

IX. APPENDIX I

SAMPLING AND ANALYTICAL METHOD FOR HYDRAZINES

This sampling and analytical method for hydrazines is adapted from NIOSH Method No. P&CAM 248 [161].

Principle of the Method

A measured volume of air is drawn through a tube containing sulfuric acid-coated silica gel to trap the hydrazine compounds. The sorbent is treated with distilled water to desorb the hydrazines. Reagent containing sodium acetate and 2-furaldehyde is added and the resulting derivatives are extracted into ethyl acetate and analyzed by gas chromatography with flame-ionization detection.

Range and Sensitivity

The ranges of the method in terms of the weight of analyte collected are:

hydrazine	4- 6,000 $\mu\text{g}/\text{sample}$
methylhydrazine	9- 9,000 "
1,1-dimethylhydrazine	15-12,000 "
phenylhydrazine	66-21,000 "

The lower ends of the ranges are the lowest levels at which the analytical method was evaluated. At these levels, the precision was no worse than 14% relative standard deviation, and the desorption efficiency was 75% or

higher. The maximum amount of each hydrazine compound retained prior to breakthrough of the first sorbent section is at least 0.2 millimole. The practical upper limit for the analysis is 0.2 millimoles of total hydrazine compounds in 2 ml of eluent. This is 25 mole% of the acid present and 20 mole% of the 2-furaldehyde reagent added. When hydrazine, methylhydrazine, or phenylhydrazine are present at such high concentrations, derivatives may not be entirely soluble in the reaction mixture. However, they will be dissolved by the ethyl acetate added for extraction.

Interferences

(a) Water vapor is not a sampling interference since it activates, rather than deactivates, the sulfuric acid in the sorbent.

(b) Any compound that has nearly the same retention time on the gas-chromatographic column as one of the derivatives of the hydrazines is an interferent.

(1) Atmospheric contaminants. A bulk sample of liquid or solid sources of vapors should be submitted at the same time as the sample tubes so that chemical identification of possible interferents can be made. The bulk sample must not be transported in the same container as the sample tubes.

(2) Reagent contaminants. Reagent grade chemicals of the highest purity available must be used. 2-Furaldehyde is unstable and must be redistilled prior to use and stored in a freezer (-20 C).

Precision and Accuracy

The volume of air sampled can be measured to within $\pm 2\%$ if a pump with a calibrated volume indicator is used. Volumes calculated from initially set flowrates may be less accurate ($\pm 5-10\%$) unless changes in flowrate are manually or electronically monitored and compensated. The collection efficiency is 100% under most conditions. This is demonstrated by a negligible amount of compound measured in the backup section of the sorbent tube. Desorption may be incomplete, particularly for methylhydrazine, near the lower limit of analytical measurement. In preparing calibration curves, desorption of standards from sorbent sections compensates for such losses, so that accuracy is increased. No losses have been observed for 1,1-dimethylhydrazine stored on sorbent sections in sealed tubes for up to 28 days at ordinary room temperatures.

The precision of the analysis is dependent on the precision and sensitivity of the technique used to quantitate the gas-chromatographic peaks of samples and standards. An electronic digital integrator with baseline correction capability is useful for this purpose. Near the lower limits of analytical measurement manual peak height measurements are more reproducible. A relative standard deviation of 0.04 has been determined for analyses of two sets of six consecutive 20-liter air samples of 1.6 and 3.8 mg/cu m of 1,1-dimethylhydrazine in air. This method gave results for 1,1-dimethylhydrazine at the levels 1-10 mg/cu m.

Advantages and Disadvantages

The method uses a small, portable sampling device involving no liquids. This is an advantage for sampling air in a worker's breathing zone without interfering with normal work activities. It also simplifies

transportation to the analytical laboratory. The sorbent tube has a high capacity. It can be used for at least 8 hours to measure a workday average concentration, or for shorter times to measure excursion concentrations. Desorption and preparation of samples for analysis involve simple procedures and equipment. Several hydrazine compounds can be collected and determined simultaneously. The gas-chromatographic analysis distinguishes which are present and at what individual concentrations they occur. Interferences by amines are less serious than in a colorimetric method.

