

School of Chemical Engineering

Guideline for Use of Hydrogen and Flammable Hydrogen Gas Mixtures

Hydrogen is a known flammable gas and gas mixtures containing hydrogen can also be flammable. This guideline, though specific to hydrogen/nitrogen, hydrogen/argon and hydrogen/helium mixtures, is applicable to all hydrogen gas mixtures that are flammable.

ISO 10156 defines the international standard for determining the flammability of gases or gas mixtures (Linde Bulletin: Flammable Gas Classification Changes.) In 2010, gas mixtures that contain **>5.5 mol% hydrogen in nitrogen** were classified as **flammable**. (The previous flammable concentration was >5.7 mol% H₂ in N₂. (Airgas MSDS)) Similarly, gas mixtures that contain **>2.94 mol% hydrogen in argon** and **>3.9 mol% hydrogen in helium** are classified as **flammable** (Airgas MSDSs).

Chemical engineering labs utilizing gas mixtures with >5.5 mol% hydrogen in nitrogen, >2.94 mol% hydrogen in argon and >3.9 mol% hydrogen in helium must be equipped with a hydrogen detector. A hydrogen detector is required when 100 mol% hydrogen is in use. If the flammable gas mixture is used intermittently, a hydrogen detector is required. Hydrogen detectors available from U.S. Industrial Products Co. Inc. (<http://www.us-industrial.com/gasdetectors.html>) have been utilized successfully in chemical engineering. The detectors utilize a catalytic sensor (<http://www.us-industrial.com/sensors.html>) for detecting 0 to 100% LEL of hydrogen and should be set at 10% of the LEL of hydrogen (0.55 mol%, 0.29 mol% and 0.39 mol% for hydrogen in nitrogen, hydrogen in argon and hydrogen in helium respectively).

Other considerations when using hydrogen gas mixtures or pure hydrogen:

- To minimize the potential for leaks, tubing and piping should be stainless steel with a minimum number of fittings. Polymeric tubing should not be used.
- A stainless steel flex hose can be used as long as the pressure rating is sufficient for the maximum system pressure (for all gases not just hydrogen). As example, standard Matheson gas manifolds come with stainless steel flex hoses (<http://www.mathesongas.com/pdfs/268-275GasDelivery.pdf>).
- The hydrogen detector should be located near and above the hydrogen source.
- The hydrogen detector should be calibrated regularly in accordance with the manufacturer recommendations.
- Automatic shut-off valves on the hydrogen supply line provide additional protection in the event of a hydrogen leak and are required to be installed when hydrogen is used in continuous systems.
- If feasible, gas cylinders should be stored in a vent hood.
- Potential ignition sources (electrical equipment/spark and flame) should be eliminated from the area.

Flammable Gas Classification Changes under ISO 10156: 2010.

Background

When filling compressed gases, manufacturing companies are required to follow national and international standards to determine the proper product classification and identification. A gas classified as non-flammable will have a different transport label than a flammable gas. And in some countries, regulations regarding the cylinder valve connection, as well as cylinder colour coding are also used to differentiate a flammable gas from a non flammable.



ISO 10156: 2010

ISO 10156 defines a standardised method for determining the flammable or oxidising ability of a gas or gas mixture. This is the international standard followed by Linde. The current version is ISO 10156: 1996. A new revision of this standard - ISO 10156: 2010 will shortly be published. While there will be no changes to the classification of pure gases under this revision, there are changes which may effect the classifications of various mixtures currently be produced at various Linde facilities.

New Tci Values

Tci is defined as the maximum content of a flammable gas which, when mixed with Nitrogen, is not flammable in air. Tci is also used as a reference parameter in any kind of mixture that contains a flammable component. The new standard includes changes to these values for a number of gases. Under the revision, new Tci values will be assigned to a variety of existing mixtures. Depending on the mixture the level may be higher (less restrictive situation) or lower (more restrictive situation) than as defined in the previous edition of the standard.

Direct implications

Once this revision comes into effect, products that have been affected will see changes in the following areas.

- A new transportation identification label may be required to show indicated changes
- In some countries, a new cylinder shoulder colour may be required to indicate the change from either a non flammable to a flammable mixture, or from a flammable to a non flammable mixture.
- The Safety Data Sheet (SDS) will need to be updated to include the updated changes for cylinder safety and transportation.
- In some countries, a different cylinder valve outlet may be required.

Indirect implications for the user

- Storage conditions may need to be reviewed (including permits for storage of dangerous substances).
- Transport conditions will need to be reviewed.
- Risk assessment to be reviewed, with operational procedures updated according to the new risk assessment outcome.
- Gas control equipment and supply system compatibility may need to be checked, as changes may be required for both cylinder connections and supply line labelling.

