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CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
MORGANTOWN, WEST VIRGINIA 26505

HAZARD EVALUATION AND TECHNICAL ASSISTANCE
REPORT NO. ~~M-PA-80-105-110~~
80-HHE-80-109-110
PATRIOT COAL COMPANY LABORATORY
KINGWOOD, WEST VIRGINIA

JUNE 1980

I. SUMMARY

On March 5, 1980, at the request of the Mine Safety and Health Administration (MSHA) District 3 Manager, The National Institute for Occupational Safety and Health (NIOSH) conducted an industrial hygiene survey of The Patriot Coal Company's Coal Laboratory located in Kingwood, WV, to assess worker exposure to ambient airborne concentrations of perchloroethylene (PCE)* vapors generated during routine float sink testing of coal.

NIOSH recommends that it is prudent to handle PCE in the workplace as if it were a human carcinogen. The recommendation is based on a study by the National Cancer Institute indicating that PCE causes liver cancer in laboratory mice (2). Neither the MSHA standard or the NIOSH recommended levels for PCE may provide adequate protection from potential carcinogenic effects because they were selected to prevent diseases other than cancer.

Results of air sampling conducted during the float-and-sink testing operation demonstrated that the personnel employed in this area were exposed to PCE in excess of the current NIOSH recommended ceiling level of 100 parts per million (ppm). The combination of incorrect work practices, inadequate ventilation and the projected workload increase at the laboratory could reasonably be expected to produce exposures in excess of the current MSHA standard (100 ppm - 8 hr. Time Weighted Average).

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*Perchloroethylene is commonly used interchangeably with tetrachloroethylene.

It is strongly recommended that changes in work practices designed to limit vapor generation occurring outside of controlled air spaces be implemented. Engineering controls should be upgraded to facilitate the changes in work practices as well as the projected increase in workload. Recommendations which should minimize employee exposures to PCE and other solvent vapors have been developed by NIOSH and are incorporated in detail in the RECOMMENDATIONS section of this report.

Ethylene dibromide (EDB) and varsol (petroleum hydrocarbons) were also used at the facility, however, results of sample analysis showed them not to present a health hazard at the time of the survey.

II. INTRODUCTION AND BACKGROUND

Under the Federal Mine Safety and Health Act of 1977, NIOSH has been delegated responsibility for evaluating, upon written request, the potential hazard of any substance in the concentrations normally used or found in the workplace.

On February 27, 1980, the District 3 Director for MSHA in Morgantown, West Virginia, requested technical assistance at the Patriot Coal Company testing laboratory. The purpose of the evaluation was to determine if solvent vapors emitted from a float-and-sink testing process during routine float-and-sink testing ofcoal created an employee health hazard.

The Patriot Coal Company operates a testing laboratory in support of one company coal preparation plant (dense medium flotation process) and two strip mines. Laboratory personnel project an increase in the amount of work performed at this facility.

Within the laboratory, float-and-sink testing (FST), has the potential for releasing solvent vapors into the air. The test procedure is utilized in order to determine the optimum specific gravity needed to maximize the recovery of coal with high BTU content while minimizing the retainment of low BTU material. The test is accomplished by immersing a coal sample in a tank containing a fluid of pre-selected specific gravity. Heavier materials (extraneous ash) sink while the lighter (cleaned coal) materials float. The coal is skimmed, dried, weighed, and analyzed for ash content and other parameters of interest [1]. With this information the preparation plant dense medium flotation process can be adjusted to produce a coal with the desired heat and ash content. Thereafter the tests are useful for monitoring the process output.

Two laboratory technicians conducted the tests in a room measuring approximately 50' x 25' in plan with a 15 foot ceiling. An enclosed canopy hood for the washing tanks was provided. However, tests were frequently conducted in five gallon buckets on the open floor where no ventilation control was available. PCE was the base chemical with varsol and EDB utilized to lower or raise the specific gravity of the mixture as required.

III. METHODS AND PROCEDURES

A portable Wilks Miran 1A infrared spectrophotometer was utilized to qualitatively identify the solvent vapors generated by float-and-sink testing. Figure 1a is an air scan of the infrared spectrum from 2.5 to 14.5 micrometers for pure air plus a retracing over the initial scan for a mixture of air and reagent grade PCE. By inspection of the graph the absorbtion wavelength for PCE was determined to be 10.9 microns. Figure 1b is a repeat of the above steps with the exception that for the second tracing, vapor over the FST container was substituted for the PCE reagent. The significant conclusion drawn from a comparison of figures 1a and b was that PCE was the only material evaporating in sufficient quantity to present a health hazard.

