V. WORK PRACTICES

The employment of good work practices is required if hazardous occupational exposures to PCBs are to be prevented. The carcinogenic, teratogenic, dermatologic, and fetotoxic effects of PCBs largely determine the nature of necessary work practices.

(a) All locations where occupational exposure to PCBs occurs should be established as regulated areas and posted with signs warning persons of the procedures necessary upon entering or leaving.

When an otherwise closed PCB system is opened, eg, during the loading and unloading of storage tanks, the following work practices are desirable:

(1) Only authorized personnel should be permitted in the area;

(2) Adequate ventilation should be provided and the exhaust air should not be discharged into any environment until it has been adequately decontaminated;

(3) To prevent skin contact with PCBs, workers should be required to wear and use PCB-resistant protective clothing and equipment, including respirators.

(4) Upon leaving regulated areas, workers should be required to remove such protective clothing and equipment and place it in impervious containers pending either decontamination or disposal;

(5) After removing such protective clothing and equipment, workers should be required to wash their hands, forearms, and faces, and to shower after the last exposure of the day.

Whenever a worker must come into direct contact with PCBs, eg, during cleanup of spills or maintenance of vessels, PCB-resistant protective clothing and an appropriate respirator must be worn.

(b) Leakage and Spill Procedures

PCB spills are to be cleaned up promptly, either by the use of sorbent materials, such as sawdust, or by trapping and removal through pumping or other suitable means. In case of spillage of PCBs on clothing, the contaminated clothing should be removed as soon as practical, the skin should be thoroughly washed, and the clothing should be laundered or disposed of properly. Facilities and procedures for such cleanup must be provided at manufacturing facilities producing capacitors and transformers, because spills of PCBs are quite likely to occur during the filling and handling of such devices. Users of PCB-filled transformers should inspect them periodically for leakage. If leakage is found, the cause should be corrected and the spillage should be soaked up with sawdust or other absorbent material. The leak area should be cleaned finally with rags soaked with an appropriate safe solvent. Leaky transformer gaskets can be sealed temporarily by painting over the leaky area with epoxy cement. Refer to Transformer Askarel Inspection and Maintenance Guide [25], and Guidelines for Handling and Disposal of Capacitor and Transformer Grade Askarels Containing Polychlorinated Biphenyls [4] for further maintenance procedures.

(c) Emergencies

In emergencies, immediate measures must be taken to eliminate hazardous conditions. Non-essential workers must be evacuated until the emergency no longer exists. Any worker having visible contamination of the skin with PCBs must shower immediately unless other action is warranted.

(d) Respiratory Protection

To ensure against inadvertent exposure to PCBs, workers' respirators must be properly selected, fitted, and maintained. A guide to industrial respiratory protection [286] has been developed which contains sufficient information to enable the establishment and maintenance of a respirator program that meets the requirements outlined in 29 CFR 1910.134. The guide [286] includes information on respirator selection, use, maintenance, and inspection, as well as a complete description of various types of respirators and their advantages and limitations, respirator fitting procedures, wearer training instructions, and physiologic and psychologic constraints on respirator use.

Several NIOSH studies [287-289] have shown that respiratory protection may be inadequate in many occupational situations, eg, abrasive blasting, coal mining, and paint spraying. For this reason, respirators are generally regarded by NIOSH as a type of control to be used only where engineering controls cannot be used, made adequate, or provided.

VI. DEVELOPMENT OF STANDARD

Basis for Previous Standards

In 1942, the Subcommittee on Threshold Limits of the National Conference of Governmental Industrial Hygienists compiled a list of maximum permissible concentrations of atmospheric contaminants recommended by various state industrial hygiene units [290]. The eight states that made recommendations for PCBs (chlorodiphenyls) were unanimous in recommending 1 mg/cu m. No basis for the recommendations was given.

