X. APPENDIX I

METHOD FOR SAMPLING AND ANALYSIS OF STYRENE IN AIR

General Requirements for Styrene Air Sampling

Air samples are collected that represent the air a worker breathes while performing each job or specific operation. It is advisable to maintain records of the date, time, rate, duration, volume, and location of sampling. It is also advisable to record the temperature, pressure, and relative humidity at the time the sample was taken, as well as other pertinent information.

Sampling

(a) Sampling Strategy and Apparatus

Air samples are collected as near to the worker's breathing zone as practicable, but without interfering with the worker's freedom of movement. These air samples are collected in a manner that will allow the determination of the worker's exposure for every job he or she performs where styrene is used. It is recommended that a number of air samples be collected so that the variability of exposures throughout the work area can be determined. Statistical sampling strategies are given in the NIOSH publication Occupational Exposure Sampling Strategy Manual [341].

To collect these air samples on charcoal tubes, battery-operated pumps are needed that have clips for attachment to the worker's clothes. It is necessary that these pumps be capable of calibration within 5% at operational flow-rates.

The analytical method as described later in this appendix is for samples collected by use of glass tubes, 7 cm long, with an outside diameter of 6 mm and an inside diameter of 4 mm. These tubes contain two sections of 20/40 mesh activated coconut-shell charcoal that was fired at 600°C. The first section is the adsorbing section and contains 100 mg of charcoal. The second, or reserve (backup) section, contains 50 mg of charcoal. The sections are separated by 2 mm of urethane foam, with 3 mm of urethane foam placed between the reserve section and the end of the tube; a plug of silylated glass wool is placed between the other end of the tube and the adsorbing section. Tubes that contain larger amounts of charcoal are also available. Such tubes may be used if results obtained using the standard size tubes indicate that breakthrough has occurred or if substantial amounts of organic compounds that may interfere with styrene collection are also known to be present. The pressure drop across the tube must be less than 1 inch of mercury at a flow-rate of 1 liter/min. Tubes that meet the specifications described above are commercially available.

(b) Calibration of Sampling Instruments

Air sampling instruments should be calibrated at operational flow-rates with a representative charcoal tube in line. Positive-displacement diaphragm pumps require accurate determination of the stroke factor. In addition, pumps must be recalibrated after any repair to, or modification of, the sampling system is made. It is also necessary to spot check the volumetric flow-rate through the sampling system and to make adjustments before and during each study to ensure accurate airflow data.

(c) Collection and Handling of Samples

The following steps are recommended for the proper collection and handling of air samples:

(1) Immediately before sampling the air, both ends of the charcoal tube are scored and broken so that openings of at least one-half the 4-mm internal diameter of the tube are made.

(2) The smaller, or reserve, section of charcoal is positioned toward the sampling pump.

(3) The charcoal tube is placed in a vertical position during sampling to prevent channeling and consequent sample loss.

(4) The air sample is drawn directly through the adsorbing section of charcoal without first passing it through any tubing; tubing may be used to connect the back of the tube to the pump.

5) Sampling at 1 liter/min for 15 minutes should provide an adequate sample for measuring ceiling concentrations. A sampling rate of 250 ml/min is recommended for measuring TWA exposures over an entire shift.

(6) Immediately after sampling, the charcoal tubes are sealed with plastic caps that are inert to, and contain no styrene. Under no circumstances should rubber caps be used.

(7) Prepare a charcoal tube to serve as an analytical blank. No air is drawn through this tube, but it is broken, sealed, and, if appropriate, transported in the same way as the charcoal tubes that were used to collect the sample.

(8) If tubes are to be shipped it is necessary to ensure that they are packed tightly and well padded to prevent breakage.

(9) A sample of the bulk styrene used in the facility where the air has been sampled should be submitted to the laboratory in a glass container sealed with a Teflon-lined cap. This sample should not be transported in the same container as the charcoal tubes.

Principle of the Method of Styrene Analysis

A measured volume of air is drawn through a charcoal tube to adsorb airborne styrene onto the charcoal. The adsorbed styrene is subsequently desorbed from the charcoal with carbon disulfide. A suitable portion of the desorbed sample is subjected to gas chromatography, and the amount of styrene is determined by comparing the area under the styrene peak with a standard curve that relates peak areas to the concentration of a known standard.

