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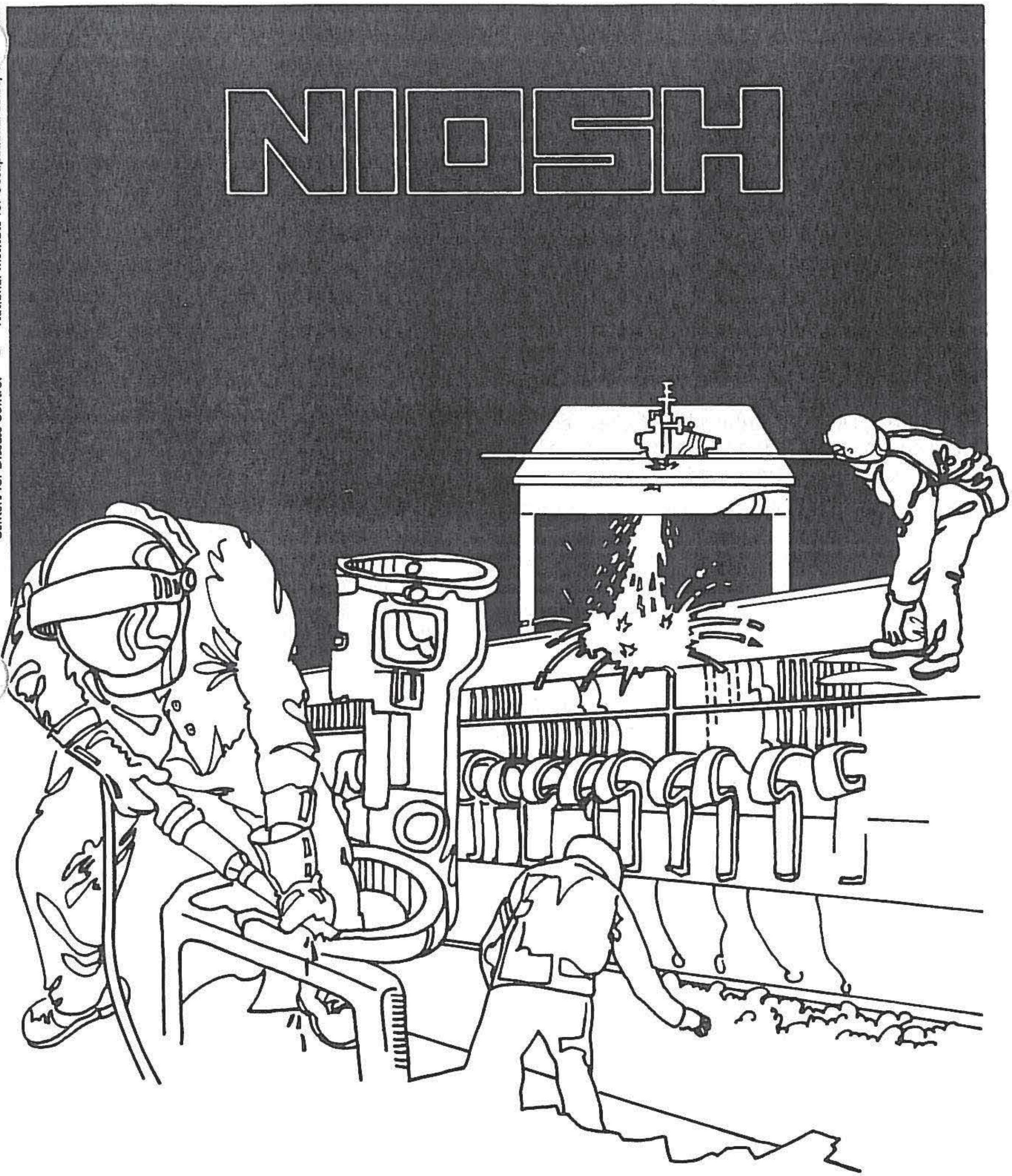
Centers for Disease Control ■ National Institute for Occupational Safety .th




# Health Hazard Evaluation Report

HETA 81-414-1047
A.E. STALEY COMPANY
DECATUR, ILLINOIS

## PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 81-414-1047
February 1982
A.E. Staley Co.
Decatur, Illinois

NIOSH INVESTIGATORS
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## I. SUMMARY

On August 3, 1981, an authorized union representative of AIWA Local 837 requested the National Institute for Occupational Safety and Health (NIOSH) to investigate an explosion of a PCB-filled transformer which occurred at A.E. Staley Co., Decatur, Illinois, on July 11, 1981.