Some examples

Gas	T _{ci}	T _{ci}
	ISO 10156: 1996	ISO 10156: 2010*
Hydrogen (H ₂)	5.7	5.5
Methane (CH ₄)	14.3	8.7
Ethylene (C ₂ H ₄)	6.0	4.1
Ethylene Oxide (C ₂ H ₄ O)	3.1	4.8
R152a	4.6	8.7

A mixture with 10% Methane in Nitrogen is currently classified as non flammable according to ISO 10156:1996, but will become flammable according to the new revision of the standard. This will require a different transportation label – from UN1956 to UN1954 – and where legislated, the shoulder colour will change from green to red. As noted, a new cylinder valve designation may also be required.

A mixture with 4% Ethylene Oxide in Nitrogen is currently classified as flammable according to ISO 10156:1996, it will become non flammable according to the new revision of the standard. This will require a different transportation label – from UN1954 to UN1956 – and where legislated, the shoulder colour will change from red to green. And as noted, a new cylinder valve designation may also be required.

In both cases there will be changes required to the Safety Data Sheet currently provided.

HiQ® Equipment

If notified that new gas regulating equipment is required, HiQ BASELINE®, or REDLINE® cylinder regulators are available to meet your requirements. For more information on our HiQ Specialty Gases Equipment offer, visit us at <http://hiq.linde-gas.com>, or contact your local Linde Specialty Gases office.

* Value examples shown are based on the current ISO 10156:2010 draft currently in committee, and are subject to change until final documentation is published by ISO.

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Material Safety Data Sheet

Flammable Gas Mixture (FID-Flame Ionization Fuel): Hydrogen 5.71-99% / Nitrogen 1-94.29%

Section 1. Chemical product and company identification

Product name : Flammable Gas Mixture (FID-Flame Ionization Fuel): Hydrogen 5.71-99% / Nitrogen 1-94.29%

Supplier : AIRGAS INC., on behalf of its subsidiaries
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

Product use : Synthetic/Analytical chemistry.

Synonym : Flame Ionization Mixture

MSDS # : 002006

Date of Preparation/Revision : 5/27/2009.

In case of emergency : 1-866-734-3438

Section 2. Hazards identification

Physical state : Gas.

Emergency overview : DANGER!
FLAMMABLE GAS.
MAY CAUSE FLASH FIRE.
CONTENTS UNDER PRESSURE.
Keep away from heat, sparks and flame. Do not puncture or incinerate container. Use only with adequate ventilation. Keep container closed.
Contact with rapidly expanding gases can cause frostbite.

Routes of entry : Inhalation

Potential acute health effects

Eyes : Contact with rapidly expanding gas may cause burns or frostbite.

Skin : Contact with rapidly expanding gas may cause burns or frostbite.

Inhalation : Acts as a simple asphyxiant.

Ingestion : Ingestion is not a normal route of exposure for gases

Potential chronic health effects : **CARCINOGENIC EFFECTS:** Not available.
MUTAGENIC EFFECTS: Not available.
TERATOGENIC EFFECTS: Not available.

Medical conditions aggravated by over-exposure : Acute or chronic respiratory conditions may be aggravated by overexposure to this gas.

See toxicological information (section 11)

Section 3. Composition, Information on Ingredients

<u>Name</u>	<u>CAS number</u>	<u>% Volume</u>	<u>Exposure limits</u>
Hydrogen	1333-74-0	5.71 - 99	Oxygen Depletion [Asphyxiant]
Nitrogen	7727-37-9	1 - 94.29	Oxygen Depletion [Asphyxiant]

Section 4. First aid measures

No action shall be taken involving any personal risk or without suitable training. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

- Eye contact** : Check for and remove any contact lenses. Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical attention immediately.
- Skin contact** : In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Clean shoes thoroughly before reuse. Get medical attention immediately.
- Frostbite** : Try to warm up the frozen tissues and seek medical attention.
- Inhalation** : Move exposed person to fresh air. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.
- Ingestion** : As this product is a gas, refer to the inhalation section.

