< 15% SILANE In HYDROGEN
Material Safety Data Sheet

1. PRODUCT AND COMPANY IDENTIFICATION

Product Name < 15% SILANE In HYDROGEN
Product Code(s) G-198
UN-Number UN1954
Recommended Use Electronics.

Supplier Address* Linde Gas North America LLC  -  Linde Merchant Production Inc.  - Linde LLC
575 Mountain Ave.
Murray Hill, NJ 07974
Phone: 908-464-8100
www.lindeus.com

Linde Gas Puerto Rico, Inc.
Las Palmas Village
Road No. 869, Street No. 7
Catano, Puerto Rico 00962
Phone: 787-641-7445
www.pr.lindegas.com

Linde Canada Limited
5860 Chedworth Way
Mississauga, Ontario L5R 0A2
Phone: 905-501-1700
www.lindecanada.com

* May include subsidiaries or affiliate companies/divisions.

For additional product information contact your local customer service.

Chemical Emergency Phone Number Chemtrec: 1-800-424-9300 for US/ 703-527-3887 outside US

2. HAZARDS IDENTIFICATION

DANGER!

Emergency Overview
Extremely flammable
Pyrophoric gas-Dangerous fire and explosion hazard.
Irritating to eyes, respiratory system and skin
Contents under pressure
Keep at temperatures below 52°C / 125°F

Appearance Colorless. Physical State Compressed gas. Odor Pungent

OSHA Regulatory Status This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Potential Health Effects
Principle Routes of Exposure
Inhalation. Eye contact. Skin contact.

Acute Toxicity
Inhalation
May cause irritation of respiratory tract. Exposure to silane may cause headache and nausea. The hydrolysis of silane in the body tissues would form silicic acid and hydrated silica.

Eyes
Contact may form silicic acid causing irritation.

Skin
Contact may form silicic acid causing irritation. Ignited gas can cause thermal burns.

Skin Absorption Hazard
No known hazard in contact with skin.

Ingestion
Not an expected route of exposure. May cause irritation.

Chronic Effects
None known.

Aggravated Medical Conditions
Skin disorders. Respiratory disorders. Pre-existing eye disorders.

Environmental Hazard
See Section 12 for additional Ecological Information.

3. COMPOSITION/INFORMATION ON INGREDIENTS

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>CAS-No</th>
<th>Volume %</th>
<th>Chemical Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td>1333-74-0</td>
<td>&gt; 85</td>
<td>H₂</td>
</tr>
<tr>
<td>Silane</td>
<td>7803-62-5</td>
<td>&lt; 15</td>
<td>SiH₄</td>
</tr>
</tbody>
</table>

Additional information: Composition listed covers broad ranges rather than exact percentages for specific products.

4. FIRST AID MEASURES

General Advice
Call 911 or emergency medical service. Remove and isolate contaminated clothing and shoes.

Eye Contact
Immediately flush with plenty of water. After initial flushing, remove any contact lenses and continue flushing for at least 15 minutes. Call a physician immediately.

Skin Contact
Wash off immediately with plenty of water for at least 15 minutes. Seek immediate medical attention/advice.

Inhalation
PROMPT MEDICAL ATTENTION IS MANDATORY IN ALL CASES OF INHALATION OVEREXPOSURE. RESCUE PERSONNEL SHOULD BE EQUIPPED WITH SELF-CONTAINED BREATHING APPARATUS. Conscious inhalation victims should be assisted to an uncontaminated area and inhale fresh air. If breathing is difficult, administer oxygen. Unconscious persons should be moved to an uncontaminated area and, as necessary, given artificial resuscitation and supplemental oxygen. Treatment should be symptomatic and supportive.

Ingestion
None under normal use. Get medical attention if symptoms occur.

Notes to Physician
Treat symptomatically.

Protection of First-aiders
Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

5. FIRE-FIGHTING MEASURES

Flammable Properties
Spontaneously combustible (pyrophoric). May be spontaneously flammable in air. Containers may explode when heated.
Suitable Extinguishing Media
Carbon dioxide (CO2). Foam. Dry powder. DO NOT EXTINGUISH A LEAKING GAS FIRE UNLESS LEAK CAN BE STOPPED.

