SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1. Product identifier : Hydrogen Refrigerated

CAS No. : 1333-74-0

Chemical formula : H2

Synonyms : Hydrogen (refrigerated), Cryogenic Liquid Hydrogen, Liquid Hydrogen

REACH Registration Number: Listed in Annex IV / V REACH, exempted from registration.

1.2. Relevant identified uses of the substance or mixture and uses advised against

Use of the Substance/Mixture : Industrial and professional use. Perform risk assessment prior to use.

Restrictions on Use : Not for consumer use.

1.3. Details of the supplier of the safety data sheet : Air Products Ireland Ltd
Unit 950 Western Industrial Estate
Kileen Road
Dublin 12
Ireland

Email Address – Technical Information : GASTECH@airproducts.com

Telephone : 1-4659650

1.4. Emergency telephone number : (01) 463 4200 / +353 1 463 4200

SECTION 2: Hazards identification

2.1. Classification of the substance or mixture

Flammable gases - Category 1A H220:Extremely flammable gas.
Gases under pressure - Refrigerated liquefied gas. H281:Contains refrigerated gas; may cause cryogenic burns or injury.

2.2. Label elements

Hazard pictograms/symbols

Signal Word: Danger

Hazard Statements:

H220:Extremely flammable gas.
H281:Contains refrigerated gas; may cause cryogenic burns or injury.

Precautionary Statements:

Prevention	:	P210:Keep away from heat, hot surfaces, sparks, open flames, and other ignition sources. No smoking. P282:Wear cold insulating gloves/face shield/eye protection.
Response	:	P377 :Leaking gas fire: Do not extinguish, unless leak can be stopped safely. P381 :In case of leakage, eliminate all ignition sources. P336 :Thaw frosted parts with lukewarm water. Do not rub affected area. P315 :Get immediate medical advice/attention.
Storage	:	P403:Store in a well-ventilated place.

2.3. Other hazards

Burns with an invisible flame.
Can ignite on contact with air.
Extremely cold liquid and gas under pressure.
Extremely flammable liquefied gas.
Vapors may spread long distances and ignite.
Direct contact with liquid can cause frostbite.
Avoid breathing gas.
Can cause rapid suffocation.
Self-contained breathing apparatus (SCBA) may be required.
High concentrations that can cause rapid suffocation are within the flammable range and should not be entered.
Immediate fire and explosion hazard exists when mixed with air at concentrations exceeding the lower flammability limit (LFL).
Substance does not meet the criteria for PBT and vPvB according to Regulation (EC) No 1907/2006, Annex XIII.

SECTION 3: Composition/information on ingredients

3.1. Substances

Components	EINECS / ELINCS Number	CAS Number	Concentration (Volume)
Hydrogen	215-605-7	1333-74-0	100 %

Components	Classification (CLP)	REACH Reg. #
Hydrogen	Flam. gas 1A ;H220 Press. Gas (Ref. liq.) ;H281	*1

*1:Listed in Annex IV / V REACH, exempted from registration.
*2:Registration not required: substance manufactured or imported < 1 t/y.
*3:Registration not required: substance manufactured or imported < 1 t/y for non-intermediate uses.

Refer to section 16 for full text of each relevant hazard statement (H).

Concentration is nominal. For the exact product composition, please refer to technical specifications.

3.2. Mixtures : Not applicable.

SECTION 4: First aid measures

4.1. Description of first aid measures

General advice : Remove victim to uncontaminated area wearing self-contained breathing apparatus. Keep victim warm and rested. Call a doctor. Apply artificial respiration if breathing stopped.

Eye contact : In the case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
Keep eye wide open while rinsing. Seek medical advice.

Skin contact : In case of frostbite, obtain medical treatment immediately. Wash frost-bitten areas with plenty of water. Do not remove clothing. Cover wound with sterile dressing. Do not rub frozen parts as tissue damage may result. As soon as practical, place the affected area in a warm water bath- which has a temperature not to exceed 40 °C (105 °F).

Ingestion : Ingestion is not considered a potential route of exposure.

Inhalation : Move to fresh air. In case of shortness of breath, give oxygen. If breathing has stopped or is labored, give assisted respirations. Supplemental oxygen may be indicated. If the heart has stopped, trained personnel should begin cardiopulmonary resuscitation immediately.

