# VIII. APPENDIX I

## Air Sampling Methods

In the study of asbestosis conducted by Dreessen *et al.*[63] midget impinger count data were used as an estimate of dust exposure. All of the dust particles seen, both grains and fibers, were counted since too few fibers were seen to give an accurate measurement. The resulting count concentration was a measure of overall dust levels rather than a specific measurement of the asbestos concentration. This method was satisfactory at that time since exposures were massive and the control measures installed to reduce overall dust levels also reduced the asbestos dust levels.

As dust levels were reduced, it became necessary to measure the biologically appropriate attribute of the dust cloud. At equal levels overall dustiness, the concentration of asbestos could vary considerably from textile manufacture (75-85%) to insulation (5-15%). Furthermore, if the limit were lowered below the 5 mppcf used previously and dust counts taken by the impinger technique, it would be necessary to consider the effect of background dust, which could be as high as 1 mppcf.

A number of methods for measurement of asbestos dust concentrations have been used in the NIOSH epidemiological study of the asbestos product industry.[73,74,75,76] Based on these data, the preferred index of asbestos exposure is the concentration of fibers longer than 5 μm counted on membrane filters at 430X with phase contrast illumination.[71,72] This index is utilized in the method adopted as the standard field sampling method by the Public Health Service.

Fibers longer than 5 μm in length are counted in preference to counting all fibers seen in order to minimize observer/microscope resolving power variability. Furthermore, the British define a "fibre" as a particle, "of length between 5 μm and 100 μm and having a length-to-breadth ratio of at least 3:1, observed by transmitted light by means of a microscope at a magnification of approximately 500X."[62]

Although the British have refrained from standardizing on a single method of measurement, recent measurements have been performed by a method essentially identical to the fiber-count method described in detail below, and the British hygiene standards for use with their asbestos regulations are stated in these terms.[62]

Principles of Sampling

A dust sampling procedure must be designed so that samples of actual dust concentrations are collected accurately and consistently. The results of the analysis of these samples will reflect, realistically, the concentrations of dust at the place and time of sampling.

In order to collect a sample representative of airborne dust, which is likely to enter the subject's respiratory system, it is necessary to position a collection apparatus near the nose and mouth of the subject or in his "breathing zone".

The concentration of dust in the air to which a worker is exposed will vary, depending upon the nature of the operation and upon the type of work performed by the operator and the position of the operator relative to the source of the dust. The amount of dust inhaled by a worker can vary daily, seasonally, and with the weather. In order to obtain representative samples of workers' exposures, it is necessary to collect samples under varying conditions of weather, on different

days, and at different times during a shift.

The percentage of working time spent on different tasks will affect the concentration of dust the worker inhales since the different tasks usually result in exposure to different concentrations. The percentage can be determined from work schedules and by observation of work routines.

The daily average weighted exposure can be determined by using the following formula:

$$\frac{(\text{Hours X conc. task A}) + (\text{Hours X conc. task B}) + \text{etc.}}{\text{8 Hours (or actual hours worked)}}$$

The concentration of any air contaminant resulting from an industrial operation also varies with time. Therefore, a longer sampling time will better approximate the actual average.

With the following recommended sampling procedure, it is possible to collect samples at the workers' breathing zones for periods from 4 to 8 hours, thus permitting the evaluation of average exposures for a half or full 8-hour shift--a desirable and recommended procedure. Furthermore, dust exposures of a more normal work pattern result from the use of personal samplers. In evaluating daily exposures, samples should be collected as near as possible to workers' breathing zones.

