VII. RESEARCH NEEDS

All human exposure information forming the basis for the recommended standard for occupational exposure to carbon disulfide has been taken from data on worker experience in the viscose rayon industry. Because of the nature of the process, there is always concomitant exposure to hydrogen sulfide with carbon disulfide. This situation raises the question of whether the toxic effects when hydrogen sulfide and carbon disulfide coexist are synergistic or additive. A corollary question is whether workers in industries with exposure to carbon disulfide, but not to hydrogen sulfide, experience health effects similar to those of workers in the viscose rayon industry.

Human epidemiologic studies, with accurate measurements of workplace concentrations of carbon disulfide and hydrogen sulfide, should be conducted. Although good epidemiologic studies measuring carbon disulfide concentrations do exist, no studies give accurate data on concentrations of hydrogen sulfide and its role in chronic health problems in viscose rayon workers. Several animal studies [85-87,129] have investigated this question and reported evidence of synergism. Well-controlled experiments, using exposure schedules similar to those in the occupational environment, should be conducted to study the effects of carbon disulfide alone, hydrogen sulfide alone, and the combination.

A concerted effort is needed to investigate the health effects of occupational exposure to carbon disulfide in industries other than viscose rayon. In addition, well-designed epidemiologic studies should be conducted in the United States, as only two epidemiologic studies [51,77] have been made in this country in recent years. Although basing the recommended standard for carbon disulfide wholly on foreign studies does not necessarily weaken the recommendation, similar studies in the United States would assure a standard that would be applicable to working conditions in this country. A NIOSH-funded retrospective mortality study of viscose rayon workers by the University of Pittsburgh, begun in 1976, may provide useful data in this area.

Several studies [58,60,61] have shown very striking reproductive system disorders in viscose workers exposed to carbon disulfide at low concentrations, and one investigation [88] found an effect in rats characterized by the investigator as a weak teratogenic effect. The importance of this type of effect necessitates close note of reproductive abnormalities that may appear in employees working with carbon disulfide and of structural abnormalities in their offspring. Additional research with animals, designed to detect teratogenic and mutagenic effects resulting from exposure to carbon disulfide, is needed. NIOSH is currently planning such a study.

Because the reported effects of chronic exposure to carbon disulfide have been quite serious and diverse, the development and utilization of preclinical diagnostic tests would be extremely useful. Hanninen [63] and Tuttle et al [64] have used behavioral/psychological tests to identify carbon disulfide-affected workers prior to the onset of overt symptoms and signs of poisoning. Similar work using methods that are simpler, easier to administer, and more readily evaluated, is needed.

Although it is well established that long-term exposure to carbon disulfide has caused cardiovascular abnormalities, the mechanism of this action is not clear. Lilis et al [32] have studied renal function to determine the possible role of the kidneys in the development of cardiovascular problems. Further research in this area is needed.

Other areas of research pertinent to occupational exposure to carbon disulfide that need further research are dermal absorption of vaporized and liquid carbon disulfide in species other than the rabbit; development and validation of direct-reading sampling instrumentation for carbon disulfide; and design of more efficient engineering controls.

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IX. APPENDIX I

AIR SAMPLING METHOD FOR CARBON DISULFIDE

This sampling method is adapted from NIOSH Method No. S248. Collect breathing-zone or personal samples representative of the individual employee's exposure. Collect enough samples to permit calculation of a TWA concentration for every operation or location in which there is exposure to carbon disulfide. At the time of sample collection, record a description of sampling location and conditions, equipment used, time and rate of sampling, and any other pertinent information.

Equipment

The sampling train consists of a charcoal tube and a vacuum pump.

(a) Charcoal tube: Glass tube with both ends flame-sealed, 7 cm long with a 6-mm OD and a 4-mm ID, containing two sections of 20/40-mesh activated, coconut-shell charcoal separated by a 2-mm portion of polyurethane foam. The adsorbing section contains 100 mg of charcoal, the backup section 50 mg. A 3-mm portion of polyurethane foam is placed between the outlet end of the tube and the backup section. A plug of silylated glass wool is placed in front of the adsorbing section. The pressure drop across the tube must be less than 1 inch of mercury at a flowrate of 1 liter/minute. Tubes with the above specifications are commercially available.

