

Summary of Silane Release Testing 1996

**Testing sponsored by Sematech & conducted by FM
Global Research**

FM interest: accidents involving silane releases in
semiconductor manufacturing

Presentation by Joyce Dunkerley

FM Global

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Silane Release Testing - 1996



- **Ignition Characteristics of Releases of 100% silane**

Project studied the effect of ventilation on the ignition characteristics of pure silane thru RFO's

- **Effects of leak size & geometry on releases of 100% silane**

Studied minimum amount of dilution for a leak, maximum amount of silane in initial inventory for safe discharge & effects of geometry on leak

Nearly 300 silane releases

Silane Releases - Types of Ignition

- **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 4-4.5%, mixture becomes metastable and will auto-ignite (No ignition source needed) after a delay

Ignition Characteristics of Silane Releases



Simulated release in ventilated enclosure:

Leak from a regulated pressure line to process tool

- Line pressures: 30, 50 & 200 psi
- Ventilation Flow: 50, 100 & 200 lfpm
- RFO: 0.010 in

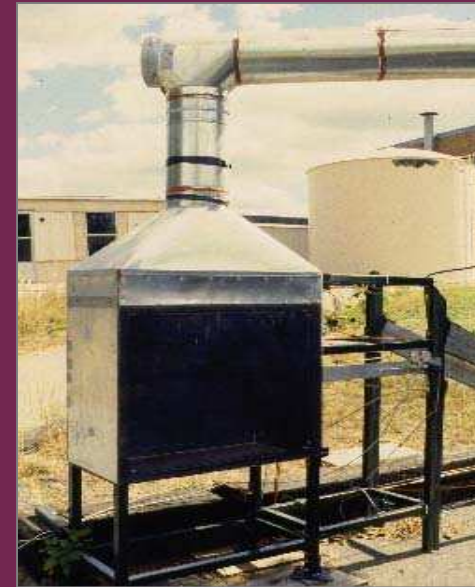
Leak from a pigtail at a nearly full cylinder

- RFO: 0.010 in & 0.020 in.

Simulation of High Pressure Release in Cabinet:

- Ventilation flow: 100 lfpm
- RFO: 0.020 in
- Source Pressure: 800 -820 psi & 1240 – 1300 psi

NOTE: All silane lines were ¼ in OD



Ignition Characteristics of Silane Releases



CONCLUSIONS:

- Silane ignition is independent of ventilation rate and RFO size. It is a function of the initial line pressure and of the geometry of the system
 - Discharges at low pressures (30 & less) more likely to promptly ignite.
 - Discharges at high pressures (>200 psi) more likely to form non-reacting jets.
 - Other variables include release geometry & temperature

Effects of geometry



Overall effect of geometry on silane ignition:

- Tests conducted in standard gas cabinet
- Replaced ¼ in. OD line with 1/8 in. line
- Aimed release to simulate obstacle created by the neck of gas bottle
- Aimed release at flat plate to simulate cabinet wall
- More than 100 tests conducted

Conclusion:

- Geometry has limited effect on prompt ignition characteristics (w/exception of 1/8 in line)
- Geometry has **significant** effect on condition at flow shutoff. Areas of high silane concentration can form where obstacles are present. Geometry affects dilution with air.

Pressure Rise from Sudden Discharge of Silane into an Enclosure: Piloted & Bulk Autoignition

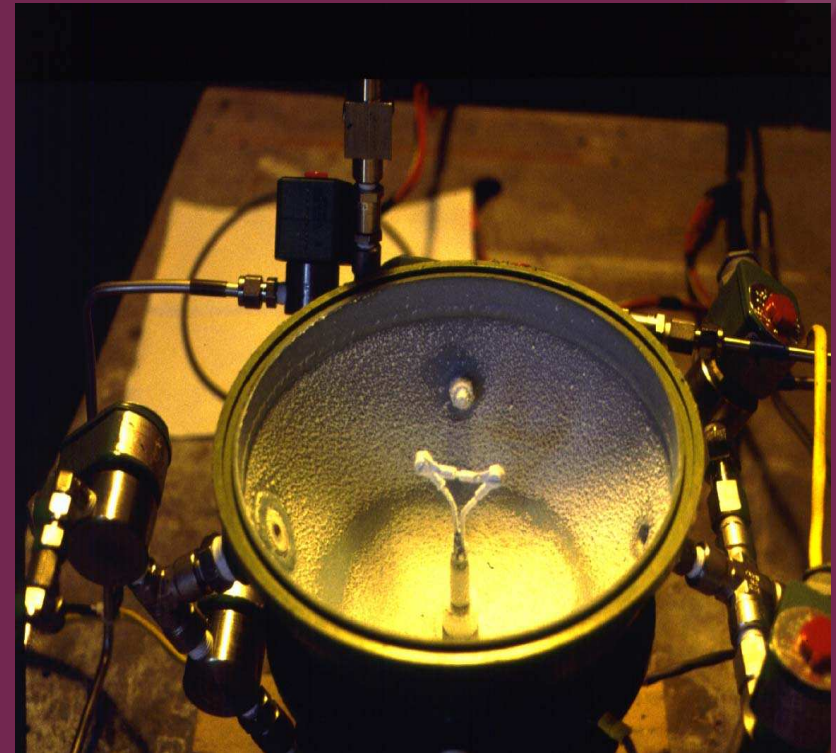


Developed technique to make silane/air mixtures of any concentration

FMRC 5.1-Liter Vessel

Tested various concentrations of 100% & 10/90 silane/N₂ mixtures

Performed **piloted** ignition tests of stable mixtures to measure pressure rise



Pressure Rise from Discharge of Silane into an Enclosure: Prompt & Delayed Ignition



- Vessel used both with and without explosion vents
- High-volume blower for post-test purging
- Measured rate of reaction of silane jet releases for both **prompt and delayed** (shutoff) ignition

FMRC 0.645-m³ Vessel



Defined stability limits of silane/air mixtures:

- concentrations up to 4.1% are stable.
- concentrations between 4.5 and 38% (the maximum attempted in the tests) are metastable. The mixtures undergo bulk auto-ignition after a delay, which becomes shorter as the silane concentration increases.
- Mixture reactivity approaches zero at a concentration of about 1.4%. This agrees with published values of the LFL of silane

Characterized the energy releases associated with three of types of ignition events:

1. Ignition at flow start-up (prompt)
2. Ignition at flow shut-off
3. Ignition during flow turn-down

Included obstructions (cylinder head & flat plate)

Conclusions

- Recommendations based on research included in FM Global Data Sheet 7-7
- Minimize property damage from catastrophic leaks under all possible ignition scenarios
- Take different combustion modes into account
 - Prevent conditions for bulk autoignition
 - Limit pressure development from ignition transient

References



FM Global Data Sheet 7-7

SEMATECH DOC ID #: 96083168A-ENG

- Title: Effects of Leak Size and Geometry on Releases of 100% Silane (ESHB001) Dated: 9/26/96

SEMATECH DOC ID #: 96013067A-ENG

- Title: Ignition Characteristics of Releases of 100% Silane (ESHB001) Dated: 3/14/96

<http://www.sematech.org/>