4.2. Most important symptoms and effects, both acute and delayed

Symptoms : Exposure to oxygen deficient atmosphere may cause the following symptoms: Dizziness. Salivation. Nausea. Vomiting. Loss of mobility/consciousness.

4.3. Indication of any immediate medical attention and special treatment needed

Treatment : If exposed or concerned: Get medical attention/advice.

SECTION 5: Firefighting measures

5.1. Extinguishing media

Suitable extinguishing media : Shutting off the source of the gas is the preferred method of control.
Be aware of the risk of formation of static electricity with the use of CO2 extinguishers and do not use them in places where a flammable atmosphere may be present.

Extinguishing media which must not be used for safety reasons. : Do not use water jet to extinguish.

5.2. Special hazards

: Ignitable by static electricity. Burns with an invisible flame. Gas is lighter than air and can accumulate in the upper sections of enclosed spaces. Spill will rapidly

arising from the substance or mixture		vaporize and create an immediate flammable atmosphere. Move away from container and cool with water from a protected position. Keep containers and surroundings cool with water spray. Do not direct water spray at container vent. Do not extinguish a leaking gas flame unless absolutely necessary. Spontaneous/explosive re-ignition may occur. Extinguish any other fire. If possible, shut off the source of gas and allow the fire to burn itself out. Vapor cloud may obscure visibility.
5.3. Advice for firefighters	:	In confined space use self-contained breathing apparatus. Standard protective clothing and equipment (Self Contained Breathing Apparatus) for fire fighters. Standard EN 137 - Self-contained open-circuit compressed air breathing apparatus with full face mask. Standard EN 469 - Protective clothing for firefighters. Standard - EN 659: Protective gloves for firefighters.
Further information	:	The presence of a hydrogen flame can be detected by approaching cautiously with an outstretched straw broom to make the flame visible.

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures	:	Evacuate personnel to safe areas. Approach suspected leak areas with caution. Remove all sources of ignition. Ventilate the area. Never enter a confined space or other area where the flammable gas concentration is greater the 10% of its lower flammable limit.
6.2. Environmental precautions	:	Prevent further leakage or spillage if safe to do so. Prevent from entering sewers, basements and workpits, or any place where its accumulation can be dangerous. Do not discharge into any place where its accumulation could be dangerous.
6.3. Methods and material for containment and cleaning up	:	Ventilate the area. Do not spray water directly at leak.
Additional advice	:	If possible, stop flow of product. Increase ventilation to the release area and monitor concentrations. Do not direct water spray at container vent. Liquid spillages can cause embrittlement of struc tural materials. If leak is from cylinder or cylinder valve, call the emergency telephone number. If the leak is in the user's system, close the cylinder valve, safely vent the pressure, and purge with an inert gas before attempting repairs.
6.4. Reference to other sections	:	For more information refer to Sections 8 & 13

SECTION 7: Handling and storage

7.1. Precautions for safe handling

May ignite if valve is opened to air. Know and understand the properties and hazards of the product before use. Before using the product, determine its identity by reading the label. Do not remove or deface labels provided by the supplier for the identification of the cylinder contents. Before connecting the container, check the complete gas system for suitability, particularly for pressure rating and materials. Before connecting the container for use, ensure that back feed from the system into the container is prevented. Close container valve after each use and when empty, even if still connected to equipment. Never attempt to repair or modify container valves or safety

relief devices. Damaged valves should be reported immediately to the supplier. If user experiences any difficulty operating cylinder valve discontinue use and contact supplier. Do not remove or interchange connections. Only transfer lines designed for cryogenic liquids shall be used. Do not smoke while handling product or cylinders. Ensure the complete gas system has been checked for leaks before use. Prevent entrapment of cryogenic liquid in closed systems not protected with relief device. When moving cylinders, even for short distances, use a cart (trolley, hand truck, etc.) designed to transport cylinders. When doubt exists as to the correct handling procedure for a particular gas, contact the supplier. Employ suitable pressure regulating devices on all containers when the gas is being emitted to systems with lower pressure rating than that of the container. Do not subject containers to abnormal mechanical shock. Remove all sources of ignition. Ensure equipment is adequately earthed.