(b) Pump: A battery-operated pump, with a clip for attachment to the employee's belt, whose flow can be maintained within 5% at the recommended flow rate.

<u>Calibration</u>

The accurate calibration of a sampling pump is essential to the correct interpretation of the volume sampled. The frequency of calibration depends on such factors as the use, care, and handling to which the pump is subjected. Pumps should also be recalibrated if they have been misused or if they have just been repaired or received from a manufacturer. If the pump receives hard use, more frequent calibration may be necessary. Maintenance and calibration should be performed on a regular schedule, and records of these should be kept.

Ordinarily, pumps should be calibrated in the laboratory both before they are used in the field and after they have been used to collect a large number of field samples. The accuracy of calibration depends on the type of instrument used as a reference. The choice of calibration instrument will depend largely upon where the calibration is to be performed. For laboratory testing, a soapbubble meter is recommended, although other standard calibrating instruments can be used. The actual setups will be similar for all instruments. For a check on performance of a pump in the field a rotameter may be used.

Instructions for calibration with the soapbubble meter follow. If another calibration device is selected, equivalent procedures should be used. The calibration setup for personal sampling pumps with a charcoal tube is shown in Figure XIII-1. Since the flow rate given by a pump is dependent on the pressure drop across the sampling device, in this case a charcoal tube, the pump must be calibrated while operating with a representative charcoal tube in line.

(a) Check the voltage of the pump battery with a voltmeter to assure adequate voltage for calibration. Charge the battery if necessary.

(b) Break the tips of a charcoal tube to produce openings of at least 2 mm in diameter.

(c) Assemble the sampling train as shown in Figure XIII-1.

(d) Turn on the pump and moisten the inside of the soapbubble meter by immersing the buret in the soap solution. Draw bubbles up the inside until they are able to travel the entire buret length without bursting.

(e) Adjust the pump flowmeter to provide the desired flow rate.

(f) Check the water manometer to ensure that the pressure drop across the sampling train does not exceed 13 inches of water at 1.0 liter/minute (or 2.5 inches of water at 0.2 liter/minute).

(g) Start a soapbubble up the buret and measure with a stopwatch the time it takes the bubble to move from one calibration mark to another.

(h) Repeat the procedure in (g) at least three times, average the results, and calculate the flow rate by dividing the volume between the preselected marks by the time required for the soapbubble to traverse the distance. If, for the pump being calibrated, the volume of air sampled is calculated as the product of the number of strokes times a stroke factor (given in units of volume/stroke), the stroke factor is the volume between the two preselected marks divided by the number of strokes.

(i) Data for the calibration include the volume measured, elapsed time or number of strokes of the pump, pressure drop, air temperature, atmospheric pressure, serial number of the pump, date, and name of the person performing the calibration.

Sampling Procedure

(a) Break both ends of the charcoal tube to provide openings of at least 2 mm, which is half the ID of the tube. A smaller opening causes a limiting-orifice effect which reduces the flow through the tube. The smaller section of charcoal in the tube is used as a backup section and therefore is placed nearest the sampling pump. Use tubing to connect the back of the tube to the pump, but tubing must never be put in front of the the charcoal tube. The tube is supported in a vertical position in the employee's breathing zone.

(b) To determine the TWA concentration of carbon disulfide, sample a minimum of 64 liters of air at a flow rate of 1 liter/minute or less. This is recommended for sampling carbon disulfide at concentrations of 1 ppm or less. To determine ceiling concentrations, use a flow rate of 1 liter/minute or less for 15 minutes.

(c) Measure and record the temperature and pressure of the atmosphere being sampled.

(d) Treat at least one charcoal tube in the same manner as the sample tubes (break, seal, and ship), but do not draw air through it. This tube serves as a blank.

(e) Immediately after samples are collected, cap the charcoal tubes with plastic caps. Do not use rubber caps. To minimize breakage during transport, pack capped tubes tightly in a shipping container.

(f) If analysis cannot be performed within 1 week, the samples should be stored under refrigeration. Carbon disulfide tends to migrate within the charcoal tube from the front section to the backup section when the tubes are held at ambient temperatures for prolonged periods of time. The tubes appear to be unaffected by short storage at elevated temperatures or by shipping under reduced pressure.