HEALTH & SAFETY LABORATORY

Flameless Venting - Dust Explosions

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Dust explosions

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- Dust explosion research programme
- Flameless venting
- Background
- Test equipment and programme
- Results
- Conclusions

Dust Explosions

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7 February 2008

Sugar dust explosion in Georgia USA.

14 killed

20 August 1997

Flour explosion in Blaye France

11 killed

Dust Explosions - background

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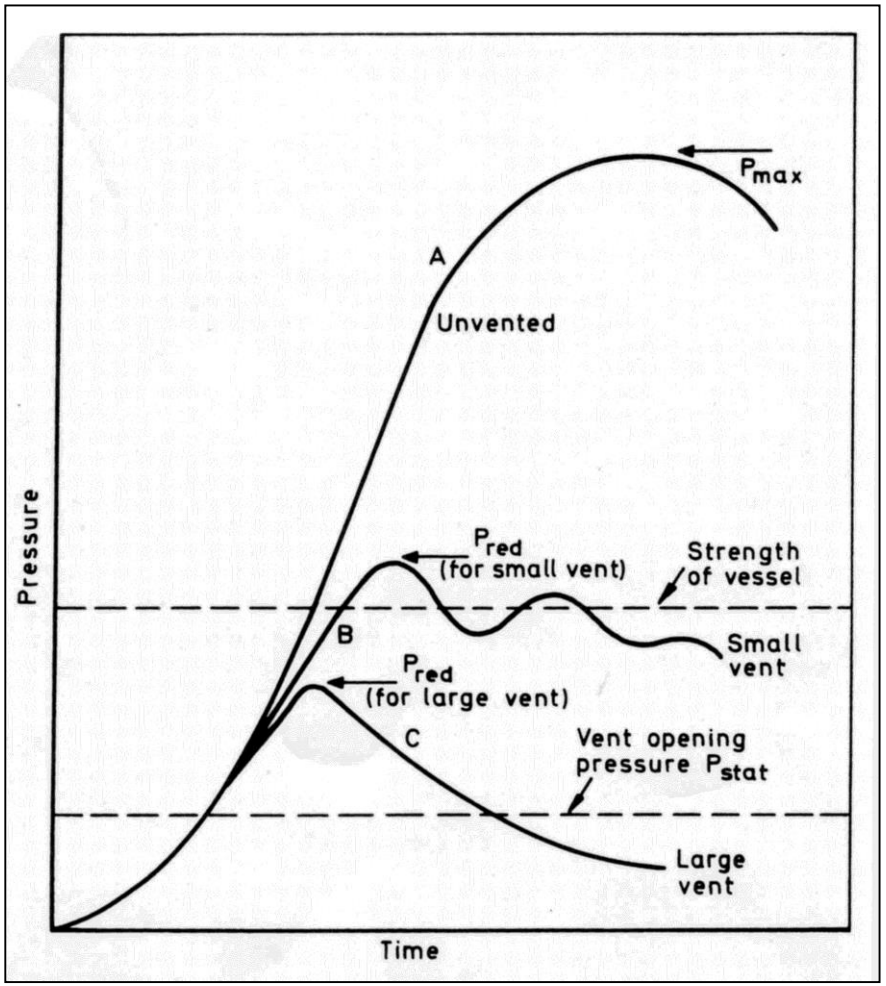
- Explosible dust
- Particle size
- Oxidant
- Dust concentration
- Ignition source

Explosion venting

Explosion protection by venting:

venting protective systems

- Venting enclosures
- Vent sizing
- Influence of vent ducts
- External flame and pressure

