Toxics Use Reduction Institute

SUMMARY OF POLICY ANALYSIS
Aug 12, 2014
Higher Hazard Substance Designation Recommendation:
Hydrogen Fluoride (CAS 7664-39-3)

The following document analyzes the implications of designating hydrogen fluoride (CAS 7664-39-3) as a Higher Hazard Substance (HHS). This chemical is on the TURA Science Advisory Board (SAB) list of more hazardous substances and has been recommended for HHS designation by the SAB.

With this designation, the reporting threshold for this chemical would be lowered from 10,000/25,000 lb/yr to 1,000 lb/year for companies in TURA-covered industry sectors with ten or more employees. New companies entering the program under the lower reporting threshold would be required to file annual toxics use reports, pay annual toxics use fees, and develop a toxics use reduction plan every two years.

This policy analysis summarizes key scientific information on this chemical, estimates the number of facilities that are likely to enter the program as a result of the lower reporting threshold, notes opportunities and challenges that new filers are likely to face, and discusses the implications of this policy measure for the TURA program. Based on this analysis, the Toxics Use Reduction Institute supports the SAB's recommendation that hydrogen fluoride be designated as a Higher Hazard Substance.

1. State of the Science

- HF is highly corrosive to all tissue. Skin contact results in burns and necrosis, and underlying bone may be decalcified. Skin contact with HF may not cause immediate pain, so systemic poisoning can begin before the person is aware of the exposure.
- Acute exposure through inhalation or skin contact can be fatal due to effects on the heart and lungs.
- Chronic inhalation of fluoride (either in the form of hydrogen fluoride or in the form of fluoride dusts) is associated with skeletal fluorosis, a disease associated with accumulation of fluoride in the bones and characterized by abnormal bone density; joint pain; and problems with joint movement. Animal studies also show evidence of liver and kidney toxicity.

2. Number of facilities affected

- To develop an estimate of the number and type of companies likely to be affected by a 1,000 lb reporting threshold, the Institute consulted sources including the TURA data; facilities reporting under EPCRA Tier II requirements; RCRA hazardous waste data; and past experience with other HHS designations.
- Uses of HF reported under TURA include etching, cleaning of metals and production of glass fibers, among others. HF can also be used as a catalyst or fluorination feedstock.
- In 2012, the most recent year for which data are available, four companies reported the use of HF under TURA: one company in the "metal cans" sector and one in the "iron and steel forgings" sector otherwise used HF, and two companies in the "semiconductors and related devices" sector manufactured and otherwise used HF. In addition, two car wash formulators reported ammonium bifluoride, which in solution dissociates into HF and ammonium fluoride.

- We estimate that approximately 26 new filers would be brought in by the HHS designation; most of these would be facilities that already file under TURA for other chemicals, and a few would be new to TURA.

3. Opportunities for New Filers

HF use and releases reported under TURA have decreased since the program's inception, although the decrease has not been uniform over the years. Use has declined 30%, and releases have declined 58%, over the period 1990 to 2012.

Alternatives to HF include:

- *Fluoride ion source:* Ammonium and sodium fluoride salts;
- *Acid applications:* Alternative acids (e.g. nitric, phosphoric);
- *Etching:* alkaline solutions;
- *Surface etching in bathtub refinishing:* mechanical abrasion or proprietary bonding agents;
- *Gold jewelry manufacturing:* alternative acids (e.g. sulfuric);
- *Car wash solutions:* dodecyldimethylamine oxide, alcohol ethoxylates, and oxalic acid-surfactant based products.

Options for increased efficiency of HF use include:

- *Diffusion dialysis* to recycle spent HF in mixed acid baths;
- *HF acid vapor etch* using an ultra-small volume chamber;
- *New metal spraying techniques* for coating ceramic parts to reduce need for etching prior to metal application.

The TURA program has worked with Massachusetts companies to pilot several of the approaches noted above.

