Buseth, T., B. R. Henriksen, M. G. Dolmen, T. Skjold, A. M. Mork, and G. H. Pedersen. 2026. The Effect of Particle Size Distribution on the Explosibility of Silicon Dust Clouds. In *Silicon for the chemical and solar industry XVIII*, edited by M. Tangstad, H. Rong, A. Valderhaug, B. Andresen, H. Dalaker, and I. G. Page. Kristiansand, Norway, September 7–10, 2026. https://doi.org/10.55669/oa900843

The Effect of Particle Size Distribution on the Explosibility of Silicon Dust Clouds

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Keywords: Silicon, dust explosions, explosive properties, particle size distribution

Silicon dust—metallurgical and higher-purity grades—exhibits ignitability and explosibility characteristics that underpin industrial applications as energetic material. Silicon has also been proposed as a possible "green fuel" for energy production through controlled combustion. However, the same energetic properties that enable these applications can, under unfavourable conditions, create hazardous situations and trigger industrial accidents. This is well recognised across the industry. Elkem has firsthand experience, including the devastating dust explosion in Bremanger in 1972. Since then, Elkem has maintained a long-standing focus on dust explosions hazards and the mechanisms that influence the explosion risk. Relevant test data for silicon dust that could be identified within the company have now been consolidated for a comprehensive review. This effort has led to an updated understanding of the behaviour and properties of silicon dust, particularly regarding the influence of dynamic variables. Among these, particle size distribution (PSD) is the most critical parameter affecting dust explosibility. Notably, PSD is not a fixed property; it is dynamic and evolves with time, mechanical forces, and degree of turbulence. Standardized dust-testing methods capture only a controlled subset of these variables, enabling comparisons across samples while simplifying the complexity of real-world conditions.

1. INTRODUCTION

This paper discusses the explosibility of silicon dust, as expressed through the maximum explosion overpressure P_{max} (bar) and the maximum rate of pressure rise $(dP/dt)_{max}$ (bar/s), also expressed as the K_{St} value (bar m/s). Other explosion-related properties of silicon dust, such as minimum ignition energy (MIE) and limiting oxygen concentration (LOC), are outside the scope of the present work. The main objective is to illustrate the effects of particle size distribution on the explosive properties of silicon dust.

Silicon is widely used as an energetic material. This includes applications such as igniters and delay charges, pyro mixtures, and general explosives (Koch & Clément, 2007). Silicon and other metals (e.g. iron) are also considered as potential green and recyclable energy carriers in controlled combustion processes (Bergthorson, 2015; Weiser et al., 2023; Heng, 2025; Baum et al., 2026). However, the same energetic properties that enable these applications can, under unfavourable conditions, create hazardous situations and trigger accidents with disastrous consequences. Dust explosions are recognized as a serious hazard in the industry and have been a recurring topic in this conference series (e.g. Tveit & Breidenthal, 2018).

A silicon dust explosion occurred at Elkem Bremanger in October 1972 (Eckhoff, 1994, 2003). This disastrous accident resulted in five casualties and four life-altering injuries. The plant area involved was destroyed and later redesigned as a wet process. The likely ignition source was hot work, with (accidental) penetration of a ventilation duct resulting in dispersion and ignition of accumulated dust, and flame propagation inside the ventilation system. The thermal effects of the secondary fireball, with flame temperatures possibly exceeding 2 000 °C, gave permanent burn injuries on unprotected skin over large distances.

Both General Electric and Dow have shared information about explosions in silicon milling installations. This includes the G.E. Waterford explosions up to 1967, and the Dow Corning mill explosion in December 1987. Back in 1969, Elkem had discussions about silicon milling explosions with Midland Silicones in UK. In August 1995, the Elkem Metals Alloy plant had an explosion in a ball mill, with a secondary filter explosion. Other resources have information about later silicon-related incidents in the industry.

Our current focus is on the coarser dusts that result from handling bulk material, and to a lesser extent the very fine particles intentionally manufactured by milling processes. Elkem also has products in the fine sized material ranges and need to handle safety aspects for these processes. Another approach is to increase the understanding on how coarse the silicon particles must be to become un-ignitable and hence safe to handle (i.e. inherently safer design).

The properties measured in standardised tests of explosion properties provide information on the amount and rate of energy release in the rapid combustion we in ordinary terms call a dust explosion. This information is important for the design of consequence-reducing measures, such as venting devices, suppression systems, and isolation systems (e.g. fast-acting valves). The parameters determined in a constant volume explosion vessel with volume V include the maximum overpressure, P_{max}, the maximum pressure rise rate, $(dP/dt)_{max}$, and the size-corrected maximum pressure rise rate, $K_{St} = V^{1/3} (dP/dt)_{max}$ (St = 'Staub', German). The testing is covered through ISO/IEC, ASTM and EN standards, some detail will be discussed later.

Other explosion related properties include the minimum ignition energy (MIE), the lower explosion/flammability limit (LEL/LFL) or minimum explosive concentration (MEC), and the limiting oxygen content (LOC). MIE and LEL/LFL/MEC or LOC are necessary data for understanding ignition properties and implementing ignition controls.

Particle size is acknowledged as the major parameter influencing ignitability and explosivity in different samples of the same material. Moisture is an important parameter with organic materials, but less important for metal dusts. Various researchers have addressed the influence of the particle size distribution (PSD) on the explosion properties of metal dust (e.g. Castellanos et al., 2014). The properties of the PSD of a given material are typically expressed by percentile diameters such as D_{10}, D_{50} (median), and D_{90}, the surface mean diameter $D_{3,2}$ (Sauter mean), the volume mean diameter $D_{4,3}$, the specific surface area (SSA), and various measures that reflect the width and degree of symmetry of the distribution (e.g. span, polydispersity, skewness, kurtosis, rank, etc.).

