at #21 Press (treaded aluminum)	58000
Lunch table at #22 Press (smooth aluminum)	52
Floor near #22 press (corrugated aluminum)	39000
Hammer handle (4.7"x11.5") from maintenance cart near #22 press (wood)	829
Tow fork steering wheel (1/2 of round, plastic wheel)**	45
Scraper handle (4.7"x40"); front area of #22 pit (wood)	2590
Wrench handle (3"x30"), front area of #22 pit (metal)	2359
Lunch table in area for maintenance mechanics (smooth aluminum)	12
Floor in area for maintenance mechanics near lunch tables (concrete)	2632
Floor in area for maintenance mechanics near lockers (concrete)	636
Bench in area for maintenance mechanics near lockers (painted wood)	7
Locker in area for maintenance mechanics (painted metal)	10

* "trace" concentrations were are of an insufficient amount to meet prescribed limits for accurate quantitation .
**Not in ug/m^2 meter

TABLE III
BULK SAMPLE RESULTS FOR PCBs
ALCOA
LAFAYETTE, INDIANA
HETA 86-445
September 3-4, 1986

SUBSTANCE/LOCATION	Concentration (ppm)	(Aroclor)
Sludge build-up on fan guard/#23 press pit	640	(1248)
Hydraulic fluid/fluid level indicator - #23 press pit	ND*	(----)
Surface sludge/stair well in #23 heater pit	55	(1248)
Surface sludge/north wall - #22 press pit	380	(1248)
Water-based hydraulic fluid/obtained from leak in #22 pit	0.6	(1248)
Surface sludge/#22 press butt shear (adjacent to wipe sample)	260	(1248)
Glove/worn by asst. heater op. 3 days at #22 press	160	(1248)
Surface sludge/motor in #21 pit during repair	19	(1254)
Surface sludge/floor in #21 press pit	170	(1248)
Glove/worn by asst. op. at #21 press	36	(1248)

*ND = non-detected

TABLE IV

SERUM PCBS IN ALCOA PERSONNEL*
ALCOA
LAFAYETTE, INDIANA

HETA 86-445
February, 1987

Unit 1			Unit 2	
Aroclor 1242	Aroclor 1260	(ng/ml)**	Aroclor 1242	Aroclor 1260
4.08ng/ml	10.5ng/ml		11.3	15.9
6.69	14.4		3.39	3.8
7.32	14.0		5.37	5.65
3.07	8.08		5.09	7.53
2.24	8.25		6.67	8.23
4.38	10.80		3.62	3.19
3.26	4.81		3.44	3.73

*management representative excluded.
**ng/ml = nanogram/milliliter

TABLE V

MEAN SERUM PCB LEVELS IN ALCOA PERSONNEL GROUPINGS*
ALCOA
LAFAYETTE, INDIANA

HETA 86-445
February, 1987

Personnel Group (number)	Aroclor 1242 (ng/ml)**	Aroclor 1260
Press Operators (2)	4.38ng/ml	4.73ng/ml
Laborers (2)	3.67	7.89
Electricians (2)	3.67	7.66
Maintenance/Gen. Mechanic (8)	5.37	7.68

*management representative excluded.
** ng/ml = nanogram/milliliter