7.2. Conditions for safe storage, including any incompatibilities

Do not allow storage temperature to exceed 50°C (122°F). Containers should be stored in a purpose build compound which should be well ventilated, preferably in the open air. Do not store in a confined space. Full containers should be stored so that oldest stock is used first. Full and empty cylinders should be segregated. Store containers in location free from fire risk and away from sources of heat and ignition. Return empty containers in a timely manner. Stored containers should be periodically checked for general condition and leakage. Protect containers stored in the open against rusting and extremes of weather. Containers should not be stored in conditions likely to encourage corrosion. All vents should be piped to the exterior of the building. Cryogenic containers are equipped with pressure relief devices to control internal pressure. Under normal conditions these containers will periodically vent product. Display "No Smoking or Open Flames" signs in the storage areas. Flammable storage areas should be separated from oxygen and other oxidizers by a minimum distance of 20 ft. (6.1 m.) or by a barrier of non-combustible material at least 5 ft. (1.5 m.) high, having a fire resistance rating of at least 1/2 hour. All electrical equipment should be explosion-proo f in the storage areas. Smoking should be prohibited within storage areas or while handling product or containers. Observe all regulations and local requirements regarding storage of containers.

7.3. Specific end use(s)

Refer to section 1 or the extended SDS if applicable.

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

If applicable, refer to the extended section of the SDS for further information on CSA.

DNEL: Derived no effect level (Workers)
None available.

PNEC: predicted no effect concentration
None available.

8.2. Exposure controls

Engineering measures

Provide natural or explosion-proof ventilation that is adequate to ensure flammable gas does not reach its lower explosive limit.
Use explosion-proof equipment.
Keep self-contained breathing apparatus readily available for emergency use.

Personal protective equipment

Respiratory protection : High concentrations that can cause rapid suffocation are within the flammable range and should not be entered. Self contained breathing apparatus (SCBA) or positive pressure airline with mask are to be used in oxygen-deficient

atmospheres. Users of breathing apparatus must be trained.

Hand protection	:	Wear work gloves when handling gas containers. Standard EN 388 - Protective gloves against mechanical risk. If the operation involves possible exposure to a cryogenic liquid, wear loose fitting thermal insulated or cryo-gloves. Standard EN 511 - Cold insulating gloves.
Eye/face Protection	:	Safety glasses recommended when handling cylinders. Wear goggles and a face shield when transfilling or breaking transfer connections. Standard EN 166 - Personal eye-protection.
Skin and body protection	:	Never allow any unprotected part of the body to touch uninsulated pipes or vessels which contain cryogenic fluids. The extremely cold metal will cause the flesh to stick fast and tear when one attempts to withdraw from it. Safety shoes are recommended when handling cylinders. Standard EN ISO 20345 - Personal protective equipment - Safety footwear. Consider the use of flame resistant anti-static safety clothing. Standard EN ISO 14116 - Limited flame spread materials. Standard EN ISO 1149-5 - Protective clothing: Electrostatic properties.
Special instructions for protection and hygiene	:	Ensure adequate ventilation, especially in confined areas.
Environmental Exposure Controls	:	If applicable, refer to the extended section of the SDS for further information on CSA.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

(a/b) Physical state/Colour	:	Liquefied gas. Colorless.
(c) Odour	:	Odorless.
(e) Relative Density	:	0.07 (water = 1)
(f) Melting point / freezing point	:	-435 °F (-259.2 °C)
(g) Boiling point/range	:	-423 °F (-253 °C)
(h) Vapor pressure	:	Not applicable.
(i) Water solubility	:	0.0016 g/l
(j) Partition coefficient: n-octanol/water [log Kow]	:	Not applicable for inorganic gases.
(k) pH	:	Not applicable for gases and gas mixtures.
(l) Viscosity	:	No reliable data available.
(m) Particle characteristics	:	Not applicable for gases and gas mixtures.

(n) Upper and lower explosion / flammability limits	:	77 %(V) / 4 %(V)
(o) Flash point	:	Not applicable for gases and gas mixtures.
(p) Autoignition temperature	:	560 °C
(q) Decomposition temperature	:	Not applicable.

9.2. Other information

Explosive properties	:	Not applicable.
Oxidizing properties	:	Not applicable.
Molecular Weight	:	2 g/mol
Odor threshold	:	Odour threshold is subjective and inadequate to warn of overexposure.
Evaporation rate	:	Not applicable for gases and gas mixtures.
Flammability (solid, gas)	:	Refer to product classification in Section 2
Upper flammability limit	:	77 %(V)
Lower flammability limit	:	4 %(V)
Relative vapor density	:	0.07 (air = 1) Lighter or similar to air.