Section 5. Fire-fighting measures

- Flammability of the product** : Flammable.
- Auto-ignition temperature** : Lowest known value: 399.85 to 573.75°C (751.7 to 1064.8°F) (Hydrogen).
- Flammable limits** : Greatest known range: Lower: 4% Upper: 75% (Hydrogen)
- Products of combustion** : Decomposition products may include the following materials:
nitrogen oxides
- Fire-fighting media and instructions** : In case of fire, use water spray (fog), foam or dry chemical.
- In case of fire, allow gas to burn if flow cannot be shut off immediately. Apply water from a safe distance to cool container and protect surrounding area. If involved in fire, shut off flow immediately if it can be done without risk.
- Contains gas under pressure. Extremely flammable. In a fire or if heated, a pressure increase will occur and the container may burst or explode. Gas may accumulate in low or confined areas or travel a considerable distance to a source of ignition and flash back, causing fire or explosion.
- Special protective equipment for fire-fighters** : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

- Personal precautions** : Immediately contact emergency personnel. Keep unnecessary personnel away. Use suitable protective equipment (section 8). Shut off gas supply if this can be done safely. Isolate area until gas has dispersed.
- Environmental precautions** : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.
- Methods for cleaning up** : Immediately contact emergency personnel. Stop leak if without risk. Note: see section 1 for emergency contact information and section 13 for waste disposal.

Section 7. Handling and storage

- Handling** : Use only with adequate ventilation. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. High pressure gas. Do not puncture or incinerate container. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Keep container closed. Keep away from heat, sparks and flame. To avoid fire, eliminate ignition sources. Protect cylinders from physical damage; do not drag, roll, slide, or drop. Use a suitable hand truck for cylinder movement.
- Storage** : Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame). Segregate from oxidizing materials. Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 52 °C (125 °F).

Section 8. Exposure controls/personal protection

Engineering controls : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Personal protection

- Eyes** : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists or dusts.
- Skin** : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
- Respiratory** : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.
The applicable standards are (US) 29 CFR 1910.134 and (Canada) Z94.4-93
- Hands** : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.
- Personal protection in case of a large spill** : Self-contained breathing apparatus (SCBA) should be used to avoid inhalation of the product.

Product name

Hydrogen Oxygen Depletion [Asphyxiant]
Nitrogen Oxygen Depletion [Asphyxiant]

Consult local authorities for acceptable exposure limits.

Section 9. Physical and chemical properties

- Melting/freezing point** : -210°C (-346°F) This is based on data for the following ingredient: Nitrogen. Weighted average: -235.2°C (-391.4°F)
- Critical temperature** : Lowest known value: -240.1°C (-400.2°F) (Hydrogen).
- Vapor density** : Highest known value: 0.967 (Air = 1) (Nitrogen). Weighted average: 0.51 (Air = 1)
- Gas Density (lb/ft³)** : Weighted average: 0.07

Section 10. Stability and reactivity

- Stability and reactivity** : The product is stable.
- Incompatibility with various substances** : Extremely reactive or incompatible with the following materials: oxidizing materials.
- Hazardous decomposition products** : Under normal conditions of storage and use, hazardous decomposition products should not be produced.
- Hazardous polymerization** : Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Toxicity data

Other toxic effects on humans : No specific information is available in our database regarding the other toxic effects of this material to humans.

Specific effects

- Carcinogenic effects** : No known significant effects or critical hazards.
- Mutagenic effects** : No known significant effects or critical hazards.
- Reproduction toxicity** : No known significant effects or critical hazards.

Flammable Gas Mixture (FID-Flame Ionization Fuel): Hydrogen 5.71-99% / Nitrogen 1-94.29%

Section 12. Ecological information

Aquatic ecotoxicity

Not available.

Products of degradation : Products of degradation: nitrogen oxides (NO, NO₂ etc.).

Environmental fate : Not available.




Environmental hazards : No known significant effects or critical hazards.

Toxicity to the environment : Not available.

Section 13. Disposal considerations

Product removed from the cylinder must be disposed of in accordance with appropriate Federal, State, local regulation. Return cylinders with residual product to Airgas, Inc. Do not dispose of locally.

Section 14. Transport information

Regulatory information	UN number	Proper shipping name	Class	Packing group	Label	Additional information
DOT Classification	UN1954	COMPRESSED GAS, FLAMMABLE, N.O.S.	2.1	Not applicable (gas).		-
TDG Classification	UN1954	COMPRESSED GAS, FLAMMABLE, N.O.S.	2.1	Not applicable (gas).		<u>Explosive Limit and Limited Quantity Index</u> 0.125 <u>ERAP Index</u> 3000 <u>Passenger Carrying Ship Index</u> Forbidden <u>Passenger Carrying Road or Rail Index</u> Forbidden
Mexico Classification	UN1954	COMPRESSED GAS, FLAMMABLE, N.O.S.	2.1	Not applicable (gas).		-

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Section 15. Regulatory information

United States

U.S. Federal regulations : **United States inventory (TSCA 8b):** All components are listed or exempted.
SARA 302/304/311/312 extremely hazardous substances: No products were found.
SARA 302/304 emergency planning and notification: No products were found.
SARA 302/304/311/312 hazardous chemicals: Nitrogen; Hydrogen
SARA 311/312 MSDS distribution - chemical inventory - hazard identification:
Nitrogen: Sudden release of pressure; Hydrogen: Fire hazard, Sudden release of pressure

Flammable Gas Mixture (FID-Flame Ionization Fuel): Hydrogen 5.71-99% / Nitrogen 1-94.29%

Clean Water Act (CWA) 307: No products were found.
Clean Water Act (CWA) 311: No products were found.
Clean Air Act (CAA) 112 accidental release prevention: Hydrogen
Clean Air Act (CAA) 112 regulated flammable substances: Hydrogen
Clean Air Act (CAA) 112 regulated toxic substances: No products were found.