.Cook [291], in his 1945 listing of Maximum Allowable Concentrations of Industrial Atmospheric Contaminants, cited PCB standards for California and Utah of 1 mg/cu m and Oregon of 0.3 mg/cu m. He [291] also cited unofficial guidelines for Massachusetts of 5 mg/cu m and for New York of 1 mg/cu m and he recommended 1 mg/cu m, based on the report of Drinker [132].

The American Conference of Governmental Industrial Hygienists (ACGIH) began listing PCBs (chloro di phenyl) with "toxic dusts, fumes and mists" in its recommendations of maximum allowable concentrations of air contaminants for 1946 [292]. It compiled its 1946 list from its 1942 list [290] and from Cook's [291] list, and continued to recommend 1 mg/cu m for PCBs.

The ACGIH continued to recommend 1 mg/cu m for PCBs (chlorodiphenyl) until 1956 when it specified 1 mg/cu m as the limit for PCBs with 42% chlorine and proposed a limit of 0.5 mg/cu m for PCBs with 54% chlorine [293]. Each recommendation was clearly defined as a threshold limit value (TLV) for an 8-hour TWA concentration to which it was "felt" workers could be repeatedly exposed without adverse effect on their health.

In 1961, the ACGIH added the notation "skin" to the TLV of those substances, including PCBs, which in liquid form can penetrate the skin to cause systemic effects [294,295].

In 1962, the ACGIH published documentation of its TLV recommendations [296]. Based on information in the reports of Schwartz [123], Drinker et al [125], Meigs et al [190], and Treon et al [203], the ACGIH [296] concluded that for PCBs chlorinated to 42%, 1 mg/cu m would seem to offer reasonably good protection against severe systemic toxicity but may not guarantee complete freedom from chloracne. They also cited the information [207] that PCBs could be absorbed through the skin, causing fatty degeneration of the liver. In documenting its recommendation for PCBs containing 54% chlorine, the ACGIH [296] cited Drinker et al [125], Drinker [132], and Treon et al [203], and on the basis of these reports it [296] considered that 0.5 mg/cu m appeared to be reasonable for repeated occupational exposures.

The American Industrial Hygiene Association's Hygienic Guide "Chlorodiphenyls (containing 42% and 54% chlorine)" [297], published in 1965, adopted the ACGIH recommendations for time-weighted average exposures and suggested a short-exposure tolerance for PCBs of 10 mg/cu m to prevent unbearable irritation, based on the report of Elkins [130]. The Hygienic Guide [297] provided information that minimum lethal doses applied to the skin of rabbits for 24 hours were 1 g/kg for PCBs containing 42% and 1.5 g/kg for PCBs containing 54% chlorine. It also recommended avoiding prolonged or repeated skin contact, and it recommended laundering of contaminated clothing before reuse, protecting the eyes from liquid splashes, treatment of the eyes if PCBs were splashed into them, and periodic examinations to detect early evidence of skin irritation or liver damage.

In 1970, the International Labour Office published permissible levels of toxic substances for several nations [298]. The PCB standards for six nations are given in Table VI-1.

TABLE VI-1

PERMISSIBLE LEVELS OF PCBs FOR SIX NATIONS

Country	Standard (mg/cu m)	Type of Standard
Czechoslovakia		
42% Chlorine	1.0	MAC
54% Chlorine	0.5	"
Finland		
42% Chlorine	1.0	MAC 8-hour
54% Chlorine	0.5	"
Poland	0.1	MAC
Romania		
42% Chlorine	1.0	"
54% Chlorine	0.5	"
USSR	1.0	"
Yugoslavia		
42% Chlorine	0.5	"
54% Chlorine	0.5	"

Adapted from reference 298

In 1975, Winell [299] compiled a list of international occupational hygienic standards for chemicals, including "chlorodiphenyl." She listed values for Sweden of 0.5 mg/cu m and for the German Democratic Republic of 1.0 mg/cu m. In both countries the standards were the same for PCBs containing 42% and 54% chlorine. The standards listed for the Federal Republic of Germany were 1.0 mg/cu m for PCBs containing 42% chlorine and

0.5 mg/cu m for those with 54% chlorine, respectively.