4. Regulatory Context

- Due to its toxicity, HF is subject to a number of regulations.
- At the federal level, HF is reportable under TRI, regulated as an Extremely Hazardous Substance (EHS) under EPCRA, and regulated as a Hazardous Air Pollutant under the Clean Air Act, among other regulations.
- At the state level, California has adopted more stringent occupational exposure limits for HF than those currently in force at the federal level.

5. Implications for the TURA program

- *General.* Designating HF as a Higher Hazard Substance would help to fulfill the intent of the 2006 amendments to TURA, providing important guidance and incentives to Massachusetts businesses to help them move away from the most hazardous chemicals and toward safer alternatives.
- *Costs to businesses of reporting, planning, and fees.* Assuming 26 new HF filers fairly evenly distributed between 100-500 employees, 50-100 employees, and 10-50 employees, assuming that four of them are completely new to TURA, and assuming that five of the facilities currently reporting under TURA have already reached their fee maximum, the total additional cost in fees to filers (and revenue to the program) could be approximately $38,000.

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Toxics Use Reduction Institute

Policy Analysis

Aug 12, 2014

Higher Hazard Substance Designation Recommendation: Hydrogen Fluoride (CAS 7664-39-3)

Hydrogen fluoride (HF, or hydrofluoric acid)

1. State of the Science

Hydrogen fluoride (HF) is a highly corrosive and toxic chemical. It is a colorless gas or fuming liquid at room temperature, though it is more often used in an aqueous solution as hydrofluoric acid. The acid burns, although it may not be felt for hours, during which time the fluoride ion is readily absorbed through skin and penetrates deep into the body's tissues and bones causing systemic injury. The main routes of exposure to HF are inhalation or dermal exposure in occupational settings.[1] Community exposures through accidental releases are also a serious concern.

Acute toxicity

- HF is highly corrosive to all tissue. Skin contact results in burns and necrosis, and underlying bone may be decalcified.[2] Skin contact with HF may not cause immediate pain, so systemic poisoning can begin before the person is aware of the exposure.[3] In addition, the HF penetrates the skin and causes systemic toxicity via chelation of calcium and magnesium which induces metabolic disorders and further tissue necrosis.[4] System effects are potentially lethal, depending on concentration of the acid and extent of exposure.
- Inhalation of, and exposure to hydrogen fluoride mist, can cause severe irritation and damage to the eye, nose and skin. Inhaling large amounts of HF can also damage the heart and lungs in humans. Acute exposure through inhalation or skin contact can be fatal due to effects on the heart and lungs.[5]
- Acute inhalation of hydrogen fluoride, for example through a facial splash, can cause "bronchiolar ulceration, pulmonary hemorrhage and edema, and death."[6]
- Fluoride binds strongly to calcium in the body. Deaths associated with HF exposure generally result either from pulmonary edema or from cardiac arrhythmias with hyperkalemia (high potassium levels), hypocalcemia (low calcium levels), and hypomagnesemia (low magnesium levels). The mechanism of systemic toxicity from dermal exposure is thought to be ion pump disruption.[7]

- Fatal exposures include a death due to refractory hypocalcemia about 12 hours after exposure of 2.5% body surface area to anhydrous hydrogen fluoride and one 13 hours after exposure from a 9%-10% body surface area burn from 70% hydrogen fluoride.[8]
- Accidental releases have caused severe respiratory symptoms in affected residents.[9]

Chronic toxicity

- Chronic inhalation of fluoride (either in the form of hydrogen fluoride or in the form of fluoride dusts) is associated with skeletal fluorosis, a disease associated with accumulation of fluoride in the bones and characterized by abnormal bone density; joint pain; and problems with joint movement.[10]
- Animal studies also show evidence of liver and kidney damage associated with HF inhalation exposure.[11]

Role of uncertainty

HF has been identified as a high priority chemical primarily based on its acute health effects. Uncertainty does not play a significant role in the development of our recommendations for this substance.