State regulations :

- Connecticut Carcinogen Reporting:** None of the components are listed.
- Connecticut Hazardous Material Survey:** None of the components are listed.
- Florida substances:** None of the components are listed.
- Illinois Chemical Safety Act:** None of the components are listed.
- Illinois Toxic Substances Disclosure to Employee Act:** None of the components are listed.
- Louisiana Reporting:** None of the components are listed.
- Louisiana Spill:** None of the components are listed.
- Massachusetts Spill:** None of the components are listed.
- Massachusetts Substances:** The following components are listed: HYDROGEN; NITROGEN
- Michigan Critical Material:** None of the components are listed.
- Minnesota Hazardous Substances:** None of the components are listed.
- New Jersey Hazardous Substances:** The following components are listed: HYDROGEN; NITROGEN (COMPRESSED OR LIQUIFIED)
- New Jersey Spill:** None of the components are listed.
- New Jersey Toxic Catastrophe Prevention Act:** None of the components are listed.
- New York Acutely Hazardous Substances:** None of the components are listed.
- New York Toxic Chemical Release Reporting:** None of the components are listed.
- Pennsylvania RTK Hazardous Substances:** The following components are listed: HYDROGEN; NITROGEN
- Rhode Island Hazardous Substances:** None of the components are listed.

Canada

WHMIS (Canada) :

- Class A: Compressed gas.
- Class B-1: Flammable gas.
- CEPA Toxic substances:** None of the components are listed.
- Canadian ARET:** None of the components are listed.
- Canadian NPRI:** None of the components are listed.
- Alberta Designated Substances:** None of the components are listed.
- Ontario Designated Substances:** None of the components are listed.
- Quebec Designated Substances:** None of the components are listed.

Section 16. Other information

United States

Label requirements :

- FLAMMABLE GAS.
- MAY CAUSE FLASH FIRE.
- CONTENTS UNDER PRESSURE.

Canada

Label requirements :

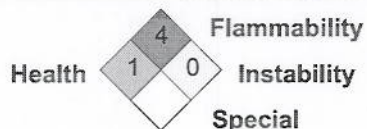
- Class A: Compressed gas.
- Class B-1: Flammable gas.

Hazardous Material Information System (U.S.A.) :

Health	1
Flammability	4
Physical hazards	0

Flammable Gas Mixture (FID-Flame Ionization Fuel): Hydrogen 5.71-99% / Nitrogen 1-94.29%

National Fire Protection Association (U.S.A.) :



Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.

Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

Material Safety Data Sheet

Flammable Gas Mixture: Argon 1-97.06% / Hydrogen 2.94-99%

Section 1. Chemical product and company identification

Product name : Flammable Gas Mixture: Argon 1-97.06% / Hydrogen 2.94-99%
Supplier : AIRGAS INC., on behalf of its subsidiaries
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253
Product use : Synthetic/Analytical chemistry.
MSDS # : 002005
Date of Preparation/Revision : **4/29/2010.**
In case of emergency : 1-866-734-3438

Section 2. Hazards identification

Physical state : Gas.
Emergency overview : DANGER!
FLAMMABLE GAS.
MAY CAUSE FLASH FIRE.
CONTENTS UNDER PRESSURE.
Keep away from heat, sparks and flame. Do not puncture or incinerate container. Use only with adequate ventilation. Keep container closed.
Contact with rapidly expanding gases can cause frostbite.
Routes of entry : Inhalation
Potential acute health effects
Eyes : Contact with rapidly expanding gas may cause burns or frostbite.
Skin : Contact with rapidly expanding gas may cause burns or frostbite.
Inhalation : Acts as a simple asphyxiant.
Ingestion : Ingestion is not a normal route of exposure for gases
Potential chronic health effects : **CARCINOGENIC EFFECTS:** Not available.
MUTAGENIC EFFECTS: Not available.
TERATOGENIC EFFECTS: Not available.
Medical conditions aggravated by over-exposure : Acute or chronic respiratory conditions may be aggravated by overexposure to this gas.