2. A COLLECTION OF HISTORIC SILICON DUST TESTING DATA

Over half a century, Elkem has accumulated more than 100 reports from dust explosion testing of silicon, ferro-silicon, and magnesium-ferro-silicon (FSM) samples. Most of the testing was conducted by the dust explosion laboratory at Chr. Michelsen Institute (CMI), which later became part of Gexcon AS. In addition, some 40 reports from different risk assessments or hazardous area classifications conducted on behalf of Elkem, and various literature sources, also contain relevant data on ignition and explosion properties for silicon. Overall, the reports illustrate a development in dust testing over time.

We assume there is a large volume of similarly unpublished or internal test reports within the individual companies in the silicon industry, and we welcome any additional reports for inclusion into our compilation!

From the literature: The US Bureau of Mines report from 1964 on ignitability of metal dusts, includes 11 different silicon samples (Jacobson et al., 1964): It is the oldest silicon and dust explosion related publication we have currently found. Noteworthy is also the Dow Corning

letter in a local Carrollton paper (C+E News) on observed low ignition energies for milled silicon (Halm, 1979), and Elkem Metals' (Allenbach, 1984) warning on materials finer than 44 µm (325 US Mesh). Later came a report on silicon testing from Japan National Institute of Occupational Safety & Health, NIOSH (Matsuda, 1984), and an article on fine sized silicon properties from Eckhoff, 1986. Some additional published data from this silicon conference series are Crawford, 2000; Wineland, 2002 and van Noort, 2002. Other important data sets are from research by Skjold, 2003, 2013 and 2026, and recent Master projects by students at the University of Bergen (Østgård, 2021; Faye & Bjørnsen, 2023; Mork, 2026). Our latest external testing data addition is on explosion testing of silicon made for Li-ion batteries (Lee, 2025).

Data from the online Gestis Dust-Ex database of combustion and explosion characteristics of dusts (Dustex, 2026) has also been included into our data collection with 22 different samples. This appears to be all the current entries identified as silicon. These will be discussed later.

The Elkem data collection today comprises silicon, ferro-silicon and magnesium-ferro-silicon data, with some additional silicon-related alloys and materials. One or several different properties have been tested and reported for each sample. The reported properties for one sample may be the result of an underlying larger test series, i.e., at different dust concentrations. An important addition is that reports of zero (i.e., not ignitable samples) are included as necessary data points.

Table I: Count of different silicon only data collected from existing test reports or from literature.

	Explosibility			Ignitability			Particle size data (µm)		
Property	K_{St}	P_{max}	$(dP/dt)_{max}$	MIE	LEL	LOC	D_{50}	D_{10} and D_{90}	$D_{3,2}$ and $D_{4,3}$
Silicon count	132	151	97	82	40	28	137	70	50
Elkem reports	78	79	44	58	19	19	65	36	18
Literature	54	72	53	24	21	9	72	34	32

For silicon we cover a total of 530 data points on explosibility and ignitability combined. It is obvious that the explosive properties have been tested the most (380 data), and that the ignition properties are probably not sufficiently investigated with 150 data points.

3. SUMMARIZING EXPLOSIVE EFFECT AGAINST PARTICLE DIMENSIONS

3.1 Samples particle size information

Information about particle sizes is rudimentary or missing for a lot of both internal and public samples. Size information from the Gestis Dust-Ex database is also limited. We were able to identify mean diameter, or D_{50}, for several samples, as indicated in Table 1. These values may be from sieving (mass), optical methods (typically volume) and other methods.

Van Wingerden, 2019 discussed the use of public test data information for a general understanding of explosive effects from different dusts, including silicon. This was based on the publicly available Gestis Dust-Ex data with D_{50} information. Those data were only 11 values for P_{max} and K_{St}, from six ignitable and five not ignitable samples. All of these were already included in the 1997 printed edition of the database. We have reproduced this in Figure 1:

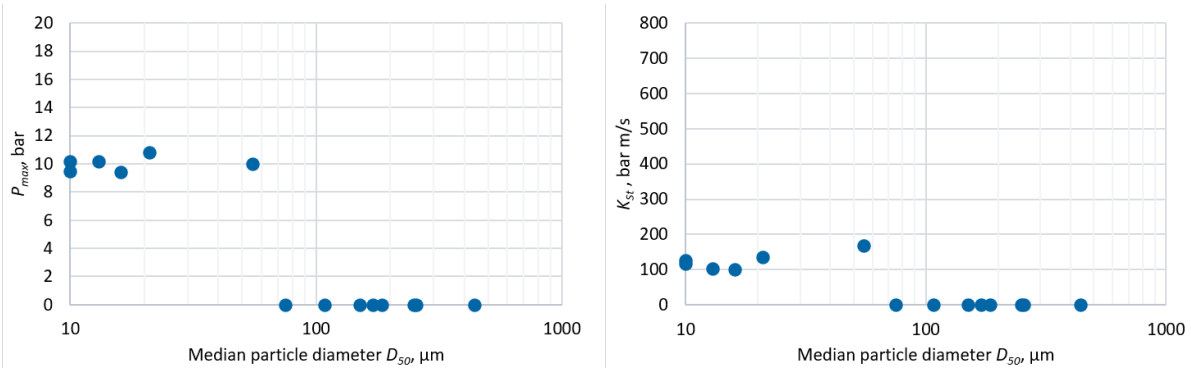

Figure 1: Maximum explosion pressure (left) and K_{St}-value (right) as function of median particle diameter D_{50}. Silicon data from the Gestis Dust-Ex database only, reproducing van Wingerden, 2019.