Collecting Sample

The method recommended in this report for taking samples and counting fibers is based on a modification of the membrane filter method described by Edwards and Lynch.[71]

The sample should be collected on a 37-millimeter Millipore type AA* filter mounted in an open-face filter holder. The holder should be fastened to the worker's lapel and air drawn through the filter by means of a battery-powered personal sampler pump similar to those approved by NIOSH under the provisions of 30 CFR 74. The filters are contained in plastic filter holders and are supported on pads which also aid in controlling the distribution of air through the filter. To yield a more uniform sample deposit, the filter-holder face-caps should be removed. Sampling flow rates from 1.0 liter per minute (lpm) up to the maximum flow rate of the personal sampler pump (usually not over 2.5 lpm) and sampling time from 15 minutes to eight hours are acceptable provided the following restraints are considered:

(a) In order to obtain an accurate estimate of the number of fibers the statistical error resulting from the random distribution of the fibers must be kept to an acceptably low level. Since fiber counts follow a Poisson distribution, a count of 100 fibers in a sample would have a standard deviation of $\sqrt{100}$ or 10 fibers or $\pm$ 10%. Thus the 95% confidence limits would be approximately 2 standard deviations or $\pm$ 20%. Since the 37 mm filter has an effective collecting area of 855 $mm^2$ and the projected field area of the Porton reticle is 0.005 $mm^2$, each field represents 1/171000 of the sample. Based on this ratio the following number of fields must be counted to measure the various limits in various sampling times:

*Mention of commercial products does not constitute endorsement by the Public Health Service or U. S. Department of Health, Education and Welfare.

| Sampling Time Minutes | Flow Rate lpm | Number of Fields for 100 Fibers 0.2 fibers/ml | 2.0 fibers/ml | 10 fibers/ml |
|---|---|---|---|---|
| 10 | 2 | 4350 | 435 | 91 |
| 15 | 2 | 2860 | 286 | 58 |
| 30 | 2 | 1430 | 143 | 29 |
| 90 | 1 | 1000 | 100 | 20 |
| 90 | 2 | 500 | 50 | 10 |
| 240 | 1 | 260 | 26 | 7 |
| 240 | 2 | 180 | 18 | 4 |
| 480 | 1 | 180 | 18 | 4 |

(b) Do not count a field containing over 20 fibers because in addition to the fibers being counted, there are also present a number of grains, which interfere with the accuracy of the count.

Based on these restraints, i.e., number of fields to be counted and maximum number of fibers per field, acceptable sampling parameters for the various limits are underlined in the above table.

The following conclusions may be drawn from this analysis:

(1) The short-term limit should be for a period of at least 15 minutes and preferably 30 minutes.

(2) The 2.0 fiber/cc limit may be evaluated over periods of from 90 to 480 minutes.

As many fields as required to yield at least 100 fibers should be counted. In general the minimum number of fields should be 20 and the maximum 100.

Mounting Sample

The mounting medium used in this method is prepared by dissolving 0.05 g of membrane filter per ml of 1:1 solution of dimethyl phthalate

and diethyl oxalate. The index of refraction of the medium thus prepared is ND = 1.47.

To prepare a sample for microscopic examination, a drop of the mounting medium is placed on a freshly cleaned, standard (25 mm X 75 mm), microscopic slide. A wedge-shaped piece with arc length of about 1 cm is excised from the filter with a scalpel and forceps and placed dust-side-up on the drop of mounting solution. A No. 1-1/2 coverslip, carefully cleaned with lens tissue, is placed over the filter wedge. Slight pressure on the coverslip achieves contact between it and the mounting medium. The sample may be examined as soon as the mount is transparent. The optical homogeneity of the resulting mount is nearly perfect, with only a slight background granularity under phase contrast, which disappears within one day. The sample should be counted within two days after mounting.

Evaluation

The filter samples mounted in the manner previously described are evaluated in terms of the concentration of asbestos fibers greater than 5 μm in length. A microscope equipped with phase-contrast optics and a 4-mm "high-dry" achromatic objective is suitable for this determination. 10X eyepieces, one of which contains a Porton or other suitable reticle at the level of the field-limiting diaphragm, should be used. The left half of the Porton reticle field serves to define the counting area of the field. Twenty fields located at random on the sample are counted and total asbestos fibers longer than 5 μm are recorded. Any particle having an aspect ratio of three or greater is considered a fiber.