To determine if workers exposed to PCB during the cleanup operation exhibited signs or symptoms of PCB intoxication, NIOSH conducted a site visit at the plant on August 10-11, 1981. NIOSH investigators examined the site of the explosion and discussed details of the cleanup operation with union and management representatives, interviewed workers potentially exposed to PCB during the cleanup and a group of non-exposed workers, and obtained blood samples from both the exposed and non-exposed workers.

Seven of twenty (35%) exposed workers and two of twelve (17%) non-exposed workers reported symptoms that have been elsewhere associated with exposure to PCB, including eye irritation or discharge, rash, fatigue, stomach ache, and sweating of palms, but the difference between the proportion of exposed and non-exposed workers reporting any specific symptom was not statistically significant. Limited physical examination of the eyes and skin revealed no findings attributable to PCB exposure.

The average concentration of PCB in serum of exposed workers was 8.9 parts per billion (ppb). For the non-exposed group, the average serum PCB level was 10.2 ppb. Excluding from the non-exposed group four electricians with probable multiple exposure to PCB in the past, the average serum PCB level of the non-exposed group was 5.9 ppb. In neither case was the difference between the group means statistically significant. Most individual values were in the range reported in previously published studies for populations without occupational or unusual exposure to PCB.

A statistically significant linear relationship was found between serum PCB level and reported duration of exposure to PCB during the cleanup operation.

Based on these results, NIOSH concluded that the workers involved in the transformer shutdown and cleanup did not exhibit signs or symptoms of PCB intoxication, and did not have abnormally high serum PCB levels. The finding of a correlation between serum PCB levels and reported length of exposure to PCB during the shutdown/cleanup suggests, however, that as a group those workers involved for longer periods of time absorbed more PCB. Only a small proportion of workers involved in the cleanup used any type of personal protective equipment. In view of the reported toxicity of PCB, NIOSH has made recommendations in Section VIII of the report regarding appropriate action in the event of future PCB transformer fluid spills or leaks, in order to minimize absorption of PCB by workers.

KEYWORDS: SIC 2046 (Wet Corn Milling), transformer explosion, PCB

## II. INTRODUCTION

On August 3, 1981, NIOSH received a request from an authorized union representative of AIWA Local 837 at the A.E. Staley Co., Decatur, Illinois, asking NIOSH to investigate a transformer explosion at the plant which had occurred on July 11, 1981. The explosion spattered polychlorinated biphenyls (PCB) on the second floor roof of Building 44, and approximately 20 workers were reported to have had skin contact with PCBs during the cleanup stage, and possible exposure to PCB vapors. As several workers felt that they had experienced adverse health effects as a result of this incident, NIOSH was asked to investigate the possibility that exposed workers had experienced health problems attributable to PCB toxicity. Accordingly, NIOSH investigators visited the plant on August 10-11, 1981.

## III. BACKGROUND

The A.E.Staley Co. plant in Decatur, Illinois is a grain processing plant employing approximately 1500 people. The company produces corn and soybean products. The incident which prompted the NIOSH investigation affected only a small number of workers in a very small area of the plant, and was not directly related to production of grain products.