In the graphs there are now 6 samples with ignition, 7 with no ignition. Two newer samples have been added in the Gestis Dust-Ex data base since the original publication, both not ignitable. Max ignited D_{50} is 55 µm, lowest no ignition D_{50} is at 75 µm. These charts could possibly open for a misunderstanding that silicon samples with D_{50} higher than 55 µm would not be ignitable. This can also demonstrate a clear warning on estimating properties from literature data only, without testing of a sample from the actual process in question.

Updates to the testing standard (like ISO/IEC 80079-20-2:2016) have also introduced an additional 'hard to ignite' test requirement with significantly increased ignition energy (2 x 1 kJ), after earlier dust testing reported samples as not ignitable at 1-10 Joule and industrial incidents demonstrated otherwise. Older test reports may have stated such samples as not ignitable. Coarser metal dusts can come into this category. For 'high density material such as metals' it is in addition permitted in the standards also to test at higher dust concentrations (up to 2 500 g/m³, versus normally up to 1 500 g/m³).

The following two graphs from our historic data was used to build an internal general engineering guideline for materials with a D_{50} coarser than 10 µm. The data points earlier shown in reproducing the van Wingerden paper are also included here. For P_{max} we have 83 data points and 20 values of no ignition (zero). For K_{St} we have 72 data point and 20 no ignition values. The uncertainties around the use of D_{50} as parameter will be discussed further.

For P_{max} at D_{50} larger than 20 µm there are a four individual points with pressures above 9.0 bar out of 32. For K_{St} there are no data above 190 bar m/s until D_{50} is finer than 10 µm. Our interpretation was that a K_{St} should not be expected to exceed 190 bar m/s for D_{50} higher than 10 µm, but there is some residual risk that pressures may exceed 9.0 bar for materials with D_{50} above 20 µm.

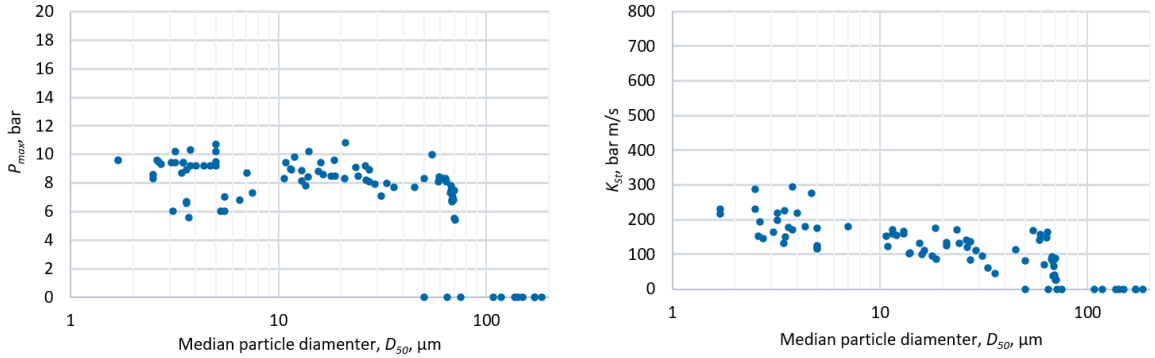

Figure 2: Currently collected silicon explosivity data with D_{50} information.

The highest D_{50} with reported P_{max} and K_{St} in the data set is 70,5 µm. We have however registered ignition for a sample with a D_{50} at 113 µm, so *the information here is also insufficient to establish a D_{50} limit for explosibility*. Literature cites avoiding particles finer than 70 to 80 µm to safeguard that no ignition may occur. In the fine end of the particle size range, data for silicon particle distributions with D_{50} finer than 10 to 20 µm must be assessed on a case-by-case basis. Here the explosive properties rapidly escalate, as can be seen by some very high K_{St} values.

For completeness, the following graphs show all the registered K_{St} and P_{max} collected, in a sequence from increasing D_{50}, and then from decreasing K_{St} without D_{50} information. A total of 152 P_{max} (119 ignition, 33 no ign.) and 132 K_{St} points (102 ignition, 30 no ign.) are included.

Overall, there are 39 out of 152 P_{max} values at > 9.0 bar. There are 13 K_{St} values > 190 bar m/s for D_{50} finer than 10 µm, and 5 high K_{St} values with no D_{50} information attached.

Table II: K_{St} and P_{max} data, with and without D_{50} information

Count of:	P_{max} data	K_{St} data
Ignition data, with D_{50}	83	72
No ignition data, with D_{50}	20	20
Ignition data, no D_{50}	36	30
No ignition data, no D_{50}	13	10

This information can now be used for preliminary discussions and to add content for analysis of new test results. The conservative approach is to set a baseline along the upper values, i.e., a K_{St} of 190 bar m/s for material coarser than a 10 µm D_{50}. But there is also possibility for a risk-based approach through a better understanding of test results that report lower values.

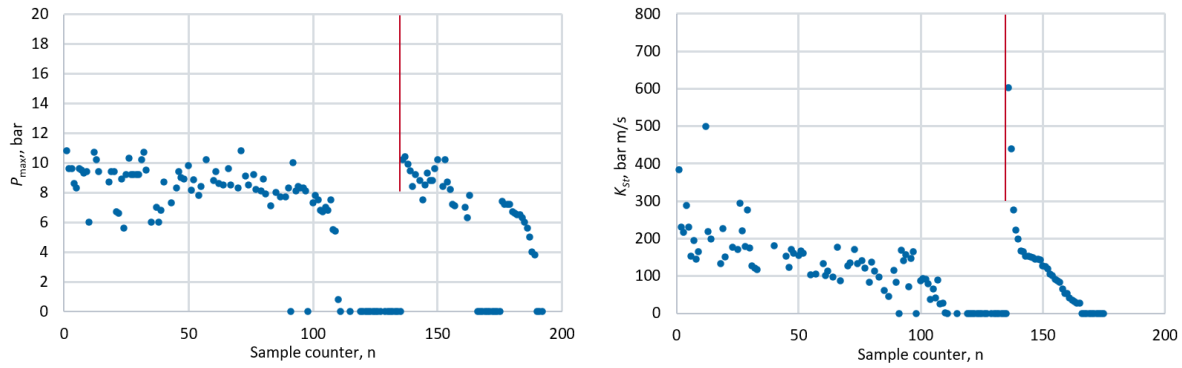

Figure 3: All our collected P_{max} and K_{St} values, the red lines separating data with and w/o D_{50} information.