The TLV documentations for PCBs published by the ACGIH in 1976 [300] did not differ significantly from the original documentations [296]. However, the ACGIH [300] recalled, citing von Wedel et al [205], that several deaths due to liver atrophy occurred among workers exposed to fumes of chlorobiphenyls and chloronaphthalenes, but pointed out that relatively few, if any reports had appeared of sytemic poisoning of workers exposed only to fumes of PCBs.

The ACGIH has retained a TWA of 1 mg/cu m as the TLV for PCBs with 42% chlorine content and a TWA of 0.5 mg/cu m as the TLV for those with 54% chlorine content (through 1976) [301]. However, a tentative short-term exposure limit (TLV-STEL) was added to the recommendations in 1976. STEL is defined by ACGIH [299] as the maximum concentration to which workers can be exposed for up to 15 minutes continuously without suffering from irritation, chronic or irreversible tissue change, or narcosis of sufficient degree to increase accident proneness, impair self-rescue, or materially reduce work efficiency. According to the ACGIH [301], the STEL is to be considered a maximum allowable concentration, or absolute ceiling not to be exceeded at any time during the 15-minute excursion period; such excursions are not to occur more than 4 times a day and there must be at least 60 minutes between them. The STEL recommended for PCBs was 1 mg/cu m regardless of the degree of chlorination. This recommendation was made on the basis that the TLV documentation for PCBs [300] suggested that the values should be ceilings never to be exceeded, rather than TWA values for 8 hours of exposure [301].

The 1968 ACGIH recommendations [302], adopted as the federal standards for PCBs (29 CFR 1910.1000, Table G-1) are TWA 8-hour exposure concentrations of 1.0 mg/cu m for mixtures containing 42% chlorine and 0.5 mg/cu m for mixtures containing 54% chlorine.

Basis for the Recommended Standard

(a) Permissible Environmental Limit

The major effects that have been found in workers exposed to PCBs are chloracne [186-191,195,196], liver injury [190-193,196], and irritation of skin and mucous membranes [192,196,197]. Exposures at peak PCB concentrations of 5-10 mg/cu m have been reported as "unbearably" irritating [130].

Chloracne has been reported after occupational exposure to Aroclors 1242 [196] and 1254 [186], and to various Kanechlors [191,192,194,195], as well as after ingestion of Kanechlor 400 [146,153]. Chloracne has frequently been associated with processes where the PCBs were heated [186-189,196]. The methodology in most of the exposure studies did not differentiate between vapor and particulate forms of the PCBs [186,190,196]. In one study of Kanechlors in capacitor manufacturing plants where chloracne was common, vapor (or small particulate) concentrations (0.095-0.95 mg/cu m) exceeded particulate concentrations (0.02-0.65 mg/cu m) [191]. In another capacitor plant where heated Aroclor 1254 was used, exposure concentrations were 5-7 mg/cu m, but the vapor components were not seperately determined [186]. In this plant, chloracne developed among workers after 4-8 months of exposure. A study of workers, in a plant where the work situation indicated the exposures were to PCB vapors, showed that chloracne developed after a minimum of 5 months and an average of 14 months of exposure [190]. In this study, exposure concentrations of an undefined PCB were reported as 0.1 mg/cu m. In other studies where PCB concentrations were not measured, chloracne developed after 3-8 months of exposure [187,189].

These data show that chloracne can develop after prolonged exposures to PCBs in concentrations as low as 0.1 mg/cu m, and that as the PCB exposure concentrations increase, the duration of exposure required for the development of chloracne decreases. The data also indicate that PCBs in the vapor phase may contribute substantially to development of chloracne. However, they do not prove that only PCB vapors cause chloracne. Particulate PCBs have been shown to be absorbed from inhaled air by experimental animals [97], and ingested PCBs have caused chloracne [146,153]. Occupational exposure to a variety of PCB mixtures (Aroclors 1242, and 1254, various Kanechlors, and others) has caused chloracne, and no commercial PCB mixture has been shown to have more or less chloracnegenic properties than others.