2. Number of facilities affected

To develop an estimate of the number and type of companies likely to be affected by a 1,000 lb reporting threshold, the Institute consulted sources including the TURA data; facilities reporting under EPCRA Tier II requirements; RCRA hazardous waste data; and past experience with other HHS designations.

Uses of HF reported under TURA include etching, cleaning of metals and production of glass fibers, among others. HF can also be used as a catalyst or fluorination feedstock.

a. Historical data on sectors using hydrogen fluoride in Massachusetts

A total of 32 facilities have reported HF use under TURA at some point. These facilities have been in the following sectors:

2842	Polishes and sanitation goods
3229	Pressed and blown glass
3291	Abrasive products
3316	Cold finishing of steel shapes
3357	Drawing and Insulating of Nonferrous Wire
3411	Metal cans
3462	Iron and steel forgings
3479	Metal coating and allied services

3661	Telephone and telegraph apparatus
3674	Semiconductors and related devices
3822	Environmental controls
4911	Electric services
5169	Chemicals and allied products

b. Current TURA data on HF use in Massachusetts

In 2012, the most recent year for which data are available, four companies reported the use of HF under TURA.

- In SIC Code 3411, “metal cans”, 1 company otherwise used hydrogen fluoride.
- In SIC Code 3462, “iron and steel forgings”, 1 company otherwise used hydrogen fluoride.
- In SIC Code 3674, “semiconductors and related devices,” 2 companies manufactured and otherwise used hydrogen fluoride.

In addition, two car wash formulators reported ammonium bifluoride in 2012, which when put into solution will dissociate into HF and ammonium fluoride.

c. Storage & hazardous waste reporting data

Reports filed under EPCRA Tier II and under RCRA indicate current or recent HF use by additional facilities. The EPCRA Tier II data show that 57 facilities reported storing HF in 2012, and the RCRA data show that 37 facilities reported HF in hazardous waste shipments in 2012. Additionally, TIER II data show that 9 companies stored ammonium fluoride or ammonium bifluoride in 2012.

Storage of at least 500 lb onsite was used as a basis for estimating the number of facilities that may be using at least 1,000 lb/year of HF. Based on the maximum amounts reported under Tier II for 2012, 22 facilities have reported at least 500 lb of HF stored onsite and have at least 10 FTEs and 3 additional facilities have reported at least 500 lb of ammonium fluoride or ammonium bifluoride stored onsite and have at least 10 employees. Sectors represented in this data set include electronics, etching, and metal finishing, among others. Eight of these are past TURA filers.

Some utilities also generate HF as a byproduct; these are not reflected in the Tier II data as they do not store HF onsite. One or more utilities could meet the 1,000 lb/year threshold.

One additional facility that appears to be in a TURA sector reports HF shipments above 1,000 lb in its hazardous waste data reported under RCRA.

d. Past experience with HHS designations

Experience since 2006 indicates that in general, an HHS designation brings in a number of new filers in the first couple of years of the designation, and this number falls in subsequent years as filers move to safer substitutes. Each sector is different, but this pattern may be indicative of future trends as well. For the six HHS for which data are currently available, the number of new filers in the first year the designation was effective ranged from 5 to 19.

e. Estimated number of companies that would be affected by a lower reporting threshold

We estimate that approximately 26 new filers would be brought in by the HHS designation; most of these would be facilities that already file under TURA for other chemicals, and a few would be new to TURA.

