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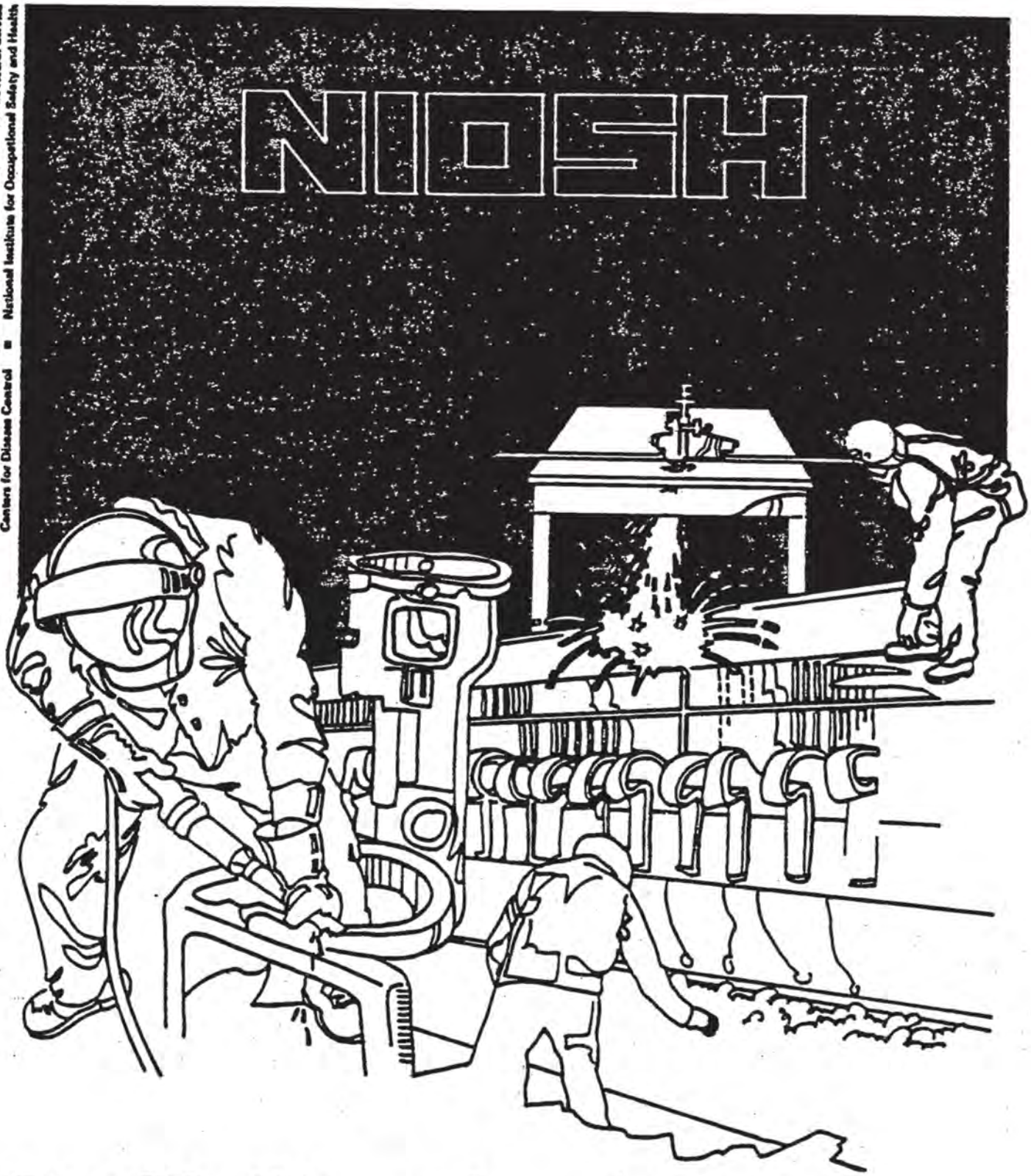

Health Hazard Evaluation Report

HETA 82-319-1475
HILL-MURRAY HIGH SCHOOL
MAPLEWOOD, MINNESOTA

HETA 82-310-1475
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HILL-MURRAY HIGH SCHOOL
MAPLEWOOD, MINNESOTA

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I. SUMMARY

On June 22, 1982, the Minnesota Pollution Control Agency and the Minnesota Department of Health requested technical assistance from the National Institute for Occupational Safety and Health (NIOSH) in the assessment of a venting of transformer dielectric oil at the Hill-Murray High School, Maplewood, Minnesota. The oil contained 45% Aroclor 1260 (polychlorinated biphenyl-PCB) and 55% chlorinated benzenes (40% trichloro- and 15% tetrachloro-) with trace additives.

The air levels of PCB measured within 40 hours of the incident were 50 to 90 micrograms per cubic meter (ug/m^3) inside the vault, and <1 ug/m^3 in other areas not immediately adjacent. The NIOSH recommended standard for PCBs is 1 ug/m^3 as a time-weighted average (TWA). Surface concentrations inside the vault were 100 to 5000 $ug/100\ cm^2$, and <0.05 to 0.29 $ug/100\ cm^2$ (equal to community background levels) in other areas not immediately adjacent. Decontamination reduced these airborne levels of PCB by 92% and surface concentrations by 98% inside the vault. Following this decontamination airborne PCB was not detected in the other areas.

The trichlorobenzene (tri-CB) and tetrachlorobenzene (tetra-CB) levels were respectively 17.6 to 22.6 milligrams per cubic meter (mg/m^3) and 18.2 to 25.7 mg/m^3 inside the vault, and <0.35 and 0.27 mg/m^3 in all other areas not immediately adjacent. The American Conference of Government Industrial Hygienists' (ACGIH) threshold limit value (TLV) for tri-CB is 40 mg/m^3 TWA; there are no standards for tetra-CB. The decontamination reduced the tri-CB and tetra-CB levels by 98% and 96% respectively.

No polychlorinated dibenzofurans (PCDF) nor dibenzo-p-dioxins (PCDD) were found in the surface or airborne samples with a limit of detection of 40 parts per billion (ppb) per isomer group.

On June 23 and 24, and July 14-20, 1982, NIOSH investigators conducted blood and urine tests and medical interviews on all 61 potentially exposed individuals (mostly fire fighters). Itching, skin irritation, unusual tiredness, and headaches occurred in more than 10% of the individuals present during this overheat. Blood PCB levels were below 16 parts per billion (ppb), well within the background levels documented in the general population by previous studies. Mean values of blood and urine biochemical and hematologic tests were within the range of normal, though the mean levels of the liver enzymes serum glutamic oxalacetic transaminase (SGOT) and glutamil transpeptidase (GGT) declined significantly over the four week period.

