

Combustible Dust Issues

Dust Collector Requirements

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Donaldson Company, Inc.



Combustible Dust – Impact on Collectors

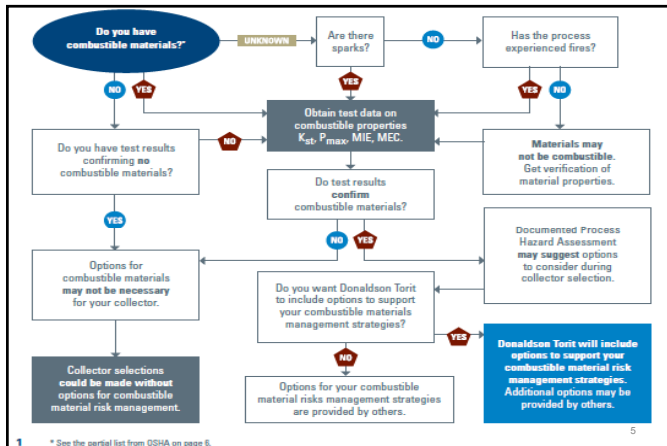
- Rules or Requirements Discussed by Customers
- What areas of the collectors are impacted by the requirements?
- What Requirements Apply and When?
 - New collectors?
 - Existing collectors?

DUST COLLECTORS AND COMBUSTIBLE DUST STRATEGIES

- Who Owns a “Combustible Dust Strategy?”
- Thoughts on “Strategy of Use”



Compliance Strategy Components



* See the partial list from OSHA on page 6.

GUIDE TO EXPLOSION/FIRE PROTECTION COMPONENTS FOR DUST COLLECTORS

ITEM #	DESCRIPTION
1	Explosion Relief Panels
2	Detector (Sensor) - Chemical or Acoustic System Devices
3	Chemical or Acoustic System Devices
4	Explosion Suppression System
5	Explosion Suppression System Panel
6	Explosion Suppression System Panel
7	Flame Arrestor
8	Flame Arrestor
9	Flame Arrestor
10	Flame Arrestor
11	Flame Arrestor
12	Flame Arrestor
13	Flame Arrestor
14	Flame Arrestor
15	Flame Arrestor
16	Flame Arrestor
17	Flame Arrestor
18	Flame Arrestor
19	Flame Arrestor
20	Flame Arrestor

TYPE	DESCRIPTION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
FIRE PROTECTION	Flame Arrestor/Flame Suppression/Spark Arresting	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Explosion Relief Panels	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Explosion Suppression System	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
EXPLOSION PREVENTION	Flame Arrestor	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Explosion Relief Panels	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Explosion Suppression System	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
DUST COLLECTOR ISOLATION	Flame Arrestor	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Explosion Relief Panels	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Explosion Suppression System	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

COMBUSTIBLE DUST STRATEGIES		OSHA ON COMBUSTIBLE DUST																									
<p>As a process owner, you are responsible for the selection of your combustible material management strategy and to ensure compliance with applicable federal, state, and local codes and standards.</p>																											
<p>DEFINITIONS</p> <p>Collectible - Having an inherent ability to agglomerate into a cohesive mass of particles of sufficient size to be captured by the equipment in a collection system.</p> <p>Combustible dust - A finely divided solid material that, in a dispersed form, is capable of being ignited by a flame source. Combustible dusts that are not combustible in the bulk state are referred to as "combustible dusts."</p> <p>Combustible dust - A finely divided solid material that, in a dispersed form, is capable of being ignited by a flame source. Combustible dusts that are not combustible in the bulk state are referred to as "combustible dusts."</p> <p>Combustible dust - A finely divided solid material that, in a dispersed form, is capable of being ignited by a flame source. Combustible dusts that are not combustible in the bulk state are referred to as "combustible dusts."</p>	<p>STANDARD CODES & GUIDELINES THAT IMPACT DUST COLLECTOR DECISIONS</p> <table border="1"> <thead> <tr> <th>CODE</th> <th>DESCRIPTION</th> </tr> </thead> <tbody> <tr> <td>29</td> <td>Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities</td> </tr> <tr> <td>68</td> <td>Standard for Combustible Metals</td> </tr> <tr> <td>69</td> <td>Standard for the Prevention of Fires and Explosions in Food Processing and Woodworking Facilities</td> </tr> <tr> <td>70</td> <td>Standard for Explosive Protection by Deflagration Venting</td> </tr> <tr> <td>71</td> <td>Standard for Explosion Protection by Deflagration Venting</td> </tr> <tr> <td>77</td> <td>Recommended Practice on Static Electricity</td> </tr> <tr> <td>91</td> <td>Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids</td> </tr> <tr> <td>484</td> <td>Standard for Combustible Metals</td> </tr> <tr> <td>499</td> <td>Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas</td> </tr> <tr> <td>654</td> <td>Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids</td> </tr> <tr> <td>664</td> <td>Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities</td> </tr> </tbody> </table>	CODE	DESCRIPTION	29	Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities	68	Standard for Combustible Metals	69	Standard for the Prevention of Fires and Explosions in Food Processing and Woodworking Facilities	70	Standard for Explosive Protection by Deflagration Venting	71	Standard for Explosion Protection by Deflagration Venting	77	Recommended Practice on Static Electricity	91	Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids	484	Standard for Combustible Metals	499	Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas	654	Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids	664	Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities	<p>Does your company or fire process any of these products or materials in powdered form? You ask...</p> <p>"If so, there is potential for a "Combustible Dust" explosion.</p> <p>Dust Control Measures</p> <p>The dust control system design and the collection system design is a function of the facility's dust control strategy and the dust control system design. The dust control system design is a function of the facility's dust control strategy and the dust control system design.</p> <p>Prevention Measures</p> <p>The facility has an ongoing dust control program that includes the following: Dust control measures are in place to prevent dust from being generated in the first place. Dust control measures are in place to prevent dust from being generated in the first place. 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Key Point