Range, Sensitivity, Precision, and Accuracy

(a) Although the lower detection limit of the method [259] has not been determined for styrene, a sample volume of 10 liters is considered adequate for measuring styrene at 10 ppm. Desorption efficiency studies [255] were conducted with amounts of styrene that would be collected from 10-liter air samples containing styrene at 50, 100, and 200 ppm. The desorption efficiencies were 0.87, 0.88, and 0.93, respectively. This method [259] is capable of measuring amounts of styrene smaller than the amounts used to evaluate it, if the desorption efficiency is determined to be adequate. The desorption efficiency must be determined over the range of concentrations to be sampled.

The method has been evaluated for precision and accuracy with styrene over the range of 100-400 ppm at 0% relative humidity and at an atmospheric temperature of 23°C and a pressure of 754 mm Hg [255]. This evaluation was performed using 5-liter air samples collected at 200 ml/min. The coefficient of variation for the total analytical and sampling method was 0.057. On the average the combined sampling and analytical method underestimated the nominal concentrations by about 8%. The method has not been tested with styrene for precision and accuracy by NIOSH below 100 ppm. However, field data from NIOSH indicates that the method has acceptable precision below 5 ppm [342].

(b) The upper limit of the range of the method is dependent on the adsorptive capacity of the charcoal tube. This capacity varies with the concentrations of styrene and other substances in the air. It was estimated that 36 mg of styrene was the maximum amount that could be collected on 100 mg of charcoal in the front (adsorbing) section before the styrene penetrated in significant amounts (i.e., 5%) to the reserve section [255]. This estimate was based on a sampling rate of 0.19 liters/min for 111 minutes in a test atmosphere that contained 400 ppm of styrene.

Interferences

(a) The volume at which breakthrough occurs in a charcoal tube is severely reduced when the humidity is high, at which time a smaller air sample should be taken or a larger charcoal tube should be used.

(b) When other compounds are known or suspected to be present in the air, the suspected identities of those compounds should be recorded.

(c) Any compound that has the same retention time as styrene using the chromatographic conditions described in this method will interfere with analysis. Such interferences may be eliminated by altering the operating conditions of the gas chromatograph or by changing the column liquid phase.

(d) Retention time data obtained by gas chromatography on a single column cannot be considered proof of chemical identity.

Apparatus

(a) Gas chromatograph (GC) equipped with a flame ionization detector.

(b) Stainless steel column (10 feet long x 1/8 inch outer diameter) with 10% free fatty acid polymer (FFAP) stationary phase on 80/100 mesh Chromosorb W HP (or equivalent), acid washed and treated with dimethyldichlorosilane (DMCS).

(c) Recorder and some method for determining peak area.

(d) Glass stoppered microtubes or vials, which can be sealed with Teflon-lined caps, that have a capacity twice the volume of carbon disulfide used for desorption (1 ml for standard size tubes).

(e) Microsyringes of appropriate size for preparing standards.

(f) Pipets that can accurately deliver the volume of carbon disulfide needed for the charcoal tubes used, such as 1.0 ml graduated in 0.1 ml increments.

(g) Volumetric flasks of appropriate sizes for preparing standard solutions.

Reagents

(a) Carbon disulfide, chromatographic quality.

(b) Styrene, reagent grade.

(c) Nitrogen, purified.

(d) Hydrogen, prepurified.

(e) Air, filtered, compressed.

Analysis of Samples

(a) Sample Preparation

Wash the equipment used for analysis in detergent followed by a tap water rinse and finally a distilled (not deionized) water rinse.

Score the charcoal tube with a file in front of the first (adsorbing) section of charcoal and break it open. Remove the glass wool and discard it. Transfer the charcoal from the first section to a 2-ml stoppered test tube or container. Remove and discard the separating foam and transfer the charcoal from the second (backup) section to another, similar, test tube or container. The two sections of charcoal are analyzed separately. Prior to analysis, when charcoal tubes containing 100 mg of charcoal in the adsorbing section are used, pipet (not by mouth) 1.0 ml of carbon disulfide into each sample container to desorb styrene from the charcoal. Use this same ratio of carbon disulfide to charcoal if larger charcoal tubes are used. A desorption time of at least 30 minutes, with occasional agitation, is recommended. It is further recommended that samples be analyzed as soon as possible after desorption; this will help prevent losses due to sample decomposition.

EXTREME CAUTION MUST BE EXERCISED AT ALL TIMES WHEN USING CARBON DISULFIDE BECAUSE OF ITS HIGH TOXICITY AND FIRE AND EXPLOSION HAZARDS. IT CAN BE IGNITED BY HOT STEAM PIPES. ALL WORK WITH CARBON DISULFIDE SHOULD BE PERFORMED UNDER AN EXHAUST HOOD.

