

# Silane

Storage And Dispense

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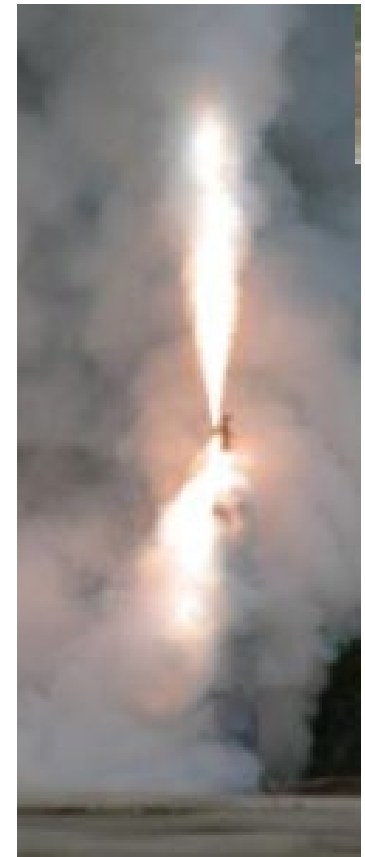
# Silane Properties

- Silicon Tetrahydride -  $\text{SiH}_4$
- CAS # 7803-62-5
- Molecular Weight 32.11
- Gas Density - 0.084 lb/ft<sup>3</sup>
- Boiling Point - -169.6°F
- Vapor Density - 1.11
- Specific Gravity in Air at 1 ATM & 70°F - 1.2
- TNT Equivalent - 1 lb of Silane equal 6 lbs of TNT




# Flame Temperature

- Lower Flammability Limit <3% Silane
  - Flame Temperature  $\sim 800^{\circ}\text{F}$
- Stoichiometric Mixture in Air (9.51% Silane)
  - Flame and Smoke is White
  - Flame Temperature  $\sim 4400^{\circ}\text{F}$




# Hazard Category

- Pyrophoric:**  
*Auto-ignition Temperature <130°F (2012 IFC Chapter 64)*
- Unstable Reactive Class 1**  
*Unstable reactive materials may react spontaneously with themselves, other chemicals or when exposed to light, heat, cold, moisture, air or physical shock (2012 IFC Chapter 66)*



## The HMEx Assistant Chemical Classification



	C.A.S. No.	Concentration	State	RTECS
	7803-62-5	100%	Gas	VVI400000

<b>Boiling Point</b>	-168.5 F	<b>LD 50</b>	NA	<b>Molecular Weight</b>	32.12
<b>Melting Point</b>	-301 F	<b>LC 50</b>	19,000P	<b>Specific Gravity</b>	0.71
<b>Flash Point</b>	ND	<b>LFL/LEL</b>	1.37	<b>Vapor Density</b>	1.11
<b>Autoignition Temp.</b>	-58 F	<b>UFL/UEL</b>	96.00	<b>Vapor Pressure</b>	ND

**IUPAC Name**

silane

**Synonyms**

silicon tetrahydride  
silicane  
monosilane  
silicon hydride

IFG Physical Hazards	IFG Health Hazards
Pyrophoric Unstable Reactive Class 1	

**DOT**

**Shipping Name**  
Silane

**Labels Required**  
FLAMMABLE GAS

**Hazard Class or Division** 2.1


**ID #** UN2203

**SARA**

**CAA Section 112 Threshold Quantity** 10,000

**Notes**

Air mixtures can detonate if released into confinement  
 Specific Gravity (liquid) at -185 degrees Centigrade  
 LC50 ihl-rat LC50: 9600 ppm/4H



# Silane Hazard

## Metastable

*Silane is a unique hazardous material in that it is also metastable, meaning that it can have delayed ignition. This metastable characteristic is dangerous because it allows a volume of gas to accumulate inside of an enclosure. In such cases, a deflagration or detonation can occur, which can cause structural damage to the facility and seriously injure or kill individuals located close to the release.*



# Silane in Air

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## 100% Silane

- $< 1.37\%$  - Non Hazardous Gas
- $>1.37\%$  -  $<4.1\%$  - Flammable Gas
- $>4.1\%$  - Pyrophoric Gas
- $>4.1\%$  -  $38\%$  Metastable Pyrophoric Gas