The major disadvantage of the method is that 2 hours are required for desorption and reaction of samples and standards. Also, when methylhydrazine is present, the reaction time must be carefully controlled.

Apparatus

(a) Air Sampling Equipment

(1) Sorbent. The silica gel substrate should be high quality, such as Silica Gel D-08, chromatographic grade, activated and fines-free, 45/60 mesh, a product of Coast Engineering Laboratories, or an equivalent grade of silica gel. The sulfuric acid coating is prepared as follows: a selected amount, W, of silica gel is weighed in a glass bottle. Reagent grade concentrated sulfuric acid (95-98%) is added directly to the silica gel with a glass dropper until the total weight in the bottle becomes 1.25 W. The bottle is immediately sealed and shaken to uniformly distribute the sulfuric acid on the silica gel. Mixing is repeated intermittently for an hour as the mixture cools. The resulting material is quite hygroscopic and should not be exposed to air any longer than necessary.

(2) Sampling Tubes. Glass tubes 8-cm long and 6-mm internal diameter, tapered and flame-sealed at one end, are packed with two 200-mg sections of sulfuric acid-coated silica gel. Glass-wool plugs are used to separate and enclose the sections. The other end of the tube is flame-sealed to prevent contamination during storage prior to use. Polyethylene caps are used to seal the tubes after sampling is completed. Pressure drops across these tubes average 6 mmHg at 200 cc/minute and 33 mmHg at 1,000 cc/minute flowrates. The primary absorbing section of the tube is that further away from either end; the backup section is butted against a taper.

(3) Personal Sampling Pump. Pumps must be capable of operation at 1 liter/minute for 2 hours with a sampling device in line and should have flow indicators. Each pump is calibrated with a representative sorbent tube in line. A wet or dry test meter or a bubble meter capable of measuring a flowrate of 1 liter/minute to within $\pm 2\%$ is used in the calibration. Figure XI-1 shows a typical calibration setup for sampling pumps with a soapbubble meter.

(b) Gas chromatograph with a flame-ionization detector. Temperature programming capability is desirable.

(c) Gas-chromatographic column, 1-meter x 2-mm internal diameter glass, silanized and packed with 10% (by weight) Silicone OV-7 on 80/100-mesh Supelcoport or equivalent support.

(d) Strip chart recorder compatible with the gas chromatograph. An electronic digital integrator is desirable.

(e) Test tubes, 5-ml, sealed by insertion of a septum.

(f) Syringes, 10- μ l.

- (g) Pipettes, 0.5-ml and 2-ml.
- (h) Volumetric flasks, 10-ml.
- (i) File.
- (j) Forceps.

Reagents

All chemicals must be ACS Reagent Grade or better.

- (a) Hydrazine.
- (b) Methylhydrazine.
- (c) 1,1-Dimethylhydrazine.
- (d) Phenylhydrazine.
- (e) Water, double distilled, aldehyde-free.
- (f) 2-Furaldehyde (furfural), boiling point 39-40 C at 5 mmHg. If this reagent is not clear, it must be redistilled prior to use to remove oxidation products. Store distillate under refrigeration.
- (g) Sodium acetate solution, 0.50 moles/liter (41 g/liter).
- (h) Reagent solution. Prepared by diluting 2 ml of 2-furaldehyde to 50 ml with the sodium acetate solution. This should be prepared fresh daily.
- (i) Gas-chromatographic gases.
 - (1) Carrier helium, Bureau of Mines Grade A.
 - (2) Hydrogen prepurified.
 - (3) Air, compressed and filtered.

Procedure

(a) Cleaning of Glassware. Wash with detergent solution, rinse with tap water and distilled water, and dry in an oven.

(b) Collection and Shipping of Samples

(1) Immediately before beginning the collection of a sample, break each end of the sorbent tube so as to provide openings of at least 2-mm diameter.

(2) Attach the tubing from the sampling pump to the backup end of the sampling tubes. Sample air must not pass through any hose or tubing before entering the sorbent tube.

(3) With the sorbent tube in a vertical position, sample the air at 1 liter/minute for 2 hours. Record the volume of air sampled on the sampling flow and time.