A combination of personal samples collected on charcoal tubes and direct measurements with the infrared analyzer (calibrated for PCE) were utilized to evaluate the workroom air. The measurements were initiated shortly after the start of a float-and-sink test. The direct PCE readout was terminated at the end of the test as was one personal sample. A second personal sample was allowed to continue for an additional hour. There was only one procedure performed that day and adjustment of the specific gravity of the mixture was not required, and therefore, not evaluated as part of the survey. Outside weather conditions were cold and rainy resulting in "worse case" conditions from a standpoint of diminished natural ventilation and subsequent vapor build-up.

Employees were questioned about the process, health status and personal protective measures. For reference, Fig 2 provides a floor plan of the FST room.

IV. TOXICITY AND EVALUATION CRITERIA

Human Toxicity

"Clinical evidence accumulated over the years clearly demonstrates that tetrachloroethylene (perchloroethylene) is toxic to the liver and kidneys in humans. Liver impairment has been noted in cases of exposure to tetrachloroethylene as evidenced by abnormal liver

function tests. Also, toxic chemical hepatitis, and enlargement of the liver and spleen have been associated with exposure to tetrachloroethylene. Tetrachloroethylene vapor is irritating to the eyes and upper respiratory tract, and may cause frontal sinus congestion and headache. Direct contact with skin can cause burns, blistering, and erythema due to the "degreasing" effect of tetrachloroethylene on the skin. Over a period of time this can result in extreme skin dryness with cracking and associated infection.

Altered physiological and behavioral responses observed in subjects exposed to tetrachloroethylene include vague nonspecific complaints generally attributed to Central Nervous System (CNS) depression. These symptoms include vertigo, impaired memory, confusion, fatigue, drowsiness, irritability, loss of appetite, nausea and vomiting. Motor coordination following tetrachloroethylene exposure requires additional mental effort, which along with memory impairment and fatigue have important implications for worker safety. Various disturbances of the peripheral nervous system such as tremors and numbness have also been associated with exposure to tetrachloroethylene. Excessive absorption of tetrachloroethylene can cause severe depression of the CNS leading to coma; ultimately death may occur from respiratory paralysis or circulatory failure.

Tetrachloroethylene is most commonly absorbed through the lungs and can be absorbed from the intestines if ingested. The skin is a less important absorption site. Physical exercise can significantly increase the amount of tetrachloroethylene absorbed through the lungs because of greater respiration and increased blood flow.

Metabolism and elimination of tetrachloroethylene is relatively slow. It is deposited in body fat and the biologic halflife of tetrachloroethylene in man is estimated at six days." [2]

In 1976 NIOSH recommended that the environmental limit for PCE be a 10-hour, 40-hour work week TWA concentration of 50 ppm with a 15-minute ceiling value of 100 ppm. These limits, it was believed, would prevent neurologic effects as well as eye and respiratory tract irritation. No evidence of liver damage at or near the recommended limit had been reported [2]. Table 1 contains a summary of the Federal standards, NIOSH recommended limits and the health effects considered in their establishment.

Recently a study by the National Cancer Institute has indicated that PCE causes liver cancer in laboratory mice. NIOSH revised recommendations now indicate that it would be prudent to handle PCE in the workplace as if it were a human carcinogen [2]. Safe levels of exposure to carcinogens have not been demonstrated, but the probability of cancer development is lowered with decreasing exposure levels. Neither the current Federal standard or the NIOSH

recommended levels for PCE may provide adequate protection from potential carcinogenic effects because they were selected to prevent diseases other than cancer (2). Thus NIOSH recommends that occupational exposures to PCE be minimized in all ways possible.

Evaluation Criteria

Four sources of criteria are generally used in NIOSH evaluations to assess worker exposure to concentrations of air contaminants in the mining industry: (1) NIOSH criteria for recommended standards; (2) Mine Safety and Health Administration's adoption of the Threshold Limit Values (TLVs) for Coal and for Metal and Nonmetal Mining; (3) other Federal standards and (4) national consensus health standards. NIOSH criteria are generally utilized in assessing worker exposure to potentially hazardous agents except in cases where more current and stringent Federal or consensus standards exist or where sufficient "state of the art" health research information is available and can be applied.

V. RESULTS

Figure 3 is a strip chart recording of the PCE vapors measured with the infrared spectrophotometer at a point 10 feet from where the FST was conducted. The peak concentration was 194 ppm. The lowest level recorded,during the test period was 110 ppm. The personal sample collected for the technician skimming the coal was 149 ppm averaged over the test period. This result is in excellent agreement with the average value one would estimate from the direct read-out tracing. The assistant's personal exposure measurement averaged over a 2-hour period was 101 ppm.