Percentages vary slightly with Carrier Gas

# Silane Release Reactions

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- **Prompt ignition**
- **Ignition during flow decay:** Gradual reduction of flow such as that with no supply connected to line with the leak.
- **Ignition at shutoff (delayed ignition):** Abrupt stop of RFO controlled flow.
- **Bulk auto-ignition:** Large amount of silane released unreacted. Reaching concentration of 4.1-4.5%, mixture becomes metastable and will auto-ignite (No ignition source needed) after a delay

# Fire and Building Code

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- Section 6405.3 of the 2015 International Fire Code addresses Silane Gas Storage and dispense. This section indicates “The use of silane gas and gas mixtures with a silane concentration of 1.37% or more by volume, shall be in accordance with *Compressed Gas Association (CGA) standard, G-13*”.



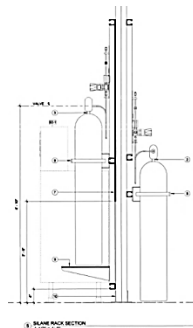
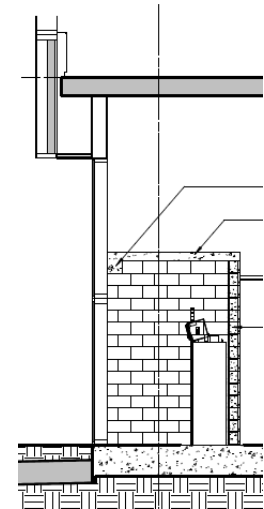
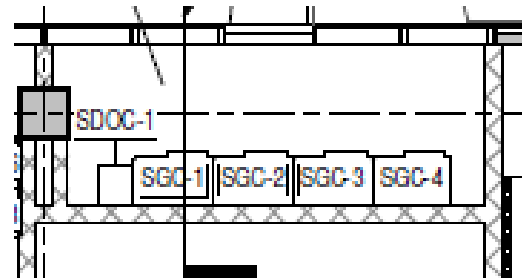
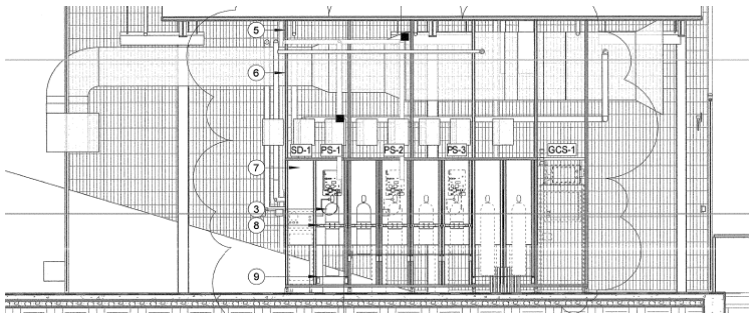
# Standards and Design Guides

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- **NFPA 318:** *“Standard for the Protection of Semiconductor Fabrication Facilities”*
- **NFPA 69:** *“Standard on Explosion Prevention Systems”*
- **NFPA 495:** *“Explosive Materials Code”*
- **FM Global Data Sheet 1-108:** *“Silane”*
- **FM Global Data Sheet 1-44:** *“Damage Limiting Construction”*

# Silane Storage

- Two Storage Options
  - Indoor Storage
  - Outdoor Storage



# Indoor Storage

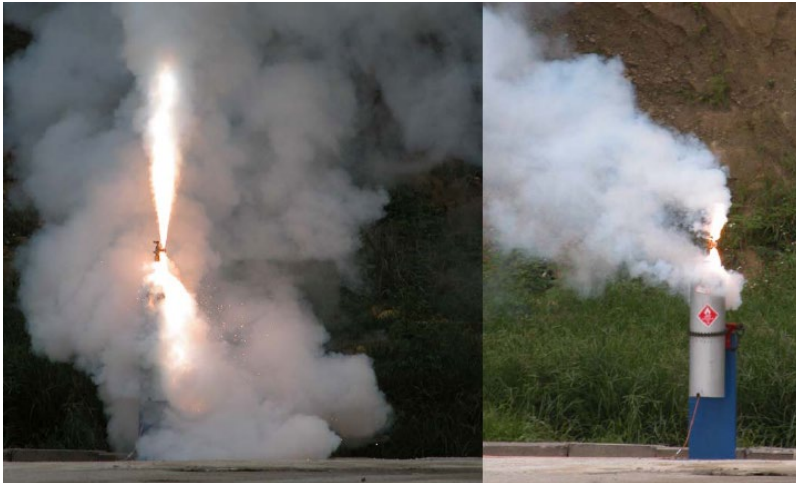
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- Prescriptive Design Requirements
  - Risk of Deflagration or Detonation
  - Silane Specific Gas Cabinets
  - Requires Blast Relief
  - Reduce Room Volume
  - Volume of Silane limited by Room Occupancy