On July 11, 1981, a 38.5 KVolt PCB-filled transformer located on the second floor roof of Building 44 exploded. The explosion spattered approximately 15-20 gallons of transformer fluid on the roof, and a metal plate from the transformer blew 10 feet into the air, breaking a third floor lunchroom window, approximately 50-75 feet from the location of the transformer. Fragments of glass hit several men in the lunchroom, and a number of workers stated that they were struck by the metal plate as it crashed through the window. According to the union representative, smoke and vapors from the overheated transformer entered open second floor windows in the areas where crystallizer machines are located. Approximately five workers were sent to shut down these machines and were thus potentially exposed to vapors. An emergency response team from the plant protection group arrived at the scene of the explosion to construct a barrier to contain the transformer fluid. Further cleanup was performed by approximately ten electricians who, unlike the members of the emergency response team, did not wear protective clothing or equipment. A number of these workers reportedly wore their PCB-soiled clothing for several days after the incident. 1,1,1-trichloroethane and an absorbent material were used for cleanup. The plate on the transformer was resecured by a welder and a tinner. The transformer was initially refilled with a PCB-containing fluid, but was subsequently drained and refilled with silicone.

The walk-through and discussion of the transformer explosion which the NIOSH investigators held on August 10-11 with union and management representatives indicated that the workers who were potentially exposed to PCB-containing transformer fluid fell primarily into three groups:

those who shut down the crystallizer machines, those who participated in the cleanup of the transformer fluid spill, and those who repaired and/or refilled the transformer. In addition, several workers reported that they were hit by the metal plate after it crashed through the lunchroom window, and stated that they came in contact with a significant amount of transformer fluid. One other worker was an "observer".

## IV. METHODS AND MATERIALS

Eighteen "exposed" workers and twelve "non-exposed" workers were included in the study. The 18 exposed workers in the study represented 75% of the total number of workers exposed during the recent incident. Two additional workers, who had been involved in repair of a transformer during a similar incident in 1980, were also included in the exposed group. The group of non-exposed workers consisted of five representatives of management, three union representatives, and four electricians not involved in the transformer explosion or subsequent cleanup.

NIOSH administered a questionnaire to all participants. The questionnaire was designed to evaluate acute health effects of PCB exposure, including fatigue, halogen acne, eye irritation and discharge, and upper eyelid swelling. Medical officers from NIOSH performed a limited physical examination of each participant's eyes and skin (including face, extremities, chest, and back where indicated). They also obtained blood specimens for determination of serum PCB levels.

Analysis of serum samples for PCB was performed utilizing the NIOSH P&CAM method 329 (1). Quality control procedures included analysis of spiked fish tissue whose true value was determined by the Environmental Protection Agency, and inclusion of a standard of Aroclor 1260 in each run to monitor instrument performance. Quality control data are presented in Table 1.

## V. EVALUATION CRITERIA

PCBs are chemically stable mixtures of chlorinated biphenyls that do not conduct electricity and can withstand long periods of high temperature and pressure. These properties have made them useful in electrical transformers and condensers.

Data obtained from animal experimentation suggest that the acute toxicity of PCBs is low (2). Animal toxicity studies have, however, shown that PCBs may decrease immunity and increase susceptibility to infection, are carcinogenic in rodents, and impair fertilization in female rodents and rhesus monkeys (2,5,14).

The toxicity of PCBs depends on the number and location of the chlorines in the PCB molecule and on the duration of exposure. Absorption is primarily through the skin or gastrointestinal tract, but inhalation can be an important route of absorption if the PCBs are heated or if one is in a confined space. The NIOSH recommended standard for occupational exposure to PCBs is a time-weighted average (TWA) of 1.0 micrograms total PCBs per cubic meter of air, for up to a 10-hour workday, 40-hour workweek (10). PCBs are lipid soluble, and thus are poorly excreted.

Knowledge of the health hazards of a single limited exposure to PCBs is very limited. Information on human toxicity has been gathered largely from workers chronically exposed (2) or populations accidentally exposed to massive amounts of PCB (Yusho incident)(3).