At the same time, the bandwidth spread in data illustrates the risks and uncertainties in sampling, testing and then estimating ignition and explosion properties from any dust sample.

3.2 Median particle size as an indicator of explosion hazard

A major limitation of using a single D_{50} value is that different samples with similar D_{50} values may represent widely different size distributions, as the D_{50} does not reflect the distribution in the fine or coarse particles content. In the current understanding of metal dust ignition and explosions, it is the finer sized particles that carry the hazards of ignition and combustion.

Polydispersity or span, kurtosis and other values can be used as indicators of such variations. Castellanos et al., 2014 tested different distributions in aluminium dusts, including constructed

distributions with approximately the same median particle diameter. The size distributions tested are shown in figure 5. Test results ranged from P_{max} 9.0 to 10.0 bar and K_{St} from 231 to 403 bar m/s for aluminium with increasing content of fine particles in the wider distributions.

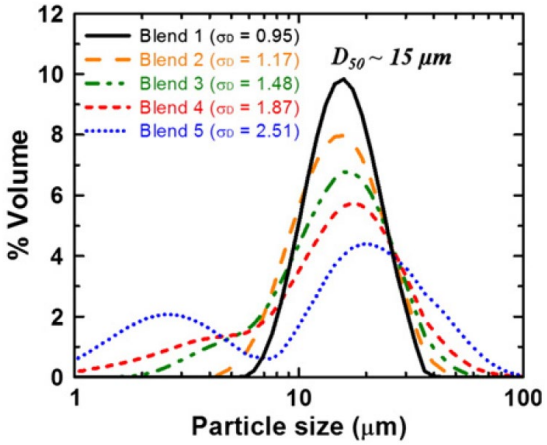

Figure 5: Different particle distributions with the same median particle size (Copy from Castellanos et al., 2014)

4. NEWER TEST DATA WITH CONTINUOUS PARTICLE SIZE DISTRIBUTIONS

Elkem has started using a Malvern Mastersizer to obtain continuous size distribution data on the dust testing samples. The laser diffraction method is not expected to report a totally 'true' distribution but is seen as a consistent indicator of the particle sizes. Additional parameters can be derived, like D_{10}, D_{90}, $D_{3,2}$ and $D_{4,3}$. We can also report a calculated specific surface area, but from the same underlying measurement data.

In combustion analysis, ignition and combustion are seen as surface-oriented processes, but the ending total combustion (burnout) is more related to the volume of droplets or particles. In dust combustion (flash fires or dust explosions) normally only a fraction of the total available dust is consumed, i.e. 25 %. A surface area-weighted or Sauter mean diameter $D_{3,2}$ and a De Brouckere or volume-weighted mean diameter $D_{4,3}$ should provide information relevant to these situations.

Master students from University of Bergen have performed dust testing for a more detailed understanding of particle distribution effects in cooperation with Elkem. Their testing is reduced from a standard program, as we try to work within a limited field of parameters. Specific reductions are restricting max dust loads to avoid operational problems, and not running complete series and repetitions with the different dust loads as required in standards.

Our focus has been to identify particle size limits for explosive behaviour – what are the hazardous size ranges that must be removed for a safe product and a safe process, and how much coarse or fine particles involved will influence the explosive properties.

Larger particles included in a dust sample may act as heat sinks in the system. This is especially valid for metal dusts with high melting points, where there are no sensible vapour pressures for a gas-phase combustion onset at lower temperatures. High dust concentrations may counter these effects, with the presence of a very large number of small particles that are easily heated to ignition by a (sufficiently strong) flame front.

Especially Mork, 2026 have compiled series of material mixes going from a coarse silicon with an increasing addition of fine sized particles, and also from fine sized silicon with a gradual addition of coarser particles. This was all based on jet milled pure silicon materials from the Elkem Silgrain® production line at Elkem Bremanger. Variability reduction was addressed

through Theory of Sampling -aligned use of a rotary divider and manual bed blending methods (more about this later).

The coarse starting material is close to non-ignitable and only yields a very limited effect at a very high dust concentration, 3 000 g/m³. Explosivity and particle size information is given in Table III. Two very fine materials were used to control the content of fine particles.

Table III: Materials used for testing changes in particle size distribution.

	Explosive data		Size range	Particle size data (µm)				
Material	P_{max}	K_{St}	(µm)	D_{10}	D_{50}	D_{90}	$D_{3,2}$	$D_{4,3}$
Fine 'A'	9.5	152	< 8	0.6	2.6	5.0	1.3	2.8
Fine 'B'	9.4	226	2-7	1.9	3.5	6.0	3.1	3.8
Coarse 'E'	0.8	1	> 40	43.2	71.4	117	66.4	76.4

It is assumed that the higher K_{St} value for the slightly coarser material B is linked to agglomeration effects in material A.