Unsuitable Extinguishing Media
Do not use halogenated extinguishing agents or foam.

Hazardous Combustion Products
Silicon dioxide.

Explosion Data
Sensitivity to Mechanical Impact
None

Sensitivity to Static Discharge
Yes.

Specific Hazards Arising from the Chemical
Silane is a pyrophoric gas that will generally spontaneously ignite upon contact with air. For spontaneous ignition, however, certain silane concentrations, turbulence, and temperature of the mixture must be satisfied. The greatest hazard of Silane is its unpredictable behavior when released into the air. Continue to cool fire exposed cylinders until flames are extinguished. Cylinders may rupture under extreme heat. Damaged cylinders should be handled only by specialists.

Protective Equipment and Precautions for Firefighters
If possible, stop the flow of gas. Do not extinguish the fire until supply is shut off as otherwise an explosive-ignition may occur. If the fire is extinguished and the flow of gas continues, use increased ventilation to prevent build-up of explosive atmosphere. Ventilation fans must be explosion proof. Use non-sparking tools to close container valves.

Isolate spill or leak area for at least 100 meters (330 feet) in all directions. Vapors may accumulate in confined areas (basement, tanks, hopper/tank cars, etc.). Vapors may travel to source of ignition and flash back. For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible withdraw from area and let fire burn.

Use water spray to cool surrounding containers. Be cautious of a Boiling Liquid Evaporating Vapor Explosion, BLEVE, if flame is impinging on surrounding containers.

As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautions
ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). All equipment used when handling the product must be grounded. Use personal protective equipment. Do not touch or walk through spilled material. Stop leak if you can do it without risk. Releases of Silane into air can produce silicon dioxide.

Environmental Precautions
Prevent spreading of vapors through sewers, ventilation systems and confined areas.

Methods for Containment
Stop the flow of gas or remove cylinder to outdoor location if this can be done without risk. If leak is in container or container valve, contact the appropriate emergency telephone number in Section 1 or call your closest Linde location.

Methods for Cleaning Up
Return cylinder to Linde or an authorized distributor.
7. HANDLING AND STORAGE

Handling

Handle in sealed, purged system. Ground and bond all lines and equipment associated with product system. All equipment should be non-sparking and explosion proof. Remove all sources of ignition. Use only in ventilated areas. "NO SMOKING" signs should be posted in storage and use areas.

Pure silane is non-corrosive and may be handled in most common structural containers. Carbon steel, stainless steel, brass, Monel® & Hasteloy C are most commonly used materials. It also compatible with ordinary glass, Pyrex®, and quartz. For gasket materials, Viton®, Nylon, Teflon®, and Kel-F® are all satisfactory. Most all silane leaks will ignite in air producing silicon dioxide. Occasionally the silicon dioxide will slow or stop the leak. Materials may accumulated behind outlet plug. Wear appropriate protective equipment and face outlet away when removing plug and connecting cylinder.

Never attempt to lift a cylinder by its valve protection cap. Protect cylinders from physical damage; do not drag, roll, slide or drop. When moving cylinders, even for short distance, use a cart designed to transport cylinders. Use equipment rated for cylinder pressure. Use backflow preventive device in piping.

Use an adjustable strap wrench to remove over-tight or rusted caps. Never insert an object (e.g. wrench, screwdriver, pry bar, etc.) into valve cap openings. Doing so may damage valve, causing leak to occur. If user experiences any difficulty operating cylinder valve discontinue use and contact supplier.

Never put cylinders into trunks of cars or unventilated areas of passenger vehicles. Never attempt to refill a compressed gas cylinder without the owner's written consent. Never strike an arc on a compressed gas cylinder or make a cylinder a part of an electrical circuit.

For additional recommendations, consult Compressed Gas Association's Pamphlet G-13.