There are some studies of PCB workers in which chloracne was not found [197-199]. In one of these studies, the Aroclor 1242 concentrations were imprecisely reported [198] and in the others the PCB mixtures were undefined [199]. The report by Levy et al [197] gave possible PCB exposure concentrations of 0.013-0.264 mg/cu m and breathing zone concentrations of 0.014-0.073 mg/cu m. Thus the data indicate that chloracne may be prevented by keeping PCB exposures below 0.1 mg/cu m (100 µg/cu m).

In some of the studies where chloracne developed, signs of liver injury were not found [186,194,195], but in the majority of studies where chloracne was found, there were also indications of liver injury [190-193,196]. Evidence of impaired liver function was found by other investigators [197] in a study where workers had not developed chloracne. Meigs et al [190] found evidence of slight liver injury in workers exposed to PCBs at 0.1 mg/cu m, and Levy et al [197] found historical evidence of liver injury in the medical records of workers in the plant where they found exposures were <0.25 mg/cu m. Among the findings in these medical records were elevated serum triglycerides [197]. Abnormal serum triglycerides have been found in exposed workers by others [191-193], and in the Japanese people who accidentally consumed PCBs [155,157,158,175,179-181]. The effect on serum triglycerides in workers was related to duration of exposure [193] and, in the workers and in the Yusho patients, to residual PCBs in the blood [175,180,193]. In the Japanese workers who were removed from exposure, the effect remained for at least 2 years [193].

Other indications of liver injury in exposed workers included occasional findings of elevated serum enzyme activities, and abnormalities in various other liver function tests [190,191,196,197]. A level of exposure at which liver injury will not occur is not indicated by the occupational exposure studies, since evidence of liver injury has been found in the occupational studies with the lowest PCB concentrations. It is not possible to determine whether liver injury occurred with exposures at the lower levels of all the occupational exposure ranges reported, but to protect workers from any liver injury it seems that exposures should be maintained below 0.01 mg/cu m (10 µg/cu m).

Animal experiments do not demonstrate a safe exposure level either. Although Treon et al [203] found no evidence of liver injury in experimental animals (rabbits, guinea pigs, cats, rats, and mice) exposed to Aroclor 1242 at concentrations of 1.9-8.6 mg/cu m for up to 31 weeks, Ouw et al [196] found evidence of liver injury in workers exposed to Aroclor 1242 at 0.32-1.44 mg/cu m. In their experiments with Aroclor 1254, Treon et al [203] found microscopic evidence of liver injury in animals exposed at 1.5 mg/cu for 31 weeks. Linder et al [228] found increased liver weights in rats fed Aroclor 1254 at 1 ppm for two generations. The intake of PCBs at this dietary level can be compared to the intake from inhalation exposure at about 0.1-0.2 mg/cu m; thus, the animal experiments appear to confirm indications of liver injury in workers exposed to PCBs in this range. The combined studies of Levy et al [197], Meigs et al [190], Hasegawa et al [191], and Ouw et al [196], and the animal studies [203,228], provide further support to the conclusion that PCB exposures must be maintained at lower levels to prevent liver injury than to prevent chloracne.

Since indications of liver injury can be found in reports of both occupational studies [190,191,196] and animal experiments [203,228] with the lowest PCB exposure, there is no proof of an exposure level that is adequately low to prevent liver injury.