VI. CONCLUSIONS AND DISCUSSION

Both individuals in the FST room were exposed to levels of PCE which exceeded the current NIOSH recommended ceiling limit of 100 ppm. A combination of incorrect work practices and inadequate mechanical ventilation were the main contributers to the build-up of PCE vapors in the workroom air. It should be emphasized that because PCE has been shown to induce liver cancer in laboratory mice, NIOSH recommends that occupational exposures be minimized in all ways possible. Safe levels of exposure to carcinogens have not been demonstrated, but the probability of cancer development is lowered with decreasing exposure levels.

The largest concentrations of PCE vapors were liberated when the float-and-sink testing of large samples was conducted on the open floor with the technician bending over the bucket (respirator not

worn). After skimming the coal it was dumped on the floor until such time as there was space in the oven to dry the samples. At the time of this writing the laboratory reported that both of these practices have been discontinued, and all testing is conducted under the canopy hood. More drying trays have been ordered so that samples will not have to be deposited on the floor prior to their being loaded on trays and placed in the drying oven. Use of the existing canopy hood may also serve to increase exposures as the design of the hood did not provide for an adequate face velocity (measured at 25 fpm) with the doors open. Further, the shape and size of the hood required the technician's head to be inside the enclosure (see Fig 4a) when running a test. An organic cartridge respirator may be ineffective in preventing exposure to PCE unless cartridges are changed frequently. The odor threshold at or above which the average person can detect PCE is approximately 50 ppm. This level may be higher for workers whose olfactory senses have become fatigued from exposure to PCE. Relying on odor alone, a person may be inadvertently exposed to excessive levels of PCE before realizing the cartridge was saturated and vapor was passing through. In a 1000 ppm concentration of PCE the standard organic vapor cartridge has a service life of 129 minutes before a breakthrough of 100 ppm. Under the same conditions it is estimated that the service life for a standard industrial size canister is 340 minutes [4].

Laboratory personnel smoked in the FST room. Open element resistance heaters were utilized for heating the room air. Upon contact with open flames or metal surfaces visibly radiating, PCE may decompose to form highly irritating materials, i.e., phosgene and hydrochloric acid.

VII. RECOMMENDATIONS

A. All float-and-sink testing should be conducted under a properly designed and operated local exhaust ventilation system. Examples of recommended systems are provided in Figures 4b and 4c. Respirators should not be relied upon as a substitute protection in lieu of proper ventilation controls.

B. Consideration should be given to substituting a suitable chemical for PCE in the float-and-sink test that has not been shown to produce cancer in animals. It is recommended that occupational exposures to PCE be minimized in all ways possible.

C. Smoking in areas where chlorinated solvents are utilized should be discontinued. Open element resistance heaters, when replaced, should be replaced with a system which does not have exposed, visibly radiating heat sources.

D. Although not observed at the time of the survey decanting PCE and EDB from the bulk containers, transporting the stock solutions and the formulation of the mixture may pose significant exposure risks. Respirators, eye protection and polyvinyl alcohol coated (or their equivalent) gloves should be worn while decanting, transporting and otherwise handling PCE and EDB. Mixing, as testing, should always be performed under the hood. NIOSH recommends a self-contained breathing apparatus operated in the pressure demand mode equipped with a full facepiece mask. Other alternatives of respiratory selection are outlined in 30CFR 11.70(a)(b).

E. All workers in this facility should be given a preplacement examination and annual medical examinations. The examinations should be general with emphasis on the hepatic and nervous systems (3).

F. Environmental monitoring and recordkeeping is recommended for this work situation as the average exposures were at or above one-half the NIOSH recommended limit (3). If after the appropriate engineering and work practice recommendations have been implemented the monitoring indicates a reduction in exposures below the 25 ppm value as a time-weighted average, monitoring on a routine basis may be discontinued.

G. Upon installation of ventilation control this organization should be requested to conduct a follow-up survey to assess the efficiency of the control measures implemented.

IX. BIBLIOGRAPHY

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5. Nelson, GO, Harder, CA: Respirator Cartridge Efficiency Studies-v. Effect of Solvent Vapor. Am Ind Hyg Assoc J 35:391-410, 1974.