Storage

Outside or detached storage is preferred. Protect from physical damage. Cylinders should be stored upright with valve protection cap in place and firmly secured to prevent falling. Store in cool, dry, well-ventilated area of non-combustible construction away from heavily trafficked areas and emergency exits. Keep at temperatures below 52°C / 125°F. Full and empty cylinders should be segregated. Use a "first in-first out" inventory system to prevent full cylinders from being stored for excessive periods of time. Always store and handle compressed gas cylinders in accordance with Compressed Gas Association, pamphlet CGA-P1, Safe Handling of Compressed Gases in Containers.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Exposure Guidelines

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>ACGIH TLV</th>
<th>OSHA PEL</th>
<th>NIOSH IDLH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silane 7803-62-5</td>
<td>TWA: 5 ppm</td>
<td>(vacated) TWA: 5 ppm (vacated)</td>
<td>TWA: 5 ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TWA: 7 mg/m³</td>
<td>TWA: 7 mg/m³</td>
</tr>
</tbody>
</table>

ACGIH TLV: American Conference of Governmental Industrial Hygienists - Threshold Limit Value. OSHA PEL: Occupational Safety and Health Administration - Permissible Exposure Limits. NIOSH IDLH: Immediately Dangerous to Life or Health.

Other Exposure Guidelines

Vacated limits revoked by the Court of Appeals decision in AFL-CIO v. OSHA, 965 F.2d 962 (11th Cir., 1992).

Engineering Measures

Showers. Eyewash stations. Explosion proof ventilation systems. Exhaust gas should be vented to a gas treatment system.

Ventilation

Use ventilation adequate to keep exposures below recommended exposure limits. Monitor cylinders with hydride monitors to detect leaks and releases along with UV/IR monitors for flame detection.

Personal Protective Equipment
Eye/Face Protection
For cylinder handling: safety glasses. For routine use (within 15 feet of Silane system): Safety glasses
and face shield. For emergency operations: Fire helmet with faceshield, fire resistant hood.

Skin and Body Protection
Work gloves and safety shoes are recommended when handling cylinders. Wear fire/flame
resistant/retardant clothing.

Respiratory Protection
General Use
If exposure limits are exceeded or irritation is experienced, NIOSH/MSHA approved respiratory
protection should be worn. Positive-pressure supplied air respirators may be required for high airborne
contaminant concentrations. Respiratory protection must be provided in accordance with current local
regulations.

Emergency Use
Use positive pressure air line respirator or self-contained breathing apparatus for exposure over
exposure limits or emergency use. For exposures above IDLH, an additional escape bottle is required.

Hygiene Measures
For routine system operations: Opening and closing valve or work within 15 ft. (4.6 m) of a Silane
system includes the following: hard hat, face shield, safety glasses, leather gloves, fire resistant
clothing/coveralls and safety shoes.

9. PHYSICAL AND CHEMICAL PROPERTIES

Product Information

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>Boiling Point</th>
<th>Melting Point</th>
<th>Molecular Weight</th>
<th>Evaporation Rate</th>
<th>Water Solubility</th>
<th>Vapor Pressure</th>
<th>Vapor Density</th>
<th>Gas Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silane</td>
<td>-112°C</td>
<td>-185°C (-301°F)</td>
<td>32.11</td>
<td>Negligible</td>
<td>Above critical temperature</td>
<td>1.11</td>
<td>1.342</td>
<td></td>
</tr>
<tr>
<td>Hydrogen</td>
<td>-252.8 °C</td>
<td>-259.2 °C</td>
<td>1.00</td>
<td>0.019 (vol/vol @ 20°C and 1 atm)</td>
<td>Above critical temperature</td>
<td>0.07</td>
<td>0.083</td>
<td></td>
</tr>
</tbody>
</table>

The following information is for the NON-INERT components of this mixture:

10. STABILITY AND REACTIVITY

Stability
Silane will ignite spontaneously in air

Incompatible Products
Silane is incompatible with: Oxidizing agents. Halogens. Alkalis.

Conditions to Avoid
Heat, flames and sparks. Explosive reaction/ignition on contact with covalent halides or halogens.
Ignites on contact with oxygen or air. Hydrogen is flammable or explosive when mixed with chlorine or
other oxidizing materials. Fluorine and hydrogen react at -418°F (-250°C) when impurities are present.
Chlorine/hydrogen mixtures explode if exposed to light. Lithium metal will burn in a hydrogen
atmosphere.