# Indoor Design Requirements

- Requires Over Pressure (Blast) Calculations on Room with Relief Panels (if Silane Quantity  $>0.05\text{SCF}$ )
  - Wall Construction 100 – 150PSF (Determined by Blast Calc)
  - 25% of room walls MUST be on perimeter of Building
  - Keep Room Volume as Small as Possible
  - Blast Relief Panels Required
  - Blast Resistant Doors / Hardware (2 Exits required if room is  $>200\text{sf}$ )
  - Fenced Exclusion zone required
  - .006” RFO w/ Pneumatic Shut-off at cylinder Recommended

# Impacts of Restrictive Flow Orifice



No RFO (Left)

0.10" RFO (Right)

Excerpt from CGA G-13, Table 5  
Impacts of RFO

	Typical gas cabinet RFO 0.006 in diameter (0.15 mm diameter)		Typical gas cabinet RFO 0.010 in diameter (0.25 mm diameter)	
	Silane flow (scfm)	Ventilation flow (scfm)	Silane flow (scfm)	Ventilation flow (scfm)
50	0.025	8	0.069	21
100	0.045	14	0.124	37
200	0.085	26	0.237	71
400	0.173	52	0.480	144
600	0.275	83	0.755	227
800	0.395	119	1.08	324
1000	0.555	167	1.51	453
1200	0.724	217	1.97	591
1500	0.913	274	2.50	750
1650	0.987	296	2.70	810

# Indoor Design Requirements

- Dedicated Exhaust and Make-up Air Systems Required
  - Exhaust Requirements:
    - 1 CFM / SF of floor area ( $\frac{1}{2}$  High &  $\frac{1}{2}$  Low)
    - Exhaust for each Cabinet Based on RO Size (per CGA G-13 Table 5)
    - Additional Exhaust based on one Open Gas Cabinet Window
    - Room to be maintained Negative to surrounding Building
  - Make-Up Air Requirements
    - 100% outside Air
    - Suggested Minimum Room Temperature - 40°F
    - Suggested Temperature Max Room Temperature – 90°F

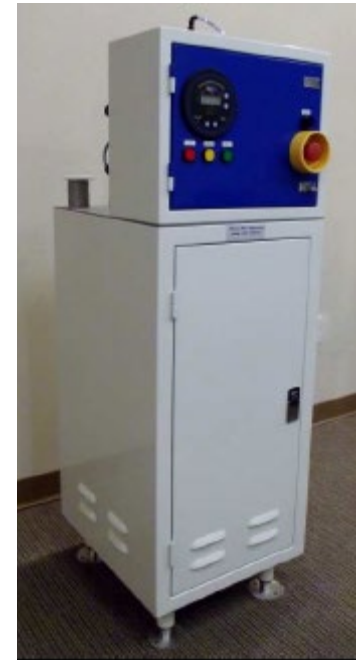
# Indoor Design Requirements

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- Dispense Silane from CGA G-13 Compliant Gas Cabinets Per CGA G-13 Section 8.2
  - ¼” Plate Separation above and Below Mechanical Joints
  - Fill Complement of Cylinder Life Safety and Process Controls
  - UVIR Detection for each Cylinders in Cabinets and in room
  - Gas Leak Detection
  - NO Pocketing (Dead Zones) (Per CGA G-13 Section 13.2.3.2)
  - Each Cabinet to have Fire Sprinklers (Quick Response Heads)
  - Additionally, room shall be sprinkered with not less than Extra Hazard Group 1 coverage

# Indoor Design Requirements

- Silane Distribution Tubing:
  - Installed per ASME B31.3, Process Piping
  - Minimum Requirements, Single Wall Tube
- Destruction of Vent Purge Required (S-DOC or Equivalent)
- Electrical Classified Room (Per CGA G-16 Table 7)