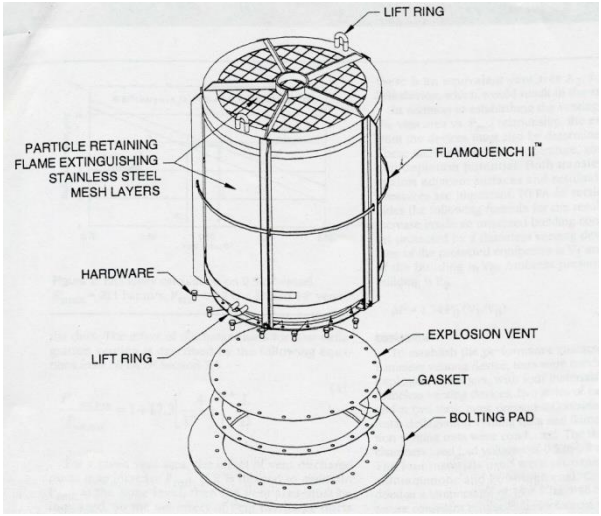


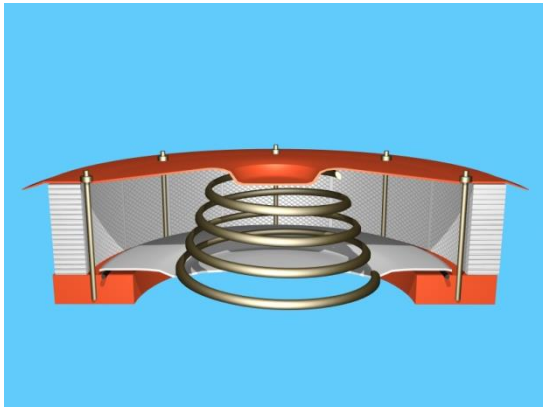
BS EN 16009:2011 Flameless explosion venting devices

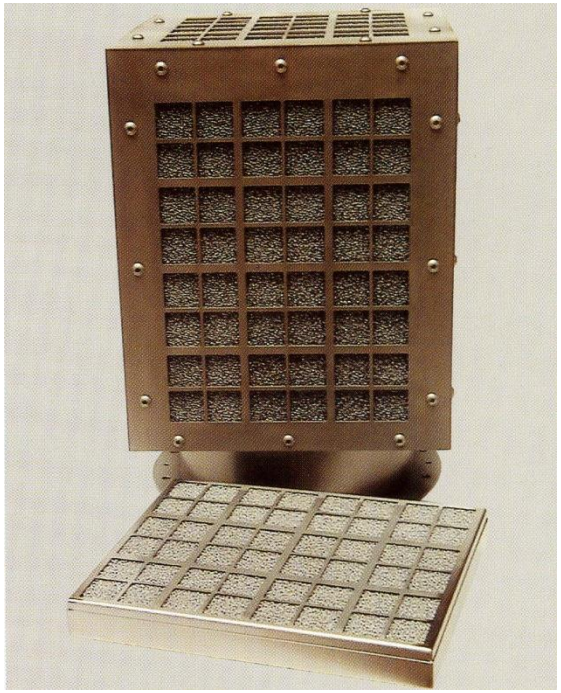
BS EN 14491:2006 Dust explosion venting protective systems

BS EN 14797:2006 Explosion venting devices

Flameless explosion venting







Test Dusts

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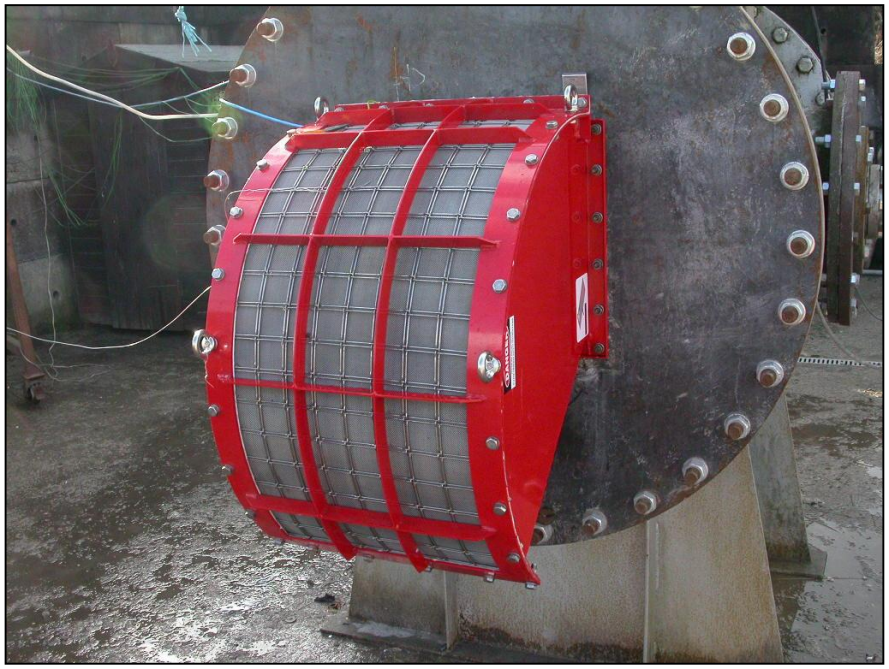
Dust	HSL reference	K_{st} (bar.m.s^{-1})	P_{max} (barg)	MIE (mJ)	MIT 5 mm dust layer (˚C)	MIT dust cloud (˚C)	Moisture content (%w/w)	Particle size distribution
Wheat flour	EC/107/09	138	8.0	30 - 100	No ignition at 500˚C	400	11	100% < 180µm 65.9% < 106µm 10% < 63µm
Cornflour	EC/084/09	147	7.9	30 - 100	No ignition at 500˚C	370	13.5	100%<63µm
MDF wood dust	EC/074/09	113	10.4	10 - 30	375	420	7.6	62.5%<500µm 49.2%<250µm 44.1%<180µm 31.4%<106µm 15.9%<63µm
Polyethylene powder	EC/072/10	167	7.5	10 - 30	Melts	470	1.0	100%<63µm