PCBs have been demonstrated to have the following toxic effects in humans (2,4):

1. Chloracne: a persistent skin eruption, similar to acne but more severe and with different distribution, generally found on exposed areas of the body

2. Eye, nose, and throat irritation

3. Swelling of the meibomian glands in the upper eyelid

4. Gastrointestinal disturbances

5. Skin rashes, thickening, and hyperpigmentation

6. Mild liver toxicity, which may be manifested as fatigue, abdominal pain, nausea, vomiting, loss of appetite, jaundice, and edema

7. Abnormalities in offspring of women heavily exposed

8. A variety of other symptoms, including weakness, headache, cough, numbness and pain in extremities, swelling and pain in joints

While mixtures of PCBs tested in mice and rats have consistently been shown to induce liver tumors, no study has been performed which adequately addresses the question of carcinogenicity of PCBs in humans. Materials which have been demonstrated to cause cancer in animals should, however, be treated as potential human carcinogens, and it would be judicious to limit exposure to those materials to the minimum level possible.

Dietary PCB exposure, the major source of population exposure, occurs especially through eating fish, but PCB residues are also found in milk, eggs, cheese, and meat. It has been estimated that the average daily dietary intake of PCB does not exceed 10 micrograms (4). Although there are no widely accepted normal values for serum PCB concentrations, levels can be compared to published values both for occupationally exposed groups and community groups without any known unusual exposure. Previously published studies have demonstrated that PCBs can be found in the serum of most non-occupationally exposed persons. Such studies have reported serum PCB values ranging from 0 to 42 parts per billion (ppb), with means from 2.1 to 24.4 ppb (13). In the largest study performed, in which 616 individuals were studied, the range of serum PCB levels was 0-29 ppb (8). Based on these results of groups without unusual exposure to PCB, a reasonable acceptable upper limit value for serum PCB would appear to be around 30 ppb. Higher PCB serum levels have been found among occupationally exposed groups. This subject is discussed in greater detail in Section VII.

## VI. RESULTS

The mean age of the 20 workers exposed to PCB was 38 years (Range 21-60). This compares to a mean age of 43 years (Range 30-58) for the 12 employees in the non-exposed group. The average length of employment for the exposed group was 16.2 years, and for the non-exposed group, 16.4 years.

Seven members of the exposed group and two members of the non-exposed group reported symptoms compatible with toxicity from PCB exposure, as follows:

| Symptom | Number reports | |
|---|---|---|
| | Exposed (N=20) | Non-exposed (N=12) |
| Eye irritation or discharge | 4 | 0 |
| Rash | 3 | 1 |
| Fatigue | 2 | 1 |
| Stomach ache | 1 | 1 |
| Sweating of palms | 1 | 1 |

No other symptoms were reported. The difference between the proportion of exposed and non-exposed workers reporting any specific symptom was not significant at the 5% level (Fisher's exact test). Limited physical examination of the eyes and skin showed no evidence of chloracne or other skin rashes, or evidence of any eye irritation or discharge in any participant in the study.

For the twenty exposed workers, the average time of exposure reported was 4.2 hours (Range 1 minute-16 hours).

Results of serum concentrations of Aroclor 1260 are shown in Table 2. The difference between the mean serum PCB levels of the exposed and non-exposed groups was not statistically significant at the 5% level (Rank sum test).

The "non-exposed" group included four electricians who, by the nature of their work, would be expected to have had previous contact with PCB. Indeed, three of the four recalled multiple exposures to transformer fluid in the past. For comparison of serum PCB levels, a more suitable control group, representative of truly non-exposed workers, would thus exclude these electricians, who had a mean serum PCB level of 19 ppb. In this case, the average serum PCB level for the newly defined non-exposed group is 5.9±2.2 ppb, lower than that of the exposed group, but a difference that is not statistically significant at the 5% level (Rank sum test).

Variation of PCB levels with age of individual was analyzed as follows:

| Age | Number | Mean serum PCB ± SD (ppb) |
|---|---|---|
| 20-29 | 4 | 4.1±3.2 |
| 30-39 | 14 | 9.1±8.9 |
| 40-49 | 7 | 10.2±9.0 |
| 50+ | 7 | 12.2±8.6 |

To test the null hypothesis that there is no linear relationship between serum PCB level and age, the Pearson correlation coefficient (r) was calculated. In this case r=0.248, which was not statistically significant at the 5% level.

