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Meeting Name: Laura Montville NFPA Committee Meeting
Summary:
Invited By: Laura Montville (lmontville@nfpa.org)

Conference Number(s): US (Toll Free):1-866-398-2885/ US (Toll):1-719-457-6209

Canada, Montreal (Local):+1 514 669 5928 Canada, Toronto (Local):+1 647 426 9172

Participant code: 196789

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National Fire Protection Association
1 Batterymarch Park, Quincy, MA 02169-7471
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TECHNICAL COMMITTEE ON EXPLOSION PROTECTION SYSTEMS
First Draft Meeting Agenda
February 1-2, 2016 8:00 AM - 5:00 PM EST
Hilton St. Petersburg Carillon Park
St. Petersburg, FL

1. Welcome. Larry Floyd, Chair

2. Introductions and Update of Committee Roster. (Page 3)

3. Approval of Meeting Minutes from January 11, 2013. (Page 7)

4. Staff updates. Laura Montville, NFPA Staff

   a) Committee membership update.
   b) Fall 2017 revision cycle schedule. (Page 11)
   c) Overview of NFPA Process.

5. Review of Public Inputs NFPA 68. (Page 12)

6. Task Group Reports

   a) Task Group on Fireball Equations: Bill Stevenson (Chair), Erdem Ural, Alfonso Ibarreta, Jerome Taveau, Robert Zalosh, Mitchel Rooker, and Dave Kirby
   b) Task Group on Metal Dusts (6.1.2-6.1.2.2): Jerome Taveau (Chair), Tim Meyers, Robert Zalosh, Martin Clouthier, Sam Rodgers, and Erdem Ural
   c) Task Group on Inertia Effect and Tether Requirements (8.2.6.2): Erdem Ural, Mitch Rooker, and Steve Stuart.
   d) Task Group on Large Scale Gas Explosions (7.2.6.3, 7.2.6.4, and gas venting example for the annex): Larry Floyd (Chair), Martin Clouthier, Robert Zalosh, Erdem Ural, Henry Febo, Alfonso Ibarreta, and Kelly Thomas

7. Additional Issues for Consideration.

   a) Proposed TIA 1210 and related changes to 8.2.2.1, Figure 8.1.1.4, and 8.4.1
   b) Use of equation 7.2.6.1(e) when P_{red}<0.9 bar
   c) Organization of Chapter 7
   d) Vent deflection devices
   e) Deflagration pipeline propagation
   f) Values for the K-flow resistance coefficient and inclusion of appropriate references in Figure A.8.5(a)
   g) Committee member recognition

8. New Business.

9. Next Meeting.

10. Adjourn.

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TECHNICAL COMMITTEE ON EXPLOSION PROTECTION SYSTEMS
NFPA 68 & NFPA 69
TIA Discussion Meeting Minutes
September 9-10, 2015 8:00 AM - 5:00 PM EDT
NFPA Headquarters, Quincy, MA

Attendees:

Larry Floyd, Chair	BASF, AL
Venkateswara Bhamidipati	Powder Process Solutions, MN
Martin Clouthier	Clouthier Risk Engineering, Canada
Michael Davies	PROTEGO, Germany
Randal Davis	IEP Technologies, MA
Nathan Egbert*	MAC Process LLC, MO
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Edward Jones	Nordson Corporation, OH
Timothy Myers*	Exponent, Inc.
David Nieman*	Bechtel Corporation, VA
Alvin Grant Roach*	Professional Loss Control Inc., Canada
Thomas Scherpa*	The DuPont Company, Inc., NH
Laurence Britton*	Process Safety Consultant, WV
Laura Montville, Staff Liaison	National Fire Protection Association, MA

*Participated by teleconference

1. **Call to Order.** The Chair called the meeting to order at 8:00 AM, September 9, 2015.
2. **Introductions.** Committee members were asked to introduce themselves. Laura Montville provided an update on new committee members appointed by the Standards Council in August.
3. **Staff Updates.** Mary Elizabeth Woodruff gave a presentation (attached) on the data analysis and research services available to committee members through the Charles S. Morgan Library, the Fire Analysis and Research Department, and the Fire Protection Research Foundation. Committee members can contact research@nfpa.org for more information.
4. **Approval of Minutes.** The minutes from the NFPA 67 Second Draft meeting held on March 31 and May 15, 2015 were approved.
5. **Committee Member Recognitions**. Two individuals have been nominated to receive a 2016 Committee Service Award, and the committee wishes to nominate five additional individuals who have contributed greatly to the field of explosion protection. Larry Floyd will convene a task group by the end of 2015 to complete these nominations. Bob Zalosh, Sam Rodgers, Steve McCoy, Erdem Ural, and Tom Sherpa will be writing nominations.
6. **TIA Discussions**.
    - NFPA 68: Sam Rodgers will submit a TIA to remove paragraph 8.2.2.1 and the related reference to 8.2.2.1 from Figure 8.1.1.4, and correct the reference to A_{vep} in paragraph 8.4.1.
    - NFPA 68: A task group was formed to review research and data to determine if the existing fireball equations address all factors of possible hazards. Task group members are Bill Stevenson (chair), Erdem Ural, Alfonso Ibarreta, Jérôme Taveau,