Flameless explosion venting test equipment

2 m^3 explosion test vessel with rectangular CV explosion vent panel

0.4 m x 0.5 m vent

P_{stat} 0.1 barg



2 m^3 explosion test vessel with flameless explosion vent assembly (including explosion vent panel)

Flameless explosion venting test equipment

4 m^3 explosion test vessel with two 0.2 m^2 rectangular CV explosion vent panels and flameless venting devices

Flameless explosion venting

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- Tests generally in accordance with the principles of BS EN 14797:2006 and BS EN 16009:2011.
- BS EN 14491 used to establish the test conditions. The vent cover has a specific mass <0.5 kgm^{-2}.
- Using the test conditions and the measured P_{red} , K-value is calculated for the explosion.
- The test is repeated with the conventional stainless steel bursting panel and with the flameless venting device.
- The P_{red} in the vessel measured.
- Temperatures at the surface of the flame arrestor and at 1 m.
- Noise measurements and peak external pressures at 1 m and 5 m.

Test method

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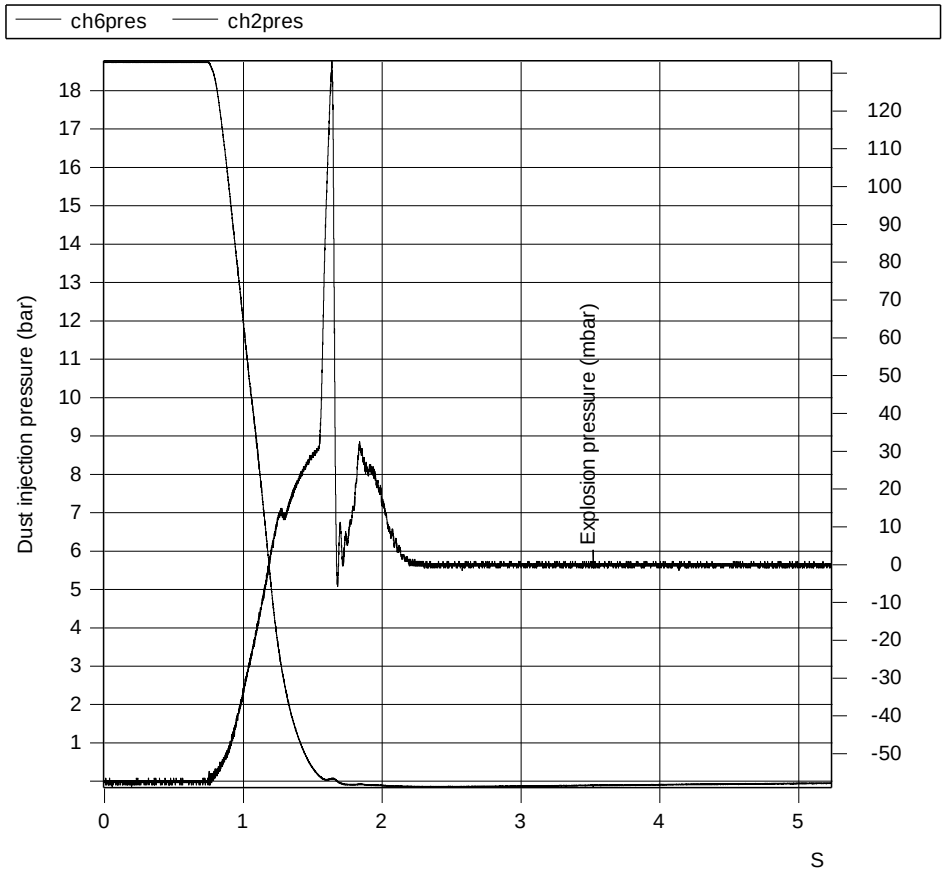
- Initial tests – development of test method using 2m^3 vessel and 0.2 m^2 vent opening.
- The dust injection system was modified to achieve a dust injector volume/vessel volume ratio closer to that used in BS EN 14034-2:2006.
- Time delay between dust injection and ignition was modified. It was found that 600- 850 ms was required to achieve total injection of the dust.
- Vacuum system introduced – partial evacuation of the vessel prior to dust injection.