NIOSH concludes that a potential health hazard existed during the transformer incident at the Hill Murray School in Maplewood, Minnesota. Headaches, itching, exposed skin irritation, unusual tiredness and subclinical elevations of liver enzymes may have occurred acutely as a result of this exposure. Recommendations are made in the report to reduce the chance of exposure and adverse health effects at similar incidents.

KEYWORDS: SIC 9224(Fire Protection), 4911(Electrical Services) PCBs, PCDFs, PCDDs, Transformer-incidents, fire fighters

II. INTRODUCTION AND BACKGROUND

On June 22, 1982, at about 3:00 a.m., the main power transformer at the Hill-Murray High School, Maplewood, Minnesota, became pressurized and vented approximately 50 of the 290 gallons of dielectric fluid into the transformer vault. The transformer was equipped with a pressure relief valve set at about 15 psi, designed to prevent rupture of the casing if the transformer becomes pressurized due to the generation of gas or vapors by internal arcing. The vault is located in the basement, at the northeast corner of the 2-story building. The transformer, installed in 1958, contained a thermal-dielectric fluid with the tradename "Pyranol" consisting of 45% polychlorinated biphenyl (PCB) Aroclor 1260 and 55% chlorinated benzenes (40% trichloro- and 15% tetrachloro-benzenes).

The temperature of the emission was estimated to be >248'F based on the maximum thermometer setting of the transformer. The emission from the transformer, characterized by a "white mist", occurred over approximately a 4-hour period with resultant contamination of some basement and first floor areas.

The incident was initially discovered by the school's night watchman, who called the police and fire departments. A squad car and two volunteer fire departments responded to the call. Other than the night watchman, a student, and three fire department personnel, all individuals in close proximity to the transformer vault wore self contained breathing apparatuses (SCBA's) and protective clothing. A total of 61 individuals were present in the area of this overheated transformer.

During the morning of June 22, the Minnesota Pollution Control Agency and Minnesota Department of Health requested technical assistance from the National Institute for Occupational Safety and Health (NIOSH) in conducting an assessment at the school. The NIOSH assessment was performed independent of that by the decontamination contractor.

On June 23, 1982, the NIOSH medical officer met with representatives of the various public and private agencies concerned with this incident. The health effects of PCBs, polychlorinated dibenzo-p-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs) were outlined, as well as a suggested approach to the acute and chronic evaluation of those individuals exposed to this transformer incident. That evening a meeting was also conducted with all individuals potentially exposed, explaining the proposed study and the potential effects of these chemicals.

During the next 48 hours, all 61 potentially exposed individuals came to the St. Paul Ramsey Medical Center or at a local firehouse for blood and urine tests.

On June 23 and July 7, 1982, NIOSH conducted the pre- and post-decontamination environmental assessments. The results of these assessments were reported, within one week of testing, to the Minnesota Pollution Control Agency and Minnesota Department of Health. Letter reports were issued to both groups on July 26 and August 6, 1982.

Between July 14 and 20, 1982, blood and urine tests were repeated and a medical questionnaire administered. On Oct. 21, 1982 the individuals tested were informed of their individual results by mail.

III. MATERIALS AND METHODS

A. Environmental

The contamination assessment was designed to determine the extent and relative degree of contamination from the transformer in the school, involving measurement of both surface and airborne contamination.

1. Surface (Wipe) Sampling

Wipe samples of school surfaces were obtained by applying moderate pressure to the backs of pesticide quality cyclohexane moistened Whatman No. 50 smear tabs and wiping a unit area of approximately 100 square centimeters. A fresh, disposable, polyvinylchloride glove was worn for each wipe sample to prevent cross contamination of the samples. After wiping the surface, the smear tab was folded face-inward, then folded inward once more, and sealed in a 30 milliliter glass vial with a Teflon-lined screw cap. In the laboratory, the samples were extracted with toluene and analyzed using a gas chromatograph equipped with an electron capture detector, according to NIOSH analytical method P&CAM 244.[1] The surface PCB concentrations are expressed in micrograms of PCB per 100 square centimeters ($ug/100\ cm^2$).

2. Air Sampling

Area airborne PCB and tri- and tetra-chlorobenzene samples were collected with calibrated constant flow vacuum pumps operating at 1.0 liter per minute (Lpm). Florisil® (30 to 40 mesh) sorbent tubes were used as the collection medium. These were standard 7 millimeters (mm) (4 mm Inner Diameter) tubes with a 100 milligrams (mg) front section preceded by glass wool and separated from the 50 mg backup section by a urethane foam plug. The PCB and chlorinated benzenes were desorbed from the Florisil with hexane and analyzed using a gas chromatograph equipped with an electron capture detector according to NIOSH P&CAM Method 244.[1] The PCB airborne concentrations are reported as micrograms per cubic meter of air sampled (ug/m^3). The chlorinated benzene airborne concentrations are reported as milligrams per cubic meter of air sampled (mg/m^3).

3. Askarel Characterization - Polychlorinated Dibenzofurans (PCDFs) and Polychlorinated Dibenzodioxins (PCDDs)

A bulk sample of the askarel was analyzed for PCDFs and PCDDs by chlorine isomer group (monochloro through octachloro compounds). Prior to analysis, an aliquot of the askarel proceeded through a two-step cleanup procedure: 1) separation of the PCBs and any PCDFs and PCDDs from the askarel matrix by column chromatography on Florisil® and liquid-liquid partition, and 2) separation of the PCBs from any PCDFs and PCDDs by selective absorption on alumina.

The cleanup procedure was effective in removing approximately 99% of the PCBs from a 3.66 gram sample of askarel. Analysis of the cleaned-up extract was completed using a high resolution capillary column gas chromatograph (HR/GC) interfaced to a mass spectrometer operated in the selected ion monitoring mode (SIM-MS).

B. Medical

Medical questionnaires were administered by the NIOSH investigators 3 to 4 weeks after the incident to solicit exposure and symptom prevalence information from firefigthers and other potentially exposed individuals during the incident. The questionaires elicited information concerning amount and duration of exposure, protective equipment utilized, past and/or current relevant medical conditions, previous exposures, cigarette and alcohol use, allergic histories, and the presence of symptoms previously reported to be associated with PCB exposures.

Blood and urine samples were collected within 48 hours of the incident from all exposed individuals. This blood was analyzed for complete blood count, liver enzymes, liver profile, blood urea nitrogen, sodium, potassium chloride, glucose, creatinine, calcium, phosphorus, and uric acid. These tests were performed again on blood samples collected four weeks after the incident. Further, blood samples were analyzed for hepatitis A core antibody, PCB levels, and urine was analyzed qualitatively for porphobilinogen at the time of the first evaluation.