The following formulae are used to determine the number of fibers/ml:

$$(1) \quad \frac{\text{Filter area } (mm^2)}{\text{Field area } (mm^2)} = K$$

$$(2) \quad \frac{\text{Average net count X K}}{\text{Air volume sampled (ml)}} = \text{fibers/ml}$$

For example, assume the following: area of the filter used was 855 $mm^2$, counting area of one field under the Porton reticle was 0.005 $mm^2$; average net count per field of 20 fields was 10 fibers; and sample was collected at 2 liters per minute for 90 minutes: Then:

$$\frac{855 mm^2}{0.005\ mm^2} = 171{,}000\ (K)$$

$$\frac{10 \text{ fibers x } 171{,}000}{2{,}000 \text{ ml/min x } 90 \text{ min}} = 9.5 \text{ fibers/ml}$$

Calibration of Personal Sampler

The accuracy of an analysis can be no greater than the accuracy of the volume of air which is measured. Therefore, the accurate calibration of a sampling device is essential to the correct interpretation of an instrument's indication. The frequency of calibration is somewhat dependent on the use, care, and handling to which the pump is subjected. Pumps should be calibrated if they have been subjected to misuse or if they have just been repaired or received from a manufacturer. If hard usage is given the instrument, more frequent calibration may be necessary.

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 is dependent 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 1-liter burette or wet-test meter should be used. In the field, a rotameter is the most convenient

instrument used. The actual set-up will be the same for all of these instruments. The calibration instrument will be connected in sequence to the filter unit which will be followed by the personal sampler pump. In this way, the calibration instrument will be at atmospheric pressure. Connections between units can be made using the same type of tubing used in the personal sampling unit. Each pump must be calibrated separately for each type of filter used, if, for example, it has been decided to use a filter with a different pore size. The burette should be set up so that the flow is toward the narrow end of the unit.

Care must be exercised in the assembly procedure to insure adequate seals at the joints and that the length of connecting tubing be kept at a minimum. Calibration should be done under the same conditions of pressure, temperature and density as will be encountered. The rotameter should be used only in the field as a check if the diaphragm or piston pumps are not equipped with pulsation dampeners. The pulsating flow resulting from these type pumps causes the rotameter to give results which are not as accurate as that obtained with a burette or wet-test meter. Calibration can be accomplished with any of the other standard calibrating instruments, such as spirometer, Marriott's bottle, or dry-gas meter. The burette and wet-test meter were selected because of their accuracy, availability, and ease of operation.

## IX. APPENDIX II

### NUMERICAL HAZARD RATING SYSTEM

The numerical hazard ratings given to products for each category of hazard shall be in accordance with the following criteria. Figure 2 graphically illustrates the hazard identification system.

Health hazards shall be rated as follows:

The health hazard rating of a material shall be determined by evaluating the potential for exposure and the relative toxicity of the most toxic ingredient of a compound or mixture. For this evaluation, the following relative toxicity criteria* for absorbed or exposure dose will be used:

| Commonly Used Term | $LD_{50}$ Simple Oral Dose Rats mg/kg | Inhalation 4-hr. Vapor Exposure, Rats Mortality of 2/6 to 4/6 ppm | $LD_{50}$ - Skin Rabbits mg/kg |
|---|---|---|---|
| Extremely toxic | $\leq 1$ | $\leq 10$ | $\leq 5$ |
| Highly toxic | 1.1 to 50 | 11 to 100 | 5.1 to 43 |
| Moderately toxic | 50.1 to 500 | 101 to 1000 | 44 to 340 |
| Slightly toxic or practically non-toxic | 501 to 15,000 | 1,001 to 100,000 | 350 to 22,600 |
| Relatively harmless | 15,000 | 100,000 | 22,600 |

Degree 4: Extremely Hazardous.