(4) Immediately after sampling is completed, cap the sorbent tubes with the polyethylene caps. Rubber caps must not be used.

(5) Obtain a blank sample by handling one tube in the same manner as the sample tubes (break, seal, and ship) except pump no air through it.

(6) Pack the tubes tightly to minimize chances of breakage during transit. Tubes should not be subjected to extremes of high temperature or low pressure.

(c) Analysis of Samples

(1) Preparation of Samples. Score each tube with a file 5 mm in front of the first glass-wool plug and break it open. Remove the glass-wool plug that precedes the first sorbent section and transfer it along with this initial section to a 5-ml test tube that can be septum-

sealed. Likewise, transfer the second plug and sorbent section to another test tube. Label each appropriately for separate analysis.

(2) Desorption. Desorb the hydrazine compounds from the sulfuric acid-coated silica gel by adding 2 ml of distilled water to each sorbent section. Seal the tubes. Shake the mixtures occasionally over a period of 1 hour. Tests have shown that desorption reaches a maximum within an hour.

(3) Derivatization. Add 2 ml of reagent solution to each test tube containing sorbent and eluent. When methylhydrazine is expected in the sample or standard, the time of reagent addition must be exactly noted for each mixture. Mix the reagents thoroughly.

(4) Extraction. After 1 hour of reaction, add 0.5 ml of ethyl acetate to each test tube, seal tightly, and shake vigorously for 1 minute. For methylhydrazine, the reaction time must be exactly 1 hour, since a secondary reaction is occurring in the aqueous solution. Allow the ethyl acetate layer to settle out on top of the aqueous layer. Centrifuging accelerates this process. Samples of the ethyl acetate extracts are then analyzed by gas chromatography.

(d) Gas-Chromatographic Conditions. Typical operation conditions for the gas chromatograph are as follows:

- (1) Helium carrier gas flowrate, 50 ml/minute.
- (2) Hydrogen gas flowrate to detector, 40 ml/minute.
- (3) Air flowrate to detector, 540 ml/minute.
- (4) Injection port temperature, 150 C.
- (5) Detector temperature, 200 C.

(6) Column temperature--programmed, 80 C for 12 minutes, to 185 C at 24 C/minute, and for 8 minutes. When only methylhydrazine and 1,1-dimethylhydrazine are present, isothermal analysis at 80 C is appropriate; when only hydrazine and phenylhydrazine are present, 185 C is appropriate.

(e) Injection of Sample. To eliminate difficulties arising from blowback or distillation within the syringe, use the solvent-flush injection technique. Flush the 10- μ l syringe several times with ethyl acetate to clean the barrel and plunger. Draw in 1 μ l of ethyl acetate. With the needle removed from contact with liquid, pull the plunger back about 0.4 μ l to form a pocket of air. Then immerse the tip of the needle in the ethyl acetate extract layer of a sample and withdraw a 3- μ l portion, taking into consideration the volume in the needle. Remove the needle from the sample and pull the plunger back another 0.4 μ l to minimize evaporation from the tip of the needle. Inject and analyze duplicate 3- μ l aliquots of each sample and standard extract.

(f) Gas-Chromatographic Peak Measurement. Measure the areas or peak heights of the hydrazine derivative peaks obtained from analyses of samples and standards. At lower concentrations peak-height measurements may be more precise.

Calibration and Standards

(a) Preparation of a Standard Solution in Water. Calculate for each compound i the volume V_i (μ l):

$$V_i = \frac{X_i \times V_s}{D_i \text{ (or } C_i)}$$

X_i = the anticipated average concentration (mg/cu m) of compound i in air.

V_s = volume (liters) of air sampled.

D_i = density (g/ml) of a pure compound i .

C_i = concentration (g/ml) of the compound i in a known standard aqueous solution

Add the calculated volumes of each compound or aqueous standard solution to a 10-ml volumetric flask and dilute to the mark. A 10- μ l portion of this new standard contains amounts of compounds equal to the amounts collected from V_s of concentration X_i . Aqueous solutions of hydrazine compounds are unstable and should be prepared fresh when used.