Analysis of the blood samples for PCB was performed according to a modification of NIOSH analytical method P&CAM 329.[2] This modification was the use of a capillary column for quantification instead of a packed gas chromatographic column. Capillary columns produce outstanding resolution of individual components from complex mixtures of PCBs in human serum.[3] The serum samples were analyzed specifically for Aroclor 1260 with an instrumental detection limit of 5 parts per billion (ppb). Other blood and urine analyses were performed by standard medical laboratory methods.

A chi-square test was utilized to assess significance of differences in symptom frequency between exposure groups and over time. A student T test was used to assess the significance of differences in mean blood values between exposure groups. A one sample t test was performed on the mean of the individual differences between first and fourth week blood values when the distribution of the mean was normal. When the distribution of the mean was markedly non-normal, a sign rank test was applied to assess significance.

IV. 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, Occupational Safety and Health Administration's (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 solely 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 required by the Occupational Safety and Health Act of 1970, (29 USC 651, et seq) to meet only 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.

A. POLYCHLORINATED BIPHENYLS (PCBs)

Polychlorinated biphenyls (PCBs) are a class of chlorinated aromatic hydrocarbons. They were first available in the United States in 1929, and became widely distributed between 1957 and 1977 when large quantities were commercially produced by the Monsanto Industrial Chemicals Company and marketed under the trade name "Aroclor". At least nine different Aroclors were manufactured, and designated by numbers such as 1221, 1242, 1254, and 1260, where the last two digits represent the percent by weight of chlorine in the mixtures. Another grade of Aroclor, 1016, was made primarily of tri, and tetrachlorbiphenyl compounds and contained 41% chlorine by weight.

Over the past decades, PCBs found a wide range of industrial uses. Properties such as thermal stability, non-flammability, and dielectric capability, led to the use of PCBs as a major component in most "askarels" marketed after 1932. Askarel is the generic term used to refer to a broad class of synthetic chlorinated hydrocarbon insulating liquids used in electrical capacitors and transformers. Transformer-grade askarels were usually mixtures of trichlorobenzene and more highly chlorinated PCBs.

Other properties of PCBs, such as their chemical stability, resistance to biodegradation, and lipid solubility, have led to their wide-spread accumulation in the environment. An increasing concern with the public health and ecological effects of this contaminination resulted in the promulgation of regulations by the Environmental Protection Agency (EPA) governing the use and disposal of PCBs, and subsequently led to the cessation of their manufacture in the United States. Occupational exposure to PCBs is now limited primarily to workers servicing equipment containing PCBs, and to persons who have inadvertent exposure through leakage or explosion of this equipment. In addition, exposure can occur at processes involving the recycling of sludges, oils, and other products containing PCBs.[4,5]

In human beings high dose PCB exposure has been documented to produce a variety of toxic effects:[6]

1. Chloracne, a chemically induced acne, consisting of blackheads, pimples, and pustules in exposed areas of the body. Additionally, red, pruritic contact dermatitis, upper airway irritation, and persistent body odor have been reported following exposure.
2. Nausea and digestive disturbances have been noted following high-dose exposure, and mild asymptomatic liver dysfunction has been recorded after chronic low level exposure.
3. Dysfunction of sensory and motor nerves in the extremities has occurred, evidenced by numbness, pain, tingling, and weakness in the hands or feet.

In animals high-dose PCB exposure has been documented to produce:[6]

1. Eye, nose, mouth and throat irritation, with facial swelling and a loss of hair.
2. Liver damage with stomach irritation and ulcers.
3. Bone marrow suppression, producing anemia and an impaired ability to combat infection by the immune system. Low blood protein levels have also been recorded.
4. Increased numbers of miscarriages, low birth weight offsprings, and newborn deaths, as well as fewer members per litter.
5. Increased numbers of liver cancers in animals, and mutations in bacteria.

Based on the adverse reproductive and tumorigenic effects that PCBs have shown in experimental animals, NIOSH recommends that occupational exposure to PCBs be controlled so that no worker is exposed at an airborne concentration greater than 1.0 ug/M^3 total PCBs on a TWA basis for up to a 10-hour workday, 40-hour workweek.[4] In addition,

NIOSH recommends that exposure to PCBs through skin contact be minimized through the use of safe work practices and proper personal protective equipment. The current OSHA standard for exposure to PCBs is 1.0 mg/M^3 for PCB mixtures containing 42% chlorine, and 0.5 mgM^3 for mixtures containing 54% chlorine on an 8-hour TWA basis.[7] There is neither an ACGIH TLV or OSHA Permissible Exposure Limit for Aroclor 1260, the PCB class contained in the Hill-Murray School transformer.

Although laboratory experiments[8] and industrial studies[9] have documented cutaneous absorption of PCBs, there is no established health criterion for exposure to PCBs on surfaces. The final Environmental Protection Agency (EPA) regulation on environmental PCB contamination (40 CFR Part 761, Federal Register Vol. 47, No. 165, August 25, 1982) does not include a specific guideline to define the extent of cleanup of PCB releases. The regulation does state, however, that all spills, leaks, and other uncontrolled discharges should be cleaned up to pre-existing background levels whenever there is threat of contamination of water, food, feed, or human beings. Data collected in non-manufacturing buildings in Cincinnati, Ohio; Maplewood, Minnesota; and Boston, Massachusetts suggest an upper limit background PCB concentration of 0.5 ug/100 cm^2 (range <0.01 to 0.45, mean 0.09, S.D. $\pm$0.08, N = 125).[10]

Due to the above background environmental levels of PCBs, a number of studies have demonstrated that PCBs can be found in the serum of most persons residing in the United States. These studies have reported serum PCB values from 0 to 42 parts per billion (ppb), with mean concentrations ranging from 2.1 to 24.4 ppb.[11]

B. CHLORINATED BENZENES

In humans, chlorinated benzenes have been noted to cause irritation to skin and mucous membranes and at high doses affect central nervous system function. Chronic high level exposure in animal studies have produced liver, kidney, and lung damage.[12] Based on the irritative properties of this substance, ACGIH has recommended that exposure to 1,2,4-trichlorobenzene should not exceed 5 parts of contaminant per million parts of air (ppm) or 40 mg/M^3 at any time.[13] There are no available recommended exposure level standards for tetrachlorobenzene.

V. RESULTS

A. Environmental

In order to estimate the PCB and chlorinated benzene (tri- and tetra-chloro compounds) exposures by firefighters, who may have entered the transformer vault, a sample was obtained of askarel that had pooled on the surface of an electric panel box located at the vault's southwest corner. The sample was presumed to estimate the airborne concentration of PCB and chlorinated benzenes in the liquid aerosol that existed in the vault during the emission period (estimated by the firefighters to be approximately 4 hours). The sample contained 14,000 ppm (1.4%) PCB Aroclor 1260, 330,000 ppm (33%) trichlorobenzene, and 270,000 ppm (27%) tetrachlorobenzene.