(b) GC conditions (should be optimized according to the manufacturer's specifications). Typical operating conditions for the gas chromatograph are:

(1) 50 ml/min (60 psig) nitrogen carrier gas flow.

(2) 65 ml/min (24 psig) hydrogen gas flow to detector.

(3) 500 ml/min (50 psig) air flow to detector.

(4) 195°C injector temperature.

(5) 255°C manifold temperature (detector).

(6) 109°C column temperature.

(c) Injection of sample

To eliminate difficulties that may arise from blowback or distillation within the syringe needle, the solvent flush injection technique should be used for injection of the sample into the gas chromatograph. With this technique, the syringe is first flushed with carbon disulfide several times to wet the barrel and plunger and then 3 µl of carbon disulfide is drawn

into the syringe to increase the accuracy and reproducibility of the injected sample volume. The syringe needle is removed from the carbon disulfide and the plunger is pulled back about 0.2 µl so that the solvent flush is separated from the sample with a pocket of air, which may be used as a marker. The needle is then immersed in the sample, and a 5-µl portion is withdrawn. The volume of the needle is taken into consideration since the sample in the needle will be completely injected. After the needle is removed from the sample, and prior to injection, the plunger is pulled back a short distance to minimize evaporation of the sample from the tip of the needle. It is recommended that duplicate injections of each sample and standard be made. Using this technique, the maximum difference expected between results of duplicate injections is 3%.

Other injection techniques, such as use of automatic sample injectors, are acceptable if their reproducibility is at least as good as the solvent flush injection technique.

(d) Measurement of area

Measure the area of the sample peak by an electronic integrator or some other suitable form of area measurement, and read the preliminary results from a standard curve prepared as discussed below.

Determination of Desorption Efficiency

It is necessary to determine the percentage of styrene on the charcoal that is removed by the desorption process. This desorption efficiency may vary with the amount of styrene adsorbed onto the charcoal and the adsorption characteristics of the batch of charcoal being used. These variables necessitate determination of a desorption efficiency curve for each batch of charcoal as described below for 100-mg quantities of charcoal. Charcoal from the batch used in preparing the sample tubes can be obtained from unused tubes of the same batch.

Measure 100-mg quantities of charcoal into glass tubes that are 5 cm long, 4 mm inside diameter, and flame-sealed at one end. Inject known amounts of styrene directly into the charcoal with a microliter syringe, and cap the tubes with an inert plastic (e.g., Parafilm).

At least five tubes that contain different amounts of styrene are prepared in this manner and allowed to stand at least overnight to ensure complete adsorption of styrene onto the charcoal. Preparation of replicate tubes with each amount of added styrene is recommended. These tubes will be referred to as the desorption samples. Prepare a parallel blank tube in the same manner, except for addition of styrene. Desorb and analyze the desorption samples and blanks in exactly the same manner as previously described.

Prepare desorption standards by injecting the same volumes of styrene into 1.0 ml of carbon disulfide with the same syringe used in the preparation of the desorption samples. Replicate standards are recommended with each amount of added styrene. These are analyzed with the desorption samples.

The desorption efficiency equals the difference between the average GC peak area due to styrene recovered from the charcoal and the corresponding peak area due to the charcoal blank divided by the average peak area due to styrene added directly to the carbon disulfide or,

$$\text{desorption efficiency} = \frac{\text{area of desorption sample - area of blank}}{\text{area of standard}}$$

The desorption efficiency is plotted vs. weight of styrene found, and the curve is used for correction for incomplete desorption.

Calibration and Standards

It is convenient to prepare standards in terms of milligrams of styrene/1.0 ml of carbon disulfide if samples are desorbed in this amount of carbon disulfide. To minimize error due to variability of carbon disulfide, 10 times the weight of styrene can be injected into 10 ml of carbon disulfide. For example, to prepare 0.2 mg/1.0 ml of standard, inject 2.0 mg of styrene into exactly 10 ml of carbon disulfide in a glass-stoppered flask. Use the density of styrene (0.9018 g/cu cm at 25°C) to convert mg into µl for easy measurement with a microliter syringe.

Prepare a series of standards, varying the amount of added styrene over the range of interest, and analyze them under the same GC conditions and during the same time period as the unknown samples. Establish curves by plotting average peak area vs. milligrams of styrene/volume of carbon disulfide used for desorption.