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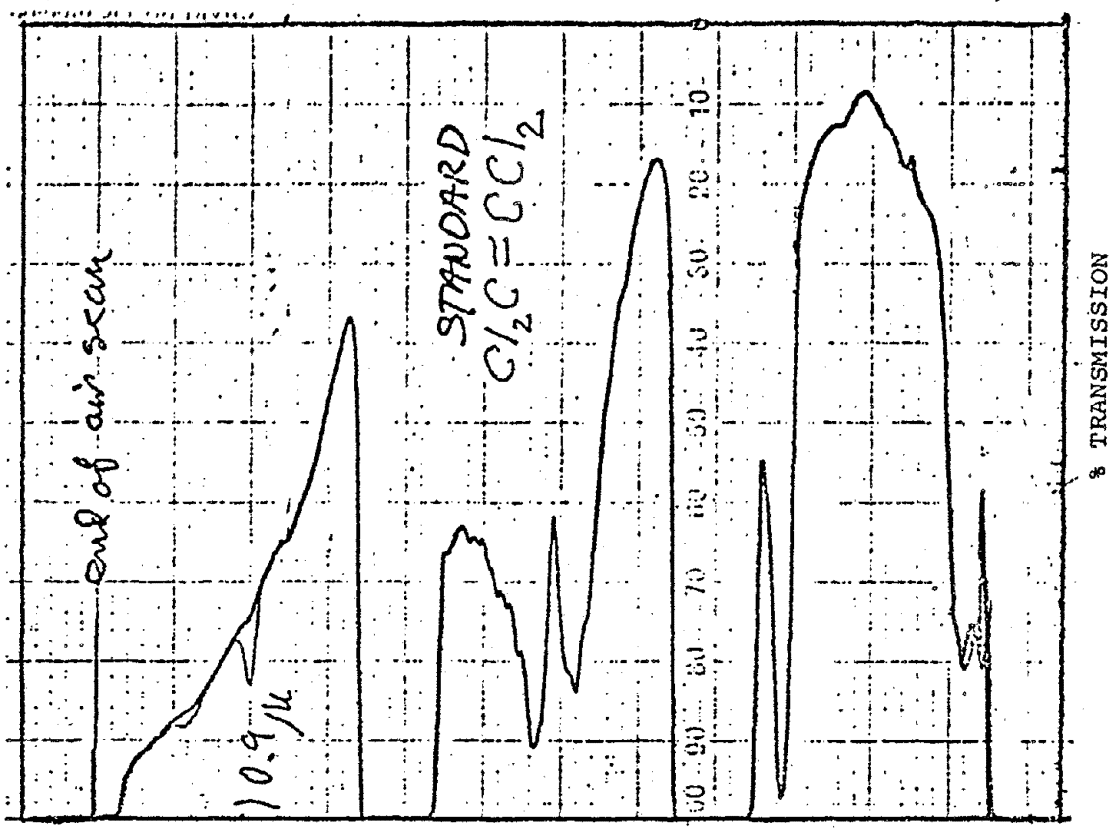
TABLE I

SUMMARY OF NIOSH RECOMMENDATIONS FOR OCCUPATIONAL HEALTH STANDARDS
OCTOBER, 1978 [4]

SUBSTANCE	MSHA ENVIRONMENTAL STANDARD	NIOSH RECOMMENDATION FOR ENVIRONMENTAL, EXPOSURE LIMIT	HEALTH EFFECT CONSIDERED	COMMENTS
Perchloro-ethylene	100 PPM TWA	50-PPM TWA (339 mg/cu m); 100-PPM ceiling (678 mg/cu m) (15-minute)	Nervous System, heart, respiratory, liver effects	Medical warning of possible congenital abnormalities required; demonstrated animal carcinogen
Ethylene Dibromide	25 PPM TWA (skin)	1 mg/cu m ceiling (0.13-PPM) (15-minute)	Damage to skin, eyes, heart, liver, spleen, respiratory & central nervous systems, potential for cancer and mutagenesis	Medical warnings to workers of potential reproductive abnormalities and cancer following direct administration in animals; hazardous liquid, contact to be prevented
Refined Petroleum Solvent	--	350 mg/cu m TWA; 1800 mg/cu m ceiling (15-minute)	Skin, lung, and nerve irritation	Blood and urine monitoring required. Action level for petroleum ether, rubber solvent, naptha be 200 mg/cu m TWA; action level for mineral spirits and stoddard solvent to be 350 mg/cu m TWA; action level for kerosene be 100 mg/cu m TWA. Hazardous substance skin