Hazardous Decomposition Products
Silicon dioxide. Hydrogen gas. at 788°F/420°C.
11. TOXICOLOGICAL INFORMATION

Acute Toxicity

Product Information

LD50 Oral: No information available.
LD50 Dermal: No information available.
LC50 Inhalation: No information available.

Inhalation

Toxicological data for silane in the open literature is extremely limited. Four out of ten mice died following inhalation of 9600 ppm for 4 hours. The four hour LC50 value for the rat has been cited as 4000 ppm and 9600 ppm. In the absence of subacute or chronic data for silane, the ACGIH TLV is based on silicon tetrahydride being one-tenth as toxic as germanium tetrahydride. The margin of safety associated with this TLV has yet to be determined.

Repeated Dose Toxicity

No information available.

Component Information

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>LD50 Oral</th>
<th>LD50 Dermal</th>
<th>LC50 Inhalation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td></td>
<td></td>
<td>&gt; 15000 ppm (Rat) 1 h</td>
</tr>
<tr>
<td>Silane</td>
<td></td>
<td>&gt; 9600 ppm (Rat) 4 h</td>
<td></td>
</tr>
</tbody>
</table>

Chronic Toxicity

Chronic Toxicity

None known.

Carcinogenicity

Contains no ingredient listed as a carcinogen.

Irritation

No information available.

Sensitization

No information available.

Reproductive Toxicity

No information available.

Developmental Toxicity

No information available.

Synergistic Materials

None known.

Target Organ Effects

Respiratory system. Central nervous system (CNS). Skin.

12. ECOLOGICAL INFORMATION

Ecotoxicity

The environmental impact of this product has not been fully investigated.

Ozone depletion potential; ODP; (R-11 = 1): Does not contain ozone depleting chemical (40 CFR Part 82).
13. DISPOSAL CONSIDERATIONS

Waste Disposal Methods
Do not attempt to dispose of residual waste or unused quantities. Return in the shipping container PROPERLY LABELED WITH ANY VALVE OUTLET PLUGS OR CAPS SECURED AND VALVE PROTECTION CAP IN PLACE to Linde for proper disposal.

Contaminated Packaging
Do not re-use empty containers.

14. TRANSPORT INFORMATION

DOT
Proper shipping name: Compressed gas, flammable, n.o.s.
Hazard Class: 2.1
Subsidiary Class: None
UN-Number: UN1954
Description: UN1954, Compressed gas, flammable, n.o.s. (Silane, Hydrogen), 2.1
Emergency Response Guide Number: 115

TDG
Proper Shipping Name: Compressed gas, flammable, n.o.s.
Hazard Class: 2.1
UN-Number: UN1954
Description: UN1954, COMPRESSED GAS, FLAMMABLE, N.O.S. (Silane, Hydrogen), 2.1

MEX
Proper Shipping Name: Compressed gas, flammable, n.o.s.
Hazard Class: 2.1
UN-Number: UN1954
Description: UN1954 Compressed gas, flammable, n.o.s. (Silane, Hydrogen), 2.1

IATA
UN-Number: UN1954
Proper Shipping Name: Compressed gas, flammable, n.o.s.
Hazard Class: 2.1
ERG Code: 10L
Description: UN1954, Compressed gas, flammable, n.o.s. (Silane, Hydrogen), 2.1
Maximum Quantity for Passenger: Forbidden
Maximum Quantity for Cargo Only: 150 kg
Limited Quantity: Forbidden

IMDG/IMO
Proper Shipping Name: Compressed gas, flammable, n.o.s.
Hazard Class: 2.1
UN-Number: UN1954
EmS No.: F-D, S-U
Description: UN1954, Compressed gas, flammable, n.o.s. (Silane, Hydrogen), 2.1

ADR
Proper Shipping Name: Compressed gas, flammable, n.o.s.
Hazard Class: 2.1
UN-Number: UN1954
15. REGULATORY INFORMATION

International Inventories

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>TSCA</td>
<td>Complies</td>
</tr>
<tr>
<td>DSL</td>
<td>Complies</td>
</tr>
<tr>
<td>EINECS/ELINCS</td>
<td>Complies</td>
</tr>
</tbody>
</table>

Legend

TSCA - United States Toxic Substances Control Act Section 8(b) Inventory
DSL/NDSL - Canadian Domestic Substances List/Non-Domestic Substances List
EINECS/ELINCS - European Inventory of Existing Commercial Chemical Substances/EU List of Notified Chemical Substances

U.S. Federal Regulations

SARA 313
Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). This product does not contain any chemicals which are subject to the reporting requirements of the Act and Title 40 of the Code of Federal Regulations, Part 372.

SARA 311/312 Hazard Categories

- Acute Health Hazard: Yes
- Chronic Health Hazard: No
- Fire Hazard: Yes
- Sudden Release of Pressure Hazard: Yes
- Reactive Hazard: Yes

Clean Water Act
This product does not contain any substances regulated as pollutants pursuant to the Clean Water Act (40 CFR 122.21 and 40 CFR 122.42).

Risk and Process Safety Management Programs
This material, as supplied, contains one or more regulated substances with specified thresholds under 40 CFR Part 68 or regulated as a highly hazardous chemical pursuant to the 29 CFR Part 1910.110 with specified thresholds:

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>U.S. - CAA (Clean Air Act) - Accidental Release Prevention - Toxic Substances</th>
<th>U.S. - CAA (Clean Air Act) - Accidental Release Prevention - Flammable Substances</th>
<th>U.S. - OSHA - Process Safety Management - Highly Hazardous Chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silane</td>
<td>-</td>
<td>10000 lbs</td>
<td>-</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>10000 lbs</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Clean Air Act, Section 112 Hazardous Air Pollutants (HAPs) (see 40 CFR 61)
This product does not contain any substances regulated as hazardous air pollutants (HAPs) under Section 112 of the Clean Air Act Amendments of 1990.

CERCLA/SARA
This material, as supplied, does not contain any substances regulated as hazardous substances under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (40 CFR 302) or the Superfund Amendments and Reauthorization Act (SARA) (40 CFR 355). There may be specific reporting requirements at the local, regional, or state level pertaining to releases of this material.

U.S. State Regulations
California Proposition 65
This product does not contain any Proposition 65 chemicals.

U.S. State Right-to-Know Regulations

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>Massachusetts</th>
<th>New Jersey</th>
<th>Pennsylvania</th>
<th>Illinois</th>
<th>Rhode Island</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silane</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>X</td>
</tr>
</tbody>
</table>

International Regulations

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>Carcinogen Status</th>
<th>Exposure Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silane</td>
<td>-</td>
<td>Mexico: TWA 5 ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mexico: TWA 7 mg/m³</td>
</tr>
</tbody>
</table>

Canada
This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all the information required by the CPR.

WHMIS Hazard Class
A Compressed gases
B1 Flammable gas
D2B Toxic materials

16. OTHER INFORMATION

Prepared By
Product Stewardship
23 British American Blvd.
Latham, NY 12110
1-800-572-6501

Issuing Date
26-May-2011

Revision Date

Revision Number
0

Revision Note
Initial Release.

<table>
<thead>
<tr>
<th>NFPA</th>
<th>Health Hazard 1</th>
<th>Flammability 4</th>
<th>Stability 1</th>
<th>Physical and Chemical Hazards -</th>
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</thead>
<tbody>
<tr>
<td>HMIS</td>
<td>Health Hazard 0</td>
<td>Flammability 4</td>
<td>Physical Hazard 3</td>
<td>Personal Protection -</td>
</tr>
</tbody>
</table>

Note: Ratings were assigned in accordance with Compressed Gas Association (CGA) guidelines as published in CGA Pamphlet P-19-2009, CGA Recommended Hazard Ratings for Compressed Gases, 3rd Edition.
General Disclaimer
For terms and conditions, including limitation of liability, please refer to the purchase agreement in effect between Linde LLC, Linde Merchant Production, Inc. or Linde Gas North America LLC (or any of their affiliates and subsidiaries) and the purchaser.

DISCLAIMER OF EXPRESSED AND IMPLIED WARRANTIES
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End of Safety Data Sheet