Alternatively, carbon disulfide containing a predetermined amount of an internal standard can be used, and the styrene concentration in mg/ml can be plotted against the ratio of the area of styrene to the area of the internal standard. However, it needs to be established whether the concentration of the internal standard in solution is changed by adsorption on the charcoal.

Calculations

(a) From the standard curve, read the weight in milligrams that corresponds to the peak area. No volume corrections are needed since the standard curve is based on mg styrene/volume of carbon disulfide used for desorption, and the volume of sample injected is identical to the volume of the standards injected.

(b) The weights of styrene on the front and reserve sections of the charcoal tube must be determined separately.

(c) Corrections to the styrene weights, determined on both the front and reserve sections, for the weights of the respective sections of the blank charcoal tube are made in the following manner:

(1) Subtract the weight of styrene found on the front (adsorbing) section of the blank charcoal tube from the weight of styrene found on the front section of the sample charcoal tube to determine the corrected front section weight.

(2) Subtract the weight of styrene found on the reserve (backup) section of the blank charcoal tube from the weight of styrene found on the reserve section of the sample charcoal tube to determine the corrected reserve section weight.

(3) Add the corrected amounts of styrene present on the front and backup sections of the sample tube to determine the total amount of styrene in the sample, and divide this total weight by the appropriate desorption efficiency to obtain M, the total (corrected) milligrams per sample. The sample should be considered invalid if the backup section contains more than 20% of the amount of styrene on the front section.

(d) Convert the liters of air sampled (V) to the volume (V') at standard conditions of 25°C and 760 mm Hg, as follows:

$$V' = \frac{298VP}{760(T+273)} = \frac{0.392VP}{(T+273)}$$

Where:

V' = volume of sampled air in liters at 25°C and 760 mm Hg
V = measured volume of sampled air in liters
P = barometric pressure in mm Hg, measured at time of sampling
T = temperature of air in degrees Celsius, measured at time of sampling

(e) The concentration of styrene in the sampled air at the standard conditions (25°C, 760 mm Hg) can be expressed in various ways using M, the weight of styrene obtained in (c)(3), and V', the standardized sample volume, obtained in (d), as follows:

(1) mg/l = M/V'

(2) mg/cu m = µg/liter = 1,000 M/V'

(3) ppm = 235 M/V'

XI. APPENDIX II

DETERMINATION OF MANDELIC ACID IN URINE

General Considerations

About 50-85% of absorbed styrene is eliminated as urinary mandelic acid in humans [88,144,148]. Urinary mandelic acid has been demonstrated to correlate with time-weighted average (TWA) styrene exposures [79,91,92,125, 282]. Another major styrene metabolite, urinary phenylglyoxylic acid, can also be effectively determined, but this information adds little information to that gained from the determination of mandelic acid [156].

Urine contains many substances that may react with the reagents used to determine mandelic acid by colorimetric and polarographic methods. In colorimetric methods, phenols react with sulfuric acid-formalin [121], and lactic acid reacts with ferric chloride [144]; in polarographic analysis, phenylalanine, as well as mandelic acid, will be converted to benzaldehyde [144], the material that is analyzed. Because of varying interferences from such substances, these colorimetric and polarographic methods are not specific and cannot be relied upon to give accurate results at low urinary concentrations of mandelic acid. However, because of their simplicity, colorimetric and polarographic methods may be useful for spot checks when other analytical methods are not readily available.

Gas chromatography can be specific for mandelic acid in urine; methods have been well developed, interferences are minimal, and sensitivity is sufficient to evaluate occupational exposures to styrene. The method of Engstrom and Rantanen [79], as modified by Riihimaki and Pfaffli [154], has been successfully used to relate urinary concentrations of mandelic acid to the 8-hour TWA styrene exposures of workers and is presented at the end of this appendix; mandelic acid is analyzed by gas chromatography as its trimethylsilyl derivative. In 1979, Wilson et al. [343] used a similar method that included the use of phenyllactic acid as an internal standard.

Biological monitoring should consist of the collection and analysis of each worker's urine for mandelic acid at the time of personal industrial hygiene monitoring of airborne styrene. Mandelic acid concentrations in urine samples collected at the end of a workshift have been found to be roughly proportional to TWA styrene exposures. Because a substantial portion of styrene absorbed during a workshift is still present the next day [92,159,282], the measured value of urinary mandelic acid may reflect styrene exposure within the preceding 24 hours.

