# Combustible Dust Issues

## Dust Collector Requirements

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## Combustible Dust - Impact

- How are Requirements Set for Dust Collectors?  
  - Rules or Guidelines  
  - AHJ
- What Requirements Apply to Collectors?  
  - OSHA  
  - NFPA  
  - ICC - IMC & IFC  
  - Factory Mutual  
  - Others
When do Requirements Apply

- New Collectors?
- Existing Collectors?

Requirement Impact

Requirement May Impact Decisions on -
- Collector Styles or Types
- Collector Locations
- Collector Options & Accessories
- Collector Operation & Servicing
NFPA Standards?

- NFPA Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities - 2008
- NFPA Standard for Explosion Protection by Deflagration Venting - 2007
- NFPA Standard on Explosion Prevention Systems - 2008
- NFPA National Electric Code - 2008
- NFPA Recommended Practice on Static Electricity - 2007
- NFPA Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids - 2004
- NFPA Standard for Combustible Metals - 2009
- NFPA Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas - 2007
- NFPA Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids - 2006 (Upcoming - 2011)

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: Chapter 5 provides guidelines for reasonably protection of life, property and health from the hazards associated with exhaust systems, air contaminants and smoke development in the event of fire. In most cases, these hazards involve materials and gases that have the potential to be an explosive or to otherwise be hazardous. Where contaminants are known to be present in quantities that may lead to an explosion in the occupant's health or any potential in a fire, both naturally and mechanically ventilated spaces must be equipped with mechanical exhaust systems capable of collecting and removing the contaminants.

This chapter contains requirements for the installation of exhaust systems, with emphasis on the structural integrity of the system and equipment involved, and the overall impact of the system on the fire safety performance of the building. It includes requirements for the exhaust of commercial kitchen grease and smoke-laden air, hazardous fumes and toxic gases, clothes dryer accumulation and heat and cold, smoke, stock and refuse incinerators.

CHAPTER 5 EXHAUST SYSTEMS

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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 dust 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 applicable to the chapter contents.

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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
NFPA 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 aof 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

Requirement Impacts

- Collector Type
- Collector Location
- Collector Options
- Accessories
- Operation & Servicing
Impact On Collector Types

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

Type - Metal’s NFPA 484

- Aluminum - Chapter 6
  - Dry-type dust collectors shall be located outside of buildings.
  - Electrostatic collectors **shall not be used.**
  - Wet-type collectors
- 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 dust collectors shall be located outside of buildings.
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.

Exceptions to:
- Location - Can be indoors
- Explosion Venting - not required

Limitations
- No more than 5,000 cfm capacity
- No closer than 20 ft to an egress, normally occupied area, or other collectors.
Collector Type – Grain NFPA 61

Cyclones with a 30 in. diameter or less 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.

Impact – Collector Size

- Single Use
  - or -
- Centralized (Manifold Ducts)
### 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.

### Size – Central vs Dedicated

**NFPA 654 – Combustible Dusts**

Manifolding of dust collection ducts to air–material separators shall not be permitted.

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 nonassociated 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.
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.

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

Impact – Collector Location

- Outside
- Inside
  - IF’s
- Proximity of other Collectors
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 ...

Location - Outdoors

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.
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.

Collector Options
- Hopper & Legs –or– Bin Vent
- Media Selection
- Bonding & Grounding
- Housing Reinforcements
**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.

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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.
- **654 Combustible Dust:** Filter media shall be permitted to be constructed of combustible material.
- **664 Wood:** The collection equipment shall be designed and constructed entirely of noncombustible material suitable for the use intended.

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

- 654 Combustible Dust
  - Bonding and grounding with a resistance of less than $1.0 \times 10^6$ ohms to ground shall be provided for conductive components.
- 484 Metals - Aluminum
  - All components of duct collection systems shall be electrically bonded and grounded.

Collector Options: Reinforcing

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.

*Generally not feasible for Dust Collectors*
OSHA Update – Penalties

Common problems
- Missing or ineffective Dust Control
- Dust Collector indoors
- No Isolation on inlet &/or outlet
- Explosion Vent inadequacies
  - Dust Collectors with no vents
  - Vents indoors to unsafe area

Collector Accessories
- Fire Suppression
  - Deflagration Vents
- Flameless Vent
- Explosion Suppression
- Isolation Devices
  - Inlet, Outlet, & Hopper Discharge
Design Impacts on Accessories

- Deflagration Vent Impacted by:
  - Properties of the Dust – $K_{st}$ & $P_{max}$, MIE, MEC
  - Shape of the Collector – L/D Ratio (How long & skinny)
  - Location of the Vents – Top &/or Side
  - Location of the Collector
    - Vent Discharge Duct – Length & Strength

NFPA Key Parameters

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

- $A_v$ = 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]
Term Explanations

- **$K_{st}$** – Deflagration Index
  - Maximum rate of pressure rise [bar m/ sec]

- **$P_{max}$** – Maximum Pressure
  - Maximum pressure in an enclosed deflagration

- **$P_{red}$** – Reduced Pressure
  - Maximum pressure in a vented deflagration

Impact – Vent Location

Volume used to determine required vent area

- DAP + Bags & Bag Restraint + Removed
- DAP Below the Bags
6.4.3.3 The effective volume of the enclosure, $V_{\text{eff}}$, 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, $H$. 

Impact - Hopper Height
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 Pred.

6.8.5.1 When vent ducts include bends, the support calculations shall include reaction forces based on the expected Pred.

Q: What is a “Hydraulic Diameter”?

A: Commonly used term when handling flow in noncircular tubes

\[ D_H = \frac{4A}{P} \]

\( A = \) Cross Sectional Area

\( P = \) Perimeter of the cross-section

For a rectangular ducts the equation becomes:

\[ D_H = \frac{4A}{P} = \frac{4LW}{2(L+W)} \quad \text{or} \quad \frac{2LW}{L+W} \]
Impact - Vent Ducts

Other Impacts - Collector Operation

- Vents for Positive Pressure
- Vents and Downtime Pulsing
- Discharge of Vents
  - “Safe Location”
  - Deflectors
  - Weather Covers
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.

Vent Discharge – Fireball

\[ D = K \times \left( \frac{V}{n} \right)^{1/3} \]

\( D = \) 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
Vent Discharge - Deflector

Shall not be used for enclosure volume greater than 20 m³

Collector Accessories

- Fire Suppression Components
- Flameless Vents
- Explosion Suppression System Components
- Isolation Devices
  - Inlet, Outlet, & Hopper Discharge
Other Accessories - Isolation

- Inlet
- Outlet / Return Air
- Hopper Discharge

Additional Option Issues

- Isolation for Returned Airstream
- Discharge Devices
  - AN Valves / CI Valves
  - Flex Hose to Drum Cover w/ Latches
Impact - Operational

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

Returned Air Restrictions

System designed to **prevent** the return of
- dust at a 99.9% efficiency @ 10micron
- energy from a fire or explosion to the building