3. Opportunities for New Filers

In this section, we briefly review trends in hydrogen fluoride use among existing TURA filers, and summarize basic information on HF alternatives in selected applications.

a. Trends in hydrogen fluoride use

HF use reported under TURA has decreased since the program's inception. Use has declined from 676,170 lb in 1990 to 475,894 lb in 2012 (a 30% decrease), and releases have declined 58%, from 12,263 lb in 1990 to 5,123 lb in 2012 (figures not adjusted for changes in production levels).   The decrease in use is not uniform over the years; in 1991, 1992, 2000 and 2008, use was over 1,000,000 lbs; in 1995 it was under 600,000 lbs. Large uses over the years include forging, metal working , solar panel manufacturing and glass lighting tubes, Likewise, the decrease in releases has varied, with over 100,000 lbs reported from 1991 to 2008, and a peak in 2000 of 339,326 lbs. Electrical utilities have dominated releases of HF.

Massachusetts TURA Hydrogen Fluoride Use and Release Data: 1990 and 2012 (figures not adjusted for production)

	Year		**Change In lbs**	**% Change**
	1990	**2012**		
Hydrogen Fluoride used (lbs)	676,170	475,894	-200,276	-30%
Hydrogen Fluoride released (lbs)	12,263	5,123	-7,140	-58%

b. Opportunities to reduce HF use

Opportunities to reduce HF use include adopting alternatives for specific applications, and using HF more efficiently where alternatives are not available. The TURA program has worked with individual companies on both approaches, as noted below.

Options for adopting alternatives include the following:

- In cases in which HF is used as the source of a fluoride ion, it may be possible to eliminate transportation and storage of HF by adding the ion in the form of a salt (e.g., ammonium and sodium fluoride salts).
- For etching, pickling and cleaning metals, alternative acids (e.g., nitric, hydrochloric, phosphoric) may be viable substitutes.[12]
- ASE Americas Inc. partnered with UMass Lowell researchers to investigate electrochemical etching in an alkaline solution to replace the acid solution. ASE partnered with the UMass Lowell Electrical Engineering Department, with funding through TURI's University Research in Sustainable Technologies Program.[13]
- HF is also used in bathtub refinishing, to etch the surface of the tub to promote adhesion of the new acrylic or other coating to the surface of the tub. Mechanical abrasion like sanding is an effective alternative to the use of HF or other chemicals for acrylic fiberglass tubs. For older porcelain or enamel tubs, which have harder surfaces, pumice or automotive compound have been suggested as alternatives, however these would require significant energy to effectively abrade the surface for subsequent adhesion. Other alternatives include proprietary bonding agents.
- HF is used in gold jewelry manufacturing. The acid treatment is necessary for removing the plaster from the casting mold. Compared to hydrofluoric acid, sulfuric acid is not always capable of dissolving all plaster residues, so in some cases manual treatment has to be applied. Sulfuric acid is also a toxic chemical[14].
- Some car wash shops use HF or ammonium bifluoride, which dissociates into HF, to remove dirt, brake dust and road grime from wheels fast and efficiently. HF is also used for car wash equipment cleaning. An alternative product with dodecyldimethylamine oxide, alcohol ethoxylates as main ingredients is available as a less hazardous solution[15]. Other wheel brightener alternatives include oxalic acid-surfactant based products.

Options for increased efficiency include the following:

- Diffusion dialysis may be used in some cases to recycle spent hydrofluoric acid in mixed acid baths, reducing consumption of virgin HF.[16] [17] Two local manufacturers currently offer diffusion dialysis units: Zero Discharge Technologies, Inc. of Chicopee, MA and Pure Cycle LLC in North Haven, CT.
- In 1999, TURI sponsored a demonstration site event in which ASE Americas Inc. in Billerica demonstrated a hydrofluoric acid vapor acid etch process for silicon wafers using an ultra-small volume chamber. This new process reduced their use of hydrofluoric acid by nearly 99% compared to the liquid batch etching process. However, the use of hydrofluoric acid vapor rather than liquid introduced new safety concerns to the process that had to be addressed by implementing strict procedures.[18]
- Texas Instruments implemented a new metal spraying technique for coating ceramic parts that decreased the need for hydrofluoric acid etching of the ceramic parts prior to metal application.[19]

4. Regulatory context and exposure limits

Due to its toxicity, HF is subject to a number of regulations. Selected federal regulations are shown in the table below.