Airborne concentrations of PCBs and tri- and tetra-chlorinated benzenes were measured in the transformer vault and adjacent areas on June 23, 1982. The measurements were made within 40 hours of the incident. The PCB concentrations ranged from 50 to 90 ug/m^3 inside the vault; 20 ug/m^3 immediately outside the vault; 2 ug/m^3 in Room 018 adjacent to the vault; and <1 ug/m^3 in other areas. By comparison, the NIOSH recommended standard is 1 ug/m^3 TWA. The corresponding trichlorobenzene and tetrachlorobenzene concentrations ranged respectively, from 17.6 to 22.6 mg/m^3 and 18.2 to 25.7 mg/m^3 inside the vault; 10.2 and 11.7 mg/m^3 immediately outside the vault; 0.73 and 1.21 mg/m^3 in Room 018 adjacent to the vault; and 0.12 to 0.35 mg/m^3 and 0.26 to 0.27 mg/m^3 in other areas. The ACGIH TLV for trichlorobenzene is 40 mg/m^3 TWA; there is currently no criteria for tetrachlorobenzene. (Table I)

Airborne PCB and tri- and tetra-chlorinated benzenes were measured in the transformer vault and adjacent areas on July 7, 1982. The samples were obtained in the same areas initially tested on June 23, 1982. A PCB concentration of 7 ug/m^3 was measured in the vault, but PCB was not detected (<1 ug/m^3) in the other areas tested. The post-decontamination concentration (7 ug/m^3) represented a 92% decrease in the airborne CB level. The tri- and tetra-chlorinated benzenes were measured in all areas at a concentration ranging from 0.01 to 0.33 mg/m^3 and 0.03 to 0.65 mg/m^3, respectively. The maximum post-decontamination concentrations represented respectively, 98% and 96% decrease in airborne levels. Subsequently, the concrete and masonry surfaces in the transformer vault were sealed with an epoxy sealant to prevent potential future vaporization. (Table II)

Wipe samples for PCBs were obtained from vertical and horizontal surfaces in the transformer vault and other areas of the school on June 23, 1982. PCB surface concentrations inside the transformer vault ranged from 100 to 5000 ug/100 cm^2, <0.05 to 20 ug/100 cm^2 in areas suspected of being contaminated based on proximity to the vault; and <0.05 to 0.29 ug/100 cm^2 in all other areas. Samples obtained to represent comparative background levels averaged 0.12 ug/100 cm^2 (S.D. ±0.13, range <0.05 to 0.29 ug/100 cm^2). The decontamination contractor determined the average comparative background to be 0.09 ug/100 cm^2 and employed 0.11 ug/100 cm^2 (or 1.0 ug/sq ft) as a guideline for cleanup. (Tables III and IV)

Wipe samples for post-decontamination PCB levels were obtained in the tranformer vault and other areas of the school on July 7, 1982. The average pre-decontamination surface concentration of 2620 ug/100 cm^2 in the transformer vault was reduced to an average concentration of 46 ug/100 cm^2, which is equivalent to a reduction of approximately 98% and within the background range. The masonry and concrete surfaces were then sealed with an epoxy sealant to prevent contact with the residual PCB. (Table V)

Analysis of the askarel showed that neither PCDFs or PCDDs were present, with an analytical detection limit of 40 ppb (weight to weight) per isomer group.

B. Medical

1. Exposure

The individuals at this incident were stratified with respect to amount of exposure based on questionaire responses:

Group 1 - Moderately Exposed without SCBA:

Thirteen individuals, without wearing self contained breathing apparatus (SCBA), spending time in the areas with mist in the air and deposited oil on the walls and floor.

Group 2 - Moderately Exposed with an SCBA:

Twelve individuals, wearing SCBA's, spending time in the areas with mist in the air and deposited oil on the walls and floor.

Group 3 - Lightly Exposed:

Thirty three individuals in the immediate area of the school but not entering the building.

2. Symptomatology:

Six (24%) of the moderately exposed groups (1 & 2) reported headaches, 5 (20%) reported unusual tiredness, 4 (16%) reported exposed skin irritation and redness, and 2 (8%) reported pimples, abdominal pain, nausea, dizziness, and numbness/tingling within one week of exposure. The prevalence of all of these symptoms decreased over the next three weeks with the exception of the reported occurence of pimples, though this decrease was significant only for headaches ($p<0.05$). A poor appetite was reported by one individual within the first week who was joined by a second after the four weeks. (Tables VI, VII, VIII)

Seven (20%) of the lightly exposed group (3) reported headaches, 3 (9%) reported nausea, and 2 (6%) reported pimples, itching, unusual tiredness, and increased eye discharge during the first week after exposure. All of these symptoms were less prevalent four weeks after exposure. (Tables VI, VII, VIII)

3. Blood Analysis:

Polychlorinated biphenol levels in blood samples drawn within 48 hours of the exposure ranged between a nondectectable amount in 37% to 16 ppb in one of the individuals. The mean levels were 2.0 ppb for the moderately exposed group without SCBA's, 5.0 ppb for the moderately exposed group with SCBA's and 5.0 ppb for the lightly exposed group. (Table IX)

Other than a consistent, expected non-fasting elevation of non-fasting triglycerides, no uniform deviation from the norm was detected in the blood chemistries or hematologic values in any of the individuals tested either during the first 48 hours or after

four weeks. No significant differences in mean blood chemistry or hematologic values were found between exposure groups. Hepatitis A Core Antibody was negative for all individuals tested, as was qualitative testing for porphobillinogen in the urine. (Table X)

The mean values of hemoglobin, red blood cell count, cholesterol, serum glutamic oxalacetic transaminase, and gamma glutamil transpeptidase were significantly ($p<0.05$) higher for all the participants during the first week than they were in the fourth week. The mean values of mean corposcular volume, blood urea nitrogen, and triglycerides revealed a significantly ($p<0.05$) lower level during the first week than in the fourth week. The lightly exposed group demonstrated a mean corposcular hemoglobin level significantly ($p<0.05$) lower in the first than the fourth week. No other blood examinations showed no significant differences within exposure groups over the four week observation period. (Table XI)

VI. DISCUSSION

A. Environmental

Although normally operating PCB transformers are totally enclosed units, the Hill-Murray incident further documents that internal electrical malfunction may cause significant pressurization and release of hundreds of pounds of PCBs. This incident demonstrates that the release of hot pressurized PCB transformer fluid can entrain considerable quantities of PCB as a fine mist. A sample of askarel that had pooled on a surface in the vault suggests that the mist may of contained approximately 14000 ppm (weight to weight basis) PCB. There was probably a significant pressure and temperature differential which promoted the distribution of the PCB contaminant to other areas of the building. The heating, ventilation and air conditioning system was not operating during the incident. The actual airborne concentrations of PCB and the chlorinated benzene that permeated the vault and surrounding areas were initially higher than represented by the analyses due to loss by vaporization during the approximately 40-hours between the time of the emission and collection of the samples.

