
	MODIFIED STARCH DRYING PROJECT – ARGANA – ROMANIA						
	EXPLOSION VENT CALCULATION						
	Project No.	Discipline	Document Type	Plant / Equipment No	Sequence No.	Rev.	
	5204	PR	CL	000	02	00	

EXPLOSION VENTS CALCULATION

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1. EXPLOSION VENTS CALCULATION

1.1. INTRODUCTION

A dust explosion risk analysis (often called ATEX risk assessment in Europe or Facility Dust Hazard Assessment - DHA - in US) aims at identifying the areas where an explosion can occur (ATEX zone classification), defines the risk associated with any potential source of ignition, **and propose measures to avoid or mitigate the risk to protect the installation.**

It is mandatory for a factory operator to perform a dust explosion risk assessment and put in place all the measures required to prevent explosions. Sometimes however the residual risk is too high and **explosion mitigation measures must be implemented such as explosion panels on hopper, silos, filters on some conveyors.** This page is explaining how are built explosion panels and propose approximate methods to size them.

1.2. Reference



The vent sizing calculations have been conducted in accordance with the BS EN 14491 standard.

1.3. Summary of Results

Summary of explosion vent calculation is according to below table:

Summary of Explosion Vent Calculation Table

Dryer Position	Required Explosion Vent Area (m2)	Actual Area Of Explosion Vents (m2)
From Feed Material to Cyclones (A to G)	4.01	4.1
Inlet Ducts to cyclones (H)	0.26	0.39
From Cyclones to Fan	4.15	4.15
From Cyclone's outlet ducts to Hopper & Hopper	0.22	0.38

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1.4. Dust Characteristic and Pre-requisites to sizing explosion vents

Knowing the dust explosion properties In order to be able to size an explosion panel allowing to relieve the pressure of a dust explosion, it is necessary to know "how" the dust will explode, that is to say it is required to measure the dust explosion properties of a material.

- **Kst Value:** 147 bar.m/sec
- **Dust Explosion Class:** St 1
- **Max. Explosion Over-Pressure (Pmax):** 8.7 barg
- **Lower Explosion Limit (LEL):** 60 gr/m³
- **Min. Ignition Energy (MIE):** 300 < MIE < 1000 mJ
- **Dust Cloud Ignition Temperature:** 380°C
- **Glow Temperature:** > 280°C
- **Auto-Ignition Temperature:** 175°C
- **Specific Volume Resistance:** 10⁸ Ω.m (non-conductive)
- **Burning Number:** BZ4

1.5. Explosion Vent Area (BS EN 14491)

For enclosures, the following formula allow the calculation of the required vent area A. The required vent area can, in practical application, be divided into several smaller areas as long as the total area equals the required vent area:

$$A = B(1 + C \times \log L/D)$$

$$B = [3.264 \times 10^{-5} \times P_{max} \times K_{st} \times P_{req}^{-0.569} + 0.27(P_{stat} - 0.1)P_{req}^{-0.5}]V^{0.753}$$

$$C = (-4.305 \times \log(P_{req}) + 0.758)$$

A: Required Vent Area, m²

L: Length of the tube or enclosure, m

D: Tube or enclosure diameter, m



P_{max}: maximum over pressure, bar, 5<P_{max}<10

K_{st}: Maximum value of the pressure rise per unit time, bar.m/s, 10<K_{st}<300

P_{req.}: Maimum over pressure generated by an explosive atmosphere, bar ,0.1<P_{req}<2

P_{stat}: Vent Opening Pressure, bar, 0.1<P_{stat}<1

V: Volume of tube or enclosure, m³ , 0.1<V<10,000

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To calculate the required vent area for the explosion vent, the entire dryer system is divided into several zones, and calculations are performed separately for each zone. These zones include the following sections:

1. From the starch inlet to the cyclone inlets
2. The cyclone assembly

1.5.1. Explosion Vent Area from Feed Material to Cyclones.

The first section—from the starch inlet to the cyclone inlets—is further subdivided into several parts due to changes in pipe diameter in certain areas and the transition from circular to rectangular ducting at the end. To ensure more accurate calculations, this section is divided into 7 segments, with relevant parameters calculated separately for each segment. Finally, the total required vent area is determined.

