

Volcanic gas hazard

If concentrations of gases exceed the limits given by the Administration of occupational Safety and Health in Iceland work is prohibited.

- Always carry a personal gas sensor clipped below the knee
- If sensor alarm sounds evacuate immediately uphill
- Approach lava and or effusing craters from upwind
- Stay away from depressions
- Make use of goggles and gas masks as appropriate – insure filter cartridges in gasmask are appropriate for the gas risk. **Note that in general filter cartridges do not remove CO and CO₂**
- Be extra cautious in calm weather as gases will concentrate in the air as they are not dispersed by the wind. Also note that wind direction can change abruptly.
- **Always keep an oxygen mask and portable oxygen tank close by in case of emergency**

	Concentration	Exposure limit	
	ppm	hours	minutes
SO ₂	0.5	8	
	1	0	15
CO ₂	5000	8	
	10000	0	15
CO	25	8	
	50	0	15
H ₂ S	5	8	
	10	0	15

Gas exposure limits as set by the Administration on occupational safety and health in Iceland

Magma contains dissolved gases that are released into the atmosphere during eruptions. Gases are also released from magma that either remains below ground (for example, as an intrusion) or is rising towards the surface. In such cases, gases may escape continuously into the atmosphere from the soil, volcanic vents, fumaroles, and hydrothermal systems.

The major volcanic gases emitted from basaltic magma are H₂O, CO₂, SO₂, H₂, CO, H₂S, HCl and HF. The most abundant gas is water vapor (H₂O), followed by carbon dioxide (CO₂) and sulfur dioxide (SO₂).

Uncontaminated air comprises N₂ (78%), O₂ (21%), and Ar (0.9%) with trace levels of other gases. The following table shows the density of air and the major volcanic gases. CO₂, HCl, H₂S and SO₂ are all denser than air and as such will fill up depressions in the landscape. The volcanic gases that pose the greatest potential hazard to people, animals, agriculture, and property are SO₂, CO₂, and HF.

Gas		Density * kg m ⁻³
Air	N ₂ , O ₂ , Ar	1.205
Carbon dioxide	CO ₂	1.842
Carbon monoxide	CO	1.165
Hydrogen chloride	HCl	1.528
Hydrogen sulphide	H ₂ S	1.434
Hydrogen fluoride	HF	1.15
Sulfur dioxide	SO ₂	2.279

*air at 20°C and 1 atm

The risks from exposure to such emissions are:

- Reduced oxygen levels resulting in suffocation
- Direct toxicity from gases (discussed below)
- Gas contact with water (e.g. eyes) resulting in acidic solutions

Sulphur dioxide (SO₂)

Colourless

Pungent/irritating odour

Irritates the skin, and the tissues and mucous membranes of the eyes, nose, and throat.

The effects of SO₂ on people and the environment vary widely depending on (1) the amount of gas a volcano emits into the atmosphere; (2) whether the gas is injected into the troposphere or stratosphere; and (3) the regional or global wind and weather pattern that disperses the gas.

SO₂ is a colourless gas with a pungent odour that irritates skin and the tissues and mucous membranes of the eyes, nose and throat and chiefly affects upper respiratory tract and bronchi.

- The World Health Organization recommends a concentration of no greater than 0.5 ppm over 24 hours for maximum exposure.
- A concentration of 6-12 ppm can cause immediate irritation of the nose and throat
- 20 ppm can cause eye irritation
- 10,000 ppm will irritate moist skin within minutes.

SO ₂ ppm	Health effects
1 to 5	Respiratory response in healthy individuals upon exercise or deep breathing
3 to 5	Gas noticeable. Fall in lung function and rest. Increased airway resistance
5	Increased airway resistance in healthy individuals
6	Immediate irritation of eyes, nose, and throat
10	Worsening irritation
10 to 15	Threshold of toxicity for prolonged exposures
20+	Paralysis or death occurs after prolonged exposures
150	Maximum concentration that can be withstood for a few minutes by healthy individuals

Administration of Occupational Safety and Health in Iceland sets a concentration limit of 0.5 ppm (1.3 mg/m³) over 8 hours but 1 ppm (2.6 mg/m³) for 15 minutes. Concentration of 100 ppm is lethal.

Carbon dioxide (CO₂)

Colourless
Odourless

Normally does not pose a direct hazard to life as it typically becomes diluted to low concentrations. However, CO₂ is denser than air and as such can accumulate to dangerous levels. Breathing air with more than 30% CO₂ can quickly induce unconsciousness and cause death.

Avoid areas where emissions occur, especially small accumulation depressions. The boundary between air and lethal gas can be sharp – every step uphill may be adequate to preserve life.