Although the contamination assessment indicated the necessity to decontaminate the transformer and adjacent areas, the entire building was decontaminated as a precautionary measure. The vertical and horizontal surfaces were washed with a liquid alkaline synthetic detergent formulated for penetration and removal of PCBs from surfaces. The post decontamination surface wipe data indicated that the clean-up was generally successful. However, the analyses indicated that several areas required further cleaning. These areas were cleaned again to assure that the PCB surface concentration was below the cleanup guideline of 0.11 uy/100 cm^2. Established based on data collected in non-manufacturing buildings in Cincinnati, Ohio; Maplewood, Minnesota; and Boston, Massachusetts which suggest an upper limit background PCB concentration of 0.5 ug/100 cm^2 (range <0.01 to 0.45, mean 0.09, S.D. $\pm$0.08, N = 125).[10]

The pyrolytic conditions that may have existed in the transformer during the electrical malfunction did not result in the thermal formation of detectable quantities of PCDFs or PCDDs.

B. Medical

1. Symptomatology:

Only itching, exposed skin irritation, unusual tiredness, and headaches occured in more than 10% of the firefighters and other individuals present during this overheat. Headaches affected 24% of the moderately exposed and 20% of the lightly exposed individuals. Headaches were the most frequent symptom, and the only one that decreased significantly over the next month. None of these symptoms occurred in significantly greater frequency in those moderately exposed than those lightly exposed.

2. Blood Analysis:

All blood PCB levels were below 16 parts per billion (ppb), well within the background levels documented in the general population by previous studies. Further, there was no difference in mean blood PCB concentration between exposure groups, suggesting that in general, there was no appreciable absorption of PCBs.

Blood chemistries indicated a mild subclinical increase in the liver enzymes SGOT and GGT that might be consistent with an exposure to PCBs. These elevations decreased over the four week period. This may indicate an effect of exposure to this type of incident, however, as these changes were not consistent for all liver enzymes there is considerable question as to their cause.

None of the other significant differences in blood chemistries or hematologic values over time were consistent with the known effects of PCBs nor are they explainable with respect to the exposure in this incident.

The ability to draw conclusions from this study is limited in several ways. The number of people involved is small and, therefore, the ability to detect minor changes in health status is limited. Further, accurate estimates of exposure are lacking. Finally, chronic effects, especially carcinogenesis, cannot be assessed due to the cross sectional nature of this study design and small cohort size.

VII. CONCLUSIONS

1. Transformer overheats of the type herein described do not appear to liberate detectable quantitities of PCDDs or PCDFs. This is probably due to the limited elevation in temperature produced by this type of incident.

2. Clinically significant acute health effects were not apparent in these firefighters, though, headaches, itching, exposed skin irritation, unusual tiredness, and subclinical elevations of hepatic enzymes may be acute effects of this type of exposure.

3. Exposure at this incident did not appear to cause clinicaly detectable elevations in serum PCB levels, however some PCB absorption could have occurred.

VIII. RECOMMENDATIONS

NIOSH believes that fire-related transformer incidents can present risks of exposure by emergency response personnel, cleanup workers and others to toxic contaminants such as volatilized PCBs and certain pyrolysis products of PCB-askarels. The following recommendations are intended to help prevent significant exposures by emergency response workers and others involved in these incidents.

A. Prevention

Institution of fire hazard inspection and preventive programs may be the initial step to reduce the likelihood of future fires involving this equipment. These programs should include, on a regular and frequent basis, (a) preventive maintenance of the various electrical components used in conjunction with tranformers (switchgear, breakers, cables, etc.) and (b) inspections to assure proper dielectric fluid levels and that combustible are not in a transformer vault or in the immediate area of a transformer.

Measures to mitigate the risks associated with a transformer fire-related incident should include the following:

1. A method to quickly disconnect the power to the transformer. The installation of circuit breakers on the high voltage side, perhaps activated by temperature, infrared or ionization based sensors in the vault, would do much to reduce the duration of the incident and other conditions conducive to the formation of the toxic pyrolytic products.

2. The installation of a network protector on the secondary side of the transformer which would prevent current from being fed back into a failed transformer.

3. The installation of secondary disconnect switches exterior to the transformer room.

4. The development of architectural design features to seal off the vault from other areas of the building or adjacent buildings.

5. Since continued operation of the building's heating, ventillation, and air conditioning (HVAC) system can contribute to the spread of contamination, the HVAC controls could be keyed to a fire or smoke sensor in the vault to allow for automatic shut down in the case of a fire.

B. Emergency Response

The highest priority in responding to a PCB-transformer incident is to prevent exposures of emergency response personnel such as fire fighters. One of the primary factors that increase the risks of exposure is fire fighters being unaware that they are responding to a fire-related incident involving a PCB-transformer. The registration of PCB -transformers with local fire departments may be the most effective way of assuring early recognition of the potential hazards in the event of fire. This registration should include for each transformer (a) serial number, manufacture and kilovolt/amperage (KVA) rating; (b) total volume and generic composition of dielectric fluid; and (c) exact location. Another way of assuring early recognition is through signs and labeling. Although all PCB-transformers are required by the United States Environmental Protection Agency (USEPA) to be labelled (47 FR 3742, Aug. 25, 1982), this labeling should also be placed in the other areas near the transformer location indicating that a PCB-transformer is in the building. Additionally, the exterior of the transformer vault doors should be labeled at heights of approximately two- and five-feet above the floor. The label at the two-foot height would likely be visible to a fire fighter crawling in a smoke filled area.

1. Protective Clothing and Equipment

A fire fighter entering any area in which there might be airborne exposure to the contaminants should wear an SCBA, with full facepiece, operated in the positive pressure mode. In addition to wearing standard turn-out clothing, consideration should be given to the utilization of disposable coveralls because of the uncertain efficacy of decontamination of clothing. If exposure is to combustion soot, the coveralls should be made of a non-woven fabric such as spunbonded polythylene, Tyvek™. In cases of exposure to liquids, the coveralls should be made of chemically resistant materials such as disposable laminates, e.g., Saranex coated Tyvek.[14]

2. Decontamination of Protective Clothing and Equipment

All disposable clothing should be placed in marked and USEPA approved containers (47 FR 37342, Aug. 25, 1982) and disposed of appropriately. All reusable clothing and equipment should be grouped according to perceived degree of contamination (i.e., high, moderate, or low). These pieces may be initially cleaned on site with a nonionic synthetic detergent, beginning with the material thought to be least contaminated. All materials should be rinsed twice with a clean solution of the nonionic synthetic detergent.