Flameless explosion venting



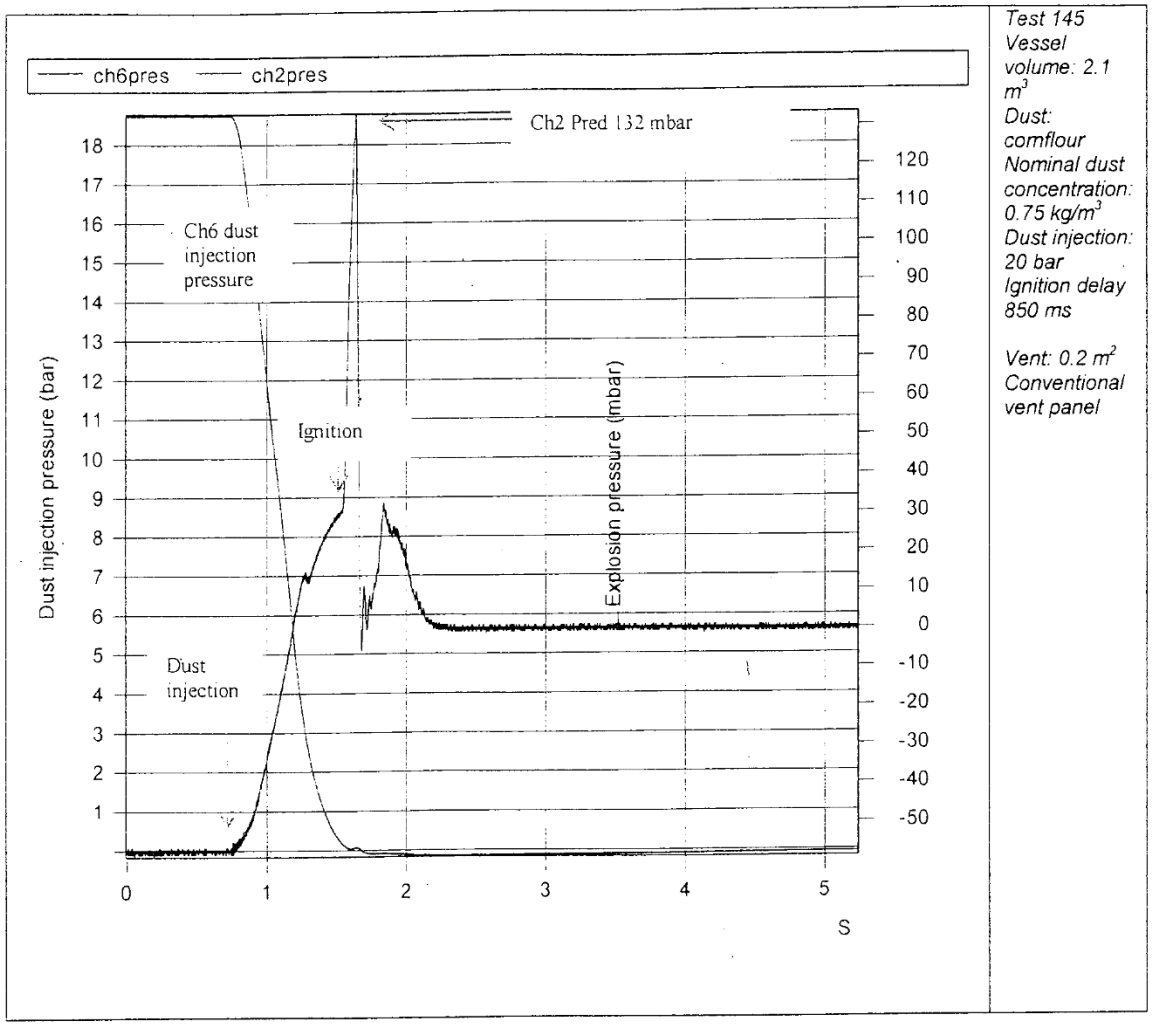
2 m^3 vessel

Vent 0.2 m^2 CV panel

Dust: Cornflour
Concn. 0.75 kg/m^3

P_{red} 132 mbar

Flameless explosion venting



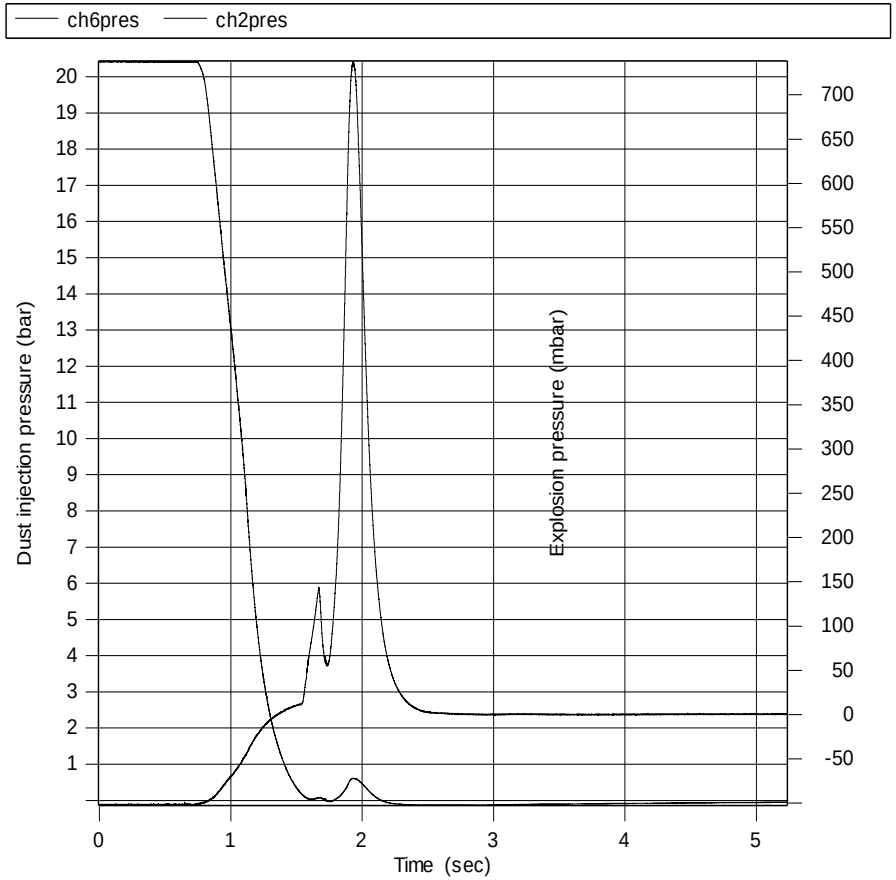
2 m³ vessel

Vent 0.2 m² CV panel

Dust: Cornflour
Concn. 0.75 kg/m³

P_{red} 132 mbar

Flameless explosion venting



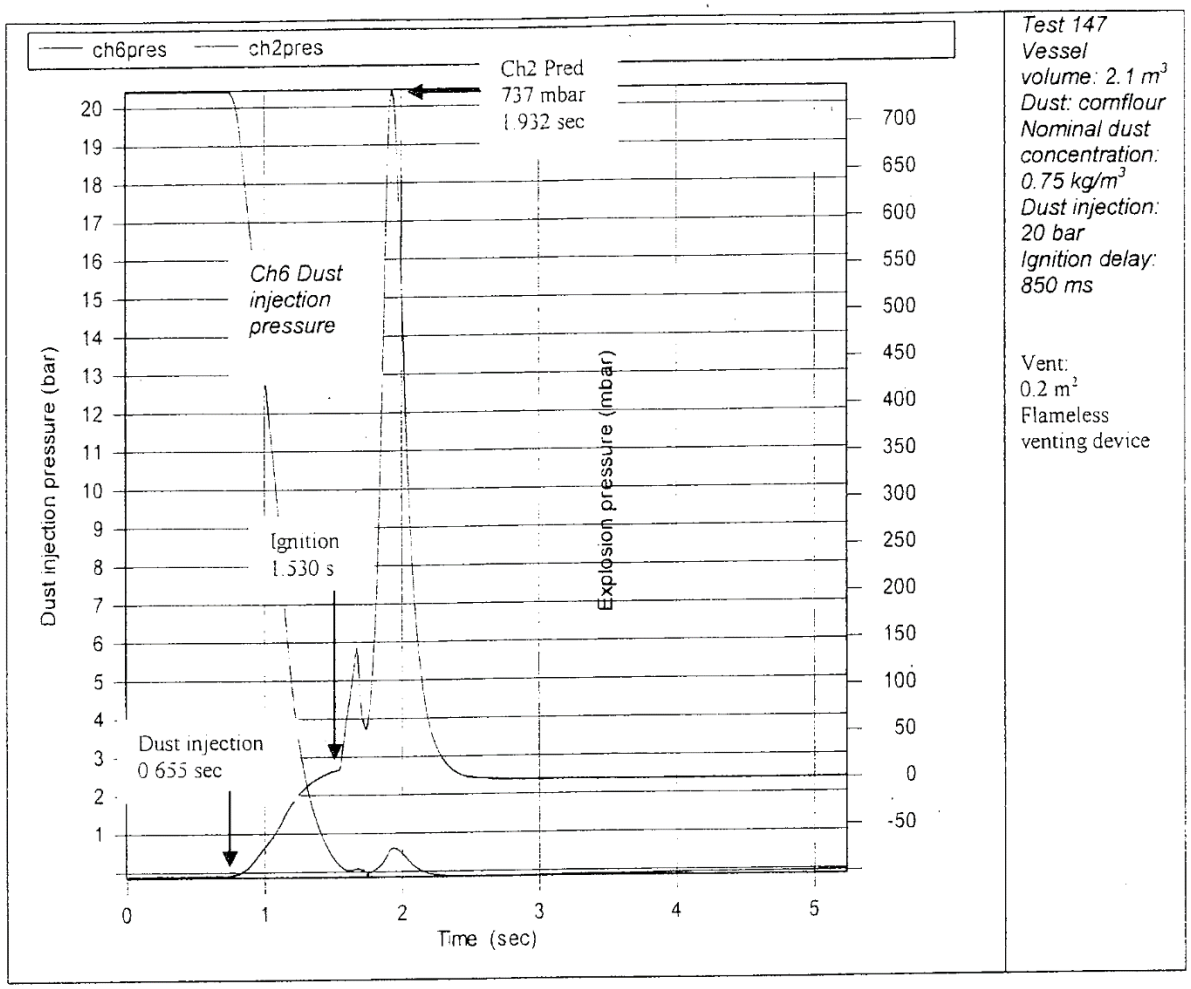
2 m^3 vessel

Vent 0.2 m^2 CV panel and flameless vent

Dust: Cornflour
Concn. 0.75 kg/m^3

P_{red} 737 mbar

Flameless explosion venting



2 m³ vessel