Figure 1

a. Pure Air Plus $Cl_2C = CCl_2$ Standard



b. Pure Air Plus Test Vapor

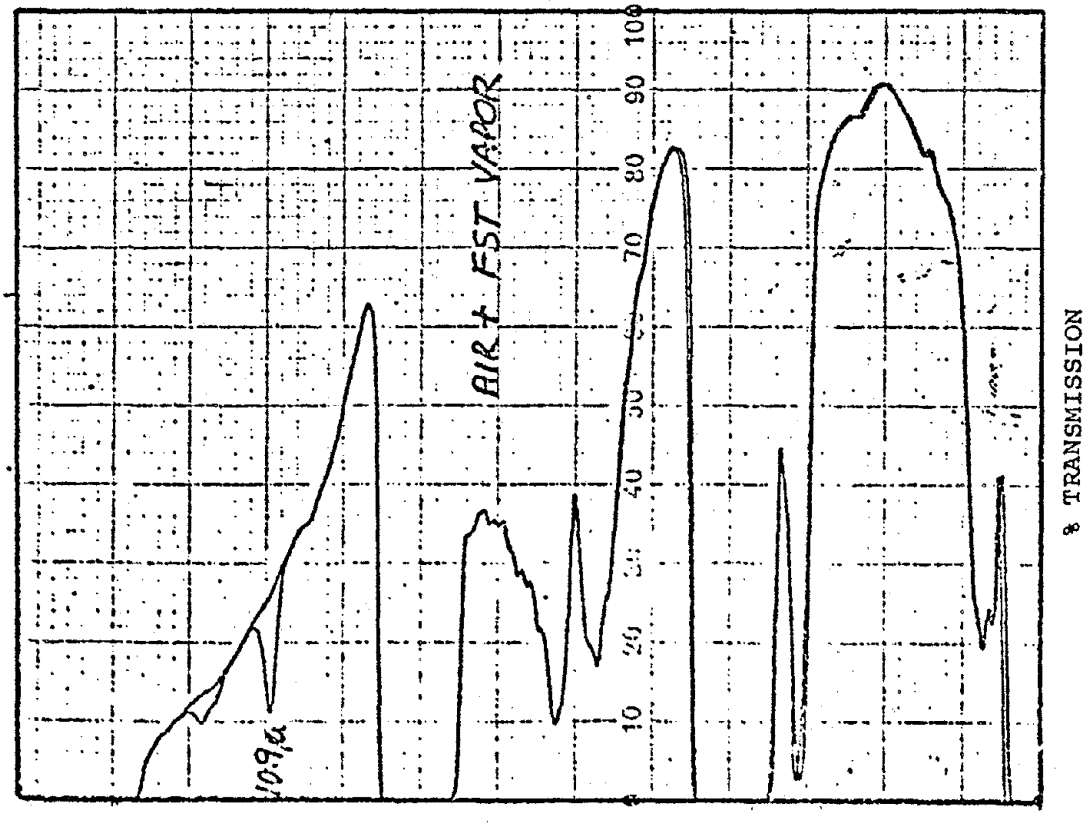


Figure 2

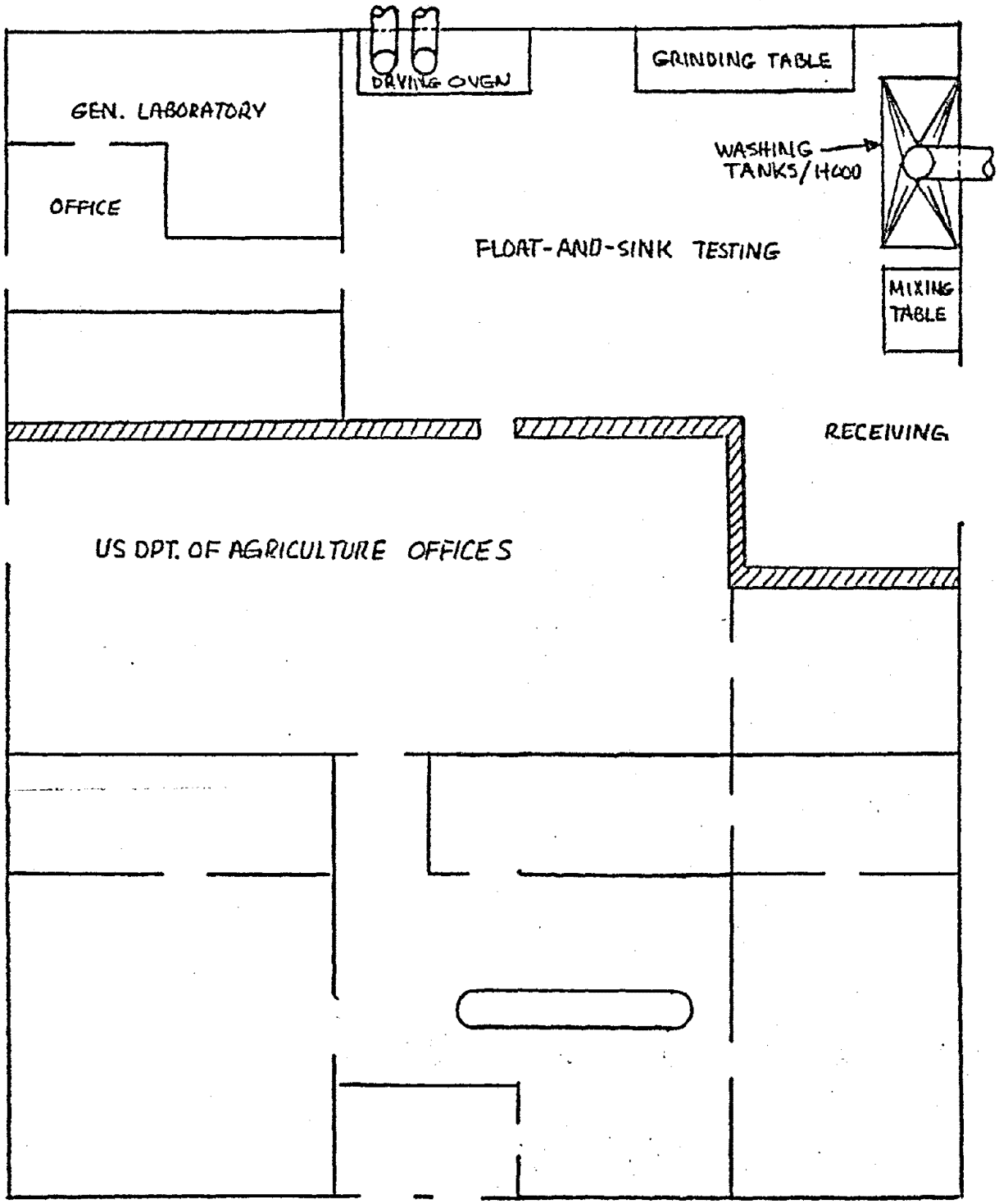

DRYING OVEN
GRINDING TABLE
GEN. LABORATORY
WASHING TANKS/HOOD