EPCRA	• Reportable under TRI[20] • Subject to US EPA Tier II reporting requirements[21] • Regulated as an Extremely Hazardous Substance (EHS) under EPCRA Section 302.[22]
CAA	• Regulated as a Hazardous Air Pollutant (HAP)[23] • Clean Air Act Section 112(r) List of Substances for Accidental Release Prevention for concentrations 50% or greater (threshold quantity: 1,000 lb. per process)[24]
CWA	• Designated as a hazardous substance under section 311(b)(2)(A) of the Federal Water Pollution Control Act and further regulated by the Clean Water Act Amendments of 1977 and 1978.[25]
RCRA	• Must be managed as hazardous waste.[26]
CERCLA	• Reportable quantity: 100 lb.[27]
OSHA PEL	• 3 ppm TWA[28]
NIOSH	• NIOSH REL: TWA 3ppm, Ceiling 6 ppm [15-minute][29] • Immediately Dangerous to Life and Health: 30 ppm[30]
ACGIH TLV (TWA)	• 0.5 ppm[31]
ACGIH TLV-STEL	• 2 ppm ceiling[32]

Other state regulations

- California has adopted more stringent occupational exposure limits for HF than those currently in force at the federal level. California OSHA sets a time-weighted average level of 0.4 ppm and a short-term exposure limit of 1 ppm for occupational exposures to HF.

5. Implications for the TURA program

Designating HF as a Higher Hazard Substance would help to fulfill the intent of the 2006 amendments to TURA, providing important guidance and incentives to Massachusetts businesses to help them move away from the most hazardous chemicals and toward safer alternatives.

There would be some additional cost to companies that would begin reporting HF based on a lower reporting threshold, including preparing annual toxics use reports and biennial toxics use reduction plans, and paying toxics use fees.

Based on the Tier II data, we estimate new reporting by 26 facilities fairly evenly distributed between 100-500 employees, 50-100 employees, and 10-50 employees. Most of these filers would not be new to the program and already pay a base fee, but would begin to pay a per-chemical fee of $1,100. In addition, some facilities are already paying the maximum fee corresponding to their size; these facilities would not pay any additional fee.

After two years of reporting toxics use, companies are required to engage in TUR planning. The cost of planning depends on the number of chemicals used and the complexity of the process.

Companies that want to have their own in-house TUR planner can qualify either by relying on past work experience in toxics use reduction or by having a staff member take the TUR Planners' training course. Those companies with experienced staff can become certified for as little as $100. For those that want staff to take a course the cost is $650. Companies with in-house toxics use reduction planners are likely to reap ancillary benefits from having an employee who is knowledgeable about methods for reducing the costs and liabilities of toxics use. Additionally, through the process of planning and reducing or eliminating HF use, companies may be able to expand markets, improve compliance with other regulations, and achieve financial savings through process improvements.

Assuming 26 new HF filers with the size distribution listed above, assuming that four of them are completely new to TURA, and assuming that five of the facilities currently reporting under TURA have already reached their fee maximum, the total additional cost in fees to filers (and revenue to the program) could be approximately $38,000.

[1] Agency for Toxic Substances and Disease Registry (ATSDR). September 2003. "*Toxicological Profile for Fluorides, Hydrogen Fluoride, and Fluorine.*" Retrieved from http://www.atsdr.cdc.gov/toxprofiles/tp11.pdf, accessed May 29, 2014, p. 30.

[2] World Health Organization/International Programme on Chemical Safety. 1990. "*Poisons Information Monograph 268*", pp.1-25. Cited in U.S. National Library of Medicine Hazardous Substances Databank. Retrieved from http://toxnet.nlm.nih.gov/cgi-bin/sis/search2/f?./temp/~WhnmH3:1

[3] ATSDR 2003, p. 8-9.