Adding a very fine material, starting at 2 wt%, immediately gives a clear explosive effect with the coarse material. The effect is increasing with higher fines content. Adding 2 % of A or B changes the surface mean diameter $D_{3,2}$ from 66.4 to 53.8 (A) or 51.6 µm (B), whereas the average diameter D_{50} changes from 71.4 to 70.5 and 70.1 µm. The explosion pressure increases significantly (Figure 6), whereas pressure rise rate shows a more gradual increase (Figure 7).

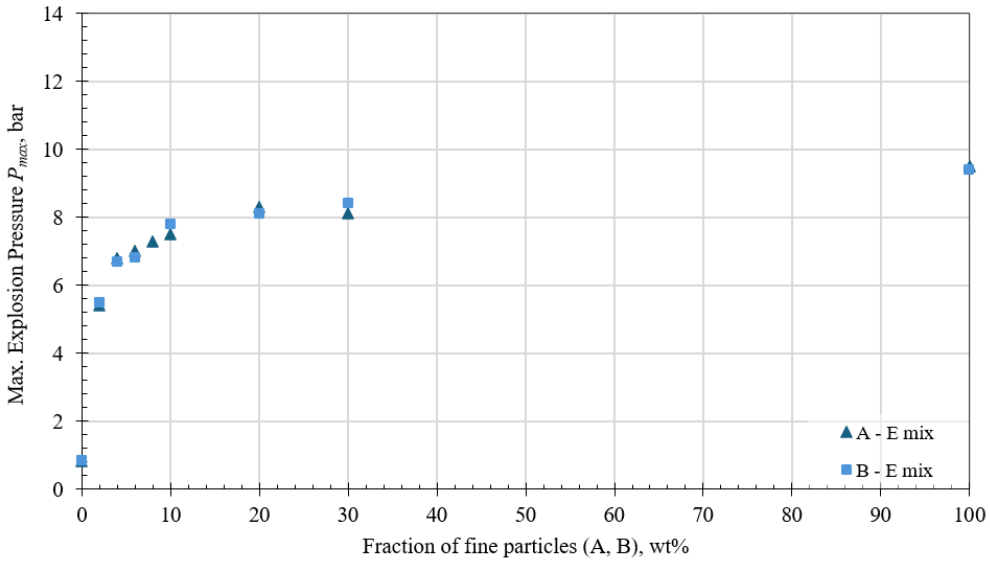

Figure 6: Changes in P_{max} from increasing fine particles content in coarse material (based on Mork, 2026)

The other observation is from the very fine end; adding increasing amounts of coarse particles up to 80 wt% do not shift P_{max} or K_{St} values of the fine materials significantly.

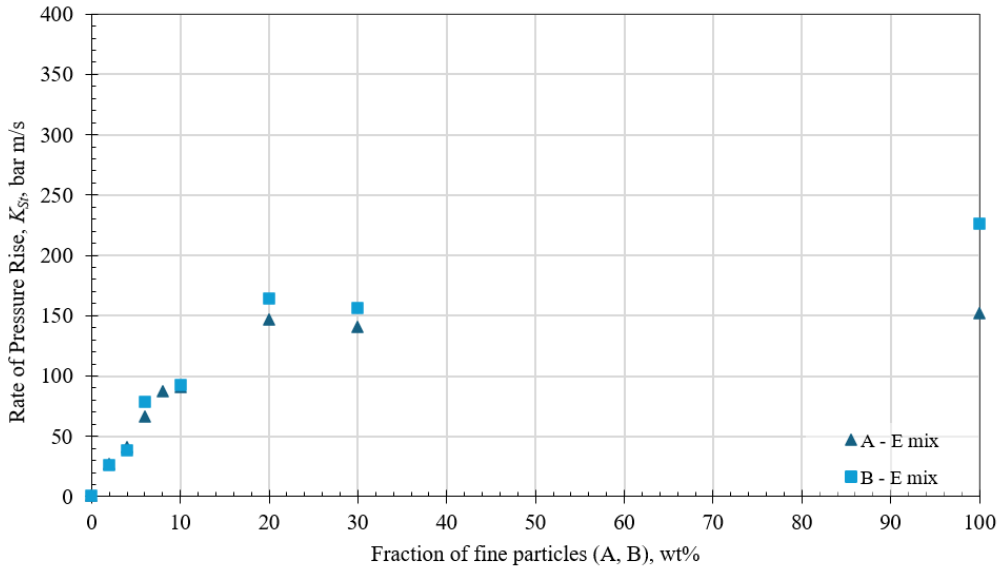

Figure 7: Changes in pressure rise rate K_{St} from increasing fine particles (based on Mork, 2026)

The change in explosive effect by particle size can be further illustrated by looking at individual results from the varying dust loads. In figures 8 and 9 the detailed results from one of the test series are shown. From the equipment limitations we chose not to test at the initially very high ignitable concentration, but the graphs indicate that maximum effect is not determined at lower concentrations until a 30 – 70 % mix ratio of fine to coarse material.