Exceptions to codes may be possible, as long as the AHJ approves!

Key Point to think about

- Inlet Isolation
- Hopper Outlet Isolation
- Air Outlet Isolation

- ## Commonly Referenced NFPA Dust Collection Standards
- 61 – Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities - **2008**
 - 68 – Standard for Explosion Protection by Deflagration Venting – **2007**
 - 69 – Standard on Explosion Prevention Systems – **2008**
 - 70 – National Electric Code – **2008**
 - 77 – Recommended Practice on Static Electricity - **2007**
 - 91 - Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids – **2004**
 - 484 – Standard for Combustible Metals - **2009**
 - 499 – Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas - **2008**
 - 654 – Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids – **2006**
(Upcoming - 2011)
 - 664 – Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities - **2007**

Other Requirements

- What have you run across?

International Mechanical Code - 2009

Chapter 5 – Exhaust Systems

- Section 510 – Hazardous Exhaust Systems
- Section 511 – Dust, Stock, and Refuse Conveying Systems

Chapter 5 Exhaust Systems

Section 510 Hazardous Exhaust Systems

Section 511 Dust, Stock, and Refuse Conveying Systems

Section 512 Exhaust Systems

Section 513 Exhaust Systems

Section 514 Energy Recovery Ventilating Systems

International Fire Code – Chapter 13

Combustible Dust-Producing Operations

Chapter 13 Combustible Dust-producing Operations. The requirements of Chapter 13 seek to reduce the likelihood of dust explosions by managing the hazards of ignitable suspensions of combustible dusts associated with a variety of operations including woodworking, mining, food processing, agricultural commodity storage and handling, and pharmaceutical manufacturing, among others. Ignition source control and good housekeeping practices in occupancies containing dust-producing operations are emphasized. As with other chapters of the International Fire Code, Section 1302 contains a definition that is applicable to the chapter contents.

NEW YORK STATE COMBUSTIBLE DUST-PRODUCING OPERATIONS	SECTION NUMBER
Section	
1300 General	1300
1301 Definitions	1301
1302 Provisions	1302
1303 Explosion Protection	1303

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Factory Mutual – Property Loss Prevention Data Sheets

General Industry Data Sheets

- 7-0 Causes and Effects of Fires and Explosions, 2006
- 7-73 Dust Collectors and Collection Systems, 2008
- 7-76 Prevention and Mitigation of Combustible Dust Explosion and Fire, 2009

Industry Specific Property Loss Prevention Data Sheets

- 7-4 Paper Machines and Pulp Dryers, 2009
- 7-10 Wood Processing and Woodworking Facilities, 2000
- 7-43 Loss Prevention in Chemical Plants, 2009
- 7-75 Grain Storage and Milling, 2006

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Code & Standard Requirement Impacts

- Collector Type
- Collector Location
- Collector Options
- Accessories
- Operation & Servicing

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Impact – Terms Used

- Mechanical
 - Drop Out Boxes & Cyclones
- Wet - Precipitators
- Media – Dry Dust Collectors
- Electrostatic – ESP & Media

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Type – Metal's NFPA 484

Aluminum – Chapter 6

- Dry-type dust collectors shall be located outside of buildings.
- Electrostatic collectors **shall not be used**.