(b) Preparation of Standards on Sorbent Sections. Add 200 mg of sulfuric acid-coated silica gel to each of 10 test tubes that can be tightly sealed with a septum. These may be weighed from bulk sorbent or obtained from unused tubes. Add 2.5, 5.0, 10.0, 15.0, and 20.0 μ l of the prepared standard to pairs of silica gel sections in the tubes. Use a 10- μ l syringe and inject through the septum onto the walls of the tube containing sorbent. Withdraw the syringe and shake the tube to distribute the hydrazines. These standards correspond to 0.25, 0.5, 1, 1.5, and 2 times X_i in V_s , respectively. Other standards may be similarly prepared, if desired.

If samples are to be stored for longer than 1 week before analysis, prepare standards on sulfuric acid-coated silica gel soon after receipt of the samples in the laboratory. Store samples and standards at the same conditions so that storage losses (if any) will be similar.

Calculations

(a) Prepare a calibration curve for each hydrazine compound by plotting peak areas (or heights) obtained from the analyses of standards against nominal amounts on the standard sorbent sections (A_i , μg).

$$A_i = V_i \times D_i$$

where V_i and D_i are defined in Calibration and Standards.

(b) Read the amount of each compound from the appropriate calibration curve, using average peak heights from each sample. Correct each value for the amount found in the corresponding blank, if any. Add the amounts found in the front and backup sections (if any) of the same sample tube to obtain the total weight of compound in the air volume sampled.

(c) Divide the total weight of each compound on each tube volume of air sampled (V_s) to obtain the concentration of that compound in $\mu\text{g/liter}$ or mg/cu m .

X. APPENDIX II

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 employees. The relative numerical hazard ratings and key statements are those determined by the rules in Chapter V, Part B, of the NIOSH publication, An Identification System for Occupationally Hazardous Materials. The company identification may be printed in the upper right corner if desired.

(a) Section I. Product 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, ie, "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, eg, "100 ppm LC50-rat," "25 mg/kg LD50-skin-rabbit," "75 ppm LC man," or "permissible exposure from 29 CFR 1910.1000," or, if not available, from other sources of publications such as the American Conference of Governmental Industrial Hygienists or the

American National Standards Institute Inc. 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 (mmHg); 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 employees.

(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 employees 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 MSHA approval class, ie, "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 employees 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 employees. 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 employees.

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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 ₂ O=1)		VAPOR PRESSURE
VAPOR DENSITY (AIR=1)		SOLUBILITY IN H ₂ O, % 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 _____

XI. TABLES AND FIGURE

TABLE XI-1

PHYSICAL AND CHEMICAL PROPERTIES OF HYDRAZINE

Molecular formula	H ₂ NNH ₂
CAS Number	000302012
Formula weight	32.05
Appearance	Colorless, oily liquid; fumes in air
Autoignition temperature	24 C on iron-rust surface, 270 C on a glass surface
Boiling point	113.5 C
Explosive limits	4.7-100% by volume in air
Flashpoint (open cup)	38-52 C
Freezing point	1.4-1.5 C
Odor	Ammonia-like or fishy
Specific gravity (25/4 C)	1.004
pKa	8.07
Solubility	Soluble in water, ethanol, and isobutanol; insoluble in chloroform and ether
Vapor density (air = 1)	1.04
Vapor pressure	14.4 mmHg at 25 C
Saturation concentration at 25 C	18,900 ppm
Conversion factors (at 760 mmHg and 25 C)	1 ppm = 1.31 mg/cu m 1 mg/cu m = 0.76 ppm

Adapted from references 9-11,20-22

TABLE XI-2

PHYSICAL AND CHEMICAL PROPERTIES OF METHYLHYDRAZINE

Molecular formula	CH ₃ NHNH ₂
CAS Number	000060344
Formula weight	46.07
Appearance	Colorless liquid
Autoignition temperature	Unknown
Boiling point	87.5 C
Explosive limits	2.5-92% by volume in air
Flashpoint (open cup)	63 C (145 F)
Freezing point	-21 to -52 C
Odor	Ammonia-like
Specific gravity (20/4 C)	0.874
pKa	7.87
Solubility	Soluble in water, ethanol, and ether
Vapor density (air = 1)	1.59
Vapor pressure	49.6 mmHg at 25 C
Saturation concentration at 25 C	65,300 ppm
Conversion factors (at 760 mmHg and 25 C)	1 ppm = 1.88 mg/cu m 1 mg/cu m = 0.53 ppm