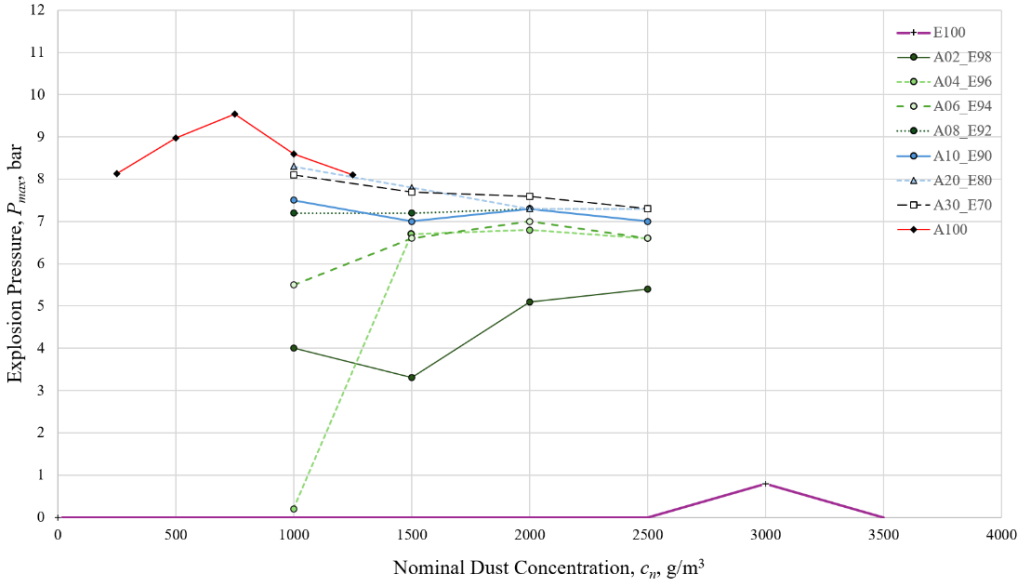

Figure 8: Changes in pressure P_{max} at different dust loads (from Mork, 2026)

The pressure measurements are a clear indication on how little fine particles are needed to render a coarser distribution highly ignitable, across a wide range of dust concentrations. The pressure rise rate demonstrates a more gradual effect.

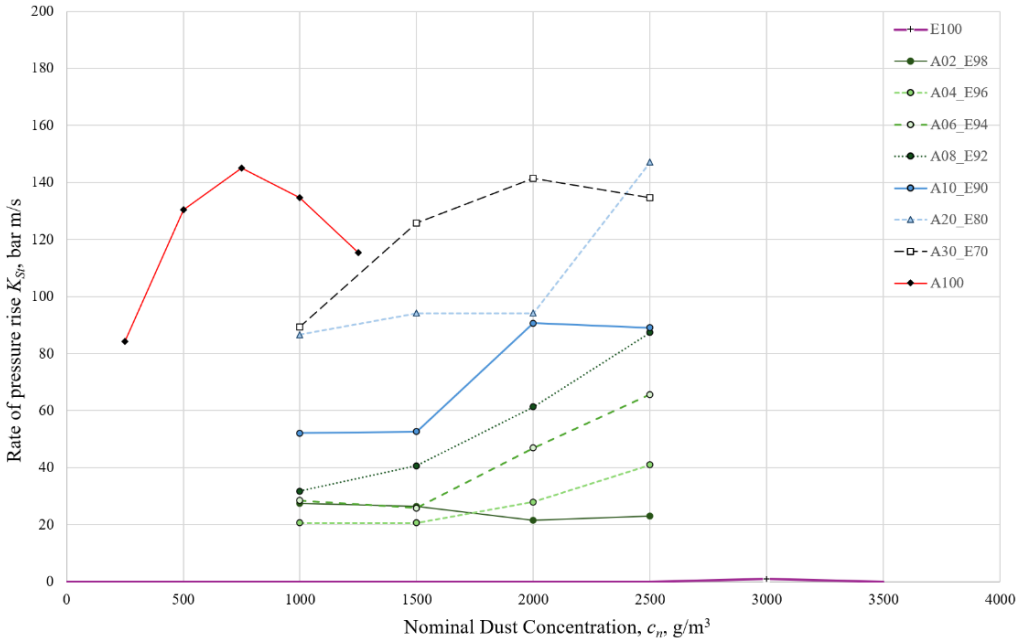

Figure 9: Changes in pressure rise rate K_{St} from increasing content of fine particles at various dust loads.

Adding an increasing mass of coarse particles to fine sized shifts the maximum points to higher dust concentrations, from 500 g/m³ for the finest material and into the only 3 000 g/m³ concentration for the coarse material without any fines addition.

In figures 10 and 11 below, P_{max} and K_{St} values are summarized as a function of the measured surface mean diameter $D_{3,2}$, from Mork, 2026. The surface mean diameter offers a better correlation than any of the other tested size variables like D_{10} or $D_{4,3}$.

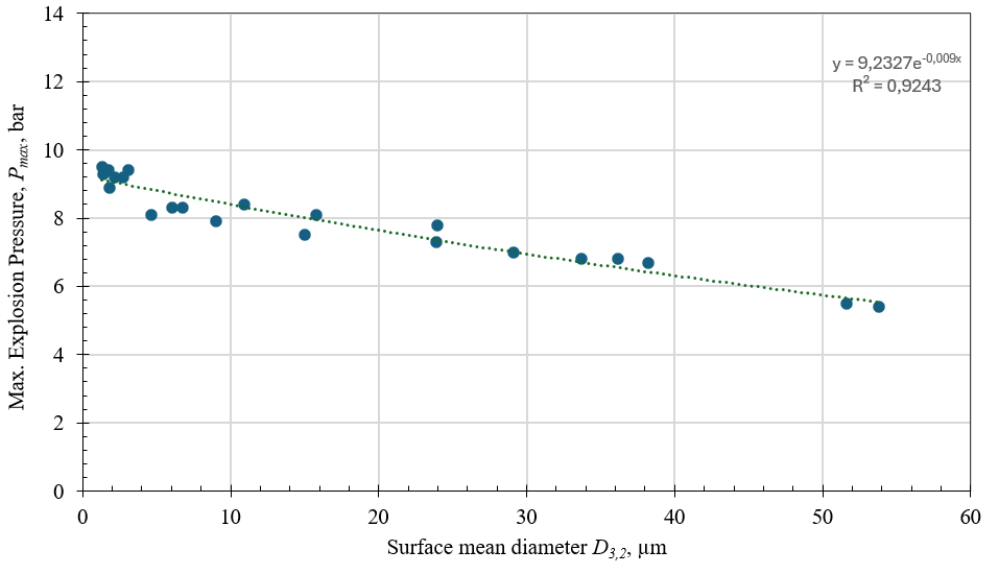

Figure 10: Overall P_{max} versus surface mean diameter $D_{3,2}$ from current testing.