Magnesium – Chapter 7

- Either a wet-type collector or a cyclone collector and blower located outdoors.

Titanium – Chapter 10

- Connected to liquid precipitation separators,...
- Dry-type **cyclone** dust collectors shall be located outside of buildings.

Metals not covered by other chapters – Chapter 12

- Dry-type **cyclone** dust collectors shall be located outside of buildings.

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Type – Wood NFPA 664

Enclosureless Collector - An air-material separator designed and used to remove dust from the transport air possessing **ALL** of the following:

- (1) The filtration is accomplished by passing dust-laden air through filter media, collecting the dust on the **inside of the filter media**, and allowing cleaned air to **exit to the surrounding area**.
- (2) The filter medium is **not enclosed or in a container**.
- (3) The filter medium is **not mechanically shaken or pressure-pulsed**.
- (4) The filter medium is under **positive pressure**.
- (5) Removal of the collected dust is **not continuous or mechanical**.

Note: Can be **indoors** and explosion venting **not required**

But.....

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664 Enclosureless Collector

Limitations

- No more than 5,000 CFM capacity each
- No closer than 20 ft to an egress, normally occupied area, or other collectors.
- Wood only!

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Collector Type – Grain NFPA 61

Cyclones with a 30 in. diameter or less (no FB sections) used as air-material separators shall be allowed to be placed inside buildings without explosion protection when the following conditions are present:

- (1) The room, building, or other enclosure is **not a Class I, Division 1 or 2 or Class II, Division 1** area as defined by Article 500 of NFPA 70, National Electrical Code.
- (2) The material being processed has a minimum ignition energy of **more than 10 mJ**.
- (3) The system is a closed process, excluding cleaning vacuum systems.
- (4) The material being processed has a **Kst of less than 200 bar-m/sec**.

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Impact – Collector Size

- Single Use
- OR -
- Centralized (Manifold Ducts)

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Impact – Size

664 Wood:

- The **capacity** of the system shall be **calculated** on the basis of **all hoods and other openings** connected to the system being **open** or equipped with means to ensure minimum conveying velocity in all sections of the system.

654 Combustible Dust:

- The rate of airflow at each hood or other pickup point shall be designed so as to **convey and control** the material
- All **ductwork** shall be sized to provide the air volume and air velocity necessary to keep the **duct interior clean and free of residual materials**

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Size – Central vs Dedicated – NFPA Interpretation

NFPA 654 – Combustible Dusts

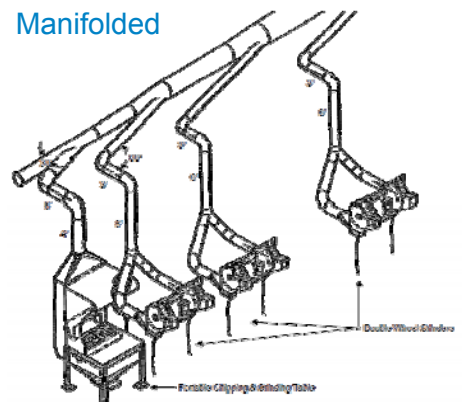
Manifolding of dust collection ducts to air-material separators **shall not be permitted.** (NFPA 654 7.13.1.4)

Exceptions:

- Dust collection ducts from a single piece of equipment or from multiple pieces of equipment interconnected on the same process stream **shall be permitted to be manifolded.**
- Dust collection ducts from non-associated pieces of equipment **shall be permitted to be manifolded** provided that each duct is equipped with an isolation device prior to manifolding
- Dust collection ducts for centralized vacuum cleaning systems **shall be permitted to be manifolded.**

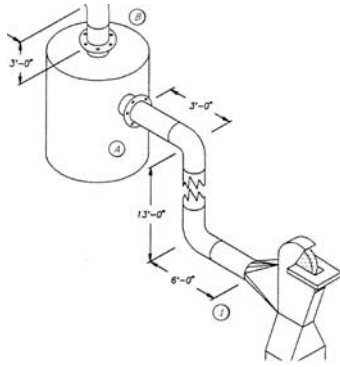
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Manifolded



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Non-Manifolded



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Centralized vs Dedicated

Aluminum – NFPA 484

- Grinding operations shall not be served by the same dust collection system as buffing and polishing operations.
- Dust collection systems shall be dedicated to the collection of aluminum or aluminum alloy dust only. **WHY?**

Grain – NFPA 61

- Dust collection systems for one or more hammer mills or pulverizer mills shall not be manifolded with other types of machinery
- Each department in starch manufacturing and handling (i.e., starch drying, grinding, dextrine cooking) shall have a separate dust collection system

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Location – Outdoors (OSHA NEP)

Although alternatives to out-of-doors locations are permitted, allowing indoor locations under special circumstances, **outdoor locations are highly recommended**. It is not advisable to locate dust collectors on the roofs of buildings.

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How do the Requirements Impact Location?

- Outside
Inside if.....
- Proximity of other Collectors

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Location – Indoors IF

- Deemed to have **no fire or deflagration hazard**
- A **fire hazard only** & protected in accordance with ...
- Equipped with listed deflagration **suppression system**
- **Equipped with deflagration relief vents with relief duct extending to safe areas** outside the building & the collector meets the strength requirement of ...
- When **equipped with deflagration relief vents exhausting through listed flame-quenching devices** and the collector meets the strength requirement of ...

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664 Location – Proximity Issues

Industry, Wood – Enclosureless Collectors

- At least 20 feet from other collectors.
- At least 20 feet from any means of egress or area routinely occupied by personnel.

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Engineering Data Requirements

- Collector Model
- Location – City, State
- Elevation (above grade)
- Clearance below the hopper flange
- Inlet Size
- K_{st}
- P_{max}
- Duct Length
- Accessories
- Airflow
- Hopper Type

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Collector Options

- Hopper & Legs –or– Bin Vent
- Media Selection
- Bonding & Grounding
- Housing Reinforcements

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Collector Options: Hopper

61 Grain

- **Bin vent dust collectors directly mounted without a hopper** on a tank or bin, whose primary function is to filter air displaced during filling or blending operations and return dust directly to the bin, **shall be permitted inside or outside of buildings without explosion protection**. Filters that return air to inside of buildings shall be capable of a minimum efficiency of 99.9 percent at 10 microns.
- **Take-away: Sell CPV!**

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Collector Options: Media

484 Aluminum: Dust-collecting filter medium shall be designed to be **conductive** so as to dissipate static electric charges.

- Available Torit-TEX CD
- EpiTropic

654 Combustible Dust: Filter media shall be permitted to be constructed of **combustible** material.

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Collector Construction

664 Wood: The collection equipment shall be designed and constructed entirely of noncombustible material suitable for the use intended. (no plastic)

Exception: Filter bags and explosion vent diaphragms fabricated from combustible material shall be permitted.

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Collector Options: Bonding

654 Combustible Dust

- Bonding and grounding with a resistance of less than 1.0×10^6 ohms to ground shall be provided for conductive components.

-Available: Ground Test Documentation

484 Metals - Aluminum

- All components of dust collection systems shall be electrically bonded and grounded.

-Available: Ground Test Documentation

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Collector Options: Reinforcing – no vents and no suppression

NFPA 69 Chapter 13: Containment

- ...specifying the design pressure of a vessel and its appurtenances so they are capable of withstanding the maximum pressures resulting from an internal deflagration.
- R, is the ratio of the maximum deflagration pressure, in absolute pressure units, to the maximum initial pressure, in consistent absolute pressure units.

Sometimes referenced as "10 bar" construction

Generally NOT feasible for Dust Collectors

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Technical Data Sheet

DFO 2-4 & DFO 3-6 COLLECTOR TECHNICAL DATA SHEET

MODEL	SHIP WT (LBS)	NO OF CART	FILTER AREA (SQ FT)		VALVE QTY	DIMENSIONS (IN)			EXPLOSION VENTS (A,B)	
			ULTRA-WEB	FIBRA-WEB & ULTRA-TEK		HT	WIDTH	DEPTH	COLLECTOR VOL. (CU FT)	MAX Kst QTY
DFO 2-4	1125	4	760	356	4	119	45	61	42.4	1 475
DFO 3-6	1395	6	1,140	534	6	137	45	61	55.5	1 415

- (A) Contact Home Office for explosion vent information. L/D > 2 for the DFO 3-6 which lowers the Kst value accordingly. Calculations based on NFPA-68-2007. Assumes standard hopper, enclosure strength of up to 2/3 the ultimate strength, no ductwork, and no volume modifications. Calculations based on max A/C = 6 with Ultra-Web filters. For dusts with higher Kst values, contact Home Office.
- (B) Contact Home Office for assistance to determine Kst values when ducting relief panels. Refer to CDMS for details on flange adapters.
- AR inlet sizes: 6-12, in one-inch increments.
- Models DFO 2-4 and 3-6 require clean, dry compressed air at maximum 60 psi.

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Technical Data Sheet

COLLECTOR TECHNICAL DATA SHEET

T	DIMENSIONS (IN)		EXPLOSION VENTS (A,B)		
	WIDTH	DEPTH	COLLECTOR VOL. (CU FT)	QTY	MAX Kst
9	45	61	42.4	1	475
17	45	61	55.5	1	415

L/D > 2 for the DFO 3-6 which lowers the Kst value accordingly. Assumes standard hopper, enclosure strength of up to 2/3 the ultimate strength, no ductwork, and no volume modifications. Calculations based on max A/C = 6 with Ultra-Web filters.

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Technical Data Sheet Notes

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- AR inlet sizes: 6-12, in one-inch increments.
- Models DFO 2-4 and 3-6 require clean, dry compressed air at maximum 60 psi.

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Collector Accessories

- Fire Suppression
- Deflagration Vents
- Flameless Vent
- Explosion Suppression
- Isolation Devices
 - Inlet, Outlet, & Hopper Discharge

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NFPA Key Parameters

$$A_v = 1 \times 10^{-4} \left(1 + 1.54 P_{stat}^{4/3} \right) K_{st} V^{3/4} \sqrt{\frac{P_{max}}{P_{red}}} - 1$$

- A_v = Vent Area [m²]
- P_{stat} = Burst pressure of vent [bar]
- K_{st} = Maximum Rate [bar-m/sec]
- V = Volume of enclosure [m³]
- P_{red} = Reduced pressure after venting [bar]
- P_{max} = Maximum Pressure [bar]

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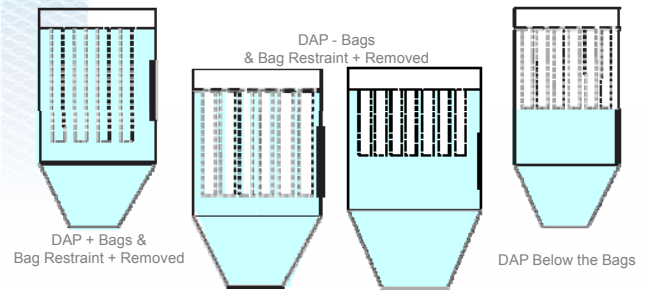
P_{red} Values for Various Products

- CPC 0.18 bar (72" water)
- DFT 0.40 bar (160" water)
- DFO Small 0.35 bar
- DFO Med-Large 0.40 bar
- MBW 0.34 bar
- MBT 0.24 bar
- UMA 0.35 bar
- TG-Series Varies
- Dalamatic Varies

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Impact – Vent Location

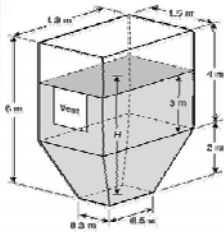
Volumes used to determine required vent area



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Impact – Vent Location

6.4.3.3 The **effective volume of the enclosure, V_{eff}** , shall be determined based on the volume of that part of the enclosure through which the flame can pass as it travels along **the maximum flame length, H**.



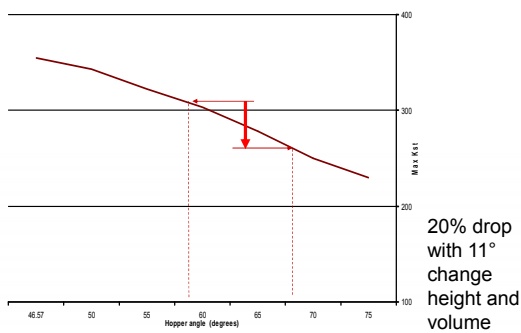
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Take Away

- Change the hopper changes the “H”
- Change the “H” changes the volume
- Changing volume changes vent area and suppression required

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Impact – Hopper Height



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Impact - Vent Ducts

- 6.8.1 If it is necessary to locate enclosures with deflagration vents inside of buildings, vent ducts shall be used to direct vented material from the enclosure to the outdoors.
- 6.8.2 A vent duct shall have a cross section at least as great as that of the vent itself.
- 6.8.3* Vent area calculations shall include the effects of vent ducts. (See Sections 7.4 and 8.5 for gases and dusts, respectively.)
- 6.8.4 Vent ducts and nozzles with total lengths of less than one hydraulic diameter shall not require a correction to increase the vent area.
- 6.8.5 Ducts that are used to direct vented gases from the vent to the outside of a building shall be of noncombustible construction and shall be strong enough to withstand the expected P_{red} .
- 6.8.5.1 When vent ducts include bends, the support calculations shall include reaction forces based on the expected P_{red} .

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Take Away – Collector Inside

- Direct vents outside
- Get as close to wall as possible
- Make vents of non-combustible material
- Ducts need to be match collector strength
- If collector located one HD or less no correction for vent area

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Impact - Vent Ducts

Q: What is a “Hydraulic Diameter”?

A: Commonly used term when handling flow in noncircular tubes

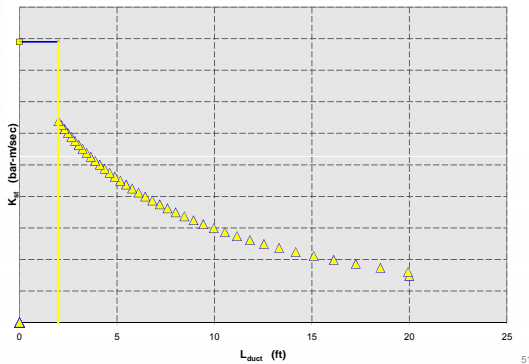
$$D_H = \frac{4A}{P} \quad \begin{array}{l} A = \text{Cross Sectional Area} \\ P = \text{Perimeter of the cross-section} \end{array}$$

For a rectangular ducts the equation becomes:

$$D_H = \frac{4A}{P} = \frac{4LW}{2(L+W)} \quad \text{or} \quad \frac{2LW}{L+W}$$

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Example Impact - Vent Ducts



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Other Impacts – Collector Operation

- Vents for Positive Pressure
- Vents and Downtime Pulsing
- Discharge of Vents
 - “Safe Location”
 - Deflectors
 - Weather Covers
- Multi-mod collectors that have different vent configurations will be analyzed with the worst case configuration

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Vent Discharge

- Deflagration venting shall be arranged to avoid ignition of adjacent property.
- Deflagration venting shall be arranged to avoid blast damage to adjacent property.
- Deflagration venting shall be arranged to avoid projectile damage to adjacent property.

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Vent Discharge – Fireball

$$D = K * \left(\frac{V}{n} \right)^{1/3}$$

D = axial distance (front) from the vent [m]

K = flame length factor

= 10 for metal dusts

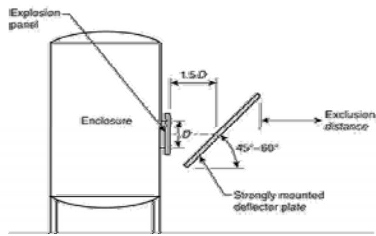
= 8 for chemical & agricultural dusts

V = volume of vented enclosure [m³]

n = number of evenly distributed vents

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Vent Discharge - Deflector



Shall not be used for enclosure volume greater than 20 m³ (6'x6'x15')

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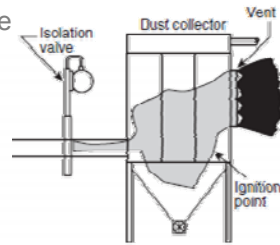
Collector Accessories

- Fire Suppression Components
- Flameless Vents
- Explosion Suppression System Components
- Isolation Devices
 - Inlet, Outlet, & Hopper Discharge
- Sprinklers
 - Apply on combustible dusts except.....
- Spark Abatement Systems
- Spark cooler for thermally generated dusts

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Other Accessories - Isolation

- Inlet
- Outlet / Return Air
- Hopper Discharge



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Hopper Discharge RAL Requirements

- Housing must meet P_{red} of collector
- Designed for K_{st} and P_{max}
- Valve must be certified and tested
- Valve must be at least 6 vane
- 2 vanes in contact at all times
- Body of RAL must be metal
- Bearings must be exterior
- Vanes .007-.008" clearance

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Impact - Operational

Service Interval

484 Aluminum: Dust shall be removed from dry collectors at least once each day and at more frequent intervals if conditions warrant.

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Returned Air Restrictions

Air can only be returned if the system **prevents** the return of

- dust (Filter must provide an efficiency of at least 99.9% @ 10micron)
- energy from a fire or explosion into the building.
- No metals, no gases

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Questions?