The prevention of liver injury is of particular concern because there is substantial evidence that arene oxides are formed during the metabolism of PCBs by animals [51,68,69,74,75,81,115,116,118], and the data offer no reason to suspect that humans metabolize PCBs differently from animals. PCB metabolites have been demonstrated to bind to nuclear components of hepatic cells of rhesus monkeys [51] and rats [81] and this is sufficient evidence to arouse suspicions that PCBs could be potential carcinogens in the workplace. Commercial PCB preparations that have been adequately tested in rats [218,242] (Federal Register 42:6532-55, February 2, 1977) and mice [221,240,241] have been demonstrated to cause liver tumors. No liver tumors were found in rats fed Aroclors 1242, 1254, and 1260 at 1 ppm in the diet, but each of these mixtures produced tumors at 10 ppm (Federal Register 42:6532-55, February 2, 1977). In this same experiment a high incidence of pituitary tumors was found in PCB-fed rats. In Yusho patients [160,161], and in American workers (written communications, HA Sinclaire, June 1976; G Rousch, September 1976), preliminary studies only indicate that the occurrence of certain cancers may be excessive. However, the findings in rats and mice demonstrate reproducible production of liver tumors after ingestion of various PCB mixtures, and NIOSH concludes that PCBs in workplace air are potential carcinogens.

Additional concerns for the health of workers and their families are adverse reproductive effects [228,230,232,233], including terata in animals fed various PCBs (FL Earl et al, written communication, 1976), and adverse effects in human and animal infants nursed by PCB-exposed mothers [101,182,233]. PCBs resembling those in maternal blood both qualitatively and quantitatively have been found in human cord blood and in tissues of newborn humans and animals [101,138,139,168]. Fetal resorptions were common, and dose related incidences of terata were found in pups and piglets when bitches and sows were fed Aroclor 1254 at 1 mg/kg/day or more. Terata were not found in babies of Yusho patients (maximum consumption of PCBs of about 0.15 mg/kg/day); however, many undesirable effects including low birth weights and chloracne-like lesions at birth and after nursing were found [176,182,183].

Based on the findings of adverse reproductive effects, on its conclusion that PCBs are potential carcinogens in humans and on its conclusion that occupational and animal studies have not demonstrated a level of exposure that will not subject the worker to possible liver injury, NIOSH recommends that the TWA concentrations of PCBs in the breathing zone of workers be maintained at or below the minimally detectable TWA concentration for up to a 10-hour workday, 40-hour workweek. NIOSH considers the minimally detectable concentration of PCBs for the monitoring of occupational exposures to be 1 μg/cu m, based on its review of the literature and the methodology presented in Appendices I and II.

Maintenance of exposures to PCBs at or below this concentration should reduce risks of reproductive and carcinogenic effects, and protect the employees from metabolic dysfunction, hepatic injury, and dermal effects due to PCB exposures during their working lifetimes.

It is recognized that employees handling PCBs may have skin contact with these substances, potentially resulting in dermatologic and systemic effects. Consequently, appropriate work practices, training programs, and other measures should be required, regardless of the concentrations of airborne PCBs. Therefore, occupational exposure to PCBs has been defined as working with PCBs or with equipment containing PCBs that can become airborne or that can spill or splash on the skin or into the eyes, or the handling of any solid products that may result in exposure to PCBs by skin contact or by inhalation.

(b) Sampling and Analysis

Based on an evaluation of the literature and on its own studies, NIOSH recommends sampling and analysis for PCBs as detailed in Appendices I and II. Florisil has been selected as the solid sorbent for PCBs because it will collect vapors as well as particulates and PCBs can be quantitatively recovered from it. The recommended Florisil sampling tubes have been shown to have an adequate sorption capacity (at least 100 μg) for monitoring occupational exposures at the recommended limit for up to a 10-hour workday. NIOSH has used the sampling method for monitoring TWA occupational exposures at 10-250 μg/cu m [197,244] by sampling at about 200 ml/minute for the entire workday. Total sample volumes of up to 100 liters were collected. At 1 μg/cu m, 100 liters of air would contain 100 ng of PCBs. The lower limit of PCB detection by GLC with EC detection was found to be 32 pg/4-μl injection. Since the contents of the Florisil tubes are dissolved in 5 ml of solvent, this represents a total of 40 ng of adsorbed PCBs. Although NIOSH recommends sampling at 200 ml/minute, it may be feasible to use pumps that sample at faster rates if there are analytical difficulties with samples of about 100 liters due to low concentrations of PCBs.