See toxicological information (section 11)

Section 3. Composition, Information on Ingredients

<u>Name</u>	<u>CAS number</u>	<u>% Volume</u>	<u>Exposure limits</u>
Hydrogen	1333-74-0	2.94 - 99	Oxygen Depletion [Asphyxiant]
Argon	7440-37-1	1 - 97.06	Oxygen Depletion [Asphyxiant]

Section 4. First aid measures

No action shall be taken involving any personal risk or without suitable training. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

Eye contact : Check for and remove any contact lenses. Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical attention immediately.

Flammable Gas Mixture: Argon 1-97.06% / Hydrogen 2.94-99%

- Skin contact** : In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Clean shoes thoroughly before reuse. Get medical attention immediately.
- Frostbite** : Try to warm up the frozen tissues and seek medical attention.
- Inhalation** : Move exposed person to fresh air. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.
- Ingestion** : As this product is a gas, refer to the inhalation section.

Section 5. Fire-fighting measures

- Flammability of the product** : Flammable.
- Auto-ignition temperature** : Lowest known value: 399.85 to 573.75°C (751.7 to 1064.8°F) (hydrogen).
- Flammable limits** : Greatest known range: Lower: 4% Upper: 75% (hydrogen)
- Products of combustion** : No specific data.
- Fire-fighting media and instructions** : In case of fire, use water spray (fog), foam or dry chemical.

In case of fire, allow gas to burn if flow cannot be shut off immediately. Apply water from a safe distance to cool container and protect surrounding area. If involved in fire, shut off flow immediately if it can be done without risk.

Contains gas under pressure. Extremely flammable. In a fire or if heated, a pressure increase will occur and the container may burst or explode. Gas may accumulate in low or confined areas or travel a considerable distance to a source of ignition and flash back, causing fire or explosion.

- Special protective equipment for fire-fighters** : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

- Personal precautions** : Immediately contact emergency personnel. Keep unnecessary personnel away. Use suitable protective equipment (section 8). Shut off gas supply if this can be done safely. Isolate area until gas has dispersed.
- Environmental precautions** : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.
- Methods for cleaning up** : Immediately contact emergency personnel. Stop leak if without risk. Note: see section 1 for emergency contact information and section 13 for waste disposal.

Section 7. Handling and storage

- Handling** : Use only with adequate ventilation. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. High pressure gas. Do not puncture or incinerate container. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Keep container closed. Keep away from heat, sparks and flame. To avoid fire, eliminate ignition sources. Protect cylinders from physical damage; do not drag, roll, slide, or drop. Use a suitable hand truck for cylinder movement.
- Storage** : Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame). Segregate from oxidizing materials. Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 52 °C (125 °F).

Flammable Gas Mixture: Argon 1-97.06% / Hydrogen 2.94-99%

Section 8. Exposure controls/personal protection

Engineering controls : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Personal protection

Eyes : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists or dusts.

Skin : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

The applicable standards are (US) 29 CFR 1910.134 and (Canada) Z94.4-93

Hands : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.

Personal protection in case of a large spill : Self-contained breathing apparatus (SCBA) should be used to avoid inhalation of the product.

Product name

hydrogen Oxygen Depletion [Asphyxiant]
argon Oxygen Depletion [Asphyxiant]

Consult local authorities for acceptable exposure limits.

Section 9. Physical and chemical properties

Melting/freezing point : -189.2°C (-308.6°F) This is based on data for the following ingredient: argon. Weighted average: -224.55°C (-372.2°F)

Critical temperature : Lowest known value: -240.1°C (-400.2°F) (hydrogen).

Vapor density : Highest known value: 1.38 (Air = 1) (argon). Weighted average: 0.72 (Air = 1)

Gas Density (lb/ft³) : Weighted average: 0.13

Section 10. Stability and reactivity

Stability and reactivity : The product is stable.

Incompatibility with various substances : Extremely reactive or incompatible with the following materials: oxidizing materials.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Hazardous polymerization : Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Toxicity data

Other toxic effects on humans : No specific information is available in our database regarding the other toxic effects of this material to humans.

Specific effects

Carcinogenic effects : No known significant effects or critical hazards.

Mutagenic effects : No known significant effects or critical hazards.

Reproduction toxicity : No known significant effects or critical hazards.

Flammable Gas Mixture: Argon 1-97.06% / Hydrogen 2.94-99%

Section 12. Ecological information

Aquatic ecotoxicity

Not available.

Environmental fate : Not available.




Environmental hazards : No known significant effects or critical hazards.

Toxicity to the environment : Not available.

Section 13. Disposal considerations

Product removed from the cylinder must be disposed of in accordance with appropriate Federal, State, local regulation. Return cylinders with residual product to Airgas, Inc. Do not dispose of locally.