Robert Zalosh, Mitchel Rooker, and Dave Kirby. The task group will provide a report by the end of 2015.

- NFPA 68: Sam Rodgers will submit a TIA to revise paragraph 8.5.5. The statement was not intended to prevent the use of the vent duct equations for sub-atmospheric conditions.
- Jérôme Taveau gave a presentation on Scaling-up Metal Dusts Explosion Severity (attached). A task group was formed to review NFPA 68 paragraphs 6.1.2-6.1.2.2 and NFPA 69 paragraph 6.2 and proposed TIA language drafted by Sam Rodgers. Task group members are Jérôme Taveau (chair), Tim Meyers, Bob Zalosh, Martin Clouthier, Sam Rodgers, and Erdem Ural, some of whom also sit on the ASTM E27 or NFPA 484 committees.
- Martin Clouthier, Larry Britton, and Sam Rodgers presented draft language for two TIAs to NFPA 69 (attached). One TIA would address the adjusted LOC values in Table C.1(a), and the other would provide users with a method to calculate LOC values for mixtures. This task group will submit both TIAs.
- NFPA 68: A task group was formed to discuss equation 8.2.6.2 and reconsider the inertia effect and tether requirements for the next edition. The task group members are Erdem Ural, Mitch Rooker, and Steve Stuart.
- NFPA 68: When using equation 7.2.6.1(e) with $P_{red}<0.9$ bar, the result exceeds the speed of sound. Sam Rodgers will submit a Public Input to address this and section 7.2.1 as described in the meeting agenda.
- NFPA 68: After a discussion on the organization of Chapter 7, it was agreed that Sam Rodgers would submit Public Input to reorganize the chapter and clarify applicability of requirements.

7. **Large scale gas explosion testing.** Dave Kirby presented results from vented enclosure explosion testing completed by the Explosion Research Cooperative. The results are restricted to committee members at this time but will be published in the spring. A task group was formed to review paragraphs 7.2.6.3 and 7.2.6.4 in light of this research. Proposed revisions will be submitted as either a TIA or as Public Input for the next edition. This task group will also work on developing an example to add to the Annex which explains how to apply the gas venting equations. The task group members are Larry Floyd (Chair), Martin Clouthier, Bob Zalosh, Erdem Ural, Henry Febo, Alfonso Ibarreta, and Kelly Thomas.
8. **New Business.**
    - NFPA 68: The Committee discussed the applicability of vent sizing methodology developed in Chapter 7 for hydrogen service. It was pointed out that Chapter 7 can be used for burning velocities up to 3 m/s, which would cover most hydrogen applications. The Committee decided that no action is needed at this time.

- NFPA 69: Mike Hard raised the issue of high pressure tank inspection requirements, mechanical integrity of protective systems, and requalification of equipment. He will draft language and submit as Public Input.
- NFPA 68: Mitch Rooker asked that Table 8.8.3.3 be clarified in the next edition. He will submit Public Input to revise the P_{red} column headings. He will also submit Public Input on paragraph 8.7.3, noting that it can be interpreted as locating the vent in the filter housing, which should not be acceptable.
- NFPA 69: The question was raised whether or not NFPA 69 allows the inference of inert atmosphere without constant measurement, through continuous or occasional measuring of oxygen. It was pointed out that this is addressed in paragraph 7.7.2.7.3. Martin Clouthier will submit a Public Input to revise 7.7.2.7.2 and 7.7.2.7.3 as subsections below 7.7.2.7.1 because they provide options that do not require checking the oxygen concentration.
- The following items were identified as new business and will be discussed at a future meeting:
    - NFPA 68: Vent deflection devices. Sam Rodgers
    - Deflagration pipeline propagation (presentation attached). Jérôme Taveau
    - NFPA 69: 11.2.1.3 Isolation design.
    - NFPA 85: Figure A.8.5(a) and accompanying text regarding values for the K-flow resistance coefficient, and the inclusion of appropriate references. Erdem Ural and Sam Rodgers.