S-DOC



# Outdoor Storage

- Less Prescriptive Design Requirements
  - No Containment, Risk of Deflagration or Detonation Mitigated
  - Open Gas Racks
  - Blast Relief and Calculations NOT required
  - Open Fenced Area with weather protection Roof
  - Volume of Silane limited by Separation Distances (Controlling Thermal Load on Surroundings Per CGA G-13, Table 3)



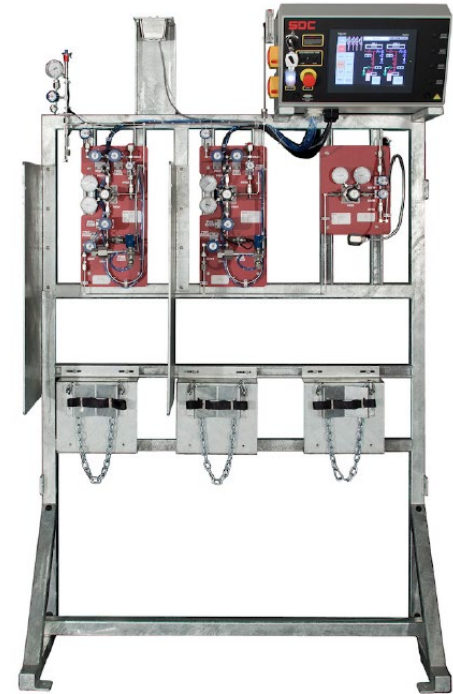
# Outdoor Design Requirements

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- Over Pressure (Blast) Calculations NOT Required
  - Rated Wall Construction required if Adjacent to Building
  - Three Sides of Enclosure MUST be exterior to Building
  - Fenced Exclusion required, Intrusion Alarms Recommended
  - Weather Protection Roof Required
  - .006” RFO w/ Pneumatic Shut-off at cylinder Recommended

# Outdoor Design Requirements

- Dedicated Air System Requirements
  - Exhaust Requirements:
    - None
  - Ventilation Air Requirements
    - 100% outside Air
    - Temperature Minimum - 40°F
    - Air Flow Rate (CGA G-13 Section 13.1)



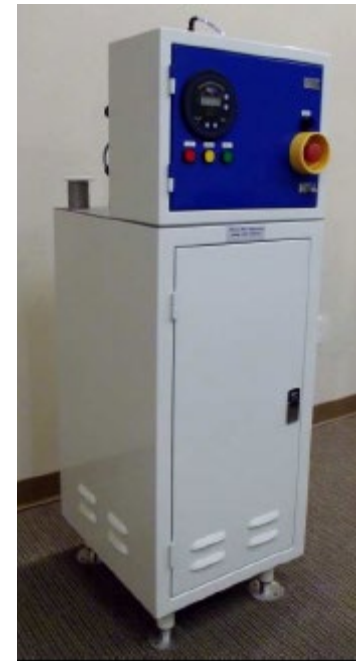
# Outdoor Design Requirements

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- Dispense Silane from CGA G-13 Compliant Gas Racks Per CGA G-13 Section 6.4.4
  - ¼” Plate Separation above and Below Mechanical Joints
  - Fill Complement of Cylinder Life Safety and Process Controls
  - UVIR Detection for each Cylinders
  - Gas Leak Detection
  - Area Shall have Deluge Sprinklers (0.3gpm/sf for 2 hours)

# Outdoor Design Requirements

- Silane Distribution Tubing:
  - Installed per ASME B31.3, Process Piping
  - Minimum Requirements, Single Wall Tube
- Destruction of Vent Purge (S-DOC or Equivalent) or contained open flare
- Electrical Classified Room (Per CGA G-13 Table 8)



S-DOC

# Conclusion

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## **CGA G 10, Paragraph 6.2.1, Location**

Silane sources and systems shall be located outdoors. .... Although indoor locations are allowed, it is preferred that areas for the storage and use of silane be located outdoors to minimize risk to users and facilities in the event of a fire or explosion. By locating silane installations in an unconfined space, the surrounding environment is able to absorb unlimited amounts of heat, and the surrounding environment is free to infinitely expand allowing overpressures to quickly attenuate.

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# DISCUSSION

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