Materials, which on very short exposure, can cause death or major permanent injury, even though prompt medical treatment were given, including those which are too dangerous to be approached without specialized

*(Reference: A.I.H.A. Quarterly, Vol. 15, No. 2, June 1954. "Safe Handling Procedures for Compounds Developed by the Petro Chemical Industry," p. 141.)

protective equipment, such as self-contained breathing apparatus or a hose mask with blower, and impervious clothing. This rating includes:

(a) Carcinogens

(b) Materials capable of producing sensitization

(c) Extremely toxic materials which can penetrate ordinary protective clothing.

(d) Extremely hazardous materials, when under normal conditions give off gases that are extremely toxic or corrosive through inhalation or by contact with or absorption through any body surface.

Degree 3: Highly Hazardous.

Materials which on short exposure can cause serious temporary or residual injury, even though prompt medical treatment were given, including those requiring protection from all bodily contact. This rating includes:

(a) Materials giving off highly toxic combustion products

(b) Materials giving off highly toxic gases or vapors, under normal conditions

(c) Materials corrosive to living tissue or highly toxic by skin absorption

Degree 2: Hazardous.

Materials which on continued exposure can cause temporary incapacitation or possible residual injury unless prompt medical treatment is given. This rating includes:

(a) Materials giving off moderately toxic combustion products

(b) Materials which either under normal conditions or under fire conditions give off moderately toxic vapors lacking warning properties.

Degree 1: Slightly hazardous.

Materials, which on exposure at normal conditions, would cause irritation but only minor residual injury even if no treatment is given.

This rating includes:

(a) Materials which under fire conditions give off slightly toxic or irritating combustion products

(b) Materials which on the skin could cause irritation without destruction of tissue

Degree 0: Harmless.

Materials which on exposure by skin contact, inhalation, or ingestion are relatively harmless or which under fire conditions offer no hazard beyond that of ordinary combustible materials.

Flammability hazards shall be rated as follows:

Degree 4.

Materials which will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature or which are readily dispersed in air, and which will burn readily. This degree should include: Gaseous materials: Cryogenic materials; any liquid or gaseous material which is a liquid while under pressure and having a flash point below 73°F (22.8°C) and having a boiling point below 100°F (37.8°C). (Class 1A flammable liquids.)

Materials which on account of their physical form or environmental conditions can form explosive mixtures with air and which are readily dispersed in air, such as dusts of combustible solids and mists of flammable or combustible liquid droplets.

Degree 3.

Liquids and solids that can be ignited under almost all ambient temperature conditions. Materials in this degree produce hazardous

atmospheres with air under almost all ambient temperatures, are readily ignited under almost all conditions. This degree should include: Liquids having a flash point below 73°F (22.8°C) and having a boiling point at or above 100°F (37.8°C) and those liquids having a flash point at or above 73°F (22.8°C) and below 100°F (37.8°C). (Class 1B and Class 1C flammable liquids);

Solid materials in the form of coarse dusts which may burn rapidly but which generally do not form explosive atmosphere with air;

Solid materials in a fibrous or shredded form which may burn rapidly and create flash fire hazards, such as cotton, sisal and hemp;

Solids which burn with extreme rapidity usually by reason of self-contained oxygen (e.g., dry nitrocellulose);

Materials which ignite spontaneously when exposed to air.

Degree 2.

Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur. Materials in this degree would not under normal conditions form hazardous atmospheres with air, but under high ambient temperatures or under moderate heating may release vapor in sufficient quantities to produce hazardous atmospheres with air. This degree should include:

Liquids having a flash point about 100°F, but not exceeding 200°F; solids and semisolids which readily give off flammable vapors.

Degree 1.

Materials that must be preheated before ignition can occur. Materials in this degree require considerable preheating, under all ambient temperature conditions, before ignition and combustion can occur.

This degree should include:

Materials which will burn in air when exposed to a temperature of 1500°F for a period of five minutes or less;

Liquids, solids and semisolids having a flash point above 200°F; this degree includes most ordinary combustible materials.

Degree 0.