Adapted from references 9-11,20-22

TABLE XI-3

PHYSICAL AND CHEMICAL PROPERTIES OF 1,1-DIMETHYLHYDRAZINE

Molecular formula	(CH ₃) ₂ NNH ₂
CAS Number	000057147
Formula weight	60.10
Appearance	Colorless, mobile liquid
Autoignition temperature	249 C
Boiling point	62.5-63.9 C
Explosive limits	2-95% by volume in air
Flashpoint (open cup)	1 C
Freezing point	-58 C
Odor	Ammonia-like or fishy
Specific gravity (25 C)	0.782
pKa	7.21
Solubility	Soluble in water, ethanol, and ether
Vapor density (air = 1)	2.08
Vapor pressure	157 mmHg at 25 C
Saturation concentration at 25 C	206,600 ppm
Conversion factors (at 760 mmHg and 25 C)	1 ppm = 2.46 mg/cu m 1 mg/cu m = 0.41 ppm

Adapted from references 9-11,20-22

TABLE XI-4

PHYSICAL AND CHEMICAL PROPERTIES OF 1,2-DIMETHYLHYDRAZINE

Molecular formula	CH ₃ NHNHCH ₃
CAS Number	000540738
Formula weight	60.1
Appearance	Colorless liquid
Autoignition temperature	Unknown
Boiling point	80-81 C
Explosive limits	Unknown
Flashpoint	"
Freezing point	"
Melting point	-9 C
Odor	Ammonia-like or fishy
Specific gravity (20/4 C)	0.827
Solubility	Soluble in water, ethanol, and ether
Vapor density (air = 1)	2.08
Vapor pressure	69.9 mmHg at 25 C
Saturation concentration at 25 C	92,000 ppm
Conversion factors (at 760 mmHg and 25 C)	1 ppm = 2.46 mg/cu m 1 mg/cu m = 0.41 ppm

Adapted from references 5,20

TABLE XI-5

PHYSICAL AND CHEMICAL PROPERTIES OF PHENYLHYDRAZINE

Molecular formula	C ₆ H ₅ NHNH ₂
CAS Number	000100630
Formula weight	108.14
Appearance	Yellow, monoclinic crystals or oil
Autoignition temperature	174 C
Boiling point	243.5 C with decomposition
Explosive limits	Unknown
Flashpoint (open cup)	378 C
Freezing point	19.4-19.6 C
Odor	Faint aromatic
Specific gravity (25/4 C)	1.0978
pK _b	8.79
Solubility	Soluble in alcohol, benzene, chloroform, and ether; sparingly soluble in water, petroleum ether, and dilute acid solutions
Vapor density (air = 1)	3.74
Vapor pressure	0.04 mmHg at 25 C
Saturation concentration at 25 C	50 ppm
Conversion factors (at 760 mmHg and 25 C)	1 ppm = 4.42 mg/cu m 1 mg/cu m = 0.23 ppm

Adapted from references 9-11,20-22

TABLE XI-6

OCCUPATIONS WITH POTENTIAL EXPOSURE TO HYDRAZINES

Agricultural chemical workers	Water treaters
Analytical chemists	Jet fuel handlers
Anticorrosion additive workers	Jet fuel makers
Boiler operators	Nitron makers
Catalyst reclaimers	Organic chemical synthesizers
Chlorine scavenger makers	Oxygen scavenger makers
Drug makers	Photographic developer makers
Dyemakers	Rocket fuel handlers
Explosive makers	Rocket fuel makers
Foamed plastic makers	Rubber workers
Fuel cell makers	Silverplating workers
Herbicide makers	Solder flux makers
Hydraulic fluid workers	Solderers
Hydrazine and hydrazine- derivative makers	Textile dyers, acrylic and vinyl
Insecticide makers	Vat dyemakers

