



Hydrogen Fluoride and Hydrofluoric Acid (HF)

Incident Management

Key Points

Fire

- strong acid when pure, reacts violently with bases and is corrosive; reacts violently with any compounds causing fire and explosion hazard
- attacks metals, concrete, glass, some forms of plastic, rubber and coatings
- in case of fire involving hydrogen fluoride/hydrofluoric acid use fine water spray. Wear chemical protective clothing with liquid-tight connections for whole body in combination with breathing apparatus

Health

- hydrogen fluoride causes severe and deep burns which are extremely painful and difficult to heal
- ingestion may cause burning of the mouth and throat with retrosternal and abdominal pain; there is often hypersalivation, vomiting, haematemesis and hypotension
- irritation of eyes and nose with sore throat, cough, chest tightness, headache, ataxia, confusion, dyspnoea and stridor may follow inhalation
- contact with the eyes may cause conjunctivitis, conjunctival oedema, corneal epithelial coagulation and necrosis
- exposure to hydrogen fluoride may cause systemic effects including cardiotoxicity, secondary to hypocalcaemia, hypomagnesaemia and metabolic acidosis



Environment

- avoid release to the environment; inform the Environment Agency where appropriate



Hazard Identification

Standard (UK) dangerous goods emergency action codes



Hydrogen fluoride, anhydrous

UN		1052	Hydrogen fluoride, anhydrous	
EAC		2XE	Use fine water spray. Wear chemical protective clothing with liquid-tight connections for whole body in combination with breathing apparatus*. Spillages and decontamination run-off should be prevented from entering drains and watercourses. There may be a public safety hazard outside the immediate area of the incident†	
APP		B	Gas-tight chemical protective suit with breathing apparatus‡	
Hazards	Class	8	Corrosive substance	
	Sub-risks	6.1	Toxic substance	
HIN		886	Highly corrosive substance, toxic	
<p>UN – United Nations number, EAC – emergency action code, APP – additional personal protection, HIN – hazard identification number</p> <p>* Chemical protective clothing with liquid-tight connections for whole body (Type 3) conforming to relevant standards such as BS 8428 or EN 14605, in combination with breathing apparatus BS EN 137</p> <p>† People should stay indoors with windows and doors closed, ignition sources should be eliminated and ventilation stopped. Non-essential personnel should move at least 250 m away from the incident</p> <p>‡ Normal fire kit in combination with gas-tight chemical protective clothing conforming to BS EN 943 part 2</p> <p>Reference Dangerous Goods Emergency Action Code List, National Chemical Emergency Centre (NCEC) Part of Ricardo-AEA. The Stationery Office, 2017.</p>				




Hydrofluoric acid with more than 60% hydrogen fluoride, packing group I

UN		1790	Hydrofluoric acid with more than 60% hydrogen fluoride, packing group I	
EAC		2W	Use fine water spray. Wear chemical protective clothing with liquid-tight connections for whole body in combination with breathing apparatus*. Spillages and decontamination run-off should be prevented from entering drains and surface and ground waters. Substance can be violently or explosively reactive	
APP		B	Gas-tight chemical protective suit with breathing apparatus [†]	
Hazards	Class	8	Corrosive substance	
	Sub-risks	6.1	Toxic substance	
HIN		886	Highly corrosive substance, toxic	
<p>UN – United Nations number, EAC – emergency action code, APP – additional personal protection, HIN – hazard identification number</p> <p>* Chemical protective clothing with liquid tight connections for whole body (type 3) conforming to the relevant standards such as BS 8428 or EN 14605, in combination with breathing apparatus BS EN 137</p> <p>Reference</p> <p>Dangerous Goods Emergency Action Code List, National Chemical Emergency Centre (NCEC) Part of Ricardo-AEA. The Stationery Office, 2017.</p>				