Vent 0.2 m² CV panel and flameless vent

Dust: Cornflour Concn. 0.75 kg/m³

P_{red} 737 mbar

Flameless explosion venting

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Test	Dust	Test chamber volume (m^3)	Vent area (m^2)	Vent type	Ignition delay (mbar)	P_{red} (mbar)	Vent opening pressure (mbar)	Venting efficiency (%)
144	EC/074/09 (MDF wood dust)	2.1	0.2	Fike vent panel and flameless venting device	850	525	130	62
147	EC/084/09 (Cornflour)	2.1	0.2	Fike vent panel and flameless venting device	850	737	142	47
152	EC/072/10 (polyethylene)	2.1	0.2	Fike vent panel and flameless venting device	850	376	100	85
154	EC/107/09 (Wheat flour)	2.1	0.2	Fike vent panel and flameless venting device	850	123	100	100

Flameless explosion venting

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Test	Dust	Test chamber volume (m^3)	Vent area (m^2)	Vent type	Ignition delay (ms)	P_{red} (mbar)	Vent opening pressure (mbar)	Venting efficiency (%)
130	EC/084/09	4	0.4	Fike vent panel and flameless venting device (x2)	850	321	124	75
131	EC/074/09	4	0.4	Fike vent panel and flameless venting device (x2)	850	463	129	57