The trendlines are indicative, but please observe that any safety or engineering related information must be based on the max values. This is indicated in the following graph for K_{St} values.

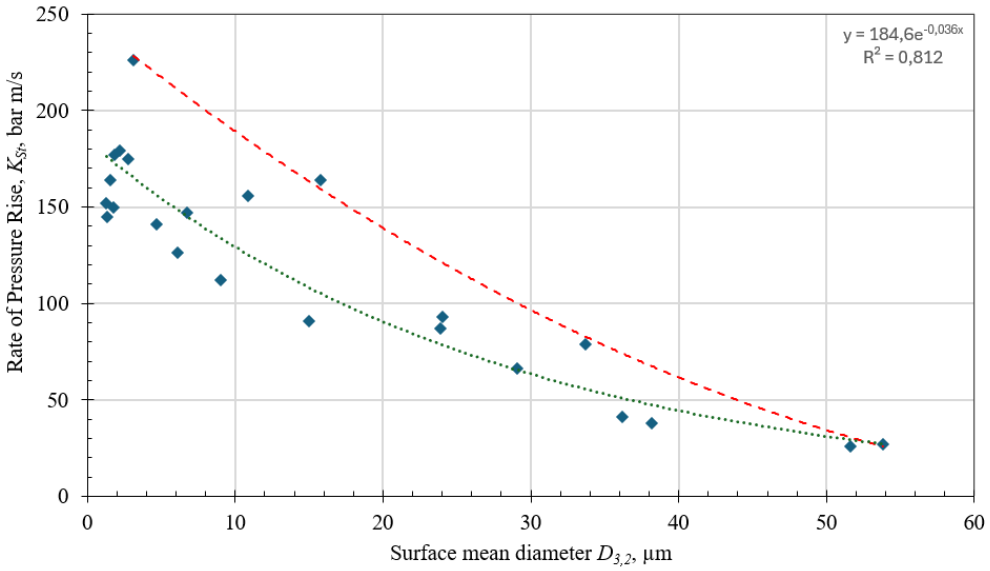

Figure 11: Max pressure rise rate K_{St} versus surface mean diameter. Added red indicator for a safety-related line.

Remark the spread with a few high data points. These might be discussed as possible outliers, but they also indicate that the correlation is still not strong enough to be used as a predictive indicator of explosivity. More work is needed to increase the fundamental consistency in dust testing.

5. OTHER INFLUENCING FACTORS IN SILICON DUST TESTING

5.1 The combustion mechanism of silicon

The silicon combustion mechanism has been discussed as a homogenous (gas phase) versus a heterogeneous (gas-solid or gas-liquid) combustion. Light elements like Al and Mg combust in the gas phase (homogenous reaction) and Fe combust from the solid/liquid state in a heterogenous reaction. Gas phase reactions can see free mixing, whereas phase interface reactions can be controlled by diffusion phenomena. For some metals, a start from heterogenous combustion with an outside (solid or liquid) oxide layer can then transfer into an exploded particle and a homogenous combustion (Lu et al, 2026). Melting and boiling temperatures of the elements and their oxides can indicate this.

Van der Wel, 1993 discussed that hybrid and heterogenous combustion mechanisms would lead to max explosive effects at dust loads high above stochiometric composition, which is typically seen for most metal dusts. The melting and boiling temperatures of silicon and the silicon oxides indicate the potential for a hybrid combustion mechanism for silicon. The silicon and the oxide SiO_2 are in a liquid state at observed and adiabatic flame temperatures, and there should be a limited vapour pressure of silicon. The additional complicating element is the monoxide SiO in a gaseous state at these temperatures, and the SiO then has a condensation reaction balance forming Si + SiO_2 at lower temperatures. The complete silicon combustion mechanism is complex, both chemically andthermodynamically. Several earlier authors model or discuss silicon combustion only from the overall reaction and omit or do not realise the importance of the suboxide $SiO_{(g)}$.

Arntzen, 2025 and MSc students at University of Bergen are developing the thermodynamic modelling of the metal dust combustion processes for implementation in the Gexcon FLACS code. Østgård 2022, Liland 2025, and now Andersen 2026 have been working in this direction. Heng et al, 2025 and 2026 documents the silicon combustion process, especially from observations of combustion of single silicon particles in their 2026 paper. Here they confirm a

shrinking core model with a d^2 rate of reaction with a SiO gaseous layer outside of the combustion liquid silicon droplet.

5.2 Elements in dust testing equipment and methods

The dust testing situation and equipment is by itself a highly variable process, mostly governed by controlling a range of variables though the relevant standards. These variations may also be seen as consequences of the dust testing situation being a combination of physical and dynamic properties: Material properties versus time dependent variables like dust concentration, particle size distribution and dispersion turbulence level. A dispersed dust cloud is a short-lived phenomenon. The settling process may also create pockets within a dust cloud with narrow fine sized domains, with high sensitivity for ignition (a low MIE situation). The standards allow for a deviation in results at up to 10 % (EN 14034-1).

A general factor in the setup and testing of borderline explosion limits is the use of pyrotechnic igniters. The pyro igniters yield an inherent pressure effect in the test equipment, and any direct measurements must be corrected for those effects. This complicates the interpretation between an ignitable and a non-ignitable material.