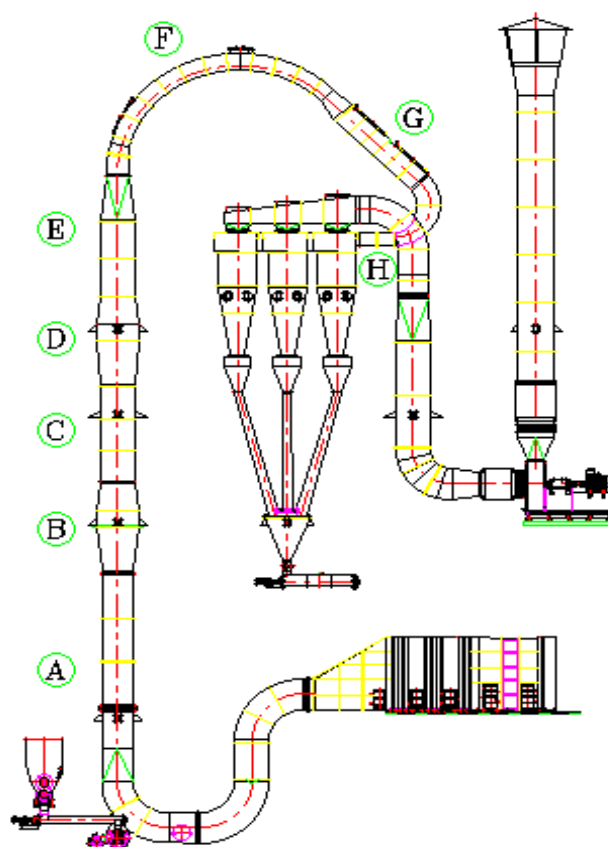


Figure 1- Flash Dryer Areas



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Table 1 – Ducts Explosion Vent Area Calculation

Position	Length(m)	Dim. /Dia.	De	L/De	Volume	Preq.	Pmax	Kst	Pstat.	B	C	A (vent Area)
A	9.5	1.3	1.3	7.31	12.60	0.75	8.7	147	0.1	0.331	1.295	0.7
B	4	1730/1300	1.58	2.53	7.84	0.75	8.7	147	0.1	0.232	1.295	0.353
C	4.5	1.4	1.4	3.21	6.92	0.75	8.7	147	0.1	0.211	1.295	0.35
D	4	1730/1400	1.60	2.50	8.04	0.75	8.7	147	0.1	0.236	1.295	0.358
E	5.6	1.4	1.4	4.00	8.62	0.75	8.7	147	0.1	0.249	1.295	0.443
F	11.8	0.75x1.37	1.15	10.26	12.25	0.75	8.7	147	0.1	0.324	1.295	0.749
G	9	0.95x1.37	1.29	6.98	11.76	0.75	8.7	147	0.1	0.314	1.295	0.658
SUM	Total Area for Explosion Vents From A to G											3.611

The total vent area is calculated from “A” to “G” with an efficiency factor of 0.9 applied to each vent, ensuring a safety margin is incorporated into the calculations. Based on past experience, the hazardous zone in the first section begins where the material has lost most of its moisture. Therefore, explosion vents are installed in the upper part of this section up to the cyclone’s inlets. The number of vents planned for the first section is 4. Thus, the total calculated vent area is divided by 4 to determine the area and diameter of each individual vent.

$$E \text{ (Efficiency)} = 0.9$$

$$A = \text{Required Area(Total Vent Area)} = \frac{3.611}{0.9} = 4.01 \text{ m}^2$$

$$Q \text{ (Quantity of Vents)} = 3 + 1$$

$$A'1 = \text{Area of Rectangular Explosion Vents} = 3 \times (1.5 \times 0.8) = 3.6 \text{ m}^2$$

$$A'2 = \text{Area of Circular Explosion Vents} = (3.14 \times 0.8^2) = 0.5 \text{ m}^2$$

$$A'1 + A'2 = \text{Total Existing Explosion Vent Area} = 3.6 + 0.5 = 4.1 \text{ m}^2$$

$$A' > A : 4.1 \text{ m}^2 > 4.01 \text{ m}^2$$

The calculations were performed for 3+1 vents; however, at the end of the duct where the main channel splits into two branches, an explosion vent is installed on each branch. For H position (Inlet of Cyclones) explosion vent area is calculated separately:



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Table 2 – Ducts Explosion Vent for “H” section

Position	Length(m)	Width(m)	Height(m)	De	L/De	Volume	Preq.	Pmax	Kst	Pstat.	B	C	A (vent Area)
H1	1.76	1.27	0.88	1.19	1.48	1.97	0.75	8.7	147	0.1	0.082	1.29	0.099
H2	0.82	0.63	0.88	0.84	0.98	0.45	0.75	8.7	147	0.1	0.027	1.29	0.027
H3	0.848	0.31	0.88	0.59	1.44	0.23	0.75	8.7	147	0.1	0.016	1.29	0.02
H4	1.43	0.31	0.88	0.59	2.43	0.39	0.75	8.7	147	0.1	0.024	1.29	0.036
H5	2.64	0.31	0.88	0.59	4.48	0.72	0.75	8.7	147	0.1	0.028	1.29	0.053
SUM													0.235

$$E \text{ (Efficiency)} = 0.9$$

$$A(\text{Total Vent Area}) = \frac{0.235}{0.9} = 0.26 \text{ m}^2$$

$$Q \text{ (Quantity of Vents)} = 2$$

$$D(\text{Diameter of Vent for H}) = 0.5\text{m}$$

$$A' = \text{Area of Vents} = 2 \times 3.14 \times \frac{0.5^2}{4} = 0.39 \text{ m}^2$$

$$A' > A : 0.39 \text{ m}^2 > 0.26 \text{ m}^2$$

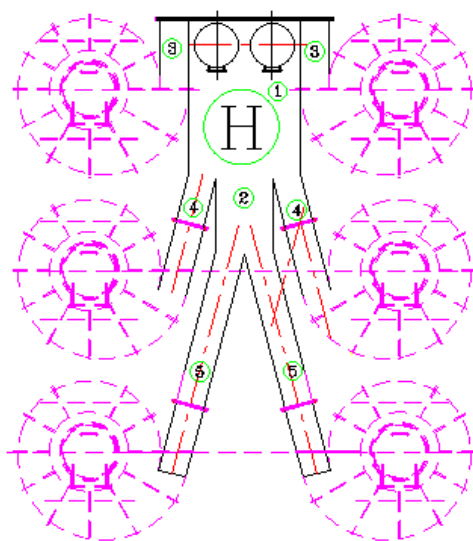




Figure 2- “H” section – Cyclones Inlet Area

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1.5.2. Explosion Vent Area on Cyclones & Outlet Duct

The Explosion vent area calculation was performed for Cyclones and outlet duct separately, there are 6 explosion vents on top of the cyclone's outlet pipe, total area of vents shall be greater than required explosion vent area for cyclones and outlet duct:

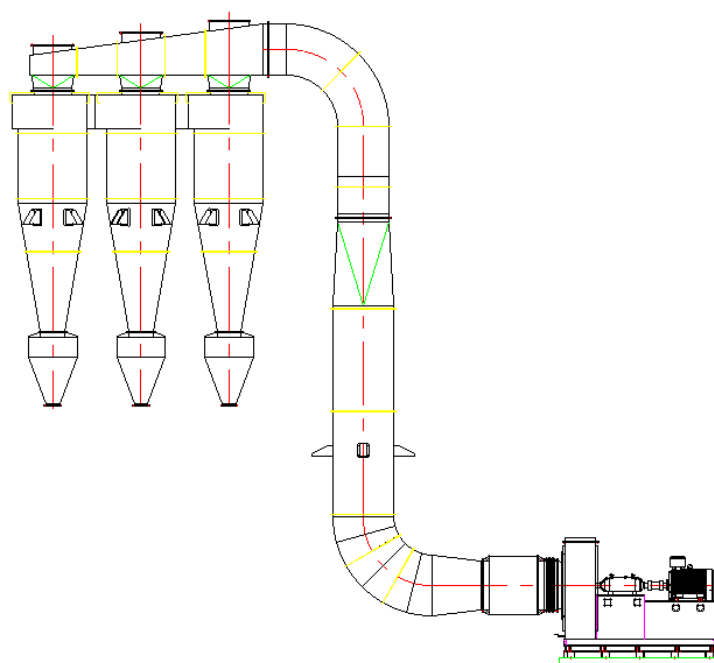




Figure 3— Cyclones & Outlet Duct

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a. Explosion Vent Area on Cyclones

There are six cyclones to which the inlet air, along with the dried starch, is directed. The separation of air from the starch takes place within these units. The explosion vent, based on process conditions and Annex “B” of BS EN14491 standard, is installed at the highest point of cyclone. The calculation of the required explosion vent area is as follows:

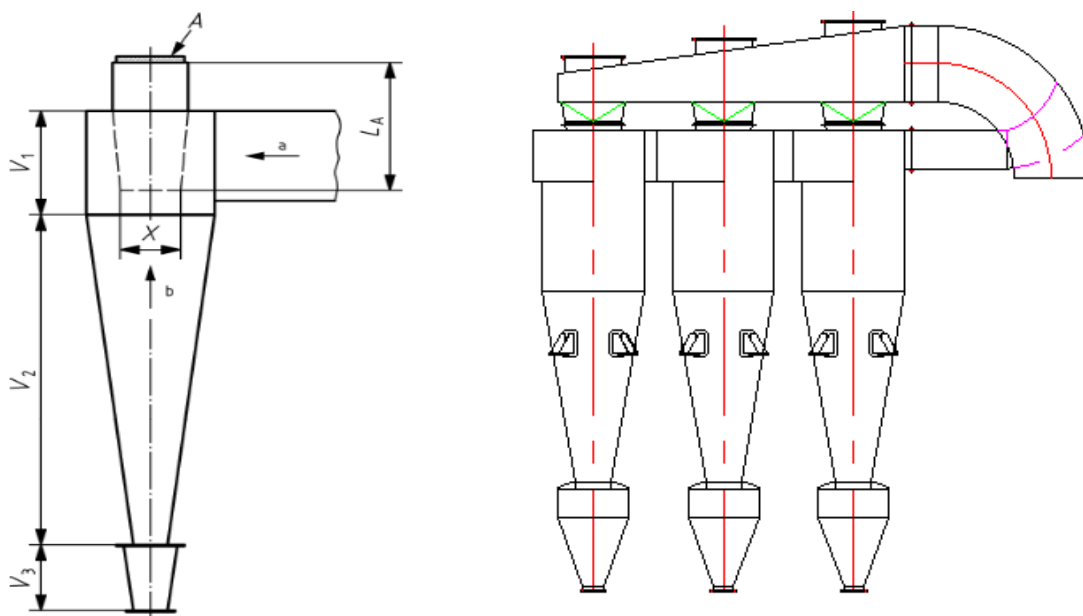


Figure 4 -Cyclones Schematic

$$A = B(1 + C \times \log LA/X)$$

$$B = [3.264 \times 10^{-5} \times P_{max} \times K_{st} \times P_{req}^{-0.569} + 0.27(P_{stat} - 0.1)P_{req}^{-0.5}]V^{0.753}$$

$$C = (-4.305 \times \log(P_{req}) + 0.758)$$

A: Required Vent Area, m^2



LA: Length of the tube or enclosure, m

X: Outlet Pipe diameter, m

P_{max}: maximum over pressure, bar, 5<P_{max}<10

K_{st}: Maximum value of the pressure rise per unit time, bar.m/s, 10<K_{st}<300

P_{req}.: Pressure after explosion that structure could be resistance without damage, bar ,0.1<P_{req}<2

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Pstat: Vent Opening Pressure, bar, $0.1 < P_{stat} < 1$

V: Volume of tube or enclosure, m^3 , $0.1 < V < 10,000 = V_1 + V_2 + V_3$

Table 3- Cyclones Explosion Vent Area

Equipment	LA(m)	X	De	LA/X	Volume	Preq.	Pmax	Kst	Pstat.	B	C	A (vent Area)
Cyclone	1	0.87	1.3	1.15	8.95	0.75	8.7	147	0.1	0.256	1.29	0.276

$$E \text{ (Efficiency)} = 0.9$$

$$A(\text{Vent Area}) = \frac{0.276}{0.9} = 0.3 \text{ m}^2$$

$$Q \text{ (Quantity of Cyclones)} = 6$$

$$A'(\text{Total Required Area for Cyclones}) = 6 \times 0.3 = 1.8 \text{ m}^2$$

b. Explosion Vent Area on Outlet Duct

For Outlet Duct, the following formula allow the calculation of the required vent area A. The required vent area can, in practical application, be divided into several smaller areas as long as the total area equals the required vent area:

$$A = B(1 + C \times \log L/D)$$

$$B = [3.264 \times 10^{-5} \times P_{max} \times K_{st} \times Preq^{-0.569} + 0.27(P_{stat} - 0.1)Preq^{-0.5}]V^{0.753}$$

$$C = (-4.305 \times \log(Preq) + 0.758)$$

A: Required Vent Area, m^2

L: Length of the tube or enclosure, m

D: Tube or enclosure diameter, m



Pmax: maximum over pressure, bar, $5 < P_{max} < 10$

Kst: Maximum value of the pressure rise per unit time, bar.m/s, $10 < K_{st} < 300$

Preq.: Maimum over pressure generated by an explosive atmosphere, bar, $0.1 < Preq < 2$

Pstat: Vent Opening Pressure, bar, $0.1 < P_{stat} < 1$

V: Volume of tube or enclosure, m^3 , $0.1 < V < 10,000$

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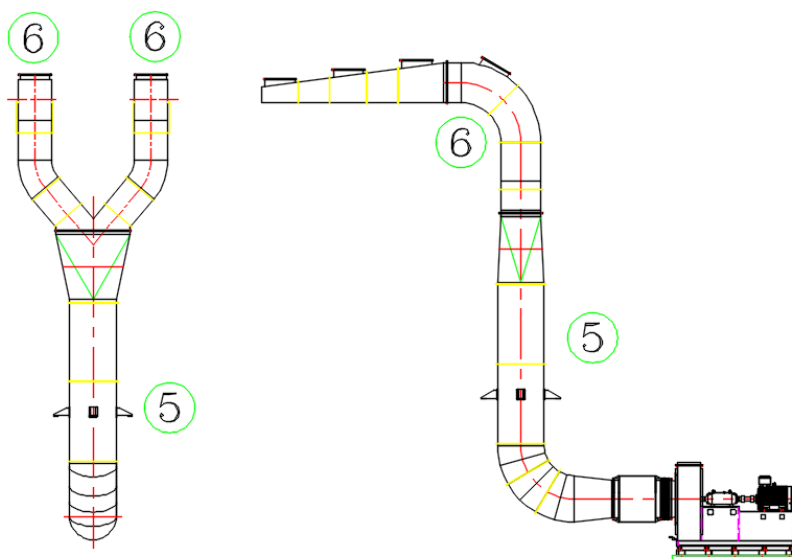




Figure 5 -Outlet Duct

Table 4- Outlet Duct Explosion Vent Area

Position	Length(m)	Width(m)	Average Height(m)	De	L/De	Volume	Preq.	Pmax	Kst	Pstat.	B	C	A (Vent Area) m2
1	5.45	1	0.83	1.03	5.30	4.52	0.75	8.7	147	0.1	0.154	1.29	0.29
1	5.45	1	0.83	1.03	5.30	4.52	0.75	8.7	147	0.1	0.154	1.29	0.29
2	5.73	1	1.2	1.24	4.63	6.88	0.75	8.7	147	0.1	0.211	1.29	0.39
2	5.73	1	1.2	1.24	4.63	6.88	0.75	8.7	147	0.1	0.211	1.29	0.39
3	1.95	1.3	1.8	1.73	1.13	4.56	0.75	8.7	147	0.1	0.155	1.29	0.16
4	7.5	-	-	1.40	5.36	11.54	0.75	8.7	147	0.1	0.31	1.29	0.6
SUM													2.12

$$E \text{ (Efficiency)} = 0.9$$

$$A(\text{Explosion Vent Area for Outlet Duct to Fan}) = \frac{2.12}{0.9} = 2.35 \text{ m}^2$$

