How to be Sure Your Dust Collector Design and Installation are NFPA Compliant

Presented by:

Jeff Kice

Kice Industries, Inc.

Who is the NFPA?

- National Fire Protection Association
- Nonprofit international organization
- More than 81,000 members
- 300 codes and standards
- Earned accreditation from the American National Standards Institute (ANSI)

NFPA 68

- On December 20, 2006, NFPA 68 changed from a Guide (2002 Edition) to a Standard (2007 Edition)
- “Should” changed to “SHALL” to show mandatory provisions for compliance
- Non-mandatory Annexes are included for informational purposes only

NFPA 68: *Standard on Explosion Protection by Deflagration Venting*, 2007 Edition

"This standard applies to the design, location, installation, maintenance, and use of devices and systems that vent the combustion gases and pressures resulting from a deflagration within an enclosure so that structural and mechanical damage is minimized."

Enforcement of NFPA Standards

- NFPA:
  - Has no enforcement capabilities
  - Does not police or verify compliance
  - Defers to “Authority Having Jurisdiction” (AHJ)
    - Fire chief, fire marshal, insurance official, company safety compliance officer, an organization such as OSHA

Applicable NFPA Standards

- NFPA 61 – *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*, 2008 Edition
- NFPA 68 – *Standard on Explosion Protection by Deflagration Venting*, 2007 Edition
- NFPA 69 – *Standard on Explosion Prevention Systems*, 2008 Edition
- NFPA 77 – *Recommended Practice on Static Electricity*, 2007 Edition
- NFPA 654 - *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, 2006 Edition
- NFPA 664 *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*, 2007 Edition

NFPA 68

Definitions:

Deflagration – "Propagation of a combustion zone at a velocity that is less than the speed of sound in the unreacted medium."

- explosions
- fires

P_{max} (Maximum Pressure) – " The maximum pressure developed in a contained deflagration of an optimum mixture."

- a function of the material being combusted
- "determined in approximately spherical calibrated test vessels of at least 20 L capacity…"

NFPA 68

Definitions (cont'd):

K_{st} – "The deflagration index of a dust cloud."

- K_{st} "shall be computed from the maximum rate of pressure rise attained by combustion in a closed…approximately spherical calibrated test vessel of at least 20 L capacity…"
- Published lists of example values are available for certain materials, but variations in characteristics, such as particle size and moisture content, of seemingly identical materials can produce varied results.

NOTE: NFPA 68 states "where the actual material is available, the Kst shall be verified by test".

NFPA 68

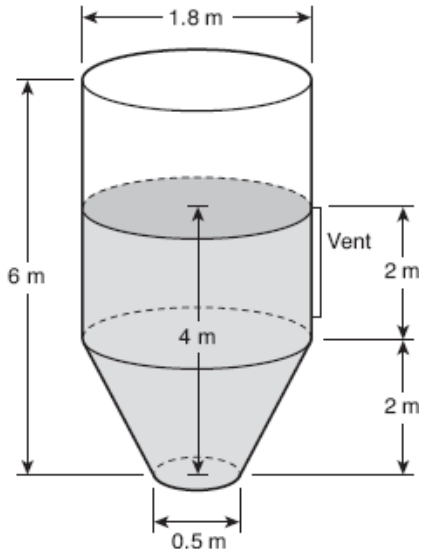
Definitions (cont'd):

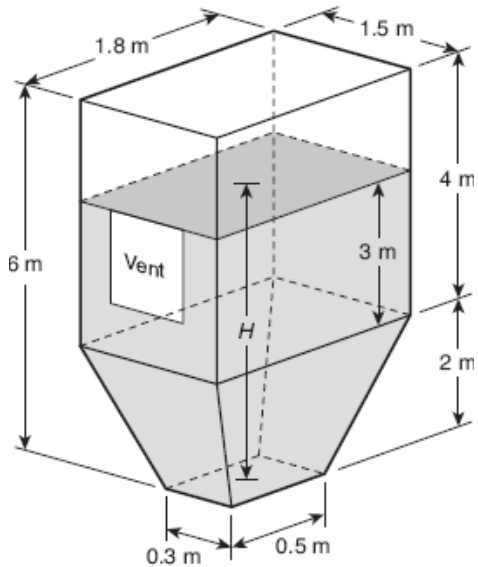
Enclosure Length-to-Diameter ratio (L/D)

If L/D ≤ 2, Equation 8.2.2 is used to calculate the minimum necessary vent area

If 2 < L/D ≤ 6, Equation 8.2.3 is used to calculate the minimum necessary vent area

For unusual shapes, the effective hydraulic diameter is used





NFPA 68

Definitions (cont'd):

P_{red} (Reduced Pressure) – "The maximum pressure developed in a vented enclosure during a vented deflagration."

"P_{red} shall not exceed two-thirds of the ultimate strength for the vented enclosure, provided deformation of the equipment can be tolerated."

- 2/3 Ultimate strength of the vessel
  - Less required vent area (lower costs)
  - Potential for permanent deformation of equipment

"Where deformation cannot be tolerated, P_{red} shall not exceed two-thirds of the yield strength for the vented enclosure."

- 2/3 Yield strength of the vessel
  - More vent area required (higher costs)
  - Permanent deformation of equipment from deflagration unlikely

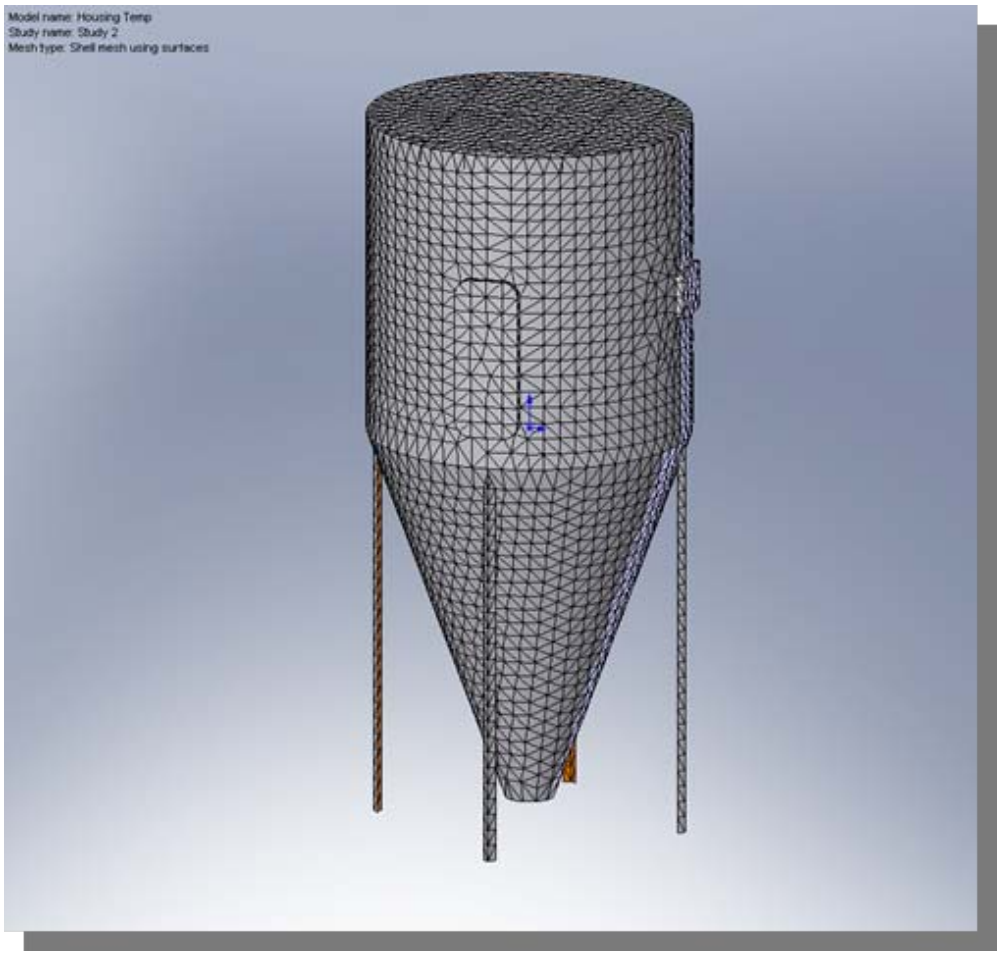
Determining P_{red}

Decide if the enclosure design pressure selection will be based on 2/3 of the ultimate strength or 2/3 of the yield strength

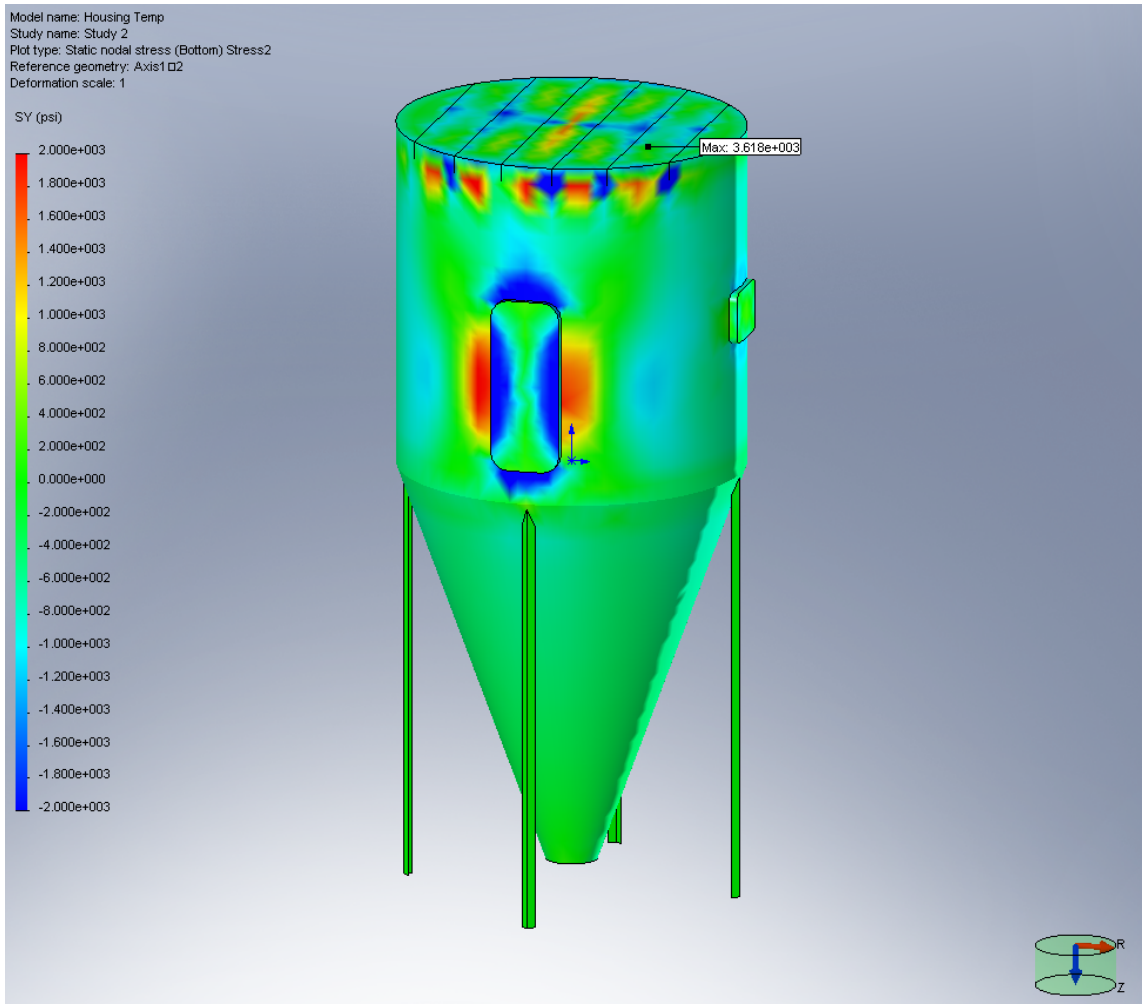
Identify weakest point of design by either:

- Performing actual test explosions, or
- Finite Element Analysis (FEA)

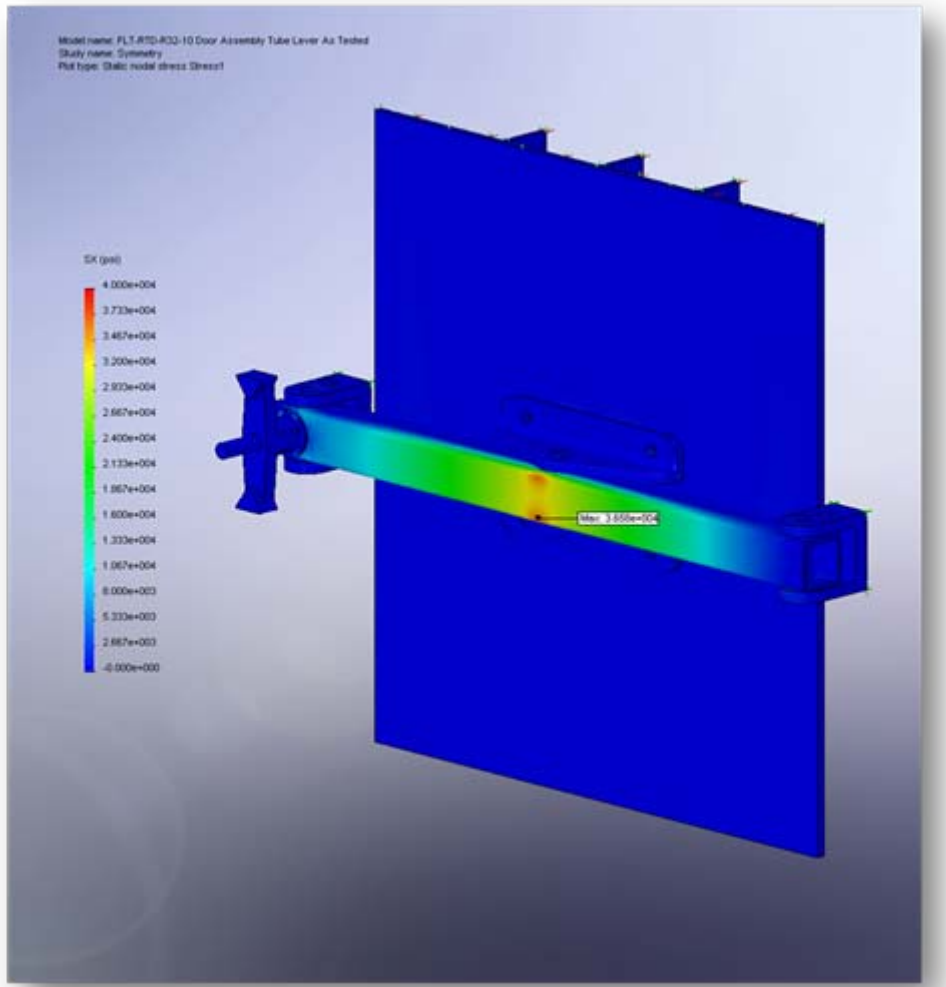
Determining P_{red} Utilizing FEA



Determining P_{red} Utilizing FEA



Determining P_{red} Utilizing FEA



Validating FEA Results by Performing Actual Test Deflagrations

Dust Collector Venting Alternatives

Alternative Arrangement 1

- Condition 1

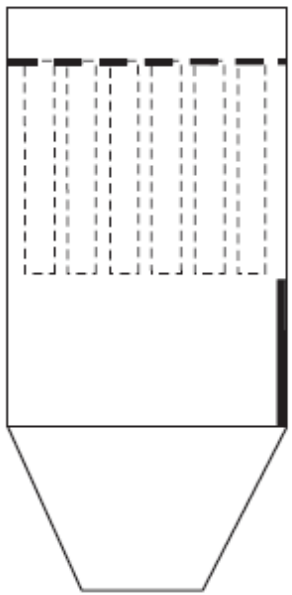
  Spacing between the bags ≤ radius of the bag

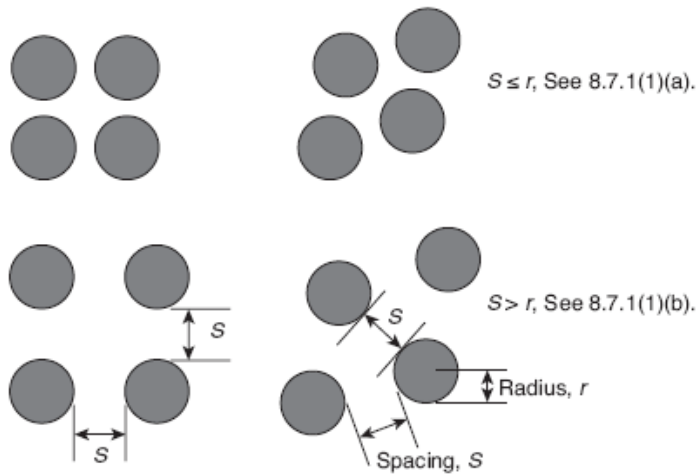
  and

  all of the venting is located below the bottom of the bags

  - "…the vent area shall be permitted to be calculated on the basis of the volume below the lower end of the bags" (lower housing and hopper)
  - yields the smallest volume and thereby reduces the required vent area
  - filter housing must be taller or the bag length shorter to provide the space beneath the bags required for the vent(s)

Venting Alternative Arrangement 1





Dust Collector Venting Alternatives

Alternative Arrangement 1

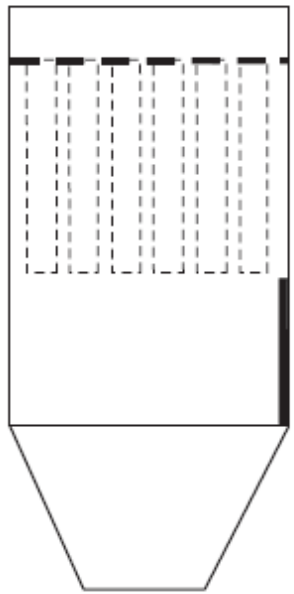
- Condition 2

  Spacing between the bags > radius of the bag

  and

  all of the venting is located below the bottom of the bags

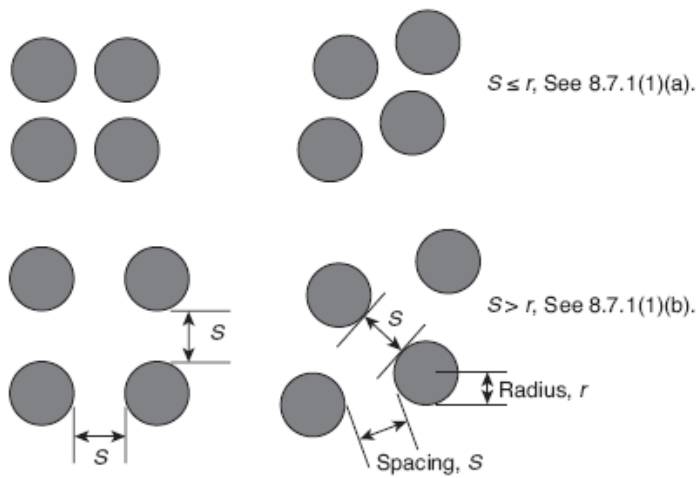
Venting Alternative Arrangement 1



Condition 2

- "…the vent area shall be permitted to be calculated on the basis of the dirty side only; that is, calculate the volume below the tube sheet, and subtract out the volume occupied by the bags."

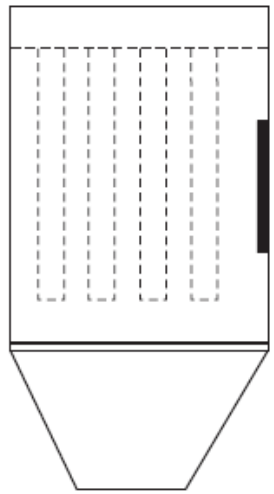
- filter housing must be taller or the bag length shorter to provide the space beneath the bags required for the vent(s)

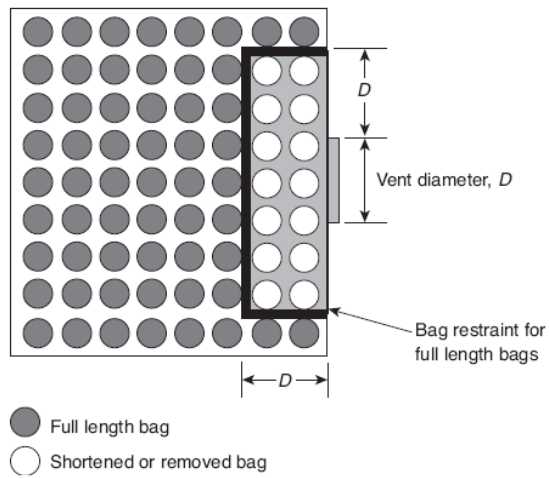


Dust Collector Venting Alternatives

Alternative Arrangement 2:

- Bottom of vent(s) above bottom of bags
- Loss of filter bag area
- Restrain remaining bags, or verify by test that bags are rigid enough to remain in place during venting
- Operational concerns about bag wear from restraint
- Increased vent area required; volume between bags included in calculation, volume of bags excluded

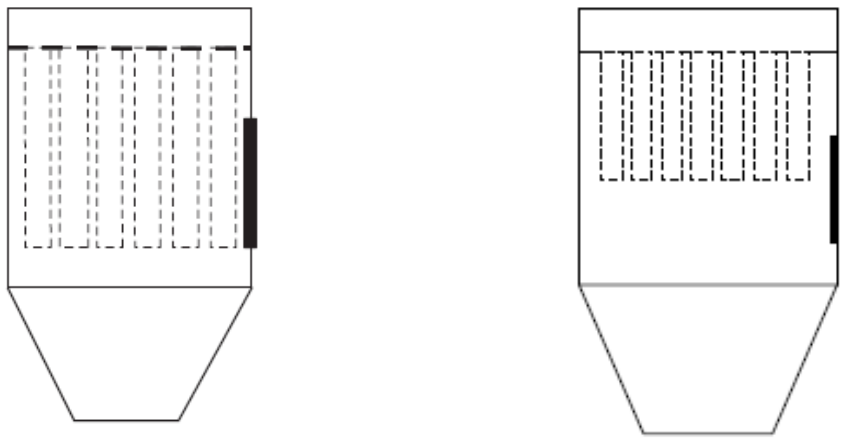




Dust Collector Venting Alternatives

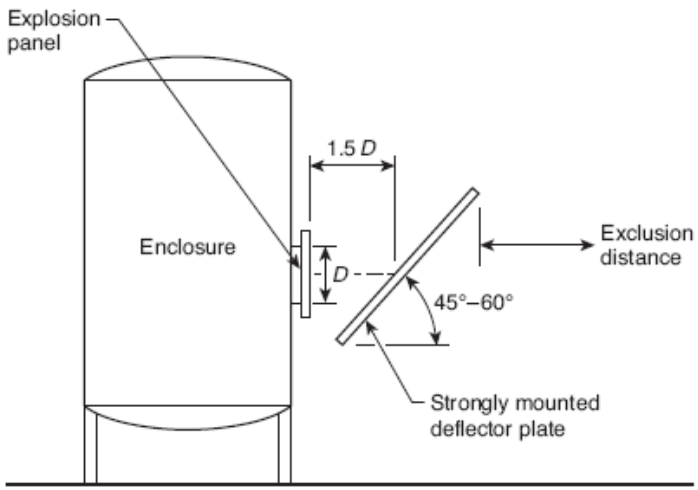
Alternative Arrangement 3:

- Bottom of vent(s) below bottom of bags
- Increased vent area required; volume between and inside bags included in calculation



Risks Associated with Fireball

- "Measures shall be taken to reduce the risk to personnel and equipment from the effects of fireball temperature and pressure."
- NFPA 68 provides equations to calculate both the axial distance of the fireball and the external pressure
- A blast deflector plate can be used to reduce the axial hazard distance to 50% of the calculated value



Effects of Panel Inertia

The mass of the vent panel can result in an incremental increase in the minimum necessary vent area.

7.2.2.5.2* The vent area determined by Equation 7.2.2 shall be adjusted for vent mass when the vent mass exceeds M_T as calculated in Equation 7.2.2.5.2:

$$M_T = \left[6.67 \cdot \left(P_{red}^{0.2} \right) \cdot \left(n^{0.3} \right) \cdot \left(\frac{V}{K_G^{0.5}} \right) \right]^{1.67} \qquad \textbf{(7.2.2.5.2)}$$

where:
M_T = threshold mass (kg/m^2)
P_{red} = bar
n = number of panels
V > 1 m^3
K_G ≤ 130

7.2.2.6 If $M > M_T$, the vent area shall be increased by adding the calculated area, ΔA_i, from Equation 7.2.2.6:

$$\Delta A_i = A_v \cdot (0.0075) \cdot M^{0.6} \cdot \frac{K_G^{0.5}}{n^{0.3}} \cdot V \cdot P_{red}^{0.2} \qquad \textbf{(7.2.2.6)}$$

where:
A_v = vent area calculated by Equation 7.2.2
M = mass of vent panel (kg/m^2)

7.2.2.7 If K_G is less than 75 bar-m/sec, $K_G = 75$ shall be used in Equation 7.2.2.6.

Effects of Vent Discharge Ducts

- If it is necessary to locate a dust collector with deflagration vents inside of a building, a vent duct **shall** be used to direct vented material from the dust collector to the outdoors.
- "A vent duct shall have a cross sectional area at least as great as that of the vent itself, but shall be limited to no more than 150% of the vent itself at any point in the vent duct."
- "Vent area calculations shall include the effects of vent ducts."
- The equation to calculate the effect of vent ducts has a solution that is iterative, requiring a trial and error process (or the goal seek button in Excel).
- Vent ducts "shall be of noncombustible construction and shall be strong enough to withstand the expected P_{red}".
- Bends in the vent duct are now allowed, but "support calculations shall include reaction forces based on the expected P_{red}".

Flame-arresting and Particulate-retention Vent Systems

- An alternative approach that eliminates the need for vent ducts and satisfies the mandate to reduce the risk from the effects of a fireball involves the use of flame-arresting and particulate-retention vent systems.

Reaction Forces

NFPA 68 provides equations to determine the reaction force, the duration of the reaction force, and the total impulse that a structure supporting a vented enclosure experiences during deflagration venting.

The supporting structure of the dust collector must “be strong enough to withstand any reaction forces that develop as a result of operation of the vent”.

Suppression Concept (NFPA 69)

- The heat of combustion develops pressure.
- Upon pressure detection, sufficient suppressant agent is dispersed into the protected volume.
- Flame is quenched which prevents any further pressure increase.
- Flame, pressure and unburned mixture are contained inside the vessel.

Explosion Isolation (NFPA 69 and 654)

- Prevent explosion propagation through ductwork

- Explosion isolation devices:
  - Chokes
  - Rotary valves
  - Automatic fast-acting valve systems
  - Flame front diverters
  - Chemical isolation (suppression) systems

Maintaining NFPA Compliance

Documentation

Inspection

Maintenance

Record Keeping and Training

NFPA 68

Required Documentation:

(1) Manufacturer's data sheets and instruction manuals
(2) Design calculations
(3) General specifications
(4) Vent closure specifications
(5) End user inspection/maintenance forms
(6) User documentation of conformity with applicable standards
(7) Vent closure identification
(8) Combustible material properties test report
(9) Copy of vent identification label
(10) Process plan view
(11) Process elevation view
(12) Vent relief (pressure and fireball) path
(13) Proximity of personnel to vent relief path
(14) Mechanical installation details
(15) Electrical supervision (if provided) installation details
(16) Vent restraint installation and design documentation (if required)
(17) Process interlocks (if provided)
(18) Event deflagration isolation requirements (if required)
(19) Employee training requirements

Maintaining NFPA Compliance

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Vent closures shall be inspected at least annually:

(1) The opening is free and clear of any obstructions on both sides.

(2) The discharged material and fireball pathway does not extend into an area normally occupied by personnel or critical process equipment.

(3) The closure has been properly installed according to manufacturer's instructions.

(4) The closure is not corroded or mechanically damaged.

(5) The closure is clearly identified with manufacturer's information.

(6) The closure is clearly labeled as an explosion relief device.

(7) The closure has no damage and is protected from the accumulation of water, snow, ice, or debris after any act of nature.

(8) The closure has not been painted or coated other than by manufacturer.

(9) The closure has no buildup of deposits on the inside surfaces or between layers of the vent.

(10) The closure has not been tampered with.

(11) The closure shows no fatigue and has not released.

(12) The closure hinges (if provided) are lubricated and operate freely.

(13) The closure restraints (if provided) are in place and operational.

(14) The closure seals, tamper indicators, or vent rupture indicators (e.g., breakwire switches), if provided, are in place.

(15) The flame-arresting and particulate-retention device is being maintained, is clean, and is unobstructed in accordance with the manufacturer's listing.

(16) The closure has no conditions that would hinder its operation.

Maintaining NFPA Compliance

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Maintenance

Record Keeping and Training

NFPA 68

Maintenance

- Vent closure maintenance shall be performed after every act of nature or process upset condition to ensure that the closure has not been physically damaged and there are no obstructions including but not limited to snow, ice, water, mud, or process material that could lessen or impair the efficiency of the vent closure.
- An inspection shall be performed after every process maintenance turnaround.
- If process material has a tendency to adhere to the vent closure, the vent closure shall be cleaned periodically to maintain vent efficiency.
- Process interlocks, if provided, shall be verified.
- Known potential ignition sources shall be inspected and maintained.
- Records shall be kept of any maintenance and repairs performed.

Maintaining NFPA Compliance

Documentation

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Maintenance

Record Keeping and Training

NFPA 68

Record Keeping and Training

1. The records of inspections and any maintenance and repairs performed shall be retained for a minimum of 3 years.
2. Initial and refresher training shall be provided and training records maintained for employees who are involved in operating, maintaining, and supervising facilities that utilize devices for venting of deflagrations.

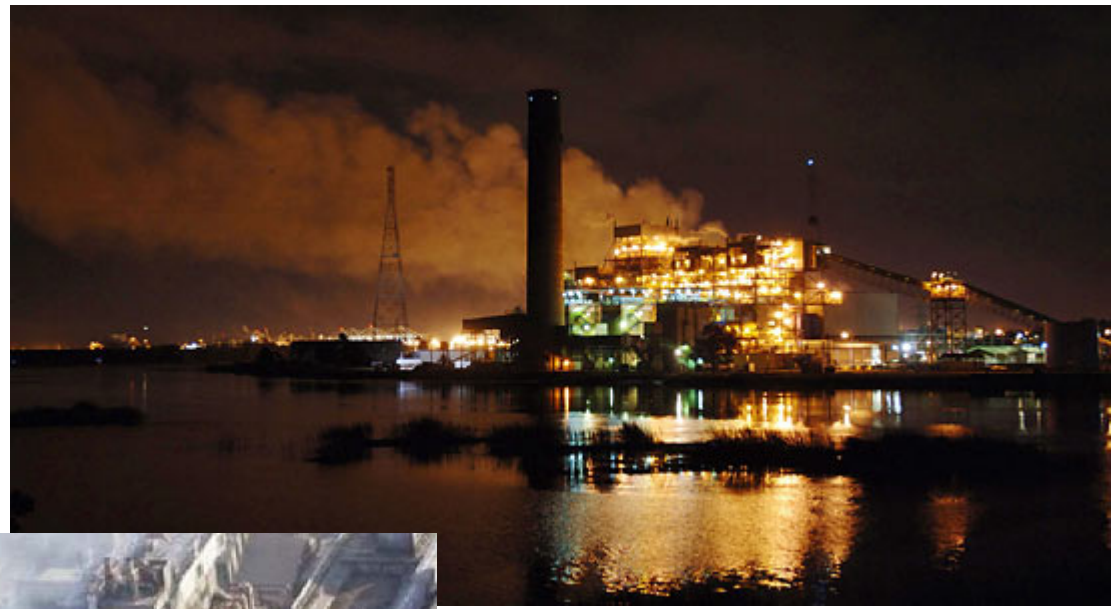
OSHA's "Combustible Dust National Emphasis Program (Reissued)"

"The purpose of this NEP is to inspect facilities that create or handle combustible dusts which can cause intense burning or other fire hazards when suspended in air, and can lead to explosions."

"As a result of a recent catastrophic accident involving combustible dust at a sugar refinery plant, OSHA is intensifying its enforcement activities at facilities where combustible dust hazards are known to exist."

Found on OSHA's new combustible dust safety and health website: http://www.osha.gov/dsg/combustibledust/index.html

Imperial Sugar Refinery Explosion on 2/7/2008



Petition from Worker Organizations

"We want OSHA to issue comprehensive combustible dust standards and we fully back the Committee on Education and Labor in their request to Secretary of Labor Elaine Chao for answers and action based on the CSB investigations and recommendations."

Sugar Plant Blast Puts Heat on OSHA's Rulemaking

"I see such an incredible lack of urgency on the part of your agency to protect workers that it is astounding," Rep. *George Miller* (D-Calif.), who heads the *House Education and Labor Committee*, told OSHA director *Edwin G. Foulke Jr*.

- Cindy Skrzycki, Business Columnist for The Washington Post

Congress > Legislation

H.R. 5522: Worker Protection Against Combustible Dust Explosions and Fires Act of 2008

110th Congress
2007-2008

To require the Secretary of Labor to issue interim and final occupational safety and health standards regarding worker exposure to combustible dust, and for other purposes.

Overview

Sponsor: Rep. George Miller [D-CA] **show cosponsors (32)**

Text: Summary | Full Text

Cost: less than $1 per American in fiscal year 2009.

Status:

☑ Introduced	Mar 4, 2008
☑ Reported by Committee	Apr 9, 2008
☑ Passed House	Apr 30, 2008
☐ Voted on in Senate	(did not occur)
☐ Signed by President	(did not occur)

This bill never became law. This bill was proposed in a previous session of Congress. Sessions of Congress last two years, and at the end of each session all proposed bills and resolutions that haven't passed are cleared from the books. Members often reintroduce bills that did not come up for debate under a new number in the next session.

Last Action: May 1, 2008: Received in the Senate and Read twice and referred to the Committee on Health, Education, Labor, and Pensions.

OSHA National News Release

U.S. Department of Labor
OSHA, Office of Communications

National News Release: 09-475-NAT
April 29, 2009
Contact: Diana Petterson
Phone: 202-693-1898

U.S. Department of Labor's OSHA announces rulemaking on combustible dust hazards

WASHINGTON - The U.S. Department of Labor's Occupational Safety and Health Administration (OSHA) is initiating a comprehensive rulemaking on combustible dust.

OSHA will issue an Advanced Notice of Proposed Rulemaking and convene related stakeholder meetings to evaluate possible regulatory methods, and request data and comments on issues related to combustible dust such as hazard recognition, assessment, communication, defining combustible dust and other concerns.

Since 1980, more than 130 workers have been killed and more than 780 injured in combustible dust explosions. These include 14 people who were killed in a dust explosion Feb. 7, 2008, at an Imperial Sugar Co. plant in Georgia and three workers who were burned in April 2009 in an Illinois pet food plant dust explosion.

"Over the years, combustible dust explosions have caused many deaths and devastating injuries that could have been prevented," said Secretary of Labor Hilda L. Solis. "OSHA is reinvigorating the regulatory process to ensure workers receive the protection they need while also ensuring that employers have the tools needed to make their workplaces safer."

Combustible dusts are solids finely ground into fine particles, fibers, chips, chunks or flakes that can cause a fire or explosion when suspended in air under certain conditions. Types of dusts include metal (aluminum and magnesium), wood, plastic or rubber, coal, flour, sugar and paper, among others.

In 2006, the U.S. Chemical Safety Board (CSB) recommended that OSHA issue a combustible dust standard. OSHA received additional support for a combustible dust standard from the CSB during a congressional hearing in 2008 when the board said a new standard, combined with enforcement and education, could save workers' lives.

More information about combustible dust is available at http://www.osha.gov/dsg/combustibledust/index.html.

Under the Occupational Safety and Health Act of 1970, employers are responsible for

Combustible Dust

Does your company or firm process any of these products or materials in powdered form?

If your company or firm processes any of these products or materials, there is potential for a "Combustible Dust" explosion.

Agricultural Products
Egg white
Milk, powdered
Milk, nonfat, dry
Soy flour
Starch, corn
Starch, rice
Starch, wheat
Sugar
Sugar, milk
Sugar, beet
Tapioca
Whey
Wood flour

Agricultural Dusts
Alfalfa
Apple
Beet root
Carrageen
Carrot
Cocoa bean dust
Cocoa powder
Coconut shell dust
Coffee dust
Corn meal
Cornstarch
Cotton
Cottonseed
Garlic powder
Gluten
Grass dust
Green coffee
Hops (malted)
Lemon peel dust
Lemon pulp
Linseed
Locust bean gum
Malt
Oat flour
Oat grain dust
Olive pellets
Onion powder
Parsley (dehydrated)
Peach
Peanut meal and skins
Peat
Potato
Potato flour
Potato starch
Raw yucca seed dust
Rice dust
Rice flour
Rice starch
Rye flour
Semolina
Soybean dust
Spice dust
Spice powder
Sugar (10x)
Sunflower
Sunflower seed dust
Tea
Tobacco blend
Tomato
Walnut dust
Wheat flour
Wheat grain dust
Wheat starch
Xanthan gum

Carbonaceous Dusts
Charcoal, activated
Charcoal, wood
Coal, bituminous
Coke, petroleum
Lampblack
Lignite
Peat, 22%H_2O
Soot, pine
Cellulose
Cellulose pulp
Cork
Corn

Chemical Dusts
Adipic acid
Anthraquinone
Ascorbic acid
Calcium acetate
Calcium stearate
Carboxy-methylcellulose
Dextrin
Lactose
Lead stearate
Methyl-cellulose
Paraformaldehyde
Sodium ascorbate
Sodium stearate
Sulfur

Metal Dusts
Aluminum
Bronze
Iron carbonyl
Magnesium
Zinc

Plastic Dusts
(poly) Acrylamide
(poly) Acrylonitrile
(poly) Ethylene (low-pressure process)
Epoxy resin
Melamine resin
Melamine, molded (phenol-cellulose)
Melamine, molded (wood flour and mineral filled phenol-formaldehyde)
(poly) Methyl acrylate
(poly) Methyl acrylate, emulsion polymer
Phenolic resin
(poly) Propylene
Terpene-phenol resin
Urea-formaldehyde/ cellulose, molded
(poly) Vinyl acetate/ ethylene copolymer
(poly) Vinyl alcohol
(poly) Vinyl butyral
(poly) Vinyl chloride/ ethylene/vinyl acetylene suspension copolymer
(poly) Vinyl chloride/ vinyl acetylene emulsion copolymer

Dust Control Measures

The dust-containing systems (ducts and dust collectors) are designed in a manner (i.e., no leaking) that fugitive dusts are not allowed to accumulate in the work area.

The facility has a housekeeping program with regular cleaning frequencies established for floors and horizontal surfaces, such as ducts, pipes, hoods, ledges, and beams, to minimize dust accumulations within operating areas of the facility.

The working surfaces are designed in a manner to minimize dust accumulation and facilitate cleaning.

Ignition Control Measures

Electrically-powered cleaning devices such as vacuum cleaners, and electrical equipment are approved for the hazard classification for Class II locations.

The facility has an ignition control program, such as grounding and bonding and other methods, for dissipating any electrostatic charge that could be generated while transporting the dust through the ductwork.

The facility has a Hot Work permit program.

Areas where smoking is prohibited are posted with "No Smoking" signs.

Duct systems, dust collectors, and dust-producing machinery are bonded and grounded to minimize accumulation of static electrical charge.

The facility selects and uses industrial trucks that are approved for the combustible dust locations.

Prevention Measures

The facility has separator devices to remove foreign materials capable of igniting combustible dusts.

MSDSs for the chemicals which could become combustible dust under normal operations are available to employees.

Employees are trained on the explosion hazards of combustible dusts.

Protection Measures

The facility has an emergency action plan.

Dust collectors are not located inside of buildings. (Some exceptions)

Rooms, buildings, or other enclosures (dust collectors) have explosion relief venting distributed over the exterior wall of buildings and enclosures.

Explosion venting is directed to a safe location away from employees.

The facility has isolation devices to prevent deflagration propagation between pieces of equipment connected by ductwork.

The dust collector systems have spark detection and explosion/ deflagration suppression systems.

Emergency exit routes are maintained properly.

OSHA® Occupational Safety and Health Administration
U.S. Department of Labor
www.osha.gov • (800) 321-OSHA • TTY (877) 889-5627

Retroactivity of NFPA Standards

NFPA 68:

Section 1.5.1.1 – "…the provisions of this standard shall not apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the standard." (December 20, 2006)

Exceptions:

"In those cases where the authority having jurisdiction determines that the existing situation presents an unacceptable degree of risk, the authority having jurisdiction shall be permitted to apply retroactively any portions of this standard deemed appropriate."

(Section 1.5.1.2)

or

"When major replacement or renovation of existing facilities is planned, provisions of this standard shall apply." (Section 1.5.3)

Thank you for the opportunity to speak with you today

Should you have any questions please visit our website at

www.kice.com

or contact me

jeffkice@kice.com