OFFICE
FLOAT-AND-SINK TESTING
MIXING TABLE
RECEIVING
US DPT. OF AGRICULTURE OFFICES

Figure 3

Workroom Concentrations of PCE During A Float-and-Sink Test

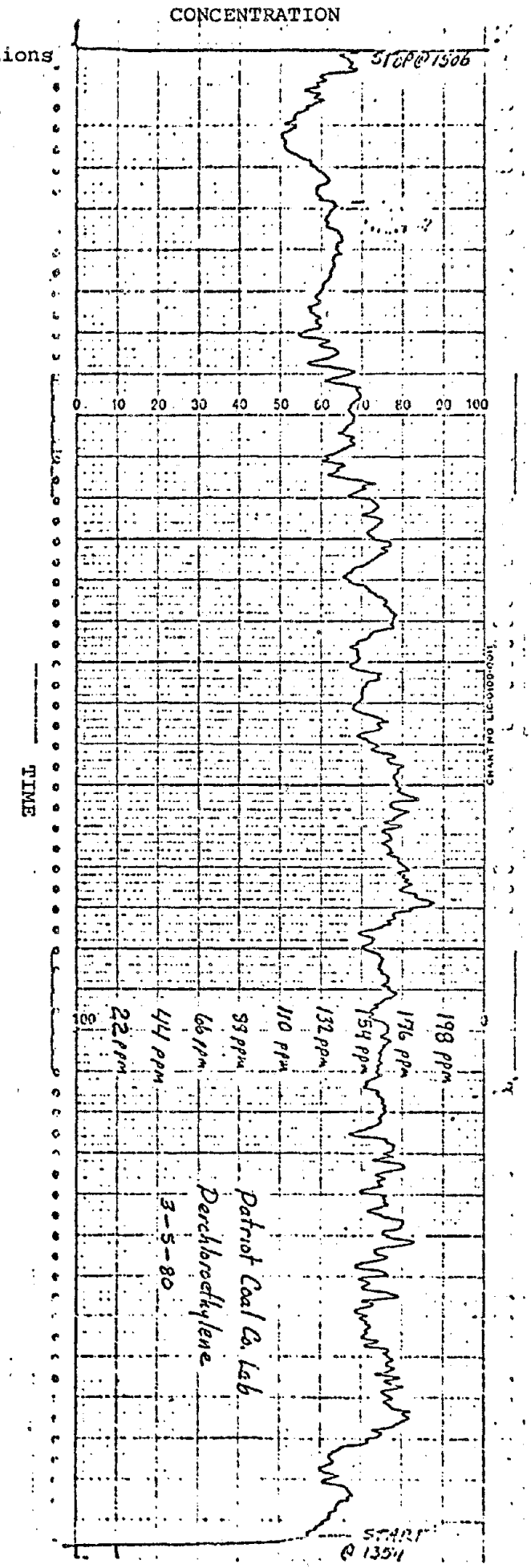
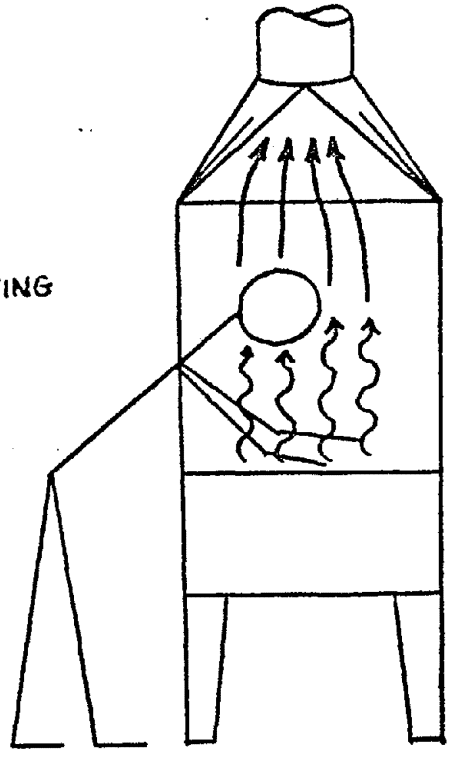