Based on the gas chromatographic method described below, on the average, a urinary mandelic acid concentration of 1,200 mg/l (adjusted to a specific gravity of 1.018) corresponds to an average 8-hour TWA styrene exposure estimate of 55 ppm, with 95% confidence limits of about 25-120 ppm (see

Figure V-1, p. 141). If the urine samples have a low specific gravity (i.e., below 1.010), additional samples should be collected. Correction may also be made by dividing the amount of mandelic acid by the amount of creatinine in the sample [92].

Because of the individual variability of urinary mandelic acid values relative to airborne styrene concentrations, urinary mandelic acid measurements serve only as a guide to estimate the overall worker exposure to styrene. However, if urinary mandelic acid concentrations tend to exceed 1,200 mg/l (adjusted to a specific gravity of 1.018), the work setting should be evaluated to identify the source of exposure. Among the possible sources that may need to be reevaluated are TWA exposure concentrations, exposure to some other substances such as ethylbenzene, improper work practices resulting in significant percutaneous styrene absorption or, conceivably, styrene ingestion or nonoccupational exposure. Among nonoccupational sources that result in urinary mandelic acid elimination are hobbies that result in styrene exposures and the use of medications that may be sources of mandelic acid.

If immediate processing of collected urine samples is not possible, the samples should be kept in a refrigerator at 4°C; Flek and Sedivec [281] found that urine samples remained unchanged for at least 14 days under those conditions.

Recommended Analytical Method [79,154]

(a) Principle of the Method

(1) Urine is collected from workers at or near the end of a workshift; specific gravity is measured.

(2) The urine is acidified with HCl, saturated with sodium chloride, and extracted with diethyl ether.

(3) An appropriate volume of the extract is removed and evaporated to dryness.

(4) A pyridine-N,O-bis-(trimethylsilyl)-trifluoroacetamide (BSTFA) solution is added (to silylate the mandelic acid) and the mixture is allowed to react at room temperature for a few minutes.

(5) A portion of the reacted material is injected directly into a gas chromatograph.

(6) The amount of mandelic acid in the urine is proportional to the height of the silylated mandelic acid GC peak; peak identification is made by comparing retention time with that of authentic silylated mandelic acid.

(b) Efficiency, Reproducibility, and Range of the Method

The mean concentration found in 10 replicate samples of urine containing 1.6 mg mandelic acid (equivalent to a concentration of 800 mg/l of urine) was 750 mg/l, an average recovery of 94% [79]. The coefficient of variation determined from replicate analyses was about 2%. The peak heights of the plot from the gas chromatograph were proportional to the concentration of mandelic acid added to normal urine over the range of 0-800 mg/l.

(c) Advantages of the Method

The collection of samples and their subsequent analysis is simple and rapid. The method can detect low concentrations and small changes in the excretion of mandelic acid; blank samples indicate little or no interference from the reagents or other substances present in the sample.

(d) Apparatus

(1) Gas chromatograph (GC) equipped with a flame ionization detector.

(2) Stainless steel column (4.6 feet long x 1/8-inch outer diameter) with 10% OV-17 stationary phase on 80/100 mesh Chromosorb W HP (or equivalent).

(3) Recorder.

(4) Microsyringes and pipets of appropriate sizes for preparing standards.

(e) Reagents

(1) Diethyl ether.

(2) Hydrochloric acid, 6N

(3) Sodium chloride.

(4) Pyridine.

(5) N,O-bis-(trimethylsilyl)-trifluoroacetamide (BSTFA).

(f) Analysis of Samples

(1) Sample Preparation

All glassware is thoroughly cleaned and rinsed. A 2-ml portion of urine is pipetted into a test tube or other convenient container and is

acidified with 40 µl of 6N HCl and saturated with NaCl. The mixture is diluted to 10 ml with diethyl ether and is shaken for 10 minutes.

A 0.5- to 5.0-ml portion of the ether extract is evaporated to dryness, and a pyridine-BSTFA (1:1,v/v) mixture is added to the residue to obtain a volume of 100 µl. After a few minutes at room temperature, a portion (1-2 µl) of the reaction mixture is injected into a gas chromatograph.

(2) GC Conditions (should be optimized according to the manufacturer's specifications). Typical operating conditions for the gas chromatograph are as follows:

(A) 15 ml/min nitrogen carrier gas flow.

(B) 60 ml/min hydrogen gas flow to detector.

(C) 300 ml/min air flow to detector.

(D) 200°C injector temperature.