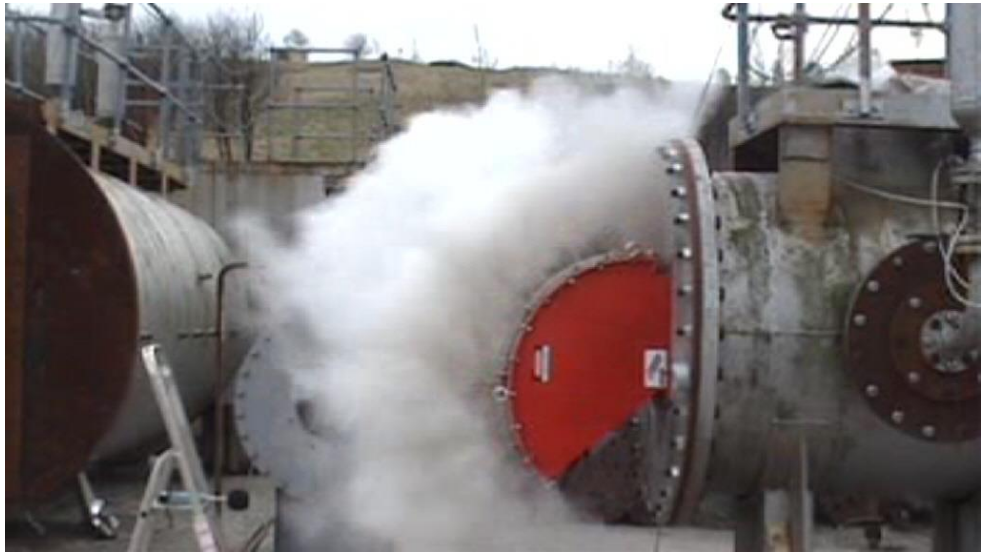
Flameless explosion venting – external effects

Test 46

2 m^3 vessel

0.2 m^2 CV panel

Cornflour 0.75 kg/m^3



Test 47

2 m^3 vessel

0.2 m^2 flameless vent

Cornflour 0.75 kg/m^3

Flameless explosion venting – external effects

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Flameless explosion venting – external effects

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Flameless explosion venting – external effects

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Test	Dust	Vessel volume (m^3)	Vent area (m^2)	Vent	Peak SPL at 1 m (dB)	Pressure at 1 m (mbar)	Peak SPL at 5 m (dB)	Pressure at 5m (mbar)
129	EC/074/09 (Wood dust)	2.1	0.2	Flameless vent	140	2	120	0.2
130	EC/084/09 (Cornflour)	4	0.4	Flameless vent (x2)	139	1.8	132	0.8
131	EC/074/09 (Wood dust)	4	0.4	Flameless vent (x2)	139	1.8	120	0.2
134	EC/074/09 (Wood dust)	2.1	0.2	Flameless vent with dust cover	148	5	128	0.5
135	EC/084/09 (Cornflour)	2.1	0.2	Flameless vent with dust cover	142	2.5	124	0.3
144	EC/074/09 (Wood dust)	2.1	0.2	Flameless vent	121	0.22	116	0.13
147	EC/084/09 (Cornflour)	2.1	0.2	Flameless vent	121	0.35	116	0.13
152	EC/072/10 (Polyethylene)	2.1	0.2	Flameless vent	150	6.3	108	0.05

Flameless explosion venting - external effects

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- Maximum surface temperature at the flame arrestor mesh of 203 degree C.
- Manikin located at 1 m from the device not blown over and no visual burn damage to polypropylene coverall (melting point 160-165 degree C).
- External noise measurements at 1 m and 5 m from the device resulted peak SPL 150 dB at 1 m and at 5 m peak SPL 132 dB.
- Dust cover slightly increased to noise levels but did not increase the $P_{red.}$
- External pressures – at 1m and 5 m from the device resulted in peak values of 6.3 mbar and 0.8 mbar respectively.

Conclusions

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- Demonstrated flame extinguishment of vented St1 dust explosions.
- Higher P_{red} values with corresponding reduction in venting efficiencies.
- Cornflour produced the lowest venting efficiency.
- Presence of a dust cover on the flameless venting device did not impede the venting process.
- Adequate provision needs to be made to protect personnel from the effects of combustion products, noise and temperature.
- Careful consideration needs to be given to process conditions during the design and selection of flameless venting devices.

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Thank you for your attention.