As the costs of testing the adequacy of the clothing decontamination is often more expensive than the piece itself, it may frequently be bypassed. NIOSH is currently evaluating a decontamination method utilizing Freon 113. In initial tests this method appears to be effective in removing over 95% of the chlorinated aromatic compounds from clothing. It may therefore prove valuable as a final decontamination step, as this method would not require post-decontamination testing in most situations.

B Medical

No special medical surveillance program is necessary for these workers with occasional exposure to PCB in transformer incidents.

VII. REFERENCES

1. NIOSH Manual Of Analytical Methods Vol 1, 2nd ed. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW (NIOSH) publication no. 77-157-A).

2. NIOSH Manual Of Analytical Methods Vol 6, 2nd ed. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1980. (DHHS (NIOSH) publication no. 80-125).

3. Tuinstra GM, Traag WA, and Keukens HJ. Quantitative Determination of Individual Chlorinated Biphenyls in Milkfat by Spitless Glass Capillary Gas Chromatography J. Assoc. Off. Anal. Chem., Vol. 63, No. 5, 1980, pp. 952-958.

4. Criteria for a Recommended Standard... Occupational Exposure to Polychlorinated Biphenyls (PCBs), National Institute for Occupational Safety and Health, D.H.E.W. Publication No. 77-225, September 1977.

5. Sources of Emissions of Polychlorinated Biphenyls into the Ambient Atmosphere and Indoor Air, Environmental Protection Agency, Health Effects Research Laboratory, EPA-600/4-79-022, March 1979.

6. The Toxicology of PCB's, Hazard Evaluation System, State of California Dept. of Health Services/Dept. of Industrial Relations, January, 1981.

7. Code of Federal Regulations, Title 29, Parts 1900-1910, U.S. Dept. of Labor, Occupational Safety and Health Administration, July 1, 1980.

8. Nishizami, M. Radioautographic Evidence for Absorption of Polychlorinated through the Skin Industrial Health 14:41-4 (1976).

9. Maroni M., Colombi A., and Cantoni S. Occupational Exposure to Polychlorinated Biphenyls in Electrical Workers I. Environmental and Blood Polychlorinated Biphenyl Contaminations British Journal of Industrial Medicine 38:49-54 (1981).

10. Kominsky, J.R., Melius, J.M., and Flesch, J.P. Assessing Polychlorinated Biphenyl Contamination from Electrical Equipment Failures Presented at the American Industrial Hygiene Conference, May, 1983, Philadelphia. (Available from HETAB, NIOSH)

11. Landrigan, P.J. General Population Exposure To Environmental Concentrations Of Halogenated Biphenyls, Chapter in Halogenated Biphenyls, Terphenyls, Napthalenes, Dibenzodioxins and Related Products, Kimbrough R.D. ed. Elsevier, Amsterdam, 1980, pp. 267-286

12. Occupational Diseases, A Guide to Their Recognition, National Institute for Occupational Safety and Health, D.H.E.W. Publication No. 77-181, January 1981.

13. Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1981, American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio, 1981.

14. Permeation of Protective Garment Material by Liquid Halogenated Ethanes and a Polychlorinated Biphenyl, National Institute for Occupational Safety and Health, D.H.E.W. Publication No. 81-110, January 1981.

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IX. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Minnesota Pollution Control Agency, Roseville, Minnesota
2. Minnesota Department of Health
3. Hill-Murray High School, Maplewood, Minnesota
4. East County Line Fire Dept., Maplewood, Minnesota
5. Gladstone Fire Dept., Maplewood, Minnesota
6. NIOSH, Region V
7. 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

Area Concentrations of Polychlorinated Biphenyls (PCBs)* and Chlorinated Benzenes
Hill-Murray High School
Maplewood, Minnesota
HETA 82-310
June 23, 1982

Sample Description	Sample Duration (Hours)	Sample Volume (Liters)	Airborne Concentration ug/m^3 PCBs	Airborne Concentration mg/m^3 Total Trichlorobenzene	Airborne Concentration mg/m^3 Total Tetrachlorobenzene
Transformer Vault: north corner of room - 5' above floor	2.54	137	50	22.6	18.2
Transformer Vault: south corner of room - 1' above floor	2.52	136	90	17.6	25.7
Immediately outside south transformer vault doors - 4' above floor	2.37	123	20	10.2	11.7
Room 018 Woodshop: approximately 15' inside of entrance door - 1' above floor	3.06	165	4	0.73	1.21
Head of stairs immediately outside of Room 109 - 2' above floor	2.67	144	<1	0.12	0.26
Cafeteria: immediately inside primary entrance doors - 3' above floor	2.98	161	<1	0.35	0.27
Time-Weighted Average Exposure Criteria			1[a]	40[b]	None

* Reported as Aroclor 1260®
[a] NIOSH recommended standard.
[b] ACGIH Threshold Limit Value. There is neither an OSHA standard nor a NIOSH-recommended criteria.

TABLE II

Area Concentrations of Polychlorinated Biphenyls (PCBs)* and Chlorinated Benzenes
Hill-Murray High School
Maplewood, Minnesota
HETA 82-310
July 7, 1982

Sample Description	Sample Duration (Hours)	Sample Volume (Liters)	Airborne Concentration ug/m^3 PCBs	Airborne Concentration mg/m^3 Total Trichlorobenzene	Airborne Concentration mg/m^3 Total Tetrachlorobenzene
Transformer Vault: S corner of room 3' above floor	2.82	169	7	0.33	0.65
Immediately outside S transformer vault doors - 3' above floor	2.83	170	<1	0.05	0.23
Immediately outside of Room 018 - 3' above floor	2.82	169	<1	0.02	0.09
Head of stairs immediately outside of Room 109 - 2' above floor	2.92	175	<1	0.01	0.04
Cafeteria: serving line counter - 3' above floor	2.92	175	<1	0.01	0.03
Time-Weighted Average Exposure Criteria			1[a]	40[b]	None

* Reported as Aroclor 1260®
[a] NIOSH recommended standard.
[b] ACGIH Threshold Limit Value. There is neither an OSHA standard nor a NIOSH-recommended criteria.