Adapted from references 11,23

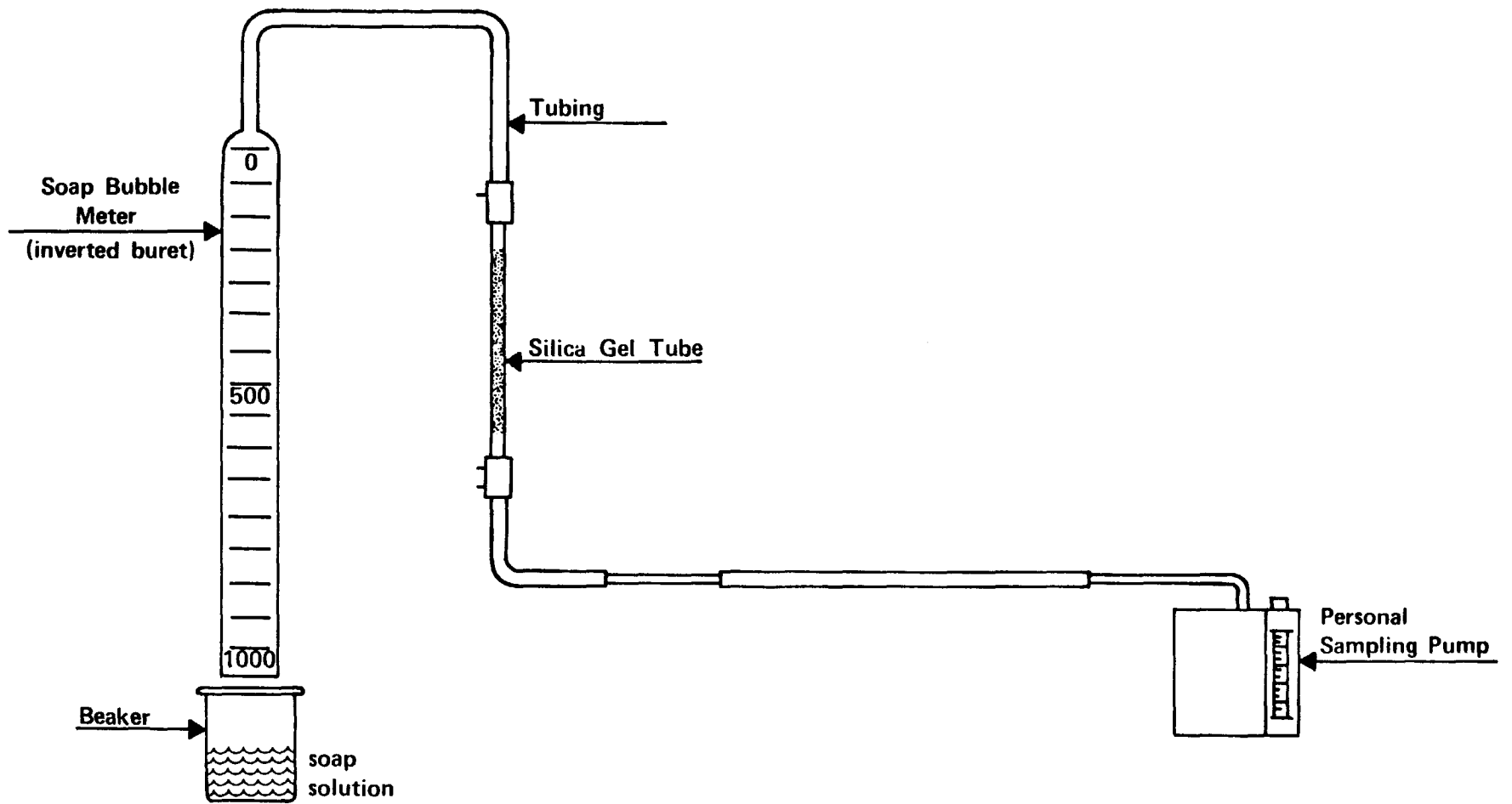


FIGURE XI-1

CALIBRATION SETUP FOR PERSONAL SAMPLING WITH SILICA GEL TUBE

**DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
ROBERT A. TAFT LABORATORIES
4676 COLUMBIA PARKWAY, CINCINNATI, OHIO 45226**

**OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE: \$300**



**POSTAGE AND FEES PAID
U.S. DEPARTMENT OF H.E.W.
HEW 396**