Figure 4

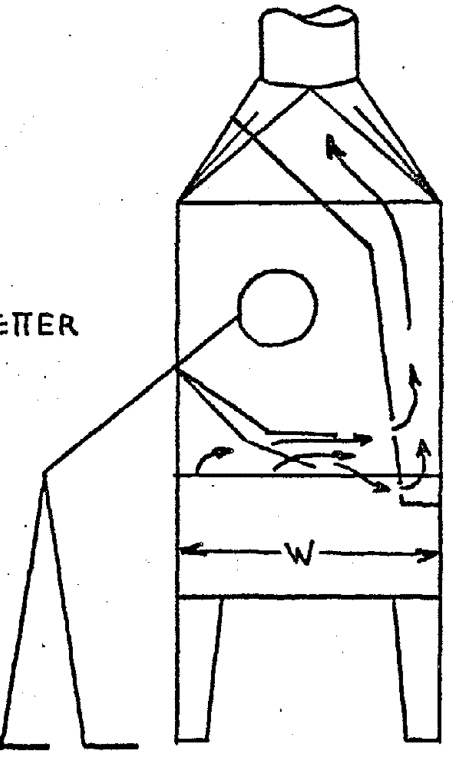
FLOAT-AND-SINK TESTING HOOD
(PERCHLOROETHYLENE)

(a) EXISTING



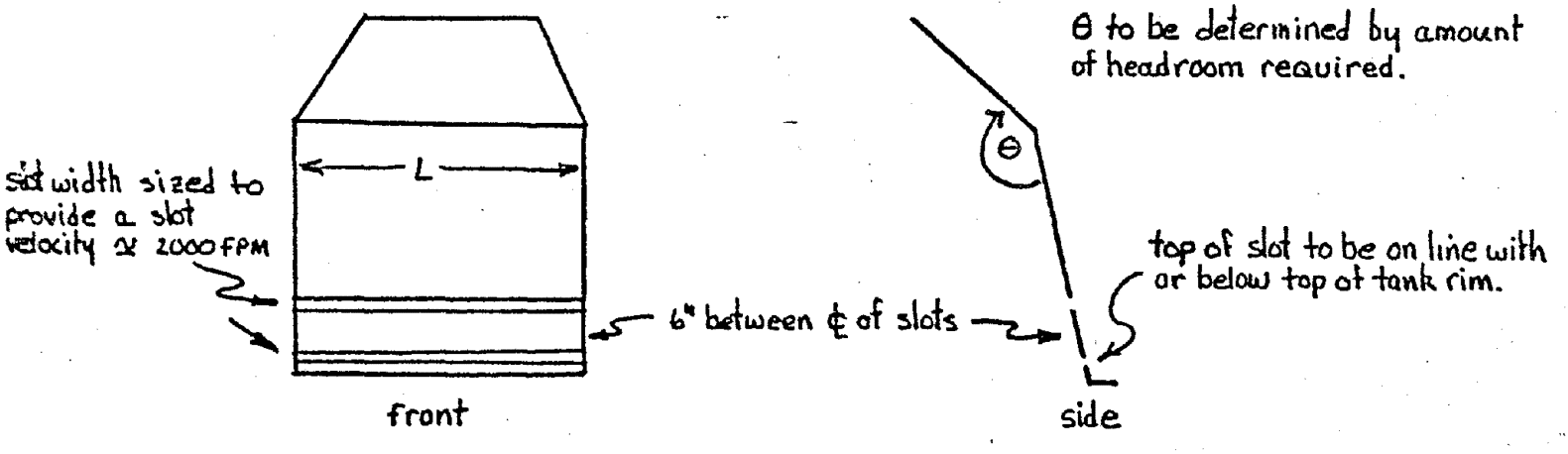
current situation-requires worker to utilize a respirator if exposure to vapors is to be avoided.