Materials that will not burn. This degree should include any material which will not burn in air when exposed to a temperature of 1500°F for a period of five minutes.

Reactivity hazards shall be rated as follows:

Degree 4.

Materials which are readily capable of detonation or of explosive decomposition or explosive reaction at normal temperatures and pressures. This degree should include materials which are sentitive to mechanical or localized thermal shock at normal temperatures and pressures.

Degree 3

Materials which are capable of detonation or of explosive decomposition or explosive reaction but which require a strong initiating source or which must be heated under confinement before initiation. This degree should include materials which are sensitive to thermal or mechanical shock at elevated temperatures and pressures or which react explosively with water without requiring heat or confinement.

Degree 2.

Materials which are normally unstable and readily undergo violent chemical change but do not detonate. This degree should include materials which can undergo chemical change with rapid release of energy at normal

termperatures and pressures or which can undergo violent chemical change at elevated temperatures and pressures. It should also include those materials which may react violently with water or which may form potentially explosive mixtures with water.

Degree 1.

Materials which are normally stable, but which may react with water with some release of energy but not violently.

Degree 0.

Materials which are normally stable, even under fire exposure conditions, and which are not reactive with water.

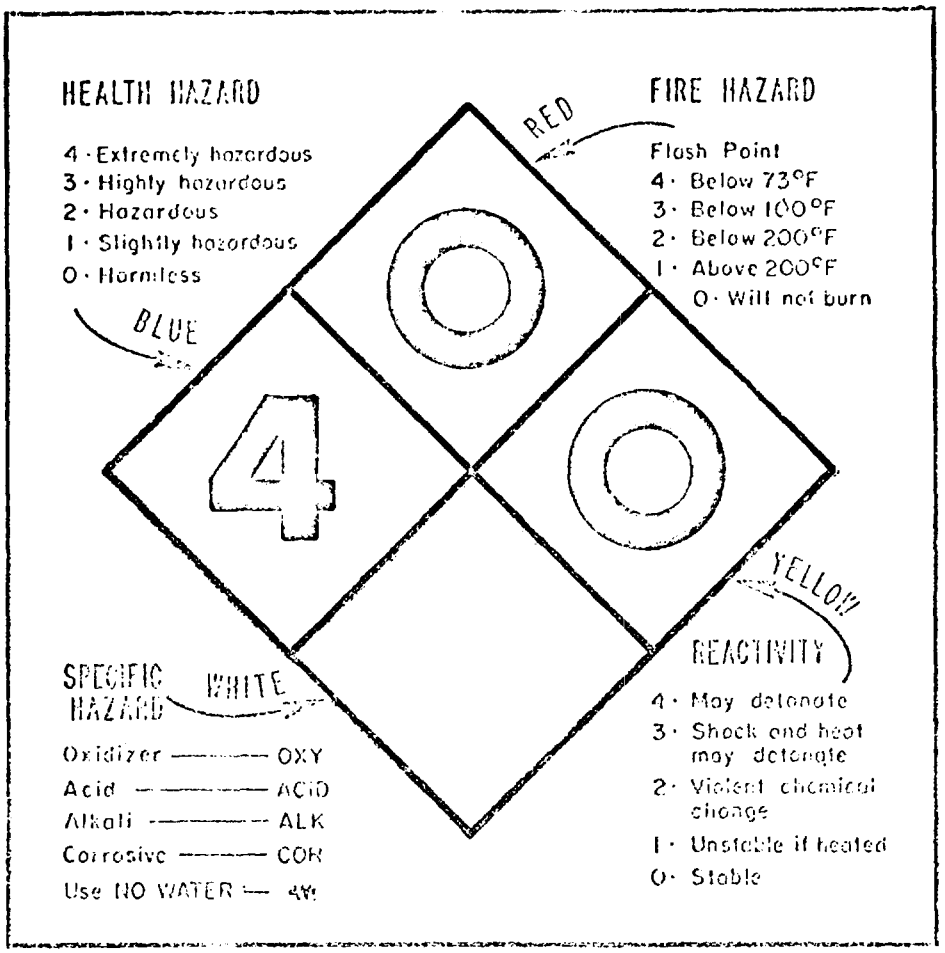
Specific hazards:

Oxidizing Material. A substance as chlorate, permanganate, peroxide, or a nitrate that yields oxygen to support combustion or which reacts readily to oxidize fuels or other combustible materials.