Excluding the five representatives of management with no history of any occupational exposure to PCB, variation of PCB level with years on the job was calculated as follows:

| Years on job | Number | Mean serum PCB ± SD (ppb) |
|---|---|---|
| 0-9 | 6 | 5.3±4.6 |
| 10-19 | 11 | 9.1±10.0 |
| 20-29 | 3 | 14.7±13.3 |
| 30+ | 7 | 13.3± 7.5 |

For the above variables, r=0.39, just significant at the 5% level.

Excluding two employees exposed to PCB in 1980, but not in 1981, PCB levels varied with reported duration of exposure to PCB during shutdown/cleanup as follows:

| Duration of exposure (hours) | Number | Mean serum PCB ± SD (ppb) |
|---|---|---|
| less than 1 | 6 | 4.7±3.4 |
| 1-5 | 8 | 7.7±4.6 |
| 5+ | 4 | 19.2±11.4 |

For the above variables, r = 0.60, P 0.01.

By means of a multiple regression analysis, it was possible to analyze the independent effects of the two variables, years on job, and reported duration of exposure to PCB during the shutdown/cleanup, on the measured serum PCB levels. The results of this analysis indicate that only reported duration of exposure is a significant variable (.01 P .05) in accounting for variation in PCB level.

The activity of the exposed workers during the PCB shutdown/cleanup was as follows:

| Activity | Number | Mean PCB ± SD |
|---|---|---|
| Crystallizer shutdown | 5 | 4.6±4.7 |
| Cleanup of spill | 7 | 14.5±10.5 |
| Welding/repair of transformer | 7 | 15.0±9.7 |
| Hit in lunchroom or "observer" | 4 | 5.8±3.8 |

(Total number exceeds 20, since some workers were involved in multiple activities).

The difference in mean PCB levels between any two activities was found not to be statistically significant at the 5% level (Rank sum test).

Only a small number of workers involved in the shutdown/cleanup used any type of personal protective equipment. For the most part, those who did report use of personal protective equipment wore rubber gloves, although usually not for the entire time they were potentially exposed to PCB. Because of the very small number of workers using personal protective clothing or equipment, attempts to correlate use of personal protective equipment with serum PCB levels were not pursued.

## VII. DISCUSSION

While toxicity of PCB to humans has been documented (2,4,10), knowledge of the health hazards of a single limited exposure to PCB is very limited. Results of the questionnaire and limited physical examination failed to provide evidence for any specific untoward health effects resulting from PCB exposure.

A number of previous studies have measured PCB serum levels in populations with and without occupational exposure. Baker et al. found the following PCB levels in a study in Bloomington, Indiana (6):

| | Mean serum PCB (ppb) |
|---|---|
| Sludge workers | 17.4 |
| Workers with occupational exposure | 75.1 |
| Workers' families | 33.6 |
| Community controls | 24.4 |

No chloracne or systemic symptoms were discovered.

Reported serum PCB concentrations in populations without occupational or unusual exposure to PCB include results of studies done in Michigan and South Carolina (8):

| | No. of subjects | Year | Mean | Range |
|---|---|---|---|---|
| Michigan | 26 | 1973-77 | 17.0 | 7-42 |
| South Carolina | 616 | 1968 | 5.7 | 0-29 |

More recently, Maroni et al. reported results of PCB measurements done on whole blood of 80 electrical workers exposed for many years to PCB mixtures in a plant in Italy(9). They reported that mean PCB recovery from serum is approximately 60% of the recovery from whole blood. Their results were as follows:

| | ppb(Mean ± SD) | Range |
|---|---|---|
| 60 currently exposed workers | 377±258 | 88-1319 |
| 17 past exposed workers | 292±161 | 94-631 |
| 3 workers with occupational exposure | 110±31 | 88-146 |

Correlating blood measurements of PCB with concentrations of PCB found in air and detected on surfaces and palms led the authors to conclude that absorption of PCB is mainly through the skin, and that blood concentration appears to be correlated with length of exposure.

