

## X. APPENDIX II

### ANALYTICAL METHOD FOR HYDROGEN FLUORIDE

#### Principle of the Method [77]

A known volume of air is drawn through a midget bubbler containing 10 ml of 0.1 N sodium hydroxide to trap hydrogen fluoride. The resulting solution is diluted to 25 ml with 0.1 N sodium hydroxide and buffered with an equal volume of total ionic strength activity buffer (TISAB). If a urine sample is involved, equal volumes of urine and TISAB are mixed. The sample is analyzed using a fluoride ion-selective electrode and an expanded scale millivoltmeter.

#### Range and Sensitivity

This method was validated over the range of 1.329-4.50 mg/cu m at an airborne temperature of 22 C and pressure of 761 mmHg using a 45-liter sample. The probable useful range of this method is 0.245-7.35 mg/cu m for 45-liter samples.

The upper limit of the range of the method is dependent on the collection efficiency of the midget bubbler. If higher concentrations than those tested are to be sampled, smaller sample volumes should be used. The collection efficiency for hydrogen fluoride was determined to be  $0.991 \pm 0.004$  when sampled for 30 minutes at 1.5 liters/minute from a test atmosphere containing 4.50 mg/cu m.

### Interferences

Hydroxide ion is the only significant electrode interference, however, addition of the TISAB minimizes this problem. Very large amounts of complexing metal ions such as aluminum may result in low readings even in the presence of TISAB.

When contaminants other than fluorides are known or suspected to be present in the air during sampling, such information should be transmitted with the sample.

### Precision and Accuracy

The Coefficient of Variation (CVT) for the total analytical and sampling method in the range of 1.329-4.50 mg/cu m was 0.057. This value corresponds to a standard deviation of 0.14 mg/cu m at the recommended environmental limit.

A collection efficiency of  $0.991 \pm 0.004$  was determined for the collecting medium.

### Apparatus

The sampling unit for the bubbler collection method consists of the following components:

(a) A standard glass midget bubbler containing the absorption medium. The bubbler stem unit consists of a 2-hole rubber stopper to fit 1/8-in OD Teflon tubing.

(b) A pump suitable for pumping at least 1.5 liters air/minute for 30 minutes. The sampling pump must be protected from splashover or solvent

condensation by a 5-cm long by 6-mm ID glass tube loosely packed with a plug of glass wool and inserted between the exit arm of the bubbler and the pump.

- (c) Thermometer.
- (d) Manometer.
- (e) Volumetric flasks: 25-ml or convenient sizes.
- (f) Pipets: 1-, 2-, 4-, and 5-ml.
- (g) Fluoride ion-selective electrode.
- (h) Reference electrode, single junction, calomel or silver/silver chloride electrode.
- (i) Expanded scale millivolt-pH meter capable of measuring to within 0.5 millivolt.
- (j) Polyethylene beakers, 50-ml capacity.
- (k) Magnetic stirrer with heat shield between stirring motor and sample, and stirring bars for 50-ml beakers.
- (l) Stopwatch.
- (m) Laboratory oven, thermostatically controlled.

All glassware and plastic ware should be washed in detergent solution, rinsed in tap water, and then rinsed with doubly distilled water.

All sampling devices, volumetric glassware, and reagent solutions must be stored under suitable conditions to protect from airborne dust and fumes, and should be reserved for exclusive use in low-fluoride analyses.

## Reagents

All chemicals must be ACS reagent grade or equivalent. Polyethylene beakers and bottles should be used for holding and storing all fluoride-containing solution.

- (a) Doubly distilled water.
- (b) Glacial acetic acid.
- (c) Sodium hydroxide, 5 N solution. Dissolve 28 g of sodium hydroxide in sufficient distilled water to give 300 ml of solution.
- (d) Sodium chloride.
- (e) Sodium citrate.
- (f) Total Ionic Strength Activity Buffer (TISAB).

Place 500 ml of doubly distilled water in a 1-liter beaker. Add 57 ml of glacial acetic acid, 58 g of sodium chloride, and 0.30 g of sodium citrate. Stir to dissolve. Place beaker in water bath (for cooling) and slowly add 5 N sodium hydroxide until the pH is 5.0. Cool to room temperature and pour into a 1-liter volumetric flask and add doubly distilled water to the mark.

- (g) Ethylenedinitrilotetracetic acid (EDTA), disodium salt.
- (h) Sodium fluoride, for preparation of standards.
- (i) Standard fluoride solution.

Dissolve 12.06 mg sodium fluoride in 0.1 N sodium hydroxide (prepared from doubly distilled water) and dilute to 100 ml with 0.1 N sodium hydroxide. This solution is equivalent to 0.0546 mg/ml fluoride ion. One ml of this solution contains the amount collected at 0.5 times the recommended environmental limit when sampling at 1.5 liters/minute for 30 minutes. The 0.5X level standard solution is made by combining 10 ml of

0.1 N sodium hydroxide with 1 ml of the standard stock solution. Likewise, the 1X level standard solution is prepared with 2 ml, and the 2X level standard solution is prepared with 4 ml of the standard stock solution. The standards are diluted to 25 ml with 0.1 N sodium hydroxide and 25 ml TISAB is added prior to analysis with the fluoride ion-selective electrode.

#### Collection of Samples

Pour 10 ml of the collection medium into the midget bubbler, using a graduated cylinder to measure the volume.

Connect the bubbler (via the adsorption tube) to the vacuum pump with a short piece of flexible tubing. The air being sampled should not pass through any other tubing or other equipment before entering the bubbler.

The bubbler stem unit consists of a 2-hole rubber stopper to fit 1/8-in OD Teflon tubing. One piece of tubing conducts the analyte to below the level of the collection medium where the analyte is trapped. The short outlet tube is connected to the sampling pump.

Turn the pump on to begin sample collection. Care must be taken to measure the flow rate and time as accurately as possible. Record the atmospheric pressure and the temperature. If the pressure reading is not available, record the elevation. The sample should be taken at a flow rate of 1.5 liters/minute. The flowrate should be known with an accuracy of  $\pm 5\%$ .

The pump rotameter should be observed frequently and adjusted if necessary, and sampling should be terminated at any evidence of a problem.

Terminate sampling at the predetermined time and note sample flow rate and collection time.

After sampling, the bubbler stem may be removed and cleaned. Tap the stem gently against the inside wall of the bubbler bottle to recover as much of the sampling solution as possible. Wash the stem with 1-2 ml of the collection medium, adding wash to the bubbler. Transfer the contents of the bubbler to a 50-ml polyethylene bottle. Rinse the bubbler with 2-3 ml of the collection medium and seal the bottle tightly for shipment.

Care should be taken to minimize spillage or loss by evaporation at all times. Refrigerate samples if analysis cannot be done within a day.

#### Calibration and Standards

Prepare three fluoride standard solutions as described under Reagents at each of three levels (0.5X, 1X, and 2X the recommended workplace environmental limit).

Insert the fluoride ion-selective electrode and the reference electrode into one of the standards at the 0.5X level, and stir the solution with the magnetic stirrer.

Record the resulting millivolt reading to the nearest 0.5 millivolt.

Repeat the above two steps for the remaining standard solutions.

Calibration at each level should be repeated twice daily.

Average the millivolt readings at each level.

Prepare the standard curve by plotting the three averaged millivolt readings vs mg F on semilog paper. Plot the mg F on the log axis.

### Analysis of Samples

The sample in each bubbler is analyzed separately.

Quantitatively transfer the contents of the polyethylene bottle to a 25-ml volumetric flask. Make up to volume with 0.1 N sodium hydroxide.

Transfer the sample to a 50-ml polyethylene beaker. Add 25 ml of TISAB and stir with a magnetic stirrer.

Lower the fluoride ion-selective electrode and reference electrode into the stirred solution and record the resulting millivolt reading (to the nearest 0.5 mV) after it has stabilized to a drift rate of less than 0.5 mV/min.

### Urine Samples

Urine samples should be collected in chemically clean bottles containing 0.2 g of EDTA. If the volume of the urine sample as determined upon receipt is greater than 100 ml, an amount of EDTA equivalent to 0.2 g/100 ml in excess of the first 100 ml should be added. Care must be taken when collecting and handling urine specimens to avoid F contamination. Upon receipt of the sample, either analyze immediately or refrigerate to retard bacterial action on urea which increases the sample pH through the generation of ammonia. Determine the specific gravity before analysis. Transfer 10 ml of well-mixed urine sample and 10 ml of TISAB into a 50-ml plastic beaker and stir with a magnetic stirrer. Proceed directly with electrode analysis. Determine F concentration by referring to a previously prepared standard curve. Calculate to mean specific gravity of 1.024. If a urinometer is used which has been calibrated against water at 4 C, a temperature correction must be made. [215]

### Calculations

Read the weight in milligrams corresponding to each millivolt reading from the standard curve. No volume corrections are needed, because the standard curve is based on mg/50 ml volume, and the volume of the samples is identical to the volume of the standards.

Corrections for the blank must be made for each sample.

$$\text{corrected mg} = \text{mg sample} - \text{mg blank}$$

where:

$$\text{mg sample} = \text{mg F found in sample bubbler}$$

$$\text{mg blank} = \text{mg F found in blank bubbler}$$

Calculate the mg of hydrogen fluoride found by multiplying the mg of fluoride ion found (corrected value) by 1.05.

The concentration of the analyte in air sampled can be expressed in mg/cu m.

$$\text{mg/cu m} = \frac{\text{Corrected mg} \times 1000 \text{ liter/cu m}}{\text{Air volume sampled (liter)}}$$

Another method of expressing concentration is ppm.

$$\text{ppm} = \text{mg/cu m} \times \frac{24.45}{\text{M.W.}} \times \frac{760}{\text{P}} \times \frac{\text{T} + 273}{298}$$

where:

- P = pressure (mmHg) of air sampled
- T = temperature (Celsius) of air sampled
- 24.45 = molar volume (liter/mole) at 25 C and 760 mmHg
- M.W. = molecular weight (g/mole) of analyte
- 760 = standard pressure (mmHg)
- 298 = standard temperature (K)



XI. 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 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, ie, "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. Flammable or reactive data

could be flash point, shock sensitivity, or other brief data indicating nature of the hazard.

(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 Fahrenheit (21.1 Celsius); 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 flash point 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, development of painful burns; prolonged or repeated contact, extreme pain and tissue destruction.

Eye Contact--intense pain and tissue destruction; 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. Pertinent specific local requirements 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 US Bureau of Mines approval class, ie, "Supplied air," "Organic vapor canister," "Suitable for dusts not more toxic than lead," 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 potentially exposed to the hazardous material. 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 <sub>2</sub> O=1)		VAPOR PRESSURE
VAPOR DENSITY (AIR=1)		SOLUBILITY IN H <sub>2</sub> O % BY WT
% VOLATILES BY VOL		EVAPORATION RATE (BUTYL ACETATE - 1)
APPEARANCE AND ODOR		





<b>VI REACTIVITY DATA</b>	
CONDITIONS CONTRIBUTING TO INSTABILITY	
INCOMPATIBILITY	
HAZARDOUS DECOMPOSITION PRODUCTS	
CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION	
<b>VII SPILL OR LEAK PROCEDURES</b>	
STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED	
NEUTRALIZING CHEMICALS	
WASTE DISPOSAL METHOD	
<b>VIII SPECIAL PROTECTION INFORMATION</b>	
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**

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XII. TABLES AND FIGURE

TABLE XII-1

PHYSICAL PROPERTIES OF HYDROGEN FLUORIDE

Property	Anhydrous Hydrogen Fluoride		Aqueous Hydrogen Fluoride
	Liquid	Gas	
Color	Colorless	Colorless	Colorless
Odor	Pungent, irritating	Pungent, irritating	Pungent, irritating
Molecular weight (monomer)	20.01	20.01	20.01
	NOTE: Hydrogen fluoride is monomeric only at high temperatures and low partial pressures. At lower temperatures polymers, especially (HF) <sub>2</sub> and (HF) <sub>6</sub> , are formed. However, at room temperature and partial pressures equivalent to the TWA limit, HF is probably monomeric.		
Boiling point, 1 atmosphere	19.5 C	----	Varies with concentration
Melting point	-83.37 C	----	"
Specific gravity 1 atmosphere	1.0 (4 C)	1.27 (34 C, air = 1)	"
Vapor pressure, 70 F (21 C)	42.19 g/sq cm	----	----
	4.1kPa	----	----
100 F (38 C)	86.9kPa	----	----
Constant boiling mixture (35.35%)	----	----	120 C
Specific volume 1 atm, 21 C	----	1204.8 ml/g	----
Solubility in water	-----Miscible in all proportions-----		

From references 2,4,5

TABLE XII-2

OCCUPATIONS WITH POTENTIAL EXPOSURE TO HYDROGEN FLUORIDE

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Aircraft workers	Fluosilicate makers
Alkylation plant workers	Freon makers
Alloy steel cleaners	Genetron makers
Alloy steel makers	Glass etchers
Aluminum fluoride makers	Graphite purifiers
Aluminum workers	Hydrogen fluoride workers
Ammonium fluoride makers	Incandescent lamp frosters
Bleachers	Isotron makers
Brass cleaners	Laundry workers
Brewers	Metal cleaners
Brick cleaners	Metal polishers
Casting cleaners	Neon sign makers
Ceramic workers	Oil well acidizers
Chemists	Ore dissolvers
Copper cleaners	Petroleum refinery workers
Cryolite makers	Phosphate rock workers
Crystal glass polishers	Phosphoric acid makers
Dye makers	Plastic makers
Electric arc welders	Polish workers
Electroplaters	Quartz crystal makers
Enamel etchers	Rocket fuel handlers
Fermentation workers	Rocket fuel makers
Fertilizer makers	Stainless steel cleaners
Filter paper makers	Stainless steel makers
Fluoborate makers	Steel casting picklers
Fluoride makers	Stone cleaners
Fluorine makers	Uranium refiners
Fluocarbon makers	Yeast makers
Fluorochemical makers	

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Adapted from reference 202

TABLE XII-3

**RELATIONSHIP BETWEEN THE CONCENTRATION OF INHALED  
HYDROGEN FLUORIDE AND ITS EFFECTS ON ANIMALS**

Reference	Exposure Concentration (mg/cu m)	Length of Exposure (hrs)	Animal	Effects
52	540	0.5 -1	Guinea pigs (5)	Death
52	205	0.5 -1	"	"
52	540	1.5 -3	Rabbits (5)	"
52	205	1.5 -3	"	"
52	40	2.0	Guinea pigs (5)	"
52	40	3.0	Rabbits (5)	Physical distress
52	25	24.0	Guinea pigs	Death
52	8	120.0	"	Labored breathing, eye irritation
52	8	186.0 (6 hrs/day)	Rabbits (15)	Death (2), weight loss and anemia (13)
52	8	"	Guinea pigs (21)	Death (7), weight loss and anemia (14)
52	8	"	Doves (4)	Death (1), weight loss and anemia (3)
52	2.5	"	Rabbits (16)	No pathologic changes
52	2.5	"	Guinea pigs (20)	"
52	2.5	"	Doves (3)	"
35	50	0.08-0.25	Rabbits (3)	Mild eye and respiratory irritation
35	50	0.08-0.25	Guinea pigs (3)	"
35	24	0.08-0.25	Rabbits (3)	"
35	24	0.08-0.25	Guinea pigs (3)	"

TABLE XII-3 (CONTINUED)

**RELATIONSHIP BETWEEN THE CONCENTRATION OF INHALED  
HYDROGEN FLUORIDE AND ITS EFFECTS ON ANIMALS**

Reference	Exposure Concentration (mg/cu m)	Length of Exposure (hrs)	Animal	Effects
35	24	41.0	Rabbit (1)	Liver and kidney damage
35	3,000	0.08-0.25	Rabbits (3)	Edema or cloudy swelling of organs and tissues
35	3,000	0.08-0.25	Guinea pigs (3)	"
54	15.2	309 (6-8 hrs/day)	Rabbits (8)	Leukocytic infiltration of lung (8), fatty degeneration of liver (2), renal tubular degeneration and necrosis
54	15.2	"	Monkey (1)	Renal tissue degeneration and inflammation
54	15.2	"	Guinea pig (1)	Pulmonary hemorrhages, alveolar exudates, atelectatic areas, liver degeneration
54	15.2	160 (6-8 hrs/day)	"	Death
54	15.2	134 (6-8 hrs/day)	"	"
55	7	180 (6 hrs/day)	Rats (15)	Subcutaneous hemorrhages in feet
55	7	"	Dogs (5)	Hemorrhagic areas in lung (1)
55	25	"	Rats (29)	Death
55	25	"	Mice (18)	"
55	25	"	Dogs (4)	Degenerative testicular changes (4) Moderate hemorrhages and edema of lungs (3)
55	25	"	"	Ulceration of the scrotum
55	25	"	Rabbits (18)	Slight pulmonary hemorrhage (4)

TABLE XII-3 (CONTINUED)

RELATIONSHIP BETWEEN THE CONCENTRATION OF INHALED  
HYDROGEN FLUORIDE AND ITS EFFECTS ON ANIMALS

Reference	Exposure Concentration (mg/cu m)	Length of Exposure (hrs)	Animal	Effects
58	4,060	0.08	Rats (10)	Respiratory distress, conjunctival and nasal irritation (10), death (5)
58	2,200	0.25	"	"
58	1,670	0.50	"	"
58	1,070	1.0	"	"
58	3,540	0.25	Guinea pigs (10)	Death (5)
58	14,900	0.08	Rats (10)	"
58	5,120	0.08	Mice (15)	"

TABLE XII-4

HYDROGEN FLUORIDE EXPOSURE - EFFECT  
DATA--HUMAN STUDIES

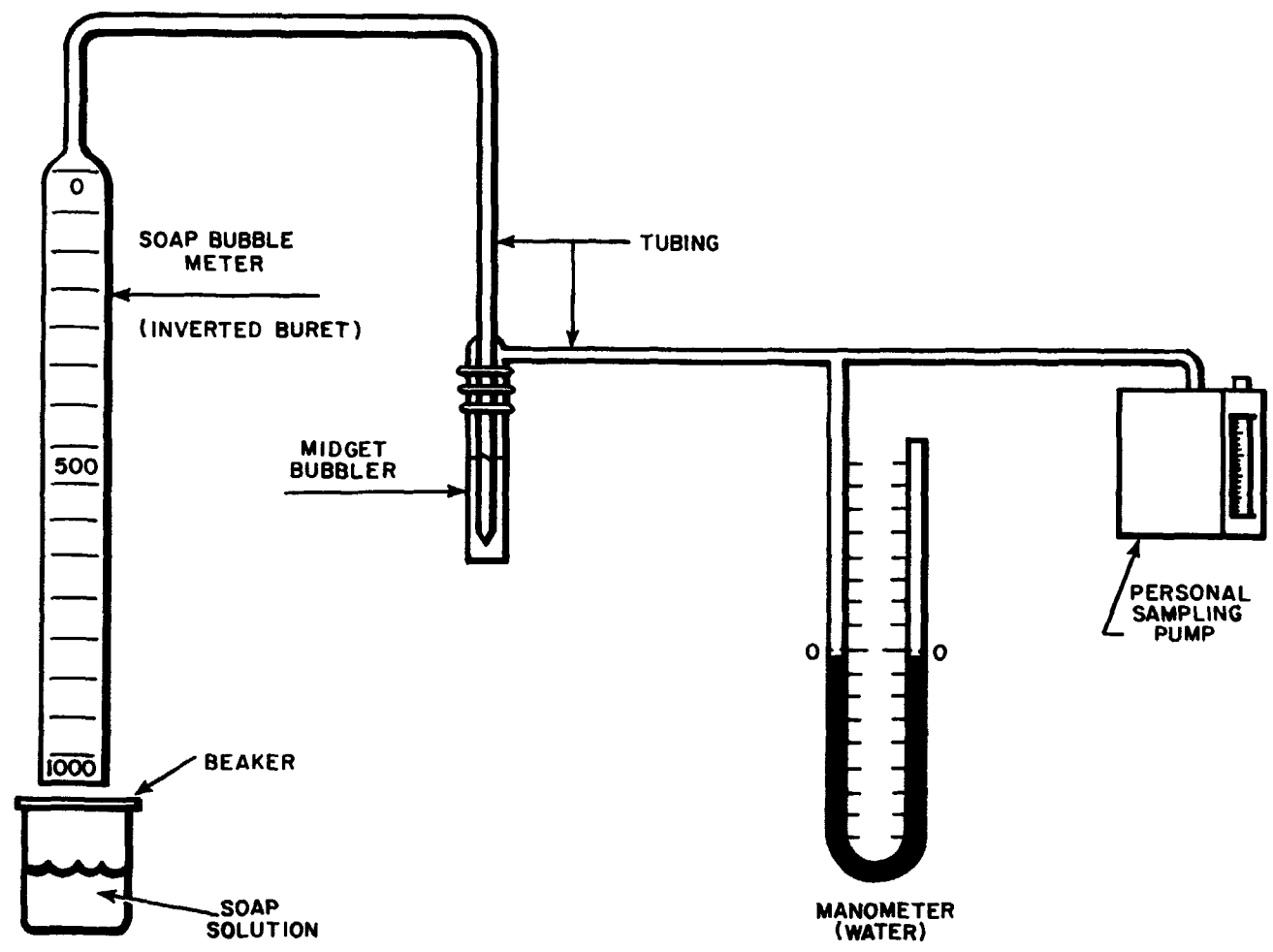
Reference	Exposure Concentration	Number Exposed	Route of Administration	Effects
32	8,000 -80,000 mg/cu m	2	Dermal exposure to 70% HF acid on clothing in chest area, resulting in inhalation exposure	Death from pulmonary edema
29	5 g	1	Dermal exposure to 100% anhydrous HF acid	Second- and third-degree burns, pain, nausea, stupor, mild throat irritation
50	2.4 -6.0 mg/cu m	46	Inhalation of gaseous and particulate fluorides	Slight blurring of bone structure
50	"	4	"	Merging of trabeculae; diffuse structureless appearance of bone
50	"	26	"	Marble-white opacity of bones of the pelvis, lumbar spine, and ribs; irregular vertebral bodies; calcification of pelvis ligaments; irregular periosteal bone formation. Marked restricted movements of the spine
48	3.38 mg/cu m (average) 1.78-7.73 (range)	17	"	Increase or questionable increase in bone density
36	0.7 mg/cu m	-	Inhalation of HF by etchers and welders	Nosebleeds



TABLE XII-4 (CONTINUED)  
 HYDROGEN FLUORIDE EXPOSURE - EFFECT  
 DATA--HUMAN STUDIES

Reference	Exposure Concentration	Number Exposed	Route of Administration	Effects
35	100 mg/cu m	2	Inhalation of HF for less than 1 minute	Smarting of exposed skin, marked conjunctival and respiratory irritation
35	50 mg/cu m	2	Inhalation of HF for unspecified time	Marked conjunctival and respiratory irritation
35	26 mg/cu m	2	Inhalation of HF for several minutes	Mild eye and nose irritation
26	2.12 mg/cu m (average)	1	Inhalation of HF 6 hrs/day, 5 days/ week for 15 days	Very slight irritation of eyes and nose, slight cutaneous erythema
26	2.78 mg/cu m (average)	1	Inhalation of HF 6 hrs/day, 5 days/ week for 10 days	"
26	2.23 mg/cu m (average)	1	Inhalation of HF 6 hrs/day, 5 days/ week for 30 days	"
26	3.46 mg/cu m (average)	1	Inhalation of HF 6 hrs/day, 5 days/ week for 50 days	"
26	3.89 mg/cu m (average)	1	Inhalation of HF 6 hrs/day, 5 days/ week for 25 days	"

Figure XII-1  
CALIBRATION SETUP FOR PERSONAL  
SAMPLING PUMP WITH MIDGET BUBBLER



**DEPARTMENT OF  
HEALTH, EDUCATION, AND WELFARE  
PUBLIC HEALTH SERVICE  
CENTER FOR DISEASE CONTROL  
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH  
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