(E) 320°C manifold temperature (detector).

(F) 155°C oven temperature.

(g) Calibration and Standards

It is convenient to prepare standards in terms of mg of mandelic acid/liter of urine (1 mg mandelic acid/ml of urine is equivalent to 1,000 mg/l). To minimize errors in weighing and measuring, a concentrated solution can be prepared, and a series of standards can be made by pipetting varying volumes from the concentrated solution into a series of volumetric flasks. The standards are treated the same as the urine samples. Measured volumes (1-2 µl) of the standards are injected into a gas chromatograph using the same solvent flush technique recommended for styrene analysis which was discussed in Appendix I; a standard curve is prepared by plotting peak heights vs. the amounts of mandelic acid injected.

Each time the analysis is performed a blank tube and at least one standard tube (in the midrange of the analysis) should also be analyzed so that corrections for day-to-day variation in technique or reagents can be made.

(h) Calculations

(1) The weight of mandelic acid in the sample is determined by comparing the peak height of the sample with the standard curve.

(2) The volume (V) of urine represented by the sample that was injected into the gas chromatograph is determined as follows:

$$V = a \times b \times c$$

Where:

a = volume of urine treated for analysis

b = fraction of the ether extract evaporated to dryness

c = fraction of silylated mixture injected into GC

For example, if 2 ml of urine was treated for analysis (a=2), and if a 5-ml portion of the ether extract was evaporated (b=5/10), and if 1.5 µl of the reaction mixture was injected (C=1.5/100), then the volume (V) of urine injected would be 0.015 ml.

(3) The concentration (C=µg/ml=mg/l) of mandelic acid in the urine sample is determined by dividing the weight of mandelic acid in µg found in (1) by the urine volume V

(4) The concentration of mandelic acid obtained in (3) is converted to the concentration in urine at specific gravity of 1.018 as follows:

$$C' = \frac{18C}{(SG-1.000)\ 1,000}$$

Where:

C' = corrected concentration (mg/l)

C = measured concentration (mg/l)

SG = measured specific gravity of the urine sample

XII. APPENDIX III

MATERIAL SAFETY DATA SHEET

The following items of information which are applicable to a specific product or material shall be provided in the appropriate block of the Material Safety Data Sheet (MSDS).

The product designation is inserted in the block in the upper left corner of the first page to facilitate filing and retrieval. Print in upper case letters as large as possible. It should be printed to read upright with the sheet turned sideways. The product designation is that name or code designation which appears on the label, or by which the product is sold or known by workers. The relative numerical hazard ratings and key statements are those determined by the rules in Chapter V, Part B, of the NIOSH publication, A Recommended Standard....An Identification System for Occupationally Hazardous Materials [306]. The company identification may be printed in the upper right corner if desired.

(a) Section I. Production Identification

The manufacturer's name, address, and regular and emergency telephone numbers (including area code) are inserted in the appropriate blocks of Section I. The company listed should be a source of detailed backup information on the hazards of the material(s) covered by the MSDS. The listing of suppliers or wholesale distributors is discouraged. The trade name should be the product designation or common name associated with the material. The synonyms are those commonly used for the product, especially formal chemical nomenclature. Every known chemical designation or competitor's trade name need not be listed.

(b) Section II. Hazardous Ingredients

The "materials" listed in Section II shall be those substances which are part of the hazardous product covered by the MSDS and individually meet any of the criteria defining a hazardous material. Thus, one component of a multicomponent product might be listed because of its toxicity, another component because of its flammability, while a third component could be included both for its toxicity and its reactivity. Note that a MSDS for a single component product must have the name of the material repeated in this section to avoid giving the impression that there are no hazardous ingredients.

Chemical substances should be listed according to their complete name derived from a recognized system of nomenclature. Where possible, avoid using common names and general class names such as "aromatic amine," "safety solvent," or "aliphatic hydrocarbon" when the specific name is known.

The "%" may be the approximate percentage by weight or volume (indicate basis) which each hazardous ingredient of the mixture bears to the whole mixture. This may be indicated as a range or maximum amount, i.e., "10-40% vol." or "10% max. wt." to avoid disclosure of trade secrets.

Toxic hazard data shall be stated in terms of concentration, mode of exposure or test, and animal used, e.g., "100 ppm LC50-rat," "25 mg/kg LD50-skin-rabbit," "75 ppm LC man," "permissible exposure from 29 CFR 1910.1000," or, if not available, from other sources such as publications of the American Conference of Governmental Industrial Hygienists (ACGIH) or the American National Standards Institute, Inc (ANSI). Flashpoint, shock sensitivity, or similar descriptive data may be used to indicate flammability, reactivity, or similar hazardous properties of the material.