Hydrofluoric acid with more than 60% hydrogen fluoride, packing group II

UN		1790	Hydrofluoric acid with more than 60% hydrogen fluoride, packing group II	
EAC		2X	Use fine water spray. Wear chemical protective clothing with liquid-tight connections for whole body in combination with breathing apparatus*. Spillages and decontamination run-off should be prevented from entering drains and watercourses	
APP		–	–	
Hazards	Class	8	Corrosive substance	
	Sub-risks	6.1	Toxic substance	
HIN		86	Corrosive or slightly corrosive substance, toxic	
<p>UN – United Nations number, EAC – emergency action code, APP – additional personal protection, HIN – hazard identification number</p> <p>* Chemical protective clothing with liquid-tight connections for whole body (type 3) conforming to the relevant standards such as BS 8428 or EN 14605, in combination with breathing apparatus BS EN 137</p> <p>Reference</p> <p>Dangerous Goods Emergency Action Code List, National Chemical Emergency Centre (NCEC) Part of Ricardo-AEA. The Stationery Office, 2017.</p>				




Classification, labelling and packaging (CLP)***Hydrofluoric acid ... %**

Hazard class and category	Acute Tox. 2	Acute toxicity, category 2 (ingestion, inhalation)	
	Acute Tox. 1	Acute toxicity, category 1 (skin contact)	
	Skin Corr. 1A	Skin corrosion, category 1A	
Hazard statement	H300	Fatal if swallowed	
	H310	Fatal in contact with skin	
	H314	Causes severe skin burns and eye damage	
	H330	Fatal if inhaled	
Signal words	Danger		
* Implemented in the EU on 20 January 2009			
Reference			
European Commission. Harmonised classification – Annexe VI to Regulation (EC) No. 1272/2008 on Classification, Labelling and Packaging of Substances and Mixtures. http://echa.europa.eu/information-on-chemicals/cl-inventory-database (accessed 08/2017).			

Specific concentration limits

Concentration	Hazard class and category	Hazard statement
$1\% \leq C < 7\%$	Skin Corr. 1B	H314
$C \geq 7\%$	Skin Corr. 1A	H314
$0,1\% \leq C < 1\%$	Eye Irrit. 2	H319
Reference		
European Commission. Harmonised classification – Annexe VI to Regulation (EC) No. 1272/2008 on Classification, Labelling and Packaging of Substances and Mixtures. http://echa.europa.eu/information-on-chemicals/cl-inventory-database (accessed 08/2017).		

Hydrogen fluoride

Hazard class and category	Acute Tox. 2	Acute toxicity, category 2 (ingestion, inhalation)	
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* Implemented in the EU on 20 January 2009 Reference European Commission. Harmonised classification – Annexe VI to Regulation (EC) No. 1272/2008 on Classification, Labelling and Packaging of Substances and Mixtures. http://echa.europa.eu/information-on-chemicals/cl-inventory-database (accessed 08/2017).			

Physicochemical Properties

CAS number	7664-39-3
Molecular weight	20.0
Chemical formula	HF
Common synonyms	Hydrofluoric acid, anhydrous hydrofluoric acid
State at room temperature	Colourless gas or colourless fuming liquid
Volatility	Vapour pressure = 760 mm Hg at 20°C
Relative density Vapour density	(water =1) 1.0 (liquid at 4 °C) 1.27 at 34°C (air = 1)
Flammability	Not combustible
Lower explosive limit	-
Upper explosive limit	-
Water solubility	Soluble in water
Reactivity	Strong acid reacts violently with bases and is corrosive. Reacts violently with many compounds causing fire and explosion hazard. Attacks metals, concrete, glass, some forms of plastic, rubber and coatings
Reaction or degradation products	May create irritating and corrosives fumes of fluorides when heated or in combination with steam or water
Odour	Strong irritating odour
Structure	$H - F$
References Hazardous Substances Data Bank. Hydrogen Fluoride HSDB No. 546 (last revision date 06/03/2008) US National Library of Medicine: Bethesda MD. http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB (accessed 08/2017) Hydrogen Fluoride (HAZARDTEXT™ Hazard Management). In Klasco RK (Ed): TOMES® System, Truven Healthcare Analytics Inc, Greenwood Village CO, US. RightAnswer.com Inc, Midland MI, US. http://www.rightanswerknowledge.com (accessed 08/2017). International Programme on Chemical Safety. International Chemical Safety Card entry for Hydrogen Fluoride. ICSC 0283, 2000. World Health Organization: Geneva.	

Reported Effect Levels from Authoritative Sources

Exposure by skin contact

%	Signs and symptoms	Reference
>2	Can cause burns	a
<20	Delayed onset of potentially severe burns (up to 24 hours)	b
20-50	Symptoms in up to 8 hours	a
>20	Systemic effects may develop	b
>40	Rapid onset of effects, immediate pain and skin damage	b
50	Immediate symptoms	a
70	Death by cardiac arrest has been reported	b

These values give an indication of levels of exposure that can cause adverse effects. They are not health protective standards or guideline values

References

a TOXBASE. Hydrofluoric acid, 2012. <http://www.toxbase.org> (accessed 08/2017).

b International Programme on Chemical Safety. Poisons Information Monograph 268: Hydrogen fluoride, 1995. World Health Organization: Geneva.

Exposure by inhalation (see note)

ppm	mg/m ³	Signs and symptoms	Reference
0.5-4.5	0.32-2.9	Very mild eye irritation	a
30-50	19.4-32.3	Mild eye irritation	a
100	64.5	Marked irritation	a

Values relate to fluorine which forms hydrofluoric acid in contact with the moisture on eyes and skin

These values give an indication of levels of exposure that can cause adverse effects. They are not health protective standards or guideline values

References

a Agency for Toxic Substances and Disease Registry (ATSDR). 2003. Toxicological profile for Fluorides, Hydrogen Fluoride, and Fluorine. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Published Emergency Response Guidelines

Emergency response planning guideline (ERPG) values

	Listed value (ppm)	Calculated value (mg/m ³)
ERPG-1*	2 ⁽¹⁾	1.64
ERPG-2 [†]	20	16.4
ERPG-3 [‡]	50	41
	10-minute values (ppm) ⁽²⁾	Calculated value (mg/m ³)
ERPG-1*	2	1.64
ERPG-2 [†]	50	41
ERPG-3 [‡]	170	139

* Maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odour

† Maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action

‡ Maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects

(1) Odour should be detectable near ERPG-1

(2) 10 minute ERPG values were published in an addendum in 1999

Reference
American Industrial Hygiene Association (AIHA). 2016 Emergency Response Planning Guideline Values. <https://www.aiha.org/get-involved/AIHAGuidelineFoundation/EmergencyResponsePlanningGuidelines/Documents/2015%20ERPG%20Levels.pdf> (accessed 08/2017).

Acute exposure guideline levels (AEGLs)

	ppm				
	10 min	30 min	60 min	4 hours	8 hours
AEGL-1*	1	1	1	1	1
AEGL-2 [†]	95	34	24	12	12
AEGL-3 [‡]	170	62	44	22	22

* Level of the chemical in air at or above which the general population could experience notable discomfort

† Level of the chemical in air at or above which there may be irreversible or other serious long-lasting effects or impaired ability to escape

‡ Level of the chemical in air at or above which the general population could experience life-threatening health effects or death

Reference
US Environmental Protection Agency. Acute Exposure Guideline Levels. <http://www.epa.gov/oppt/aegl/pubs/chemlist.htm> (accessed 08/2017).

Exposure Standards, Guidelines or Regulations

Occupational standards

Hydrogen fluoride (as F)

	LTEL (8-hour reference period)		STEL (15-min reference period)	
	ppm	mg/m ³	ppm	mg/m ³
WEL	1.8	1.5	3	2.5
WEL – workplace exposure limit, LTEL – long-term exposure limit, STEL – short-term exposure limit				
Reference				
Health and Safety Executive (HSE). EH40/2005 Workplace Exposure Limits, 2 nd Edition, 2011.				

Public health guidelines

Drinking water standard WHO guideline value	No values specified
Air quality guideline	No guideline values specified
Soil guideline values and health criteria values	No guideline values specified

Health Effects

Major route of exposure

- ingestion, inhalation, dermal or eye contact

Immediate signs or symptoms of acute exposure

Route	Signs and symptoms
Inhalation	Irritation of eyes and nose with sore throat, cough, chest tightness, headache, ataxia and confusion. Dyspnoea and stridor due to laryngeal oedema may follow. Haemorrhagic pulmonary oedema with increasing breathlessness, wheeze, hypoxia and cyanosis may take up to 36 hours to develop
Ingestion	Burning of the mouth and throat with retrosternal and abdominal pain. The larynx may also be affected causing oedema, airway obstruction and difficulty in clearing bronchial secretions. There is often hypersalivation, vomiting, haematemesis and hypotension. Oesophageal or gastric perforation may occur
Dermal	Severe and deep burns which are extremely painful and difficult to heal. Pain may appear to be disproportionate to physical findings. There may be blue-grey discoloration of the skin in severe cases
Ocular	Conjunctivitis, conjunctival oedema, corneal epithelial coagulation and necrosis
Systemic features	Hypocalcaemia, hypomagnesaemia and metabolic acidosis. Hyperkalaemia is also common. Myoclonus, tetany, convulsions, CNS depression, cardiac conduction disturbances and arrhythmias (prolonged QT interval, ventricular tachycardia and ventricular fibrillation) may occur secondary to hypocalcaemia and other electrolyte disturbances
Reference	
TOXBASE. Hydrofluoric acid, 08/2012. http://www.toxbase.org (accessed 08/2017)	
TOXBASE. Hydrofluoric acid – features and management, 02/2012 http://www.toxbase.org (accessed 08/2017)	

Decontamination at the Scene

Summary

The approach used for decontamination at the scene will depend upon the incident, location of the casualties and the chemicals involved. Therefore, a risk assessment should be conducted to decide on the most appropriate method of decontamination.

Hydrogen fluoride is a highly corrosive substance. Burns following exposure to lower concentrations may be delayed for up to 24 hours. If exposure to hydrogen fluoride is known to have taken place, decontamination should still be carried out even in the absence of symptoms. Therefore, following disrobe, improvised wet decontamination should be considered (see below for details).

People who are processed through improvised decontamination should subsequently be moved to a safe location, triaged and subject to health and scientific advice. Based on the outcome of the assessment, they may require further decontamination.

Emergency services and public health professionals can obtain further advice from Public Health England (Centre for Radiation, Chemical and Environmental Hazards) using the 24-hour chemical hotline number: 0344 892 0555.

Disrobe

The disrobe process is highly effective at reducing exposure to HAZMAT/CBRN material when performed within 15 minutes of exposure.

Therefore, disrobe must be considered the primary action following evacuation from a contaminated area.

Where possible, disrobe at the scene should be conducted by the casualty themselves and should be systematic to avoid transferring any contamination from clothing to the skin. Consideration should be given to ensuring the welfare and dignity of casualties as far as possible.

Improvised decontamination

Improvised decontamination is an immediate method of decontamination prior to the use of specialised resources. This should be performed on all contaminated casualties, unless medical advice is received to the contrary. Improvised dry decontamination should be considered for an incident involving chemicals **unless the agent appears to be corrosive or caustic**.

Improvised dry decontamination

- any available dry absorbent material can be used such as kitchen towel, paper tissues (eg blue roll) and clean cloth

- exposed skin surfaces should be blotted and rubbed, starting with the face, head and neck and moving down and away from the body
- rubbing and blotting should not be too aggressive, or it could drive contamination further into the skin
- all waste material arising from decontamination should be left in situ, and ideally bagged, for disposal at a later stage

Improvised wet decontamination

- water should only be used for decontamination where casualty signs and symptoms are consistent with exposure to caustic or corrosive substances such as acids or alkalis
- wet decontamination may be performed using any available source of water such as taps, showers, fixed installation hose-reels and sprinklers
- when using water, it is important to try and limit the duration of decontamination to between 45 and 90 seconds and, ideally, to use a washing aid such as cloth or sponge
- improvised decontamination should not involve overly aggressive methods to remove contamination as this could drive the contamination further into the skin
- where appropriate, seek professional advice on how to dispose of contaminated water and prevent run-off going into the water system

Additional notes

- following improvised decontamination, remain cautious and observe for signs and symptoms in the decontaminated person and in unprotected staff
- if water is used to decontaminate casualties this may be contaminated, and therefore hazardous, and a potential source of further contamination spread
- all materials (paper tissues etc) used in this process may also be contaminated and, where possible, should not be used on new casualties
- the risk from hypothermia should be considered when disrobe and any form of wet decontamination is carried out
- people who are contaminated should not eat, drink or smoke before or during the decontamination process and should avoid touching their face
- consideration should be given to ensuring the welfare and dignity of casualties as far as possible. Immediately after decontamination the opportunity should be provided to dry and dress in clean robes/clothes

Interim wet decontamination

Interim decontamination is the use of standard fire and rescue service (FRS) equipment to provide a planned and structured decontamination process prior to the availability of purpose-designed decontamination equipment.

Decontamination at the scene references

National Ambulance Resilience Unit. Joint Emergency Services Interoperability Programme (JESIP). Initial operational response to a CBRN incident. Version 1.0, September 2013.

NHS England. Emergency Preparedness, Resilience and Response (EPRR). Chemical incidents: planning for the management of self-presenting patients in healthcare settings. April 2015.

Clinical Decontamination and First Aid

Clinical decontamination is the process where trained healthcare professionals using purpose-designed decontamination equipment treat contaminated people individually.

Detailed information on clinical management can be found on TOXBASE – www.toxbase.org.

Important note

- if the patient has not been decontaminated following surface contamination, secondary carers must wear appropriate NHS PPE for chemical exposure to avoid contaminating themselves. The area should be well ventilated
- **decontamination is the immediate priority if the patient is responsive. This should take precedence over transfer to medical facilities, though an ambulance should be requested while decontamination is being undertaken**

Clinical decontamination following surface contamination

- **do not delay decontamination if the patient is responsive**
- **remove contaminated clothing**
- **irrigate the contaminated area with copious amounts of water as soon as possible for at least 1 minute**

Dermal exposure

For detailed clinical management advice on the use of calcium gluconate see TOXBASE – www.toxbase.org

- following decontamination apply calcium gluconate gel repeatedly to the burn. For burns to the hand the use of a surgical glove containing calcium gluconate may be effective at reducing pain
- note if calcium gluconate gel is not available continue to flush with water until it becomes available
- if skin contamination is extensive and clothing affected, be aware of the possibility of inhalation injury
- other supportive measures as indicated by the patient's clinical condition

Ocular exposure

- remove contact lenses if necessary and immediately irrigate the affected eye thoroughly for at **least 30 mins** with water or 0.9% saline
- the evidence for the efficacy of calcium gluconate following ocular exposure is lacking and it may be toxic to the conjunctiva

- repeated installation of local anaesthetics (e.g. amethocaine) may reduce discomfort and help more thorough decontamination. An anaesthetised eye should be covered to protect from traumatic injury
- patients with corneal damage, those who have been exposed to strong acids or alkalis and those whose symptoms do not resolve rapidly should be discussed **urgently** with an ophthalmologist
- other supportive measures as indicated by the patient's clinical condition

Inhalation

- remove from exposure and give oxygen
- maintain a clear airway and ensure adequate ventilation
- urgent assessment of the airway is required
- in severely affected patients, especially those with tachypnoea, stridor or upper airway damage, critical care input is essential with urgent assessment of the airway. A supraglottic-epiglottic burn with erythema and oedema is usually a sign that further oedema will occur that may lead to airway obstruction
- children are at increased risk of airway obstruction
- monitor cardiac rhythm and perform a 12-lead ECG in all patient who require assessment
- other supportive measures as indicated by the patient's clinical condition

Ingestion

- **maintain airway and establish haemodynamic stability**
- gut decontamination is contra-indicated
- **do not give neutralising chemicals** as heat produced during neutralisation reactions may increase injury
- maintain a clear airway and ensure adequate ventilation
- in severely affected patients, especially those with tachypnoea, stridor or upper airway damage, critical care input is essential with urgent assessment of the airway. A supraglottic-epiglottic burn with erythema and oedema is usually a sign that further oedema will occur that may lead to airway obstruction
- children are at increased risk of airway obstruction
- monitor cardiac rhythm and perform a 12-lead ECG in all patient who require assessment
- other supportive measures as indicated by the patient's clinical condition

Antidotes

Further information on the use of calcium gluconate gel is available on TOXBASE.

Health effects and decontamination references

- TOXBASE <http://www.toxbase.org> (accessed 08/2017)
- TOXBASE Hydrofluoric acid – features and management, 02/2012
- TOXBASE Emergency treatment prior to transfer to hospital, 2012

This document from the PHE Centre for Radiation, Chemical and Environmental Hazards reflects understanding and evaluation of the current scientific evidence as presented and referenced here.

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For queries relating to this document, please contact chemcompendium@phe.gov.uk

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