Section 14. Transport information

Regulatory information	UN number	Proper shipping name	Class	Packing group	Label	Additional information
DOT Classification	UN1954	COMPRESSED GAS, FLAMMABLE, N.O.S.	2.1	Not applicable (gas).		-
TDG Classification	UN1954	COMPRESSED GAS, FLAMMABLE, N.O.S.	2.1	Not applicable (gas).		<u>Explosive Limit and Limited Quantity Index</u> 0.125 <u>ERAP Index</u> 3000 <u>Passenger Carrying Ship Index</u> Forbidden <u>Passenger Carrying Road or Rail Index</u> Forbidden
Mexico Classification	UN1954	COMPRESSED GAS, FLAMMABLE, N.O.S.	2.1	Not applicable (gas).		-

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Section 15. Regulatory information

United States

U.S. Federal regulations : TSCA 8(a) IUR: argon; hydrogen

United States inventory (TSCA 8b): All components are listed or exempted.

SARA 302/304/311/312 extremely hazardous substances: No products were found.

SARA 302/304 emergency planning and notification: No products were found.

SARA 302/304/311/312 hazardous chemicals: argon; hydrogen

SARA 311/312 MSDS distribution - chemical inventory - hazard identification:

argon: Sudden release of pressure; hydrogen: Fire hazard, Sudden release of pressure

Clean Water Act (CWA) 307: No products were found.

Flammable Gas Mixture: Argon 1-97.06% / Hydrogen 2.94-99%

Clean Water Act (CWA) 311: No products were found.
Clean Air Act (CAA) 112 accidental release prevention: hydrogen
Clean Air Act (CAA) 112 regulated flammable substances: hydrogen
Clean Air Act (CAA) 112 regulated toxic substances: No products were found.

State regulations :

- Connecticut Carcinogen Reporting:** None of the components are listed.
- Connecticut Hazardous Material Survey:** None of the components are listed.
- Florida substances:** None of the components are listed.
- Illinois Chemical Safety Act:** None of the components are listed.
- Illinois Toxic Substances Disclosure to Employee Act:** None of the components are listed.
- Louisiana Reporting:** None of the components are listed.
- Louisiana Spill:** None of the components are listed.
- Massachusetts Spill:** None of the components are listed.
- Massachusetts Substances:** The following components are listed: HYDROGEN; ARGON
- Michigan Critical Material:** None of the components are listed.
- Minnesota Hazardous Substances:** None of the components are listed.
- New Jersey Hazardous Substances:** The following components are listed: HYDROGEN; ARGON
- New Jersey Spill:** None of the components are listed.
- New Jersey Toxic Catastrophe Prevention Act:** None of the components are listed.
- New York Acutely Hazardous Substances:** None of the components are listed.
- New York Toxic Chemical Release Reporting:** None of the components are listed.
- Pennsylvania RTK Hazardous Substances:** The following components are listed: HYDROGEN; ARGON
- Rhode Island Hazardous Substances:** None of the components are listed.

Canada

WHMIS (Canada) :

- Class A: Compressed gas.
- Class B-1: Flammable gas.

CEPA Toxic substances: None of the components are listed.
Canadian ARET: None of the components are listed.
Canadian NPRI: None of the components are listed.
Alberta Designated Substances: None of the components are listed.
Ontario Designated Substances: None of the components are listed.
Quebec Designated Substances: None of the components are listed.

Section 16. Other information

United States

Label requirements : FLAMMABLE GAS.
MAY CAUSE FLASH FIRE.
CONTENTS UNDER PRESSURE.

Canada

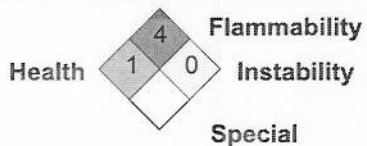
Label requirements : Class A: Compressed gas.
Class B-1: Flammable gas.

Hazardous Material Information System (U.S.A.) :

Health	1
Flammability	4
Physical hazards	0

Flammable Gas Mixture: Argon 1-97.06% / Hydrogen 2.94-99%

National Fire Protection Association (U.S.A.) :



Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.

Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

Material Safety Data Sheet

Airgas

Flammable Gas Mixture: Helium 1-96.1% / Hydrogen 3.9-99%

Section 1. Chemical product and company identification

Product name : Flammable Gas Mixture: Helium 1-96.1% / Hydrogen 3.9-99%
Supplier : AIRGAS INC., on behalf of its subsidiaries
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253
Product use : Synthetic/Analytical chemistry.
MSDS # : 002029
Date of Preparation/Revision : 4/30/2010.
In case of emergency : 1-866-734-3438

Section 2. Hazards identification

Physical state : Gas.
Emergency overview : DANGER!
FLAMMABLE GAS.
MAY CAUSE FLASH FIRE.
CONTENTS UNDER PRESSURE.
Keep away from heat, sparks and flame. Do not puncture or incinerate container. Use only with adequate ventilation. Keep container closed.
Contact with rapidly expanding gases can cause frostbite.
Routes of entry : Inhalation
Potential acute health effects
Eyes : Contact with rapidly expanding gas may cause burns or frostbite.
Skin : Contact with rapidly expanding gas may cause burns or frostbite.
Inhalation : Acts as a simple asphyxiant.
Ingestion : Ingestion is not a normal route of exposure for gases
Potential chronic health effects : **CARCINOGENIC EFFECTS:** Not available.
MUTAGENIC EFFECTS: Not available.
TERATOGENIC EFFECTS: Not available.
Medical conditions aggravated by over-exposure : Acute or chronic respiratory conditions may be aggravated by overexposure to this gas.

See toxicological information (section 11)

Section 3. Composition, Information on Ingredients

<u>Name</u>	<u>CAS number</u>	<u>% Volume</u>	<u>Exposure limits</u>
Hydrogen	1333-74-0	3.9 - 99	Oxygen Depletion [Asphyxiant]
Helium	7440-59-7	1 - 96.1	Oxygen Depletion [Asphyxiant]

Section 4. First aid measures

No action shall be taken involving any personal risk or without suitable training. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

Eye contact : Check for and remove any contact lenses. Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical attention immediately.

Flammable Gas Mixture: Helium 1-96.1% / Hydrogen 3.9-99%

- Skin contact** : In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Clean shoes thoroughly before reuse. Get medical attention immediately.
- Frostbite** : Try to warm up the frozen tissues and seek medical attention.
- Inhalation** : Move exposed person to fresh air. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.
- Ingestion** : As this product is a gas, refer to the inhalation section.

Section 5. Fire-fighting measures

- Flammability of the product** : Flammable.
- Auto-ignition temperature** : Lowest known value: 399.85 to 573.75°C (751.7 to 1064.8°F) (hydrogen).
- Flammable limits** : Greatest known range: Lower: 4% Upper: 75% (hydrogen)
- Products of combustion** : No specific data.
- Fire-fighting media and instructions** : In case of fire, use water spray (fog), foam or dry chemical.

In case of fire, allow gas to burn if flow cannot be shut off immediately. Apply water from a safe distance to cool container and protect surrounding area. If involved in fire, shut off flow immediately if it can be done without risk.

Contains gas under pressure. Extremely flammable. In a fire or if heated, a pressure increase will occur and the container may burst or explode. Gas may accumulate in low or confined areas or travel a considerable distance to a source of ignition and flash back, causing fire or explosion.

- Special protective equipment for fire-fighters** : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

- Personal precautions** : Immediately contact emergency personnel. Keep unnecessary personnel away. Use suitable protective equipment (section 8). Shut off gas supply if this can be done safely. Isolate area until gas has dispersed.
- Environmental precautions** : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.
- Methods for cleaning up** : Immediately contact emergency personnel. Stop leak if without risk. Note: see section 1 for emergency contact information and section 13 for waste disposal.

Section 7. Handling and storage

- Handling** : Use only with adequate ventilation. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. High pressure gas. Do not puncture or incinerate container. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Keep container closed. Keep away from heat, sparks and flame. To avoid fire, eliminate ignition sources. Protect cylinders from physical damage; do not drag, roll, slide, or drop. Use a suitable hand truck for cylinder movement.
- Storage** : Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame). Segregate from oxidizing materials. Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 52 °C (125 °F).

Flammable Gas Mixture: Helium 1-96.1% / Hydrogen 3.9-99%

Section 8. Exposure controls/personal protection

Engineering controls : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Personal protection

Eyes : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists or dusts.

Skin : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

The applicable standards are (US) 29 CFR 1910.134 and (Canada) Z94.4-93

Hands : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.

Personal protection in case of a large spill : Self-contained breathing apparatus (SCBA) should be used to avoid inhalation of the product.

Product name

hydrogen

Oxygen Depletion [Asphyxiant]

helium

Oxygen Depletion [Asphyxiant]

Consult local authorities for acceptable exposure limits.

Section 9. Physical and chemical properties

Melting/freezing point : -259.2°C (-434.6°F) This is based on data for the following ingredient: hydrogen.
Weighted average: -265.6°C (-446.1°F)

Critical temperature : Lowest known value: -267.9°C (-450.2°F) (helium).

Vapor density : Highest known value: 0.14 (Air = 1) (helium). Weighted average: 0.1 (Air = 1)

Gas Density (lb/ft³) : Weighted average: 0.02

Section 10. Stability and reactivity

Stability and reactivity : The product is stable.