% CO2	Symptoms
2 to 3	Shortness of breath, deep breathing
5	Breathing becomes heavy, sweating, pulse quickens
7.5	Headaches, dizziness, restlessness, breathlessness, increased heart rate and blood pressure, visual distortion
10	Impaired hearing, nausea, vomiting, loss of consciousness
30	Coma, convulsions, death

Administration of Occupational Safety and Health in Iceland sets a concentration limit of 5,000 ppm (4,500 mg/m³) over 8 hours but 10,000 ppm (9,000 mg/m³) for 15 minutes.

Carbon monoxide (CO)

Colourless
 Odourless
 Tasteless
 Initially non-irritating

Exposure at 100 ppm or greater can be dangerous to human health.

- At 800 ppm: Dizziness, muscle pain and diminished consciousness
- At 1600 ppm: Headache, dizziness, death within 2 hours.

Administration of Occupational Safety and Health in Iceland sets a concentration limit of 25 ppm (29 mg/m³) over 8 hours but 50 ppm (58 mg/m³) for 15 minutes.

Hydrogen chloride (HCl)

Colourless
 Irritating odor

MAJOR HEALTH HAZARDS: respiratory tract burns, skin burns, eye burns, mucous membrane burns.

HCl forms corrosive hydrochloric acid on contact with water found in body tissue. Inhalation of the fumes can cause coughing, choking, inflammation of the nose, throat, and upper respiratory tract, and in severe cases, pulmonary edema, circulatory system failure and death.

Exposure to the gas irritates mucous membranes of the eyes and respiratory tract. Concentrations over 35 ppm cause irritation of the throat after short exposure; >100 ppm results in pulmonary edema, and often laryngeal spasm.

Skin contact can cause redness, pain, and severe skin burns. HCl may cause severe burns to the eyes and permanent eye damage.

Exposure limits for HCl are at a ceiling of 5 ppm

Hydrogen sulphide (H₂S)

Colourless

Rotten egg odour at low concentrations (exposure to gas deadens sense of smell)

H₂S is a colorless, flammable gas with a strong offensive odor. At low concentrations it can irritate the eyes and acts as a depressant; at high concentrations it can cause irritation of the upper respiratory tract and, during long exposure, pulmonary edema.

Effects of a single (acute) overexposure may be devastating. H₂S may be fatal if inhaled. It depresses the activity of the central nervous system, causing respiratory paralysis. Effects of overexposure include headache, dizziness, vertigo, giddiness, confusion, chest pains, olfactory fatigue, unconsciousness, and death. Rhinitis, pharyngitis, pneumonitis, pulmonary edema, and cyanosis may occur.

Lack of oxygen can kill.

Upon skin contact expect skin irritation, causing local redness and swelling.

Administration of Occupational Safety and Health in Iceland sets a concentration limit of 5 ppm (7 mg/m³) over 8 hours but 10 ppm (10 mg/m³) for 15 minutes. Concentration of 100 ppm is lethal.

H₂S (ppm)	Symptoms/Effects
0.0001 to 0.0003	Typical background
0.01 to 1.5	Odour threshold (rotten eggs first noticeable). Odour becomes more offensive at 3-5 ppm
2 to 5	Prolonged exposure may cause nausea, tearing of the eyes, headaches or loss of sleep. Bronchial constriction in some asthma patients.
20	Fatigue, loss of appetite, headache, irritability, poor memory, dizziness
50 to 100	Conjunctivitis ("gas eye") and respiratory tract irritation. May cause digestive upset.
100	Coughing, eye irritation, loss of smell. Altered breathing and drowsiness. Throat irritation. Increasing severity of symptoms. Death may occur in 48 hours
100 to 150	Loss of smell
200-300	Eye and respiratory tract irritation after 1 hour. Pulmonary edema may occur after prolonged exposure
500 to 700	Staggering and collapse within 5 minutes. Serious damage to eyes in 30 minutes. Death within 1 hour.
700 to 1000	Rapid unconsciousness. Immediate collapse within 1 to 2 breaths. BREATHING STOPS. Death within minutes.
1000-2000	Nearly instant death.

Hydrogen fluoride (HF)

Fluorine is a pale yellow gas that attaches to fine ash particles, coats grass, and pollutes streams and lakes. Exposure to this powerful caustic irritant can cause conjunctivitis, skin irritation, bone degeneration and mottling of teeth. Excess fluorine results in a significant cause of death and injury in livestock during ash eruptions. Even in areas that receive just a millimeter of ash, poisoning can occur where the fluorine content of dried grass exceeds 250 ppm. Animals that eat grass coated with fluorine-tainted ash are poisoned.

Small amounts of fluorine can be beneficial, but excess fluorine causes fluorosis, an affliction that eventually kills animals by destroying their bones. It also promotes acid rain effects downwind of volcanoes, like HCl.

Based in information from USGS (<http://volcanoes.usgs.gov/hazards/gas/>) and the Administration of Occupational Safety and Health in Iceland (<http://www.vinnueftirlit.is/um-vinnueftirlitid/frettir/nr/1166>)