Complete agreement is lacking regarding baseline values for PCB in the blood of humans, both for general populations and non-exposed industrial populations. From the above-cited reports, however, it is evident that the values of serum PCB for the workers in this study fall within the range of values reported for populations without any known unusual exposure to PCB.

It is noteworthy, however, that serum PCB level is positively correlated with duration of involvement with the exploded transformer. This suggests that as a group, those workers involved for longer periods of time absorbed more PCB. Inasmuch as little use of protective equipment was made, this relationship between length of exposure and serum PCB level seems plausible.

Most workers involved in cleanup of the transformer fluid spill did not remove their work clothing or wash skin exposed to PCB immediately after work. Wearing clothing contaminated with PCB may have resulted in continued absorption of PCB through the skin.

## VIII. RECOMMENDATIONS

Recommended procedures in the event of PCB spills, leaks, or explosions are outlined in several NIOSH publications (10-12). The following recommendations are pertinent to the type of incident which occurred at A.E. Staley, and are directed specifically toward deficiencies noted in the organization and implementation of the cleanup operation.

1. Employees should be required to use impervious suits, gloves, shoe-coverings, and face shields to prevent skin contact with liquid PCB. If in an open area, workers should be required to wear organic vapor respirators. If in a confined space, they should wear air supplied respirators.

2. Only persons wearing protective equipment and clothing should be permitted in areas of spills or leaks. All other persons should be prohibited from entering the area until completion of cleanup.

3. In the event of a PCB spill or leak, the area should be ventilated, and material collected for reclamation, or soaked up in vermiculite, dry sand, earth, sawdust, or a similar material.

4. Non-impervious clothing which becomes contaminated with liquid PCB should be removed promptly and placed in closed containers for storage until it can be discarded.

5. Skin that becomes contaminated with liquid PCB should be promptly washed with soap or mild detergent and water.

6. A team of workers should receive training in emergency procedures for handling PCB spills, leaks, or explosions.

Adherence to the above recommendations in the event of a future PCB spill, leak, or explosion should minimize workers' exposure to PCB, and any consequent harmful effects which might result from absorption of excessive amounts of PCB.

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## X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request form NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161.

Copies of this report have been sent to:

1. AIWA union representative, Local 837, Decatur, Illinois
2. A. E. Staley Co., Decatur, Illinois
3. OSHA, Region V
4. NIOSH, Region V

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

## Table 1
## Quality Control Data for Aroclor 1260 Analyses

### Instrument Control

50 ppb Aroclor 1260 standard prepared from weighed pure Aroclor 1260

| Results in ppb 1260 |
|---|
| 46 |
| 48 |
| 55 |
| 48 |
| 52 |

Mean-50 ppb
S.D.- 3.6

### Procedure Control

Analyses of spiked fish tissue

Control A- True value 953 ppb Aroclor 1260
Analyzed 748 ppb Aroclor 1260
Percent recovery- 78%*

Control B- True value 111 ppb Aroclor 1260
Analyzed 85 ppb Aroclor 1260
Percent recovery- 76%*

* Most methodologies for these type of analyses report recoveries averaging near 80%.

Table 2
SERUM PCB CONCENTRATIONS
A. E. STALEY CO.
DECATUR, ILLINOIS
HETA 81-414

| SERUM PCB (ppb) | NO. EXPOSED WORKERS | NO. UNEXPOSED WORKERS |
|---|---|---|
| < 5 | 7 | 2 |
| 5-9 | 6 | 8 |
| 10-14 | 5 | 0 |
| 15-20 | 1 | 0 |
| 25-29 | 0 | 0 |
| 30-34 | 0 | 2 |
| 35-39 | 1 | 0 |

| | EXPOSED | UNEXPOSED |
|---|---|---|
| RANGE | 2.5-36 ppb | 2.5-30 ppb |
| MEDIAN | 8.5 | 7.0 |
| MEAN ± SD | 8.9±7.8 | 10.2±9.4 |

NOTE: Those PCB levels reported as "less than 5 ppb", i.e., below the limit of detection of the analytical method used, were assigned a value of 2.5 ppb for computation purposes.