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c. Total Area Required for Cyclones and Outlet Duct

$$A''(\text{Total Required Area for Cyclones and Outlet Duct}) = 1.8 \text{ m}^2 + 2.35 \text{ m}^2$$

$$A'' = 4.15 \text{ m}^2$$

$$\text{Quantiti of Vents} = (6 + 2)$$

$$\text{Each Vent Area} = \frac{4.15}{8} = 0.51 \text{ m}^2$$

$$\text{Each Vent Diameter} = 0.8 \text{ m}$$

$$\text{Actual Vent Diameter} = 0.8 \text{ m}$$

$$\text{Actual Vent Area} = 4.15 \text{ m}^2$$

1.5.3. Explosion Vent Area from Cyclone's Outlet Ducts to Hopper & Hopper

For Ducts from cyclones to hopper and hopper, the following formula allow the calculation of the required vent area A. The required vent area can, in practical application, be divided into several smaller areas as long as the total area equals the required vent area:

$$A = B(1 + C \times \log L/D)$$

$$B = [3.264 \times 10^{-5} \times P_{max} \times K_{st} \times P_{req}^{-0.569} + 0.27(P_{stat} - 0.1)P_{req}^{-0.5}]V^{0.753}$$

$$C = (-4.305 \times \log(P_{req}) + 0.758)$$

A: Required Vent Area, m^2

L: Length of the tube or enclosure, m

D: Tube or enclosure diameter, m



P_{max}: maximum over pressure, bar, $5 < P_{max} < 10$

K_{st}: Maximum value of the pressure rise per unit time, bar.m/s, $10 < K_{st} < 300$

P_{req}: Maimum over pressure generated by an explosive atmosphere, bar, $0.1 < P_{req} < 2$

P_{stat}: Vent Opening Pressure, bar, $0.1 < P_{stat} < 1$

V: Volume of tube or enclosure, m^3 , $0.1 < V < 10,000$

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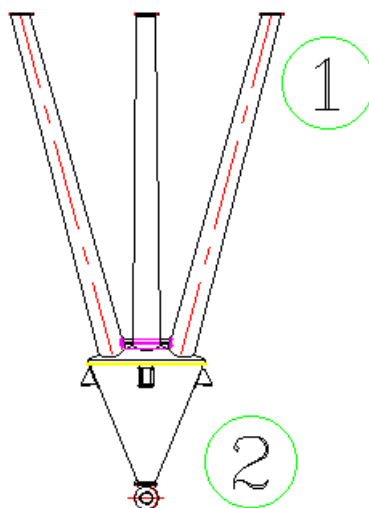


Figure 5 -Outlet Duct

Table 4- Outlet Duct Explosion Vent Area

Position	Length(m)	De	Qty	L/De	Volume	Preq.	Pmax	Kst	Pstat.	B	C	A (vent Area)
1	5.7	0.4	6	14.25	0.72	1.5	8.7	147	0.1	0.026	-0.00007	0.026
2	2.3	1.38	1.00	1.67	3.42	1.5	8.7	147	0.1	0.173	-0.00007	0.173
SUM												0.199

$$E \text{ (Efficiency)} = 0.9$$

$$A(\text{Total Vent Area}) = \frac{0.199}{0.9} = 0.22 \text{ m}^2$$

$$Q \text{ (Quantity of Vents)} = 1$$

$$A' = \text{Area of Vent} = 3.14 \times \frac{0.7^2}{4} = 0.38 \text{ m}^2$$

$$A' > A : 0.38 \text{ m}^2 > 0.22 \text{ m}^2$$