SECTION 10: Stability and reactivity

10.1. Reactivity	:	No reactivity hazard other than the effects described in sub-sections below.
10.2. Chemical stability	:	Stable under normal conditions.
10.3. Possibility of hazardous reactions	:	No data available.
10.4. Conditions to avoid	:	Heat, flames and sparks.
10.5. Incompatible materials	:	Oxygen. Oxidizing agents. Materials such as carbon steel, low alloy carbon steel and plastic become brittle at low temperatures and are subject to failure. Use appropriate materials compatible with the cryogenic conditions present in refrigerated liquefied gas systems.
10.6. Hazardous	:	Under normal conditions of storage and use, hazardous decomposition products

decomposition products should not be produced.

SECTION 11: Toxicological information

11.1. Information on toxicological effects

Likely routes of exposure

Effects on Eye	:	Contact with liquid may cause cold burns/frostbite.
Effects on Skin	:	Contact with liquid may cause cold burns/frostbite. May cause severe frostbite.
Inhalation Effects	:	In high concentrations may cause asphyxiation. Symptoms may include loss of mobility/consciousness. Victim may not be aware of asphyxiation. Asphyxiation may bring about unconsciousness without warning and so rapidly that victim may be unable to protect themselves.
Ingestion Effects	:	Ingestion is not considered a potential route of exposure.
Symptoms	:	Exposure to oxygen deficient atmosphere may cause the following symptoms: Dizziness. Salivation. Nausea. Vomiting. Loss of mobility/consciousness.

Acute toxicity

Acute Oral Toxicity	:	No data is available on the product itself.
Acute Inhalation Toxicity	:	No data is available on the product itself.
Acute Dermal Toxicity	:	No data is available on the product itself.
Skin corrosion/irritation	:	No data available.
Serious eye damage/eye irritation	:	No data available.
Sensitization.	:	No data available.

Chronic toxicity or effects from long term exposures

Carcinogenicity	:	No data available.
Reproductive toxicity	:	No data is available on the product itself.
Germ cell mutagenicity	:	No data is available on the product itself.
Specific target organ systemic toxicity (single exposure)	:	No data available.
Specific target organ systemic toxicity (repeated exposure)	:	No data available.
Aspiration hazard	:	No data available.

SECTION 12: Ecological information

12.1. Toxicity

Aquatic toxicity	:	Not applicable.
Toxicity to other organisms	:	Not applicable.

12.2. Persistence and degradability

No data available.

12.3. Bioaccumulative potential

Refer to Section 9 "Partition Coefficient (n-octanol/water)".

12.4. Mobility in soil

Because of its high volatility, the product is unlikely to cause ground pollution.

12.5. Results of PBT and vPvB assessment

If applicable, refer to the extended section of the SDS for further information on CSA.

12.6. Other adverse effects

When discharged in large quantities may contribute to the greenhouse effect.

Effect on the ozone layer	:	No known effects from this product.
Ozone Depleting Potential	:	None
Effect on global warming	:	When discharged in large quantities may contribute to the greenhouse effect.
Global Warming Potential	:	6

SECTION 13: Disposal considerations

13.1. Waste treatment methods	:	Return unused product in original cylinder to supplier. Contact supplier if guidance is required. Do not discharge into areas where there is a risk of forming an explosive mixture with air. Waste gas should be flared through a suitable burner with flash back arrestor. Refer to the EIGA code of practice Doc. 30 "Disposal of Gases", downloadable at http://www.eiga.org for more guidance on suitable disposal methods. List of hazardous waste codes: 16 05 04*: gases in pressure containers (including halons) containing hazardous substances.
Contaminated packaging	:	Return cylinder to supplier.

SECTION 14: Transport information

14.1. UN number

UN/ID No. : UN1966

14.2. UN proper shipping name

Transport by road/rail (ADR/RID) : HYDROGEN, REFRIGERATED LIQUID
Transport by air (ICAO-TI / IATA-DGR) : Hydrogen, refrigerated liquid
Transport by sea (IMDG) : HYDROGEN, REFRIGERATED LIQUID

14.3. Transport hazard class(es)

Label(s) : 2.1

Transport by road/rail (ADR/RID)
Class or Division : 2
ADR/RID Hazard ID no. : 223
Tunnel Code : (B/D)

Transport by sea (IMDG)
Class or Division : 2.1

14.4. Packing group

Transport by road/rail (ADR/RID) : Not applicable.
Transport by air (ICAO-TI / IATA-DGR) : Not applicable.
Transport by sea (IMDG) : Not applicable.

14.5. Environmental hazards

Transport by road/rail (ADR/RID)
Marine Pollutant : No

Transport by air (ICAO-TI / IATA-DGR)
Marine Pollutant : No

Transport by sea (IMDG)
Marine Pollutant : No
Segregation Group : None

14.6. Special precautions for user

Transport by air (ICAO-TI / IATA-DGR)
Passenger and Cargo Aircraft : Transport forbidden
Cargo Aircraft only : Transport forbidden

Further Information
Avoid transport on vehicles where the load space is not separated from the driver's compartment. Ensure vehicle driver is aware of the potential hazards of the load and knows what to do in the event of an accident or an emergency. The transportation information is not intended to convey all specific regulatory data relating to this material. For complete transportation information, contact customer service.

14.7. Transport in bulk according to Annex II of Marpol and the IBC Code

Not applicable.

SECTION 15: Regulatory information

15.1. Safety, health and environmental regulations/legislation specific for the substance or mixture

Country	Regulatory list	Notification
USA	TSCA	Included on Inventory.
EU	EINECS	Included on Inventory.
Canada	DSL	Included on Inventory.
Australia	AICS	Included on Inventory.
South Korea	ECL	Included on Inventory.
China	SEPA	Included on Inventory.
Philippines	PICCS	Included on Inventory.
Japan	ENCS	Included on Inventory.

Other Regulations
REGULATION (EC) No 1907/2006 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC.

COMMISSION REGULATION (EU) 2015/830 of 28 May 2015 amending Regulation (EC) No 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH).

Regulation (EC) No 1272/2008 the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006.

15.2. Chemical safety assessment

A CSA does not need to be carried out for this product.

SECTION 16: Other information

Ensure all national/local regulations are observed.

Hazard Statements:
H220 Extremely flammable gas.
H281 Contains refrigerated gas; may cause cryogenic burns or injury.

Indication of Method:
Flammable gases Category 1A Extremely flammable gas. Calculation method

Gases under pressure Refrigerated liquefied gas. Contains refrigerated gas; may cause cryogenic burns or injury. Calculation method

Abbreviations and acronyms:

ATE - Acute Toxicity Estimate
CLP - Classification Labelling Packaging Regulation; Regulation (EC) No 1272/2008
REACH - Registration, Evaluation, Authorisation and Restriction of Chemicals Regulation (EC) No 1907/2006
EINECS - European Inventory of Existing Commercial Chemical Substances
ELINCS - European List of Notified Chemical Substances
CAS# - Chemical Abstract Service number
PPE - Personal Protection Equipment
Kow - octanol-water partition coefficient
DNEL - Derived No Effect Level
LC50 - Lethal Concentration to 50 % of a test population
LD50 - Lethal Dose to 50% of a test population (Median Lethal Dose)
NOEC - No Observed Effect Concentration
PNEC - Predicted No Effect Concentration
RMM - Risk Management Measure
OEL - Occupational Exposure Limit
PBT - Persistent, Bioaccumulative and Toxic
vPvB - Very Persistent and Very Bioaccumulative
STOT - Specific Target Organ Toxicity
CSA - Chemical Safety Assessment
EN - European Standard
UN - United Nations
ADR - European Agreement concerning the International Carriage of Dangerous Goods by Road
IATA - International Air Transport Association
IMDG - International Maritime Dangerous Goods
RID - Regulations concerning the International Carriage of Dangerous Goods by Rail
WGK - Water Hazard Class

Key literature references and sources for data:
ECHA - Guidance on the compilation of safety data sheets
ECHA - Guidance on the application of the CLP Criteria
ARIEL database

Prepared by : Air Products and Chemicals, Inc. Global EH&S Department

For additional information, please visit our Product Stewardship web site at
http://www.airproducts.com/productstewardship/

This Safety Data Sheet has been established in accordance with the applicable European Directives and applies to all countries that have translated the Directives in their national laws. COMMISSION REGULATION (EU) 2015/830 of 28 May 2015 amending Regulation (EC) No 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH).

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