Incompatibility with various substances : Reactive with oxidizing agents.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Hazardous polymerization : Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Toxicity data

Other toxic effects on humans : No specific information is available in our database regarding the other toxic effects of this material to humans.

Specific effects

Carcinogenic effects : No known significant effects or critical hazards.

Mutagenic effects : No known significant effects or critical hazards.

Reproduction toxicity : No known significant effects or critical hazards.

Flammable Gas Mixture: Helium 1-96.1% / Hydrogen 3.9-99%

Section 12. Ecological information

Aquatic ecotoxicity

Not available.

Environmental fate : Not available.




Environmental hazards : No known significant effects or critical hazards.

Toxicity to the environment : Not available.

Section 13. Disposal considerations

Product removed from the cylinder must be disposed of in accordance with appropriate Federal, State, local regulation. Return cylinders with residual product to Airgas, Inc. Do not dispose of locally.

Section 14. Transport information

Regulatory information	UN number	Proper shipping name	Class	Packing group	Label	Additional information
DOT Classification	UN1954	COMPRESSED GAS, FLAMMABLE, N.O.S.	2.1	Not applicable (gas).		-
TDG Classification	UN1954	COMPRESSED GAS, FLAMMABLE, N.O.S.	2.1	Not applicable (gas).		<u>Explosive Limit and Limited Quantity Index</u> 0.125 <u>ERAP Index</u> 3000 <u>Passenger Carrying Ship Index</u> Forbidden <u>Passenger Carrying Road or Rail Index</u> Forbidden
Mexico Classification	UN1954	COMPRESSED GAS, FLAMMABLE, N.O.S.	2.1	Not applicable (gas).		-

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Section 15. Regulatory information

United States

U.S. Federal regulations : TSCA 8(a) IUR: hydrogen

United States inventory (TSCA 8b): All components are listed or exempted.

SARA 302/304/311/312 extremely hazardous substances: No products were found.

SARA 302/304 emergency planning and notification: No products were found.

SARA 302/304/311/312 hazardous chemicals: hydrogen; helium

SARA 311/312 MSDS distribution - chemical inventory - hazard identification:

hydrogen: Fire hazard, Sudden release of pressure; helium: Sudden release of pressure

Clean Water Act (CWA) 307: No products were found.

Flammable Gas Mixture: Helium 1-96.1% / Hydrogen 3.9-99%

State regulations

- Clean Water Act (CWA) 311:** No products were found.
- Clean Air Act (CAA) 112 accidental release prevention:** hydrogen
- Clean Air Act (CAA) 112 regulated flammable substances:** hydrogen
- Clean Air Act (CAA) 112 regulated toxic substances:** No products were found.
- Connecticut Carcinogen Reporting:** None of the components are listed.
- Connecticut Hazardous Material Survey:** None of the components are listed.
- Florida substances:** None of the components are listed.
- Illinois Chemical Safety Act:** None of the components are listed.
- Illinois Toxic Substances Disclosure to Employee Act:** None of the components are listed.
- Louisiana Reporting:** None of the components are listed.
- Louisiana Spill:** None of the components are listed.
- Massachusetts Spill:** None of the components are listed.
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- New Jersey Spill:** None of the components are listed.
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- New York Toxic Chemical Release Reporting:** None of the components are listed.
- Pennsylvania RTK Hazardous Substances:** The following components are listed: HYDROGEN; HELIUM
- Rhode Island Hazardous Substances:** None of the components are listed.

Canada

WHMIS (Canada)

- Class A:** Compressed gas.
- Class B-1:** Flammable gas.
- CEPA Toxic substances:** None of the components are listed.
- Canadian ARET:** None of the components are listed.
- Canadian NPRI:** None of the components are listed.
- Alberta Designated Substances:** None of the components are listed.
- Ontario Designated Substances:** None of the components are listed.
- Quebec Designated Substances:** None of the components are listed.

Section 16. Other information

United States

Label requirements

- FLAMMABLE GAS.**
- MAY CAUSE FLASH FIRE.**
- CONTENTS UNDER PRESSURE.**

Canada

Label requirements

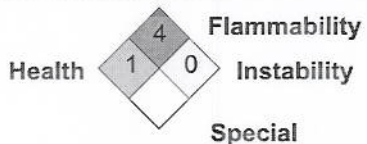
- Class A:** Compressed gas.
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Hazardous Material Information System (U.S.A.)

Health	1
Flammability	4
Physical hazards	0

Flammable Gas Mixture: Helium 1-96.1% / Hydrogen 3.9-99%

National Fire Protection Association (U.S.A.) :



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