(c) Medical Surveillance

Occupational exposure to PCBs has been shown to cause signs of liver injury and impaired liver function. Ouw et al [196], Hasegawa et al [191], and Levy et al [197] all found occasional incidents of elevated serum enzymes; exposure conditions under which these will not occur are not known. Therefore, NIOSH recommends determination of SGOT and SGPT initially and at annual intervals. The responsible physician may also wish to determine serum triglyceride concentrations since these have been found to be abnormal in some workers chronically exposed to PCBs [191-193,197]. Especially, elevated serum triglyceride concentrations have been found to be related to duration of exposure and to the concentration of residual PCBs in the blood [193].

Although the data indicate that the recommended standard will prevent chloracne, it is not known that it will prevent other skin ailments. NIOSH recommends that in comprehensive physical examinations, special emphasis be given to the condition of the skin.

PCBs fed to bitches and sows have been found to be teratogenic (FL Earl et al, written communication, 1976). Although terata have not been observed in human babies whose mothers had been exposed to PCBs [176,182,183], PCBs have been found in human embryos and fetuses [138,139,168], and undesirable effects (abnormal skin color and low birth weights) have been observed in neonates [176,182,183] born after their mothers had ingested PCBs. A woman who was occupationally exposed to PCBs had a blood PCB concentration of 25 ppb when her normal baby was born [195]. NIOSH considers that its recommended standard will protect unborn babies but recommends that women exposed to PCBs at work be advised of the potential hazards of PCB exposure to unborn children.

PCBs have been found in milk of women who have been exposed to PCBs [168,195] and babies have been adversely affected after being nursed by PCB-exposed mothers [182]. A safe level of PCBs in the milk of mothers occupationally exposed to PCBs is not known. Human milk samples in the general US population usually contain detectable amounts of PCBs, and about one-third of the whole milk samples have been found to contain >50 ppb and up to about 350 ppb (EP Savage, written communication, February 1977). It is not known if all the mothers from whom these samples were taken nursed their babies without effect. Infant monkeys who were nursed by mothers in their milk at 150-350 ppb became sick and developed chloracne [234]. After consultation, the woman who was occupationally exposed to PCBs and who had PCBs in her milk at about 250 ppb, stopped nursing her baby out of concern for its health [195]. Based on these considerations, NIOSH recommends that women working with PCBs be counseled concerning the advisability of nursing their babies.

(d) Personal Protective Equipment and Clothing

PCBs applied to the skin or cornea of experimental animals have been shown to cause local lesions and liver and kidney injuries [205-208,225]. One worker who developed chloracne after 3 months of exposure to PCBs was described as having frequently immersed his hands in the PCB mixture and his clothes were described as often being impregnated with PCBs [189]. Employees working with an askarel containing 60% Aroclor 1254 frequently developed skin rashes which were considered by the company physician to be allergic or contact dermatitis from the askarel (In the Matter of General Electric Company, File No. 2833, New York State Department of Environmental Conservation, 1975). Other complaints of these workers that were ascribed to the askarel included irritation of the eyes, nose and throat. Levy et al [197] and Ouw et al [196] found that employees exposed to PCBs at 0.013-0.264 mg/cu m and 0.32-1.44 mg/cu m, respectively, complained of similar irritations and, on examination, there were findings of skin rashes and nasal irritation. Ouw et al [196] considered that one reason the blood PCB concentrations in workers they studied did not decline (after improvements in the ventilation system had reduced the environmental concentrations of PCBs) was because the workers did not comply with the recommendations for protecting their skin from PCB contact.

Based on these reports [189,196,197,205-208,225], NIOSH recommends that employees working in situations where skin contact may occur be provided with clothing that is impervious to PCBs and that will cover all body surfaces where contact may occur. To prevent splashing PCBs into the eyes, NIOSH recommends that employees wear appropriate goggles or safety glasses in accordance with 29 CFR 1910.133 and ANSI Z87.1-1968. Since NIOSH has found PCBs to be potential carcinogens and recommends that exposures be maintained at or below 1 μg/cu m, it considers that only a self-contained breathing apparatus with a full facepiece operated in the positive-pressure mode will provide adequate protection when workers are in areas where higher concentrations exist. Based on NIOSH studies [287-289], other respiratory protective devices are not considered adequate to provide the needed protection.