Corrosive Material. Acids, alkali or other material that will cause severe damage to living tissue or to other material it contacts.

Water Reactivity Hazard (Use No Water). Any material that may be a hazard because of its specific reactivity with water.

Figure 1. Hazard Identification System




## COLOR AND DIMENSION

Color format for NEPA No. 704M designations are shown above. The colors indicated shall acceptably match in shade the applicable color of FED-STD-595 as follows:

| Color | Class |
|---|---|
| Black | 17038 |
| Red | 11105 |
| White | 17875 |
| Yellow | 13538 |
| Blue | 15102 |

Dimensions of the symbol and LAPI warning combination shall be optional but of such size and location as to be readily visible and legible.

The symbol and warning shall be applied by stenciling, painting, printing, lithographing, with fade-resistant materials.

## X. APPENDIX III

## MATERIAL SAFETY DATA SHEET

The following items of information which are applicable to a specific product or material containing 5% or more of asbestos shall be provided in the appropriate section of the Material Safety Data Sheet or approved form. If a specific item of information is inapplicable (i.e. flash point) initials "n.a." not applicable should be inserted.

(i) The product designation in the upper left hand corner of both front and back to facilitate filing and retrieval. Print in upper case letters in as large print possible.

(ii) Section I. Name and Source

(A) The name, address and telephone number of the manufacturer or supplier of the product.

(B) The trade name and synonyms for a mixture of chemicals, a basic structural material, or for a process material; and the trade name and synonyms, chemical name and synonyms, chemical family, and formula for a single chemical.

(iii) Section II. Hazardous Ingredients.

(A) Chemical or widely recognized common name of all hazardous ingredients.

(B) 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 of maximum amount, i.e., 10-20% V; 10% max. W.

(C) Basis for toxicity for each hazardous material such as established OSHA standard (TLV), in appropriate units and/or $LD_{50}$, showing amount and mode of exposure and species or $LC_{50}$ showing concentration and species.

(iv) Section III. Physical Data

(A) Physical properties of the total product including boiling point and melting point in degrees Fahrenheit; vapor pressure, in millimeters of mercury, vapor density of gas or vapor (air = 1), solubility in water, in parts per hundred parts of water by weight; specific gravity (water = 1); percent volatile, indicate if by weight or volume, at 70° Fahrenheit; evaporation rate for liquids (indicate whether butyl acetate or ether = 1); and appearance and odor.

(v) Section IV. Fire and Explosion Hazard Data.

(A) Fire and explosion hazard data about a single chemical or a mixture of chemicals, including flash point, in degrees Fahrenheit; flammable limits, in percent by volume in air; suitable extinguishing media or agents; special fire fighting procedures; and unusual fire and explosion hazard information.

(vi) Section V. Health Hazard Data.

(A) Toxic level for total compound or mixture, relevant symptoms of exposure, skin and eye irritation properties, principle routes of absorption, effects of chronic (long-term) exposure and emergency and first aid procedures.

(vii) Section VI. Reactivity Data.

(A) Chemical stability, incompatibility, hazardous decomposition products, and hazardous polymerization.

(viii) Section VII. Spill or Leak Procedures.

(A) Detailed procedures to be followed with emphasis on precautions to be taken in cleaning up and safe disposal of materials leaked or spilled. This includes proper labeling and disposal of containers containing residues,

contaminated absorbants, etc.

(ix) Section VIII. Special Protection Information.

(A) Requirements for personal protective equipment, such as respirators, eye protection and protective clothing, and ventilation such as local exhaust (at site of product use or application), general, or other special types.