(c) Section III. Physical Data

The data in Section III should be for the total mixture and should include the boiling point and melting point in degrees Fahrenheit (Celsius in parentheses); vapor pressure, in conventional millimeters of mercury (mm Hg); vapor density of gas or vapor (air = 1); solubility in water, in parts/hundred parts of water by weight; specific gravity (water = 1); percent volatiles (indicated if by weight or volume) at 70°F (21.1°C); evaporation rate for liquids or sublimable solids, relative to butyl acetate; and appearance and odor. These data are useful for the control of toxic substances. Boiling point, vapor density, percent volatiles, vapor pressure, and evaporation are useful for designing proper ventilation equipment. This information is also useful for design and deployment of adequate fire and spill containment equipment. The appearance and odor may facilitate identification of substances stored in improperly marked containers, or when spilled.

(d) Section IV. Fire and Explosion Data

Section IV should contain complete fire and explosion data for the product, including flashpoint and autoignition temperature in degrees Fahrenheit (Celsius in parentheses); flammable limits, in percent by volume in air; suitable extinguishing media or materials; special firefighting procedures; and unusual fire and explosion hazard information. If the product presents no fire hazard, insert "NO FIRE HAZARD" on the line labeled "Extinguishing Media."

(e) Section V. Health Hazard Information

The "Health Hazard Data" should be a combined estimate of the hazard of the total product. This can be expressed as a TWA concentration, as a permissible exposure, or by some other indication of an acceptable standard. Other data are acceptable, such as lowest LD50 if multiple components are involved.

Under "Routes of Exposure," comments in each category should reflect the potential hazard from absorption by the route in question. Comments should indicate the severity of the effect and the basis for the statement if possible. The basis might be animal studies, analogy with similar products, or human experiences. Comments such as "yes" or "possible" are not helpful. Typical comments might be:

Skin Contact--single short contact, no adverse effects likely; prolonged or repeated contact, possibly mild irritation.

Eye Contact--some pain and mild transient irritation; no corneal scarring.

"Emergency and First Aid Procedures" should be written in lay language and should primarily represent first-aid treatment that could be provided by paramedical personnel or individuals trained in first aid.

Information in the "Notes to Physician" section should include any special medical information which would be of assistance to an attending physician including required or recommended preplacement and periodic medical examinations, diagnostic procedures, and medical management of overexposed workers.

(f) Section VI. Reactivity Data

The comments in Section VI relate to safe storage and handling of hazardous, unstable substances. It is particularly important to highlight instability or incompatibility to common substances or circumstances, such as water, direct sunlight, steel or copper piping, acids, alkalies, etc. "Hazardous Decomposition Products" shall include those products released under fire conditions. It must also include dangerous products produced by aging, such as peroxides in the case of some ethers. Where applicable, shelf life should also be indicated.

(g) Section VII. Spill or Leak Procedures

Detailed procedures for cleanup and disposal should be listed with emphasis on precautions to be taken to protect workers assigned to cleanup detail. Specific neutralizing chemicals or procedures should be described in detail. Disposal methods should be explicit including proper labeling of containers holding residues and ultimate disposal methods such as "sanitary landfill" or incineration." Warnings such as "comply with local, state, and Federal antipollution ordinances" are proper but not sufficient. Specific procedures shall be identified.

(h) Section VIII. Special Protection Information

Section VIII requires specific information. Statements such as "Yes," "No," or "If necessary" are not informative. Ventilation requirements should be specific as to type and preferred methods. Respirators shall be

specified as to type and NIOSH or Mine Safety and Health Administration approval class, i.e., "Supplied air," "Organic vapor canister," etc. Protective equipment must be specified as to type and materials of construction.