(b) BETTER



corrected situation – vapors captured before passing through the breathing-zone of the worker.

Q = 130 CFM/SQ Ft. of tank area
Duct velocity = 2000 fpm
entry loss = 1.78 slot VP + 0.25 DUCT VP
MAX Tank width = 36"
W/L ≤ 0.5

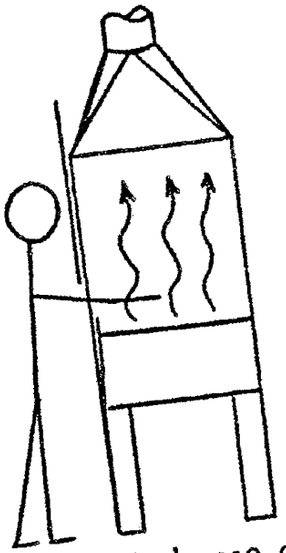


slotted plate to be fitted into the canopy hood in order to form a plenum w/2 slots.

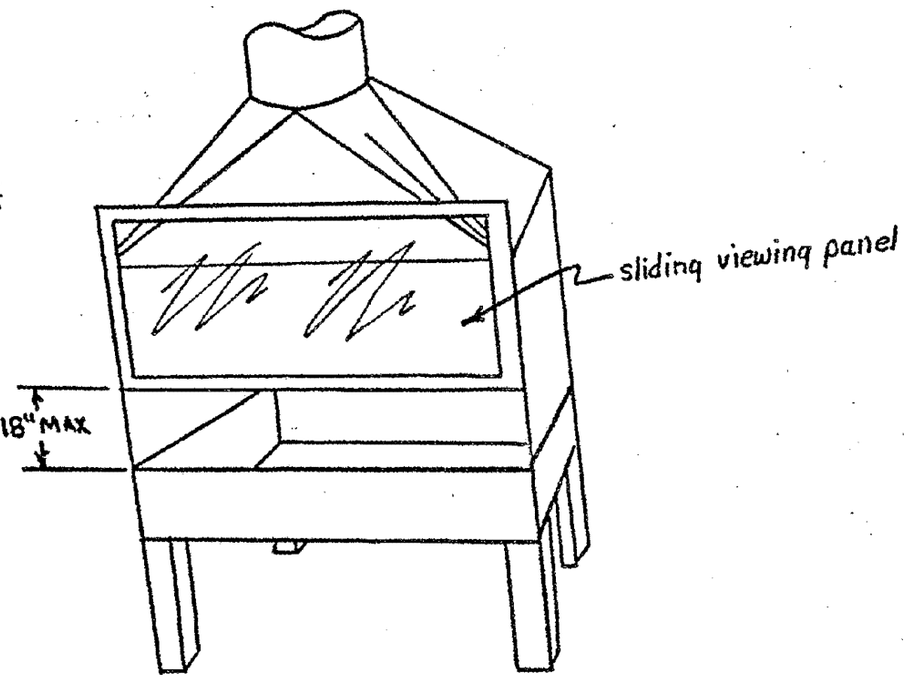
Figure 4c

FLOAT-AND-SINK TESTING HOOD
(PERCHLOROETHYLENE)

(c) BEST



minimal chance of exposure.



Q = minimum 100 CFM/SQ FT OF MAX OPEN AREA
DUCT VELOCITY = 1000 FPM MINIMUM
ENTRY LOSS = 0.25 DUCT VP