(x) Section IX. Special Precautions.

(A) Any other general precautionary information such as personal protective equipment for exposure to the thermal decomposition products listed in Section VI, and to particulates formed by abrading a dry coating, such as by a power sanding disc.

(xi) The signature of the responsible person filling out the data sheet, his address, and the date on which it is filled out.

(xii) The NFPA 704M numerical hazard ratings as defined in section (c) (5) following. The entry shall be made immediately to the right of the heading "Material Safety Data Sheet" at the top of the page and within a diamond symbol preprinted on the forms.

| PRODUCT DESIGNATION |
|---|
| |

# MATERIAL SAFETY DATA SHEET

Form Approved
Budget Bureau No.
Approval Expires
Form No. OSHA

## SECTION I SOURCE AND NOMENCLATURE

| | |
|---|---|
| MANUFACTURER'S NAME | EMERGENCY TELEPHONE NO. |
| ADDRESS (Number, Street, City, State, ZIP Code) | |
| TRADE NAME AND SYNONYMS | CHEMICAL FAMILY |
| CHEMICAL NAME AND SYNONYMS | FORMULA |

## SECTION II HAZARDOUS INGREDIENTS

| BASIC MATERIAL | APPROXIMATE OR MAXIMUM % WT. OR VOL. | ESTABLISHED OSHA STANDARD | $LD_{50}$ | | $LC_{50}$ | |
|---|---|---|---|---|---|---|
| | | | ORAL | PERCUT. | SPECIES | CONC. |
| | | | | | | |
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## SECTION III PHYSICAL DATA

| | |
|---|---|
| BOILING POINT °F. | VAPOR PRESSURE mm Hg. |
| MELTING POINT °F. | VAPOR DENSITY (Air=1) |
| SPECIFIC GRAVITY ($H_2O$=1) | EVAPORATION RATE (_____=1) |
| SOLUBILITY IN WATER Pts/100 pts $H_2O$ | VOLATILE % Vol. % Wt. |
| APPEARANCE AND ODOR | |

## SECTION IV FIRE AND EXPLOSION HAZARD DATA

| | | |
|---|---|---|
| FLASH POINT | FLAMMABLE (EXPLOSIVE) LIMITS | UPPER |
| METHOD USED | | LOWER |
| EXTINGUISHING MEDIA | | |
| SPECIAL FIRE FIGHTING PROCEDURES | | |
| UNUSUAL FIRE AND EXPLOSION HAZARDS | | |

| PRODUCT DESIGNATION | |
|---|---|

| SECTION V HEALTH HAZARD DATA | |
|---|---|
| TOXIC LEVEL | CARCINOGENIC |
| PRINCIPLE ROUTES OF ABSORBTION | SKIN AND EYE IRRITATION |
| RELEVANT SYMPTOMS OF EXPOSURE | |
| EFFECTS OF CHRONIC EXPOSURE | |
| EMERGENCY AND FIRST AID PROCEDURES | |

| SECTION VI REACTIVITY DATA |
|---|
| CONDITIONS CONTRIBUTING TO INSTABILITY |
| CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION |
| INCOMPATABILITY (Materials to Avoid) |
| HAZARDOUS DECOMPOSITION PRODUCTS |

| SECTION VII SPILL OR LEAK PROCEDURES |
|---|
| STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED |
| WASTE DISPOSAL METHOD |

| SECTION VIII SPECIAL PROTECTION INFORMATION | |
|---|---|
| VENTILATION REQUIREMENTS LOCAL EXHAUST | PROTECTIVE EQUIPMENT (Specify Types) EYE |
| MECHANICAL (General) | GLOVES |
| SPECIAL | RESPIRATOR |
| OTHER PROTECTIVE EQUIPMENT | |

| SECTION IX SPECIAL PRECAUTIONS |
|---|
| PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE |
| OTHER PRECAUTIONS |

Signature _____ Address

Date _____