(e) Other Considerations

Engineering controls are recommended to maintain PCBs in closed systems to reduce exposures to the extent feasible. Such a recommendation is consistent with the Toxic Substances Control Act (Public Law 94-469) and with the need to protect employees from exposure to PCBs. However, there are situations, such as in accidental leakage from closed systems and in repair of equipment, when PCBs may not be confined. The recommended standard prescribes general work practices for PCBs as well as emergency work practices. Employees should be informed of the hazards of working with PCBs, and trained in the recommended general work practices and the procedures to follow in emergencies. The advantages to their health of complying with the work practices and medical monitoring requirements of the recommended standard should be explained to the employees. As Ouw et al [196] pointed out, improving air quality does not go far in alleviating the workers' body burdens of PCBs without their cooperation in implementing the recommendations for protecting their skin from PCB contact.

NIOSH also recommends certain sanitation practices to minimize intake of PCBs by employees. Among these practices is the requirement that employees be provided with clean work clothing daily and that they change clothing before leaving work. The importance of this measure to the employee and the employee's family is exemplified in finding up to 180 ppm of PCBs in the dust of PCB-workers' homes [36]. PCBs may remain in contaminated premises for years [33]. Partly for the same reason, and because PCBs in contact with the skin can be irritating [196,197] and also because they have caused systemic effects in experimental animals [205-208,225], NIOSH recommends that workers shower before leaving work.

Toxic effects from ingestion of PCBs have been well documented in humans [145-185] and experimental animals [101,209-224,226-237,240-248]. Workers may have an intake of PCBs from their normal diet of 10-20 μg/day [46], and the maximum additional intake expected from NIOSH's recommended allowable work exposures might be of the order of 10 μg. NIOSH recommends that workers wash their hands before eating and that food, drinks, and smoking materials not be permitted in PCB work areas. The importance of this recommendation may be evaluated by considering that one drop of PCBs spilled on food, in drinks, or otherwise conveyed into the mouth may contain about 50 μg of PCBs, compared to a total intake of 20-30 μg from other sources, including allowable occupational exposures.

Because the consequences of working with PCBs may be substantial, NIOSH recommends that entry into PCB work areas be restricted to authorized employees whose entry is logged daily, and whose exposures are monitored at least annually to ensure that airborne exposures are at or below the recommended TWA limit.

VII. RESEARCH NEEDS

There is a clear need for information in the following areas:

(a) The effects of chronic exposure of animals and humans to PCBs at low concentrations require investigation. Epidemiologic studies of occupational groups and information on concentrations of PCBs in workroom air and any related clinical findings would be useful.

(b) Chronic exposures of animals to PCBs at concentrations in the range of the recommended environmental limit.

(c) Studies of the reproductive histories of women who have been exposed to PCBs in their occupational environments, including studies of status and development of infants born to these women.

(d) The absorption efficiencies of various PCB mixtures by the dermal and respiratory routes.

(e) The method of transport of PCBs in the blood and the partition between blood on the one hand, and fat stores and milk on the other.

(f) A problem that confounds our understanding of the toxicity of PCBs is that of the toxic activity of contaminants associated with PCBs. The contaminants found in commercially important PCB products should be identified, prepared in pure form and studied toxicologically both as individual substances and as mixtures with other, related compounds.

(g) Studies regarding methods of removing PCBs from the skin (cleansing).

(h) Studies on the use of various barrier creams as a means of minimizing dermal exposure to PCBs.

(i) There is uncertainty regarding baseline values for PCBs in the blood of humans; research should be conducted to determine baseline values for the general population and for non-exposed industrial populations.