Turbulence and wall effects in the 20 litre sphere are controlled through timing of the ignition from initial start of dispersion. A study on modified ignition timing highlighted the effects of turbulence; igniting a fine sized silicon sample at 30 ms versus the standardised 60 ms after dust dispersion increased the pressure rise rate from 219 to 500 bar m/s (Cruz, 2019). This indicates that a real life event under circumstances that deviate insignificantly from the standardised testing situation may yield very different effects. There can be a (theoretical) possibility of releasing energies in excess from what testing results indicate.

For the 20 litre spheres, the testing standards also require additional recalculation of values to align data with the 1 m^3 test data. The reported P_{ex} is not identical to the measured P_{meas}.

There is also a discussion for reactive metals that the smaller 20 l sphere may underreport explosive effects. Tests by Elkem together with Fike indicate that silicon is not in the highest reactivity class.

5.3 Particle samples and representativity

Sampling and splitting approaches and particle representativity considerations is an element to introduce here. Grab samples seem to have been the routine within dust testing, and this is far from modern understanding, as established through Theory of sampling (TOS) like from Esbensen, 2017 and the horizontal sampling standard DS 3077, 2024. Particle representativity is a necessity for testing of fine sized materials properties, as would be well known to operators of the Rochow-Müller synthesis.

To continue working with the detailed results at different dust concentrations we will need a more stable test and measurement system. We have so far not seen any publication of data on repeatability and reproducibility (i.e., Gauge R&R or MSA) in dust testing with metal dusts. Semenova et al., 2026 reports on a round robin of four hard to ignite iron powders. Dust lab round robin tests (Cesana AG) show 10 % variation in results on an organic dust (niacin), and do not use metal dust.

6. CONCLUSIONS AND FUTURE WORK

This work offers an update in the understanding of the ignition and explosion properties of silicon, with some additional special cases. For an installation in operation the data gives an indication about what particles must be securely removed to avoid explosion hazards in fine sized products. The results also demonstrate the influence of varying fine particle content and

highlight how even a small fraction of fines can significantly increase the potential for dust explosion under favourable conditions.

A D_{50} value as a particle size indicator is poorly connected to K_{St}, or $(dP/dt)_{max}$ and P_{max} values, as seen in the first part of our data. Instead of using a D_{50} for particle size information we indicate that surface mean diameter, $D_{3,2}$ is a better indicator of explosive effects (Østgård, 2022; Mork, 2026).

Coarser materials with low fines content can be ignitable at higher dust concentrations. High dust loads are for example found in fugitive dust situations and inside dust-gas separators (filter housing, etc.), and normally not present inside well-ventilated processing equipment.

Assuming a P_{max} of 9 bar may be acceptable for pressure tolerance in an inerted installation, but oxygen concentrations above LOC may increase pressure effects up to or possibly beyond this value. A K_{St} of 190 bar m/s may appear safe as an engineering value for size ranges over 10 µm from the presently available data. However, reassessment of new data based on alternative values such as $D_{3,2}$ may be a better option and should provide better values. And – any engineering assessment must be validated by appropriate verification activities in as-built and operative situations.

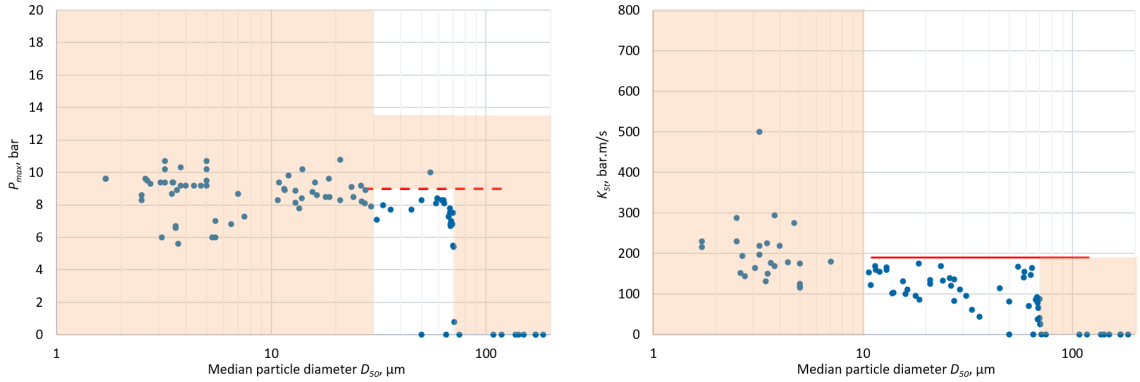

Figure 12: Indication of regimes of high uncertainty in explosive effects from median particle diameter D_{50}.

6.1 Possible future work

Currently, there is not sufficient information on ignitability properties like minimum explosive concentration MEC / lower explosive limit LEL, or the minimum ignition energy MIE. The available data are limited, and further work is required. We have reviewed the available LOC data, but do not yet have a full review with particle size effects included. Liquid silicon is a valid dust ignition source, and any ignited metal / silicon dust will represent a very strong ignition source due to the very high flame temperature.

There are indications in literature that a thermodynamic modelling related back to particle size distribution may be possible. We have so far not seen this established and validated for any materials.

The recent tests have used pure Silgrain®, avoiding any effects of impurity elements and intermetallic phases. There is a threshold where silicon composition effects influence the ignitability and explosivity through effects of intermetallic phase compositions. Silicides formation will affect the composition of individual dust particles. Some intermetallic phases are more brittle and naturally enrich into fines. Crawford, 2000 reported some data on minimum ignition energies for specific intermetallic phases.

A final general remark: Any additional historical or new test data to expand the current compilation are welcome!

8. ACKNOWLEDGEMENTS

This paper is published by permission of Elkem ASA. The contributions of our colleagues are gratefully acknowledged; Especially Christa Nimbona and Pål Baggethun at Elkem, several earlier MSc students at University of Bergen, and several resources at Gexcon.

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