[4] Burgher, Francois, et al. June 2011. "Experimental 70% hydrofluoric acid burns: histological observations in an established human skin explants ex vivo model." *Cutaneous and Ocular Toxicology*, *30*(2), 100-107. http://dx.doi.org/10.3109%2F15569527.2010.533316

[5] ATSDR 2003, p. 8-9.

[6] ATSDR 2003, p. 33.

[7] ATSDR 2003, p. 33, p. 126, p. 127.

[8] World Health Organization/International Programme on Chemical Safety. 1990. "*Poisons Information Monograph 268*", pp.1-25. Cited in U.S. National Library of Medicine Hazardous Substances Databank. Retrieved from http://toxnet.nlm.nih.gov/cgi-bin/sis/search2/f?./temp/~WhnmH3:1

[9] ATSDR 2003, p. 56.

[10] ATSDR 2003, p. 7, p. 33.

[11] ATSDR 2003, p. 18, p. 33.

[12] Toxics Use Reduction Institute. "*Massachusetts Chemical Fact Sheet: Hydrofluoric Acid.*" Retrieved from http://www.turi.org/TURI_Publications/TURI_Chemical_Fact_Sheets/Hydrofluoric_Acid_Fact_Sheet/Printable_Hydrofluoric_Acid_Fact_Sheet.

[13] Toxics Use Reduction Institute. "*Massachusetts Chemical Fact Sheet: Hydrofluoric Acid.*" Retrieved from http://www.turi.org/TURI_Publications/TURI_Chemical_Fact_Sheets/Hydrofluoric_Acid_Fact_Sheet/Printable_Hydrofluoric_Acid_Fact_Sheet.

[14] European Union Substitution Support Portal (SUBSPORT). 2012. "Substituting hydrofluoric acid in gold jewelry production." Retrieved from http://www.subsport.eu/case-stories/283-en?lang=

[15] European Union Substitution Support Portal (SUBSPORT). 2012. "Car wheel cleaner based on alcohol ethoxylates and dodecyldimethylamine oxide as alternative to fluorine containing products". Retrieved from http://www.subsport.eu/case-stories/317-en?lang=

[16] Toxics Use Reduction Institute. "*Massachusetts Chemical Fact Sheet: Hydrofluoric Acid.*" Retrieved from http://www.turi.org/TURI_Publications/TURI_Chemical_Fact_Sheets/Hydrofluoric_Acid_Fact_Sheet/Printable_Hydrofluoric_Acid_Fact_Sheet.

[17] Bonner, Francis and Donatelli, Alfred. 2001. "*Diffusion Dialysis and Acid Recovery in Metal Operations," Toxics Use Reduction Institute Technical Report No. 29*. Retrieved from http://www.turi.org/TURI_Publications/TURI-Technical-Reports/Diffusion_Dialysis_and_Acid_Recovery_in_Metal_Operations._20012

[18] Toxics Use Reduction Institute. "*Massachusetts Chemical Fact Sheet: Hydrofluoric Acid.*" Retrieved from http://www.turi.org/TURI_Publications/TURI_Chemical_Fact_Sheets/Hydrofluoric_Acid_Fact_Sheet/Printable_Hydrofluoric_Acid_Fact_Sheet.

[19] Toxics Use Reduction Institute. "*Massachusetts Chemical Fact Sheet: Hydrofluoric Acid.*" Retrieved from http://www.turi.org/TURI_Publications/TURI_Chemical_Fact_Sheets/Hydrofluoric_Acid_Fact_Sheet/Printable_Hydrofluoric_Acid_Fact_Sheet.

[20] United States Environmental Protection Agency (USEPA). October 2012. "*List of Lists: Consolidated List of Chemicals Subject to the Emergency Planning and Community Right-To-Know Act (EPCRA), Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and Section 112(r) of the Clean Air Act.*" Retrieved from http://www2.epa.gov/sites/production/files/2013-08/documents/list_of_lists.pdf , viewed May 29, 2014.

[21] US EPA. 2014. "*Emergency Planning and Community Right-to-Know Act (EPCRA) Hazardous Chemical Storage Reporting Requirements*" Retrieved from http://www.epa.gov/emergencies/content/epcra/epcra_storage.htm#msds.

[22] US EPA. 1999. 40 CFR Part 355, Appendix A. ("*Appendix A to Part 355: The List of Extremely Hazardous Substances and their Threshold Planning Quantities*"). Retrieved from http://www.gpo.gov/fdsys/pkg/CFR-2002-title40-vol24/pdf/CFR-2002-title40-vol24-part355-appA.pdf). EPCRA Section 302 requires facilities to notify the State Emergency Response Commission (SERC) and Local Emergency Planning Committee (LEPC) of the presence

of such a substance above the threshold planning quantity, and directs the facility to appoint an emergency response coordinator.
US EPA. 2012. "*Emergency Planning and Community Right-To-Know Act,*" Retrieved from http://www.epa.gov/oecaagct/lcra.html, viewed May 29, 2014.
[23] U.S. EPA. 1990. Clean Air Act Amendments of 1990 List of Hazardous Air Pollutants. Retrieved from http://www.epa.gov/ttn/atw/orig189.html, viewed May 29, 2014.
[24] US EPA. October 2012. "*List of Lists …*" Retrieved from http://www2.epa.gov/sites/production/files/2013-08/documents/list_of_lists.pdf , viewed May 29, 2014. Under this regulation, covered facilities must develop a Risk Management Program, including a hazard assessment, prevention program, and emergency response program. US EPA, "Clean Air Act Section 112(r): Accidental Release Prevention/Risk Management Plan Rule." March 2009. Available at http://www.epa.gov/oem/docs/chem/caa112_rmp_factsheet.pdf, viewed May 29, 2014.
[25] Hazardous Substances Data Bank (HSDB). 2012. *"40 CFR 116.4"*, as cited in the Hazardous Substances Data Bank (HSDB), a database of the National Library of Medicine's TOXNET system, Available from http://toxnet.nlm.nih.gov.
[26] HSDB. 2012. "*40 CFR 261.22 and 40 CFR 261.33*", as cited in the Hazardous Substances Data Bank (HSDB), a database of the National Library of Medicine's TOXNET system, Available from http://toxnet.nlm.nih.gov/cgi-bin/sis/search2/f?./temp/~WhnmH3:1.
[27] US EPA. October 2012. "*List of Lists…*" Retrieved from http://www2.epa.gov/sites/production/files/2013-08/documents/list_of_lists.pdf , viewed May 29, 2014.
[28] HSDB. 2012. "*29 CFR 1910.1000*", as cited in the Hazardous Substances Data Bank (HSDB), a database of the National Library of Medicine's TOXNET system, Available from http://toxnet.nlm.nih.gov.
[29] National Institute for Occupational Safety and Health. April 2011. "*NIOSH Pocket Guide to Chemical Hazards*: *Hydrogen fluoride*". Retrieved from http://www.cdc.gov/niosh/npg/npgd0334.html
[30] National Institute for Occupational Safety and Health. April 2011. "*NIOSH Pocket Guide to Chemical Hazards*: *Hydrogen fluoride*". Retrieved from http://www.cdc.gov/niosh/npg/npgd0334.html
[31] Occupational Safety and Health Administration. 2005. "*Hydrogen Fluoride*." Retrieved from https://www.osha.gov/dts/chemicalsampling/data/CH_246500.html, viewed May 29, 2014.
[32] Occupational Safety and Health Administration. 2005. "*Hydrogen Fluoride*." Retrieved from https://www.osha.gov/dts/chemicalsampling/data/CH_246500.html, viewed May 29, 2014.