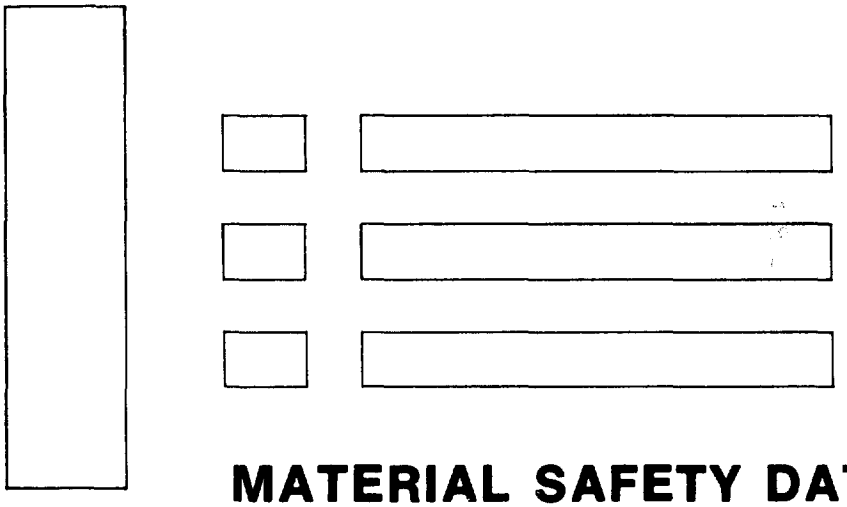
(i) Section IX. Special Precautions

"Precautionary Statements" shall consist of the label statements selected for use on the container or placard. Additional information on any aspect of safety or health not covered in other sections should be inserted in Section IX. The lower block can contain references to published guides or in-house procedures for handling and storage. Department of Transportation markings and classifications and other freight, handling, or storage requirements and environmental controls can be noted.

(j) Signature and Filing

Finally, the name and address of the responsible person who completed the MSDS and the date of completion are entered. This will facilitate correction of errors and identify a source of additional information.

The MSDS shall be filed in a location readily accessible to workers exposed to the hazardous substance. The MSDS can be used as a training aid and basis for discussion during safety meetings and training of new workers. It should assist management by directing attention to the need for specific control engineering, work practices, and protective measures to ensure safe handling and use of the material. It will aid the safety and health staff in planning a safe and healthful work environment and in suggesting appropriate emergency procedures and sources of help in the event of harmful exposure of workers.



MATERIAL SAFETY DATA SHEET

I PRODUCT IDENTIFICATION	
MANUFACTURER'S NAME	REGULAR TELEPHONE NO. EMERGENCY TELEPHONE NO.
ADDRESS	
TRADE NAME	
SYNONYMS	

II HAZARDOUS INGREDIENTS		
MATERIAL OR COMPONENT	%	HAZARD DATA

III PHYSICAL DATA		
BOILING POINT, 760 MM HG		MELTING POINT
SPECIFIC GRAVITY (H_2O=1)		VAPOR PRESSURE
VAPOR DENSITY (AIR=1)		SOLUBILITY IN H_2O % BY WT
% VOLATILES BY VOL		EVAPORATION RATE (BUTYL ACETATE=1)
APPEARANCE AND ODOR		

IV FIRE AND EXPLOSION DATA

FLASH POINT (TEST METHOD)		AUTOIGNITION TEMPERATURE			
FLAMMABLE LIMITS IN AIR, % BY VOL.	LOWER		UPPER		
EXTINGUISHING MEDIA					
SPECIAL FIRE FIGHTING PROCEDURES					
UNUSUAL FIRE AND EXPLOSION HAZARD					

V HEALTH HAZARD INFORMATION

HEALTH HAZARD DATA

ROUTES OF EXPOSURE

INHALATION

SKIN CONTACT

SKIN ABSORPTION

EYE CONTACT

INGESTION

EFFECTS OF OVEREXPOSURE

ACUTE OVEREXPOSURE

CHRONIC OVEREXPOSURE

EMERGENCY AND FIRST AID PROCEDURES

EYES:

SKIN:

INHALATION:

INGESTION:

NOTES TO PHYSICIAN

VI REACTIVITY DATA

CONDITIONS CONTRIBUTING TO INSTABILITY

INCOMPATIBILITY

HAZARDOUS DECOMPOSITION PRODUCTS

CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION

VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

NEUTRALIZING CHEMICALS

WASTE DISPOSAL METHOD

VIII SPECIAL PROTECTION INFORMATION

VENTILATION REQUIREMENTS

SPECIFIC PERSONAL PROTECTIVE EQUIPMENT

RESPIRATORY (SPECIFY IN DETAIL)

EYE

GLOVES

OTHER CLOTHING AND EQUIPMENT

IX SPECIAL PRECAUTIONS

PRECAUTIONARY
STATEMENTS

OTHER HANDLING AND
STORAGE REQUIREMENTS

PREPARED BY

ADDRESS:

DATE: