

## I. RECOMMENDATIONS FOR A HYDROGEN FLUORIDE STANDARD

The National Institute for Occupational Safety and Health (NIOSH) recommends that worker exposure to hydrogen fluoride be controlled by requiring compliance with the following sections. The standard is designed to protect the health and safety of workers for up to a 10-hour workday, 40-hour workweek over a working lifetime. Compliance with all sections of the standard should prevent adverse effects of exposure to hydrogen fluoride in the workplace. The hydrogen fluoride standard is measurable by techniques that are valid, reproducible, and available to industry and government agencies. Sufficient technology exists to permit compliance with the recommended standard. The standard will be subject to review and revision as necessary.

"Hydrogen fluoride" is defined as:

(a) Gaseous or liquified anhydrous hydrogen fluoride and aqueous solutions thereof (hydrofluoric acid). The abbreviations HF and HF acid, as used in this document, denote the anhydrous and aqueous forms, respectively.

(b) Any gaseous fluoride which is a byproduct of processes using or producing hydrogen fluoride as defined above and is emitted into the air concomitantly with HF or HF acids.

"Occupational exposure to hydrogen fluoride" is defined as exposure to HF at airborne concentrations at or above one-half the recommended time-weighted average (TWA) environmental limit.

Section 1 - Environmental (Workplace Air)

(a) Occupational exposure shall be controlled so that no worker is exposed to hydrogen fluoride at a TWA concentration greater than 2.5 milligrams of fluoride ion (atomic weight 19) per cubic meter of air (2.5 mg F/cu m) for up to a 10-hour workday, 40-hour workweek, or greater than a ceiling of 5.0 milligrams of fluoride ion per cubic meter of air (5.0 mg F/cu m) as determined by a sampling time of 15 minutes. If both particulate and gaseous fluorides are present, total fluoride exposure from all occupational sources shall not exceed the recommended TWA concentration. Control of occupational exposure to any particulate inorganic fluorides produced as a byproduct or an end product of the use or production of HF shall be governed by the criteria document, Occupational Exposure to Inorganic Fluorides.

(b) Sampling and Analysis

Procedures for sampling air for HF, calibration of equipment, and analysis of samples shall be as provided in Appendices I and II, or by any method shown to be equivalent in precision, accuracy, and sensitivity to the methods specified.

Section 2 - Medical

Medical surveillance shall be made available as specified below for all workers subject to occupational exposure to hydrogen fluoride.

(a) Preplacement examination shall include as a minimum:

(1) Medical and occupational histories to elicit data on worker exposure to hydrogen fluoride and inorganic fluorides and evidence

of respiratory and renal diseases.

(2) A judgment of the worker's physical ability to use negative or positive pressure respirators as defined in 29 CFR 1910.134.

(3) A urinalysis to determine the preexposure fluoride concentration in urine and to test for renal function.

(4) Examination of the skin and corneas for the presence of scars.

(5) An X-ray of the pelvis on all male workers (see chapter V, Radiologic Examination). Special shielding of gonads shall be provided during radiography. The physician evaluating all X-ray films shall be made aware of the fluoride exposure of the worker and shall have knowledge of the radiologic signs of osteofluorosis.

(6) A worker with evidence of renal disease, impaired pulmonary function, scarring of the skin or cornea, or osteofluorosis shall be evaluated by a physician and, if appropriate, informed of the possibility of an increased health risk resulting from exposure to HF.

(b) Periodic Examination

(1) X-ray of the pelvis of males shall be considered by the examining physician when the average of preshift urinary fluoride concentrations for the preceding 6 years exceeds 4.0 mg F/liter.

(2) Urinalysis, skin and cornea examination, and X-ray of the pelvis of males, if not already conducted, shall be offered to presently employed workers within 6 months of the promulgation of a standard incorporating these recommendations.

(3) Any worker occupationally exposed to hydrogen fluoride and exhibiting signs or symptoms of respiratory tract irritation shall be

examined by a physician and shall have follow-up chest X-rays taken and pulmonary function tests performed as considered necessary by the examining physician.

(4) Workers with eye complaints following exposure to hydrofluoric acid shall have follow-up visual acuity tests and an ophthalmological examination as necessary.

(5) Any worker whose skin comes in contact with hydrofluoric acid shall receive prompt medical attention.

(c) Biologic Monitoring

Postshift F urinalysis shall be made available at intervals not exceeding 3 months to at least one-fourth of all workers with occupational exposure to hydrogen fluoride. The employer shall ensure that each exposed worker has the opportunity of receiving an F analysis of his urine every year. Spot urine samples shall be collected at the conclusion of the workshift after 4 or more consecutive days of exposure. Urinary preshift F analysis shall be made available to all exposed workers at least annually. Preshift spot samples shall be collected at the start of the workshift at least 48 hours after the last occupational exposure. Results shall be calculated to a specific gravity of 1.024. Urine specimens with a specific gravity less than 1.010 shall be discarded and another specimen obtained. Procedures for sampling and analysis shall be as described in Appendix II or by any other procedure equivalent in precision and accuracy. If an individual's postshift urinary F level exceeds 7.0 mg/liter, preshift spot urine samples for analysis shall be collected within 2 weeks at the start of a workshift at least 48 hours after a previous occupational exposure and a repeat postshift spot sample for analysis shall be collected at the

conclusion of the workshift. This shall be done at the end of the workweek in which the preshift sample is collected. If the F level of the second sample is above either the preshift limit of 4.0 mg/liter or the postshift limit of 7.0 mg/liter, steps shall be taken to evaluate dietary sources, personal hygiene, basic work practices, and environmental controls.

If the group (job classification) median postshift urinary F levels exceed 7.0 mg/liter, the working environment shall be evaluated through an industrial hygiene survey and steps shall be taken to ensure compliance with the environmental limit. Urinary F analyses shall be performed monthly until the cause of elevated urinary F has been corrected as demonstrated by a return of the group median to a postshift value not exceeding 7.0 mg/liter. The primary methods of control will be engineering and work practices. Use of administrative controls for the individual or group can also be considered.

(d) Medical Records

All pertinent medical records including all information regarding biologic determinations shall be maintained at least 20 years after the individual's employment is terminated. These records shall be available to the medical representatives of the Secretary of Labor, of the Secretary of Health, Education, and Welfare, of the employer, and of the employee or former employee at his request.

Section 3 - Labeling (Posting)

(a) Containers of anhydrous hydrogen fluoride shall bear the following label in addition to, or in combination with, labels required by

other statutes, regulations, or ordinances:

**DANGER!**  
**HYDROGEN FLUORIDE, ANHYDROUS**  
**EXTREMELY HAZARDOUS LIQUID AND GAS**  
**SEVERE INHALATION, SKIN, AND EYE HAZARD**  
**CAUSES BURNS**  
**DO NOT BREATHE GAS**  
**DO NOT GET IN EYES, ON SKIN, ON CLOTHING**

In case of contact, immediately flush skin or eyes with water continuously, remove contaminated clothing, and continue flushing until medical attention is obtained.

**CYLINDER HANDLING AND STORAGE**

Keep away from heat.  
Protect from damage.  
Do not wash out empty cylinders with water.  
Be sure connections are tight, check for leaks.  
Loosen closure carefully, keep sources of ignition away.  
Wear respiratory protection and protective clothing when connecting, disconnecting, or opening valve.  
Do not use cylinder valve for control; connect to needle valve.

(b) Containers of aqueous hydrogen fluoride (hydrofluoric acid) more concentrated than 40% shall bear the following label in addition to, or in combination with, labels required by other statutes, regulations, or ordinances:

**DANGER!**  
**HYDROFLUORIC ACID**  
**EXTREMELY HAZARDOUS LIQUID AND GAS**  
**LIQUID CAUSES BURNS**  
**SEVERE INHALATION, SKIN, AND EYE HAZARD**  
**AVOID BREATHING GAS**  
**AVOID CONTACT WITH SKIN, EYES, AND CLOTHING**

In case of contact, immediately flush skin or eyes with water continuously, remove contaminated clothing, and continue flushing until medical attention is obtained.

**HANDLING AND STORAGE**

Before moving containers, be sure closure is securely fastened.  
Store with closure up.  
Vent regularly to release pressure, avoid sources of ignition while venting; wear respiratory, skin, and eye protection.  
Release pressure carefully.  
Avoid damage to containers.  
Keep out of direct rays of sun, away from heat.  
Do not wash out containers with water.  
In case of spillage, neutralize; then flush with water.

(c) Containers of hydrofluoric acid of 40% or less concentration shall bear the following label in addition to, or in combination with, labels required by other statutes, regulations, or ordinances:

**DANGER!**  
**HYDROFLUORIC ACID**  
**HAZARDOUS LIQUID**  
**CAUSES SEVERE BURNS WHICH MAY NOT BE IMMEDIATELY PAINFUL OR VISIBLE**  
**AVOID CONTACT WITH EYES, SKIN, CLOTHING**

In case of contact, immediately flush skin or eyes with water, remove contaminated clothing, and continue flushing until medical attention is obtained.  
In case of spillage, neutralize; then flush with water.

(d) The following warning sign shall be affixed in a readily visible location at or near entrances to areas where hydrogen fluoride is stored, handled, or used in industrial processes, excluding nonroutine

laboratory use, and in which there is a potential for emergencies involving uncontrolled release of hydrogen fluoride. This sign shall be printed both in English and in the predominant language of non-English-speaking workers. All employees shall be trained and informed of the hazardous areas, with special instruction given to illiterate workers.

**DANGER!**  
**HYDROGEN FLUORIDE HAZARD AREA**  
**UNAUTHORIZED PERSONS KEEP OUT**

Prior to entry, contact (employer-designated person).  
Entry prohibited without permit and specified protective clothing.

**SEVERE SKIN AND EYE HAZARD--CAUSES BURNS**

In emergency, do not enter without complete respiratory protection and protective clothing, located at (specific locations to be supplied by employer).

(e) Hydrogen fluoride hazard areas required to be posted in accordance with Section 3(d) shall be clearly delineated by an appropriate boundary, such as a wall with a door for controlled entry, a raised curb sufficient to contain spills and painted a distinctive color, or a painted line of a distinctive color.

(f) All hydrogen fluoride systems, piping, and associated equipment, shall be plainly marked for positive identification in accordance with American National Standard A13.1-1975. Shut-off valves and switches shall be conspicuously labeled. Hydrogen fluoride cylinders in use shall be plainly marked "in use" to distinguish them from those not in use.

(g) All protective clothing, safety equipment, tools, and removable equipment, such as motors or pumps, after having been used in



association with hydrogen fluoride shall be distinctively marked or colored to warn against use or contact by unprotected personnel.

#### Section 4 - Personal Protective Equipment

##### (a) Protective Clothing

(1) Protective clothing impervious to hydrogen fluoride shall be worn when airborne concentrations of hydrogen fluoride may exceed the environmental limits, or when direct contact with HF or HF acid may occur, eg, when closed systems are opened for maintenance, or if leaks are likely to occur. Unless eye protection is afforded by a respiratory hood or facepiece, chemical goggles and face shields shall be worn. Eye and face protective equipment, and its use, shall conform to 29 CFR 1910.133.

(2) In addition to the respiratory protection specified in Table I-1, personnel performing operations where escape of liquid or gaseous anhydrous hydrogen fluoride may occur, or performing emergency operations involving exposure to liquid or gaseous anhydrous hydrogen fluoride or exposure to sprays of aqueous hydrofluoric acid shall wear impervious gloves, boots, and a continuous-flow, air-supplied impervious full-body suit with auxiliary self-contained air supply, or an impervious full-body suit and self-contained positive pressure full facepiece breathing apparatus. If unventilated suits are worn, stay time in the work area shall be limited with due consideration of the heat stress factors involved. An adequate supply of such protective clothing shall be kept available for emergencies.

(3) Sleeves of protective clothing shall be tight at the wrists and worn over gloves or gauntlets. Trouser legs shall be worn over boot tops.

(4) Protective clothing specifically used for hydrogen fluoride protection shall be marked distinctively, preferably with a distinctive color, to differentiate it from other protective clothing.

(5) The employer shall designate a person to be in charge of posted hydrogen fluoride hazard areas. This person shall specify, in accordance with the provisions of this standard, the protective clothing required in his area of responsibility.

(6) Hydrogen fluoride protective clothing shall be basified with sodium hydrogen carbonate, washed, dried, and inspected for integrity after each use, and immediately prior to reissue. Gloves shall be inspected for pinholes.

(7) A written procedure shall be established and enforced for the sequential removal of protective clothing in such a manner as to prevent skin contact with hydrogen fluoride. A recommended procedure is:

Wash gloves, aprons, boots, or jackets and trousers (outer garments) with water.

Remove mask, hood, or face shield while gloves are still on; wash with water.

Remove aprons, jacket, trousers, boots, gloves-- in that order.

Wash hands with water, remove goggles, and wash.

(8) Where complete protective clothing is required, a change house, with separate entrances for clean and contaminated personnel, shall be provided. Lockers shall be provided for street clothing. The requirements of 29 CFR 1910.141 shall be met.

(9) The employer shall supply all required protective clothing and shall be responsible for maintaining it in a clean, sanitary, and functional condition.

(b) Respiratory Protection

Engineering controls shall be used wherever feasible to maintain airborne hydrogen fluoride concentrations at or below those recommended in Section 1 above. Compliance with the permissible exposure limits by the use of respirators is only allowed when airborne hydrogen fluoride concentrations are in excess of either workplace environmental limit while required engineering controls are being installed or tested, when nonroutine maintenance or repair is being accomplished, or during emergencies. When a respirator is thus permitted, it shall be selected and used in accordance with the following requirements:

(1) For the purpose of determining the type of respirator to be used, the employer shall measure, when possible, the airborne concentration of hydrogen fluoride in the workplace initially and thereafter whenever process, worksite, climate, or control changes occur which are likely to increase the airborne concentration of hydrogen fluoride.

(2) The employer shall ensure that no worker is overexposed to hydrogen fluoride because of improper respirator selection, fit, use, or maintenance.

(3) A respiratory protection program meeting the requirements of 29 CFR 1910.134 which incorporates the American National

Standard Practices for Respiratory Protection Z88.2-1969 shall be established and enforced by the employer.

(4) The employer shall provide respirators in accordance with Table I-1 and shall ensure that the employee uses the respirator provided.

(5) Respiratory protective devices described in Table I-1 shall be those approved under the provisions of 30 CFR 11.

(6) The employer shall ensure that employees are instructed on the use of respirators assigned to them and on how to test for leakage.

(7) Each area required to be posted in accordance with Section 3(d) shall have at least two emergency respirators and two sets of protective clothing readily available in nearby locations which do not require entry into a contaminated atmosphere for access. Each set shall consist of at least two self-contained breathing apparatus, full-facepiece pressure-demand type, and the protective clothing specified for emergencies in Section 4(a)(2) of this standard.

(8) Respirators specified for use in atmospheres of higher concentrations of hydrogen fluoride may be used in atmospheres of lower concentrations.

(9) The employer shall ensure that respirators are cleaned, maintained, and stored in accordance with 29 CFR 1910.134, as currently amended.

(10) Canisters shall be discarded after use or whenever an odor or taste is detected, and replaced with fresh canisters. Unused canisters shall be discarded and replaced when the seal is broken or at the expiration of the shelf life as recommended by the manufacturer.

TABLE I-1

RESPIRATOR SELECTION GUIDE FOR PROTECTION AGAINST HYDROGEN FLUORIDE

Multiples of TWA Limit	Respirator Type
Less than or equal to 10X	(1) Full-face gas mask, chest- or back-mounted type, with industrial size hydrogen fluoride or acid-gas canister (2) Chemical cartridge respirator with full facepiece and cartridge(s) and filter(s) providing protection against hydrogen fluoride (3) Type C supplied-air respirator, demand or pressure-demand type (negative or positive pressure), with full facepiece, hood, or helmet with shroud
Less than or equal to 100X	Combination respirator which includes a Type C supplied-air respirator, pressure-demand or other positive pressure or continuous-flow type with full facepiece and an auxiliary self-contained breathing apparatus, pressure-demand or other positive pressure type
Greater than 100X	(1) Self-contained breathing apparatus with full facepiece, pressure-demand or other positive pressure type (2) Continuous-flow air-supplied suit with auxiliary self-contained breathing apparatus, pressure-demand or other positive pressure type.

TABLE I-1 (CONTINUED)

RESPIRATOR SELECTION GUIDE FOR PROTECTION AGAINST HYDROGEN FLUORIDE

Multiples of TWA Limit	Respirator Type
Emergency situations (No concentration limit)	(1) Self-contained breathing apparatus with full facepiece, pressure-demand or other positive pressure type (2) Continuous flow air-supplied suit with auxiliary self-contained breathing apparatus, pressure-demand or other positive pressure type
Evacuation or escape	(1) Self-contained breathing apparatus with full facepiece. (2) Full-face gas mask, front or back mounted type, with industrial-size hydrogen fluoride or acid-gas canister

Section 5 - Informing Employees of Hazards from Hydrogen Fluoride

At the beginning of employment, workers whose jobs may involve exposure to HF at airborne concentrations greater than one-half the TWA limit, or who will work in areas required to be posted in accordance with Section 3(d) shall be informed of the hazards, symptoms of overexposure, emergency procedures, and precautions to ensure safe use and to minimize exposure. First-aid procedures shall be included, with emphasis on the importance of prompt, copious, and continuous irrigation of eyes and skin, despite initial lack of pain. The information shall be posted in the work area and kept on file, readily accessible to the worker.

A continuing education program, conducted by a person or persons qualified by reason of experience or special training, shall be instituted to ensure that all workers have current knowledge of job hazards, first-aid

procedures, maintenance procedures, and cleanup methods, and that they know how to use respiratory protective equipment and protective clothing. Retention of this information by workers in areas required to be posted in accordance with Section 3(d) shall be verified by drills simulating emergency situations appropriate to the work situation, held at intervals not exceeding 6 months. Drills should cover, but should not be limited to, the following:

Evacuation procedures.

Handling of spills and leaks, including decontamination.

Location and use of emergency firefighting equipment.

First-aid and rescue procedures.

Location, use, and care of protective clothing and respiratory protective equipment.

Location of shutoff valves or switches.

Location, purpose, and use of safety showers, eyewash fountains, and other sources of water for emergency use.

Operating procedures.

Entry procedures for confined spaces.

Prearranged procedures for obtaining emergency medical care.

Information, as required, shall be recorded on the "Material Safety Data Sheet" shown in Appendix III or on a similar form approved by the Occupational Safety and Health Administration, US Department of Labor.

Section 6 - Work Practices

(a) Emergency Procedures

For all work areas in which there is a potential for emergencies, procedures as specified below, as well as any other procedures appropriate for a specific operation or process, shall be formulated in advance and employees shall be instructed and drilled in their implementation.

(1) Procedures shall include assignment of individual or team responsibilities and prearranged plans for:

(A) Immediate evacuation of workers with signs or symptoms of adverse effects due to hydrogen fluoride overexposure.

(B) Transportation of injured workers.

(C) Any necessary calls, such as alerting medical facilities of the impending arrival of injured workers, and calls to suppliers or manufacturers of hydrogen fluoride for assistance.

(D) Designation of medical receiving facilities and names of physicians trained in hydrogen fluoride emergency procedures.

(2) Approved eye, skin, and respiratory protection as specified in Section 4 shall be used by personnel essential to emergency operations.

(3) Nonessential employees shall be evacuated from exposure areas during emergencies. Perimeters of areas of hazardous exposure shall be defined, posted, and secured.

(4) Personnel who cannot be evacuated shall keep upwind of spills or leaks, if possible. Personnel properly trained in the procedures and adequately protected against the hazards shall shut off sources of hydrogen fluoride, neutralize and clean up spills, and repair leaks as



quickly as possible. Supplies of lime or soda ash shall be readily available for neutralizing spills. Sources of water shall be available for washdown of spills.

(5) Water used to flush areas contaminated with hydrogen fluoride shall be impounded and guarded until neutralized. Water used to absorb hydrogen fluoride shall only be discharged to municipal sewers or drains, if it is adequately diluted or otherwise treated to meet applicable local, state, or federal discharge and water pollution regulations.

(6) In case of fire, hydrogen fluoride sources shall be shut off or removed. Cylinders shall be removed to a safe place or cooled with water. Water may be used for fighting fires involving hydrogen fluoride.

(7) Hydrogen fluoride in contact with skin or eyes must be removed by prompt, copious, and continuous washing with water until medical attention is obtained. Contaminated clothing shall be removed immediately. If hydrogen fluoride is inhaled, the victim shall be removed to an uncontaminated atmosphere, given artificial respiration, if required, and provided with immediate medical attention.

(b) Control of Airborne Hydrogen Fluoride

(1) Engineering controls, such as process enclosure or local exhaust ventilation, shall be used to maintain airborne hydrogen fluoride concentrations within the recommended limits. Ventilation systems shall be designed to prevent the accumulation or recirculation of hydrogen fluoride in the workroom and to remove hydrogen fluoride from the breathing zones of workers. Ventilation systems and equipment shall be constructed of materials resistant to corrosion by hydrogen fluoride and shall be

equipped with condensate drip safeguards. Exhaust discharged to outside air from ventilation systems must conform to applicable local, state, and federal air pollution regulations. Ventilation systems shall be subject to regular preventive maintenance and cleaning to ensure maximum effectiveness, which shall be verified by periodic airflow measurements. Adequate tempered makeup air shall be provided to workrooms in which exhaust ventilation is operating.

(2) Ventilation for electroplating or other open surface tanks containing solutions of hydrogen fluoride or generating hydrogen fluoride shall conform to the requirements of 29 CFR 1910.94.

(3) Ventilation of welding operations involving fluxes which generate hydrogen fluoride shall conform to the requirements of 29 CFR 1910.252, as currently amended.

(4) General ventilation shall be provided for all enclosed areas where anhydrous hydrogen fluoride containers or systems are located, where 40% or more concentrated aqueous hydrofluoric acid is stored, handled, used, or in transit. Relative positions of air inlets and outlets shall be located to provide uniform cross-ventilation without short circuits or dead spots. Switches for ventilation equipment shall be located outside the hydrogen fluoride area and shall be equipped with lights to indicate operation. Air outlets for hydrogen fluoride areas shall be located so that contamination of air inlets to any rooms or structures will not result.

(c) Storage

(1) Hydrogen fluoride shall be stored in cool, dry, well ventilated areas out of the direct rays of the sun.

(2) Storage areas shall be surrounded by a distinctively colored curb or barrier sufficient to contain spills and to delineate the hazardous area. Drains leading to neutralizing pits shall be provided for ease of cleanup and washdown. A source of water shall be available. Floors of storage areas shall be acid-resistant and nonporous.

(3) Hydrogen fluoride containers shall be stored with closures up for ease of venting and prevention of leaks. Metal containers shall be vented on receipt and at weekly intervals to release any hydrogen formed by reaction of hydrogen fluoride with containers. Sources of ignition shall be eliminated during the venting operation.

(4) Hydrogen fluoride containers shall be secured to prevent falling, upsetting, or rolling and shall be protected from mechanical damage, heat, and corrosion.

(5) Containers of hydrogen fluoride shall be used on a first-in, first-out basis. Stores of hydrogen fluoride shall be limited in quantity to the minimum amount necessary for the operation. Cylinders should not be stored for more than 4 months; drums should not be stored for more than 90 days.

(6) Cylinders in use shall be plainly marked "in use" to differentiate from those not in use. Empty containers shall be separated from full containers.

(7) Other materials which will react with hydrogen fluoride shall not be stored where contact can occur under uncontrolled conditions.

(8) Containers shall be periodically inspected for leaks and deterioration in accordance with 29 CFR 1910.166.

(9) Under no circumstances shall hydrogen fluoride be stored in glass, fibrous glass-reinforced plastic containers, or other noncompatible materials.

(d) Handling and General Work Practices

(1) Tools and equipment used on hydrogen fluoride containers or systems shall be neutralized where appropriate with 10% soda ash solution, washed, and inspected after each use or before repair. Completion of neutralization shall be verified with indicator paper. If necessary, tools and equipment shall be neutralized, degreased, and again neutralized.

(2) Prompt medical attention shall be obtained for any skin or eye contact with hydrogen fluoride, regardless of how slight.

(3) Returnable hydrogen fluoride containers may not be washed out with water.

(4) Valves and joints in piping carrying hydrogen fluoride shall be provided with deflectors to deflect hydrogen fluoride away from workers in the event of a leak.

(5) Safety valves and vents for hydrogen fluoride equipment shall discharge through absorbers and neutralizers.

(6) All aqueous hydrogen fluoride which cannot be diluted sufficiently to meet local, state, or federal regulations shall be discharged into pits containing sufficient alkaline material (normally soda ash or lime) for neutralization. The neutralization of discharge in such pits shall be assured prior to disposal.

(7) Scrap contaminated with hydrogen fluoride shall be decontaminated before being sold or otherwise disposed of.

(8) Safety showers and eyewash fountains shall be provided in the immediate area where hydrogen fluoride is stored, piped, handled, or used. Safety showers shall be equipped with alarms to indicate their use and to summon assistance.

(9) If cooling water is used in conjunction with hydrogen fluoride equipment, a conductivity cell or equivalent equipment shall be used to indicate any change in pH of the water due to leaking hydrogen fluoride and to prevent inadvertent discharges of contaminated water.

(10) Hydrogen fluoride systems shall be neutralized before being opened for maintenance or repair. Lime-water can be used, followed by testing with indicators to determine completion of neutralization. Workers shall be alerted to the possibility of hydrogen fluoride remaining in slag and scale. Employers shall ensure that repairs are only made on systems not in active use.

(11) Goggles may not be raised or handled with HF contaminated gloves.

(12) Valves and pumps shall be readily accessible. They may not be located in pits or in congested areas.

(13) Valves on hydrogen fluoride cylinders may not be used for flow control; they are intended only for discharge. The discharge line shall include a needle valve for flow regulation.

(14) Heat or direct flame may not be applied to hydrogen fluoride cylinders. When low temperatures reduce the pressure below the necessary pressure for transfer, an inert gas may be introduced to a point not exceeding the design pressure limitation of the cylinder.

(15) Hydrogen fluoride delivery tubes or pipes may not be immersed in other liquids without interposing an adequate trap to prevent the dangers of suckback.

(16) Air pressure may not be used to empty drums of HF acid. Drums shall always be emptied by gravity or by an acid-resistant siphon system with a bulb starter.

(17) Welding and burning on tanks or equipment which have contained hydrogen fluoride shall take place only after such tanks or equipment have been thoroughly neutralized, cleaned, purged, dried, and tested for residual acid and hydrogen.

(18) All hydrogen fluoride equipment including valves, fittings, and connections shall be checked for tightness and good working order. All newly made connections shall be inspected for leaks immediately after hydrogen fluoride is admitted. Required repairs and adjustments shall be promptly made.

(19) Written operating instructions and emergency medical procedures shall be formulated and posted where hydrogen fluoride is handled or used.

(20) When hydrogen fluoride cylinders are not in use, valve protection covers shall be in place. Cylinders shall be moved only with the proper equipment and shall be secured to prevent dropping or loss of control while moving. Slings or magnetic devices shall not be used to move hydrogen fluoride cylinders.

(21) No modification, alteration, or repair of containers and associated valves shall be made, except by the supplier or cylinder manufacturer.

(22) Before hydrogen fluoride is admitted to a system, the system shall be thoroughly cleaned, dried, and tested.

(23) Materials for handling aqueous hydrogen fluoride shall be chosen considering the variation of corrosivity with acid concentration.

(24) No one shall work alone when hydrogen fluoride is first admitted into a newly connected system, or while repairing leaks.

(25) Containers and systems shall be handled and opened with care to avoid sudden release of pressure. Approved eye, skin, and respiratory protection shall be worn while opening, connecting, disconnecting, or venting hydrogen fluoride containers and systems. When opening containers or systems, adequate ventilation shall be available to remove inadvertent discharges of hydrogen fluoride.

(26) Leaks in a hydrogen fluoride system shall be repaired only after the damaged system is disconnected and neutralized. Inadvertent entry of hydrogen fluoride into disconnected containers and systems while repair work is in progress shall be prevented by blanking off hydrogen fluoride supply lines.

(27) Any odor of hydrogen fluoride from a normally closed system or color change noted at piping connections which have been painted with an acid-indicating paint shall be reported to a responsible authority without delay.

(28) Contact lenses shall be prohibited when working with HF or HF acid. When suitable corrective lenses cannot be obtained without the use of contact lenses, protective goggles shall be worn.

(e) Work Areas

(1) Where hydrogen fluoride is used or handled, eyewash fountains and safety showers with quick-acting valves shall be located immediately outside the hydrogen fluoride area. They shall be readily accessible in case of emergency, and shall be frequently inspected and kept in good working order.

(2) Hydrogen fluoride hazard areas required to be posted in accordance with Section 3(d) shall be isolated from other work areas insofar as is practicable. They shall be delineated by an appropriate boundary. Entry shall be controlled by a permit system and required passage through a control point. An employer-designated person shall be responsible for approving the permit for entry.

(3) Floors shall be constructed of nonporous acid-resistant materials and shall slope toward drains leading to neutralizing pits.

(4) Electrical equipment shall be explosion-proof in areas where hydrogen fluoride in contact with metals may generate hydrogen.

(5) Shutoff valves and switches shall be conspicuously marked, and employees shall be familiarized with their use. Accesses to shutoff valves shall be kept unobstructed.

(6) Exits from enclosed areas required to be posted in accordance with Section 3(d) shall be plainly marked. Emergency exit doors shall be conveniently located and shall open into areas which will remain free of contamination in an emergency.

(f) Confined Spaces

(1) Entry into confined spaces such as tanks, pits, tank cars, and process vessels which have contained hydrogen fluoride shall be



controlled by a permit system. Permits shall be signed by an authorized employer representative, certifying that preparation of the confined space, precautionary measures, and personal protective equipment are adequate, and that prescribed procedures will be followed.

(2) Confined spaces which have contained hydrogen fluoride shall be inspected and tested for oxygen deficiency, hydrogen, hydrogen fluoride, and other contaminants and thoroughly ventilated, cleaned, neutralized, and washed, as necessary, prior to entry.

(3) Inadvertent entry of hydrogen fluoride into the confined space while work is in progress shall be prevented by disconnecting and blanking off hydrogen fluoride supply lines.

(4) Confined spaces shall be ventilated while work is in progress to keep any hydrogen fluoride concentration below the standard, and to prevent oxygen deficiency and build-up of hydrogen.

(5) Individuals entering confined spaces where they may be exposed to hydrogen fluoride shall be equipped with the necessary personal protective equipment and a lifeline tended by another worker outside the space who shall also be equipped with the necessary protective equipment.

(g) Enclosed Spaces

Enclosed spaces (rooms, buildings, etc) which ordinarily are safe to enter, but which, due to the failure of a system inside, could contain hazardous concentrations of hydrogen fluoride, should have a continuous automatic monitor set to sound an audible alarm inside and outside the enclosed space if hydrogen fluoride concentrations exceed the recommended ceiling. In such areas where concentrations of HF are not known to be safe, the enclosed space shall be entered only if the worker is under

observation by a co-worker and if the worker is wearing a respirator suitable for escape.

**Section 7 - Sanitation Practices**

(a) Plant sanitation shall meet the requirements of 29 CFR 1910.141.

(b) Good personal hygiene shall be encouraged. Hands, arms, and face shall be thoroughly washed prior to eating and at the end of the shift. Facilities shall be provided for this purpose in conformance with 29 CFR 1910.141(d).

(c) Food storage, preparation, and dispensing (even from vending machines), as well as eating shall be prohibited in areas where occupational exposure to hydrogen fluoride may occur. Drinking, smoking, and chewing tobacco or gum shall be prohibited in hydrogen fluoride exposure areas. The employer shall furnish an uncontaminated area for these purposes in conformance with 29 CFR 1910.141(g). A source of drinking water protected from contamination should be provided in hot environments.

**Section 8 - Monitoring and Recordkeeping Requirements**

(a) **Monitoring**

Each employer who has a place of employment in which hydrogen fluoride may be released into the workplace air shall determine if any employee is occupationally exposed to hydrogen fluoride. This determination shall be made within 6 months of the promulgation of a

standard incorporating the recommended limits, and within 30 days after first operation of a production, process, or control change resulting in possible increase in the quantity of hydrogen fluoride released, or when the employer has any reason to suspect that an employee may be occupationally exposed.

An employee shall be designated as occupationally exposed if observations and calculations made by the employer reveal that a potential exposure exists; or if any information, such as measurements of airborne concentrations of HF or the development of HF-related clinical signs or symptoms, indicate the possibility of occupational exposure; or if the employer has been advised in writing by the Occupational Safety and Health Administration (OSHA) or the National Institute for Occupational Safety and Health (NIOSH) that employees have been occupationally exposed.

If an employee is designated as being occupationally exposed, the employer shall design and implement a monitoring program which shall measure the airborne HF concentration to which the employee is exposed.

An employee's TWA exposure shall be obtained from the results of a single 8-hour sample of airborne HF, or a series of short-period samples which represent the worker's average exposure over an 8-hour work shift. At the same time that a TWA exposure is determined, the employee's peak exposure will be obtained from the results of 15-minute samples taken during periods of expected highest exposure in order to ascertain whether the ceiling limit has been exceeded. In all monitoring, samples representative of the exposure in the breathing zone of the employee shall be collected. Where more than one occupationally exposed employee works at a specific process or operation location, an adequate number of samples

shall be collected to permit construction of a TWA exposure and peak exposure for the operation or process. Variations in work and production schedules shall be considered when samples are collected. The minimum number of representative TWA exposure determinations for an operation or process shall be based on the number of workers exposed as provided in Table I-2, or as otherwise indicated by a professional industrial hygienist.

If an employee monitoring program measurement reveals that an employee is occupationally exposed, but not exposed in excess of the recommended environmental limit, the exposure of that employee shall be measured at least once every 6 months.

If an employee monitoring program measurement reveals that an employee is exposed in excess of the recommended environmental limit, the employee shall be notified, control measures required by Section 6(b) shall be initiated, and monitoring shall continue until the adequacy of the control measures has been demonstrated.

If an employee monitoring program measurement reveals that an employee is not occupationally exposed, and if the next consecutive employee monitoring program measurement made not less than 5 working days later supports this finding, the employee monitoring program may be terminated for that employee.

Monitoring shall also be performed when biologic monitoring of an occupationally exposed individual reveals urinary fluoride excretion above the postshift standard of 7.0 mg/liter, adjusted for specific gravity, or when the average postshift urinary F excretion of an exposed group (job classification) exceeds 7.0 mg F/liter, adjusted for a specific gravity of

TABLE I-2  
SAMPLING SCHEDULE

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Number of Employees Exposed	Minimum Number of Employees Whose Individual Exposures Shall Be Determined
1- 20	50% of the total number of workers
21-100	10 plus 25% of the excess over 20 workers
Over 100	30 plus 5% of the excess over 100 workers

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1.024. Monitoring of the work environment in response to a high postshift urinalysis should be conducted on the same day as the required repeat postshift urinalysis (Section 2), and 2-4 hours prior to the repeat analysis to enable correlation of the airborne concentration of HF with the urinary F concentration. Follow-up biologic monitoring shall be performed as specified in Section 2 of this standard.

(b) Recordkeeping

Employers shall maintain records of accidental hydrogen fluoride release requiring evacuation and results of all exposure measurements, environmental surveys, medical examinations, and biologic monitoring. Records shall be maintained so that exposure information is available for individual employees and shall indicate the type of personal protective devices, if any, in use at the time of sampling. Each employee shall be able to obtain information on his own environmental exposure. Such records shall be maintained for at least 20 years after the individual's employment is terminated.

## II. INTRODUCTION

This report presents the criteria and the recommended standard based thereon which were prepared to meet the need for preventing occupational diseases arising from exposure to hydrogen fluoride. The criteria document fulfills the responsibility of the Secretary of Health, Education, and Welfare, under Section 20(a)(3) of the Occupational Safety and Health Act of 1970 to "...develop criteria dealing with toxic materials and harmful physical agents and substances which will describe....exposure levels at which no employee will suffer impaired health or functional capacities or diminished life expectancy as a result of his work experience."

NIOSH, after a review of data and consultation with others, formalized a system for the development of criteria upon which standards can be established to protect the health of workers from exposure to hazardous chemical and physical agents. It should be pointed out that any criteria and recommended standard should enable management and labor to develop better engineering controls resulting in more healthful work environments and that mere compliance with the recommended standard should not be used as a final goal.

Hydrogen fluoride is a versatile material with interesting properties. Its catalytic activity in polymerization reactions has resulted in increasing usage in petroleum refining and alkylation processes. Hydrogen fluoride is an important intermediate, for example, in the manufacture of refrigerants and propellants, atomic energy feed materials, aluminum fluoride, and cryolite. Its reactivity is useful in the production of inorganic and organic fluorine-containing compounds. Its

physical properties facilitate handling in industrial processes as a liquid or gas, or as an aqueous solution. Its distinctive and irritating odor provides indication of potential exposure situations. It causes serious skin and tissue damage on contact, even in very dilute solutions or low concentrations in air.

These criteria for the standard for hydrogen fluoride are in a continuing series of criteria developed by NIOSH. The proposed standard applies only to the processing, manufacture, handling, and use of hydrogen fluoride as applicable under the Occupational Safety and Health Act of 1970.

The standard was not designed for the population at large, and any extrapolation beyond occupational exposures is not warranted. It is intended to (1) protect against injury from hydrogen fluoride, (2) be measurable by techniques that are valid, reproducible, and available to industry and official agencies, and (3) be attainable with existing technology.