TABLE III

Analyses of Polychlorinated Biphenyls (PCBs)* in Wipe Samples
Hill-Murray High School
Maplewood, Minnesota
HETA 82-310
June 23, 1982

Sample Location	Micrograms per 100 Square Centimeters Surface Area
Vault Room: top surface of washing machine	4000
Vault Room: top surface of glass electric meter on N wall	3000
Vault Room: top surface of Federal Pacific electric panel box in SW corner	1000
Vault Room: top surface of main power box for transformer along S wall	5000
Vault Room: top surface of red 5-inch dia. pipe running NE from transformer	100
Vault Room: vertical surface of N doors approx. 5' above floor	<5
Corridor Outside of Vault Room: vertical surface of ventilation duct approx. 7' above floor	<5
Room 048: top surface of grey 12" steel shelving approx. 25' SE of entrance door	20
Hallway Outside of Closed S Double Doors of Room 048: vertical surface of stored cafeteria table 6' above floor	<5
Boiler Room: vertical surface of air supply duct immediately inside door approx. 7' above floor	<5
Room 018 Woodshop: top surface of table approx. 15' inside doorway	<5
Vertical surface (approx. 7' above floor) of corridor wall towards cafeteria at junction of corridor leading N to fieldhouse	0.12
Cafeteria: top surface of table directly in from primary entrance door	0.24
Cafeteria: top surface of table immediately to left as enter primary door	0.22

* Reported as Aroclor 1260®

TABLE IV

Analyses of Polychlorinated Biphenyls (PCBs)* in Wipe Samples
Hill-Murray High School
Maplewood, Minnesota
HETA 82-310
June 23, 1982

Sample Location	Micrograms per 100 Square Centimeters Surface Area
Corridor Leading N to Fieldhouse: approx. 20' from entrance on W wall approx. 6' above floor	<0.05
Corridor Leading N to Fieldhouse: glass of W window on south side of double doors	<0.05
Vertical surface (approx. 7' above floor) of corridor wall across from Room 109	0.26
Vertical surface (approx. 7' above floor) of corridor wall adjacent to double door entrance to music suite	0.27
Top surface of glass case along W wall corridor leading N from administration office	1.6
Outside Room 106: top surface of table adjacent to Room 106 entrance	5.8
Room 106: top surface of desk in middle of room	0.95
Room 106: S window sill above grate from transformer vault	0.61
Room 138: W window sill above grate to transformer vault	2.1
Room 138: E window sill above grate from transformer vault	1.9
Room 138: top surface of free standing sink counter - top right side	1.4
Gymnasium: top surface of table	0.29
Athletic Building Lobby: top surface of wall telephone	0.14
Priory: ledge above door to gift shop	<0.05
Priory: 2nd floor - ledge above door to cloak room	<0.05

* Reported as Aroclor 1260®

TABLE V

Analyses of Polychlorinated Biphenyls (PCBs)* in Wipe Samples
Hill-Murray High School
Maplewood, Minnesota
HETA 82-310
July 7, 1982

Sample Location	Micrograms per 100 Square Centimeters Surface Area
Vault Room: top surface of power box on N wall	15
Vault Room: top surface of glass electric meter on N wall	2
Vault Room: top surface of Federal Pacific electric panel box in SW corner	120
Room 048: top surface of grey 12" steel shelving approx. 25' SE of entrance door	3
Room 018: top surface of table approx. 15' inside doorway	0.6
Top surface of exit sign on corridor wall towards cafeteria at junction of corridor leading to fieldhouse	0.4
Top surface of water fountain outside of cafeteria	1.0
Cafeteria Kitchen: top surface of food preparation counter	<0.05
Corridor Leading N to Fieldhouse: approx. 20' from entrance on W wall approx. 6' above floor	<0.05
Vertical surface (approx. 7' above floor) of corridor wall across from Room 109	<0.05
Room 106: S window sill above grate from transformer vault	0.8
Room 138: W window sill above grate to transformer vault	0.2
Room 138: top surface of free standing sink counter - top right side	0.5
Top surface of glass case along W wall corridor leading N from administration office	<0.05

* Reported as Aroclor 1260®

TABLE VI

Hill-Murray High School
Maplewood, Minnesota
HETA 82-310

SYMPTOMS IN FIRST WEEK*

SYMPTOMS	MODERATELY EXPOSED			LIGHTLY EXPOSED	TOTAL
	Without SCBA N=13 % (#)	With SCBA N=12 % (#)	Total N=25 % (#)	N=33 % (#)	N=58 % (#)
Skin irritation	15 (2)	17 (2)	16 (4)	3 (1)	9 (5)
Skin redness		8 (1)	4 (1)		2 (1)
Pimples	15 (2)		8 (2)	6 (2)	7 (4)
Itching	23 (3)	8 (1)	16 (4)	6 (2)	10 (6)
Poor appetite	8 (1)		4 (1)	3 (1)	3 (2)
Abdominal pain	15 (2)		8 (2)	3 (1)	5 (3)
Nausea	8 (1)	8 (1)	8 (2)	9 (3)	9 (5)
Vomiting				3 (1)	2 (1)
Unusual tiredness	15 (2)	25 (3)	20 (5)	6 (2)	12 (7)
Headaches	23 (3)	25 (3)	24 (6)	20 (7)	22 (13)
Dizziness	15 (2)		8 (2)	3 (1)	5 (3)
Numbness/tingling	15 (2)		8 (2)		3 (2)
Chest pain/tightness		8 (1)	4 (1)	3 (1)	3 (2)
Eye discharge			6 (2)	3 (2)	
Visual Disturbances	8 (1)		4 (1)		2 (1)

* No differences in symptom frequency between those individuals moderately exposed with a self contained breathing apparatus (SCBA) and without SCBA or between moderately exposed and lightly exposed reached statistical significance of $p<0.05$ by Fishers Exact or Chi Square Testing.

TABLE VII

Hill-Murray High School
Maplewood, Minnesota
HETA 82-310

SYMPTOMS IN FOURTH WEEK*

SYMPTOMS	MODERATELY EXPOSED			LIGHTLY EXPOSED	TOTAL
	Without SCBA N=13 % (#)	With SCBA N=12 % (#)	Total N=25 % (#)	N=33 % (#)	N=58 % (#)
Skin irritation		8 (1)	4 (1)	3 (1)	3 (2)
Pimples	15 (2)	17 (2)	8 (2)	3 (1)	9 (5)
Itching	8 (1)	8 (1)	8 (2)	3 (1)	5 (3)
Poor appetite	8 (1)	8 (1)	8 (2)		3 (2)
Abdominal pain		8 (1)	4 (1)		2 (1)
Nausea		8 (1)	4 (1)		2 (1)
Unusual tiredness	8 (1)	17(2)	12 (3)	3 (1)	7 (4)
Headaches	8 (1)	17 (2)	12 (3)	6 (2)	9 (5)
Dizziness		8 (1)	4 (1)	3 (1)	3 (2)
Shortness of breath	8 (1)		4 (1)		2 (1)
Numbness/tingling	8 (1)		4 (1)		2 (1)
Chest pain/tightness				3 (1)	2 (1)
Eye discharge	8 (1)		4 (1)	3 (1)	3 (2)
Visual Disturbances	8 (1)		4 (1)		2 (1)

* No differences in symptom frequency between those individuals moderately exposed with a self contained breathing apparatus (SCBA) and without SCBA or between moderately exposed and lightly exposed reached statistical significance of $p<0.05$ by Fishers Exact or Chi Square Testing.

TABLE VIII

Hill-Murray High School
Maplewood, Minnesota
HETA 82-310

COMPARISON OF FIRST AND FOURTH WEEK SYMPTOMS

SYMPTOMS	MOD. EXPOSED (N= 25)		LIGHTLY EXPOSED (N= 33)		TOTAL EXPOSED (N=58)	
	First Week % (#)	Fourth Week % (#)	First Week % (#)	Fourth Week % (#)	First Week % (#)	Fourth Week % (#)
Skin irritation	16 (4)	4 (1)	3 (1)	3 (1)	9 (5)	3 (2)
Skin redness	4 (1)				2 (1)	
Pimples	8 (2)	8 (2)	6 (2)	3 (1)	7 (4)	9 (5)
Itching	16 (4)	8 (2)	6 (2)	3 (1)	10 (6)	5 (3)
Poor appetite	4 (1)	8 (2)	3 (1)		3 (2)	3 (2)
Abdominal pain	8 (2)	4 (1)	3 (1)		5 (3)	2 (1)
Nausea	8 (2)	4 (1)	9 (3)		9 (5)	2 (1)
Vomiting			3 (1)		2 (1)	
Unusual tiredness	20 (5)	12 (3)	6 (2)	3 (1)	12 (7)	7 (4)
Headaches	24 (6)	12 (3)	20 (7)	6 (2)	22 (13)	9 (5)*
Dizziness	8 (2)	4 (1)	3 (1)	3 (1)	5 (3)	3 (2)
Numbness/tingling	8 (2)	4 (1)			3 (2)	2 (1)
Chest pain/tightness	4 (1)		3 (1)	3 (1)	3 (2)	2 (1)
Eye discharge	4 (1)	6 (2)	3 (1)	3 (2)	3 (2)	
Visual Disturbances	4 (1)	4 (1)			2 (1)	2 (1)
Shortness of breath		4 (1)				2 (1)

*P= 0.04 by Chi Square Testing of 1st vs. 4th week symptoms

TABLE IX

Hill-Murray High School
Maplewood, Minnesota
HETA 82-310

BLOOD PCB LEVELS*
Drawn within 48 hours of exposure

	MOD. EXPOSED without SCBA $\overline{M}$ (SD)	MOD. EXPOSED with SCBA $\overline{M}$ (SD)	LT. EXPOSED $\overline{M}$ (SD)
Number of Individuals	13	11	36
PCB Level	2.0 (3.1)	5.0 (4.7)	5.0 (3.6)

* All levels were within the range expected for the general population. There was no significant differences between the means of the different groups.

TABLE X

Hill-Murray High School
Maplewood, Minnesota
HETA 82-310

BLOOD EXAMINATIONS DRAWN WHICH DEMONSTRATED NO MEAN ABNOMALITIES AND NO SIGNIFICANT DIFFERENCES BETWEEN EXPOSURE GROUPS NOR OVER TIME

Hematocrit
MCHC
White Blood Cells
- Polys
- Bands
- Lymphs
- Eos

Platelet Count

Sodium
Potassium
Chloride
CO_2
Creatinine
Glucose
Calcium
Phosphorus
Uric Acid
Total Protein
Albumin
Total Bilirubin
Alk. Phos.
CPK
LDH
Hepatitis A Core Antibody

TABLE XI

Hill-Murray High School
Maplewood, Minnesota
HETA 82-310

STATISTICALLY SIGNIFICANT FIRST AND FOURTH WEEK COMPARISONS OF CBC AND BLOOD CHEMISTRY TESTS

TEST	MOD. EXPOSED without SCBA		MOD. EXPOSED with SCBA		LT. EXPOSED		TOTAL	
	First Week M (SD)	Fourth Week M (SD)	First Week M (SD)	Fourth Week M (SD)	First Week M (SD)	Fourth Week M (SD)	First Week M (SD)	Fourth Week M (SD)
Number	12		12		28		52	
Hgb (gm/dl)	15.2 (1.0)	15.0 (1.0)	15.9 (0.6)	15.5 (0.7)*	15.5 (0.9)	15.2 (0.7)	15.5 (1.0)	15.3 (0.8)*
Hct (%)	45.0 (3.2)	45.3 (3.3)	47.6 (1.6)	46.8 (2.3)	46.1 (2.8)	45.5 (2.6)	46.1 (2.8)	45.8 (2.7)
RBC (mil/mm^3)	4.9 (0.3)	4.9 (0.3)	5.3 (0.3)	5.1 (0.3)*	5.1 (0.3)	5.0 (0.3)*	5.1 (0.3)	5.0 (0.3)*
MCV (mic^3)	90.7 (3.2)	91.9 (3.3)†	89.1 (3.4)	90.6 (3.8)†	89.4 (2.9)	91.1 (4.2)§	89.4 (3.9)	91.3 (3.9)§
MCH (pcg)	30.6 (1.3)	30.5 (1.3)	30.1 (1.4)	30.1 (1.4)	29.9 (1.0)	30.5 (1.6)*	30.0 (1.6)	30.5 (1.5)
BUN (mg/dl)	16.0 (4.0)	16.0 (3.9)	14.0 (2.8)	14.4 (2.8)	14.7 (2.7)	16.1 (3.4)*	15.0 (3.1)	17.3(11.9)'
Chol. (mg/dl)	235 (53)	220 (45)	220 (39)	200 (30)*	228 (58)	220 (53)	227 (53)	215 (47)*
Trigl. (mg/dl)	223 (243)	205 (138)	224 (143)	318 (242)'	241 (159)	277 (207)	235 (174)	285 (225)'
SGOT (units/L)	25 (9)	22 (6)	26 (9)	21 (5)*	22 (8)	20 (5)	24 (9)	21 (5)'
GGT (units/L)	34 (21)	27 (20)	29 (25)	30 (29)	27 (21)	25 (21)	28 (21)	27 (23)'
CPK (units/L)	139 (82)	112 (34)	265 (192)	174 (93)'	159 (99)	139 (78)	176 (124)	141 (76)

* $P < 0.05$, † $P < 0.001$, utilizing a one sample t test on the mean of individual differences between first and fourth week values with a normal distribution.
' $P < 0.05$, § $P < 0.001$, utilizing a sign rank test on the mean of individual differences between first and fourth week values with a markedly non-normal distribution.