9. **Next Meeting**. The Public Input for NFPA 68 closes January 7, 2016 and the last date to hold the First Draft meeting will be in June 2015. The Committee will be polled to determine specific dates, but the members expressed interest in holding the meeting in the Southeast in February. It was also noted that the Public Input for NFPA 69 will close on January 5, 2017.
10. **Adjournment**. The meeting adjourned at 12:10 PM, September 10, 2015.

2017 FALL REVISION CYCLE

* Public Input Closing Dates may vary according to standards and schedules for Revision Cycles may change. Please check the NFPA Website for the most up-to-date information on Public Input Closing Dates and schedules at www.nfpa.org/document # (i.e. www.nfpa.org/101) and click on Next Edition tab.

Process Stage	Process Step	Dates for TC	Dates for TC with CC
Public Input Stage (First Draft)	**Public Input Closing Date**	1/7/2016	1/7/2016
	Final date for TC First Draft Meeting	6/16/2016	3/17/2016
	Posting of First Draft and TC Ballot	8/4/2016	4/28/2016
	Final date for Receipt of TC First Draft ballot	8/25/2016	5/19/2016
	Final date for Receipt of TC First Draft ballot - recirc	9/1/2016	5/26/2016
	Posting of First Draft for CC Meeting		6/2/2016
	Final date for CC First Draft Meeting		7/14/2016
	Posting of First Draft and CC Ballot		8/4/2016
	Final date for Receipt of CC First Draft ballot		8/25/2016
	Final date for Receipt of CC First Draft ballot - recirc		9/1/2016
	Post First Draft Report for Public Comment	9/8/2016	9/8/2016

Comment Stage (Second Draft)	**Public Comment closing date**	11/17/2016	11/17/2016
	Notice published on Consent Standards (Standards that receive No Comments). Note: Date varies and determined via TC ballot.	–	–
	Appeal Closing Date for Consent Standards (15 Days) (Standards That Received No Comments)	–	–
	Final date for TC Second Draft Meeting	5/18/2017	2/9/2017
	Posting of Second Draft and TC Ballot	6/29/2017	3/23/2017
	Final date for Receipt of TC Second Draft Ballot	7/20/2017	4/13/2017
	Final date for receipt of TC Second Draft ballot - recirc	7/27/2017	4/20/2017
	Posting of Second Draft for CC Mtg		4/27/2017
	Final date for CC Second Draft Meeting		6/8/2017
	Posting of Second Draft for CC Ballot		6/29/2017
	Final date for Receipt of CC Second Draft ballot		7/20/2017
	Final date for Receipt of CC Second Draft ballot - recirc		7/27/2017
	Post Second Draft Report for NITMAM Review	8/3/2017	8/3/2017

Tech Session Preparation (& Issuance)	**Notice of Intent to Make a Motion (NITMAM) Closing Date**	8/31/2017	8/31/2017
	Posting of Certified Amending Motions (CAMs) and Consent Standards	10/12/2017	10/12/2017
	Appeal Closing Date for Consent Standards (15 Days after posting)	10/27/2017	10/27/2017
	SC Issuance Date for Consent Standards (10 Days)		

Tech Session	Association Meeting for Standards with CAMs	6/4-7/2018	6/4-7/2018

Appeals and Issuance	Appeal Closing Date for Standards with CAMs (20 Days after ATM)	6/27/2018	6/27/2018
	Council Issuance Date for Standards with CAMs*	8/14/2018	8/14/2018

Public Input No. 1-NFPA 68-2015 [Chapter 2]

Chapter 2 Referenced Publications

2.1 General.

The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications.

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 69, *Standard on Explosion Prevention Systems,* 2008 edition.

NFPA 70® , *National Electrical Code®,* 2011 edition.

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids,* 2013 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response,* 2012 edition.

2.3 Other Publications.

2.3.1 API Publications.

American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005-4070.

~~API 650~~ API **STD** 650 , *Welded Steel Tanks for Oil Storage*, ~~2007~~ **2013, Errata, 2014** .

2.3.2 ASME Publications.

~~American Society of Mechanical Engineers~~ **ASME International** , Two Park Avenue, New York, NY 10016-5990.

ASME *Boiler and Pressure Vessel Code*, ~~2010~~ **2015** .

2.3.3 ASTM Publications.

ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM ~~E 1226~~ E1226 , *Standard Test Method for Explosibility of Dust Clouds,* ~~- 2010~~ **2012A** .

2.3.4 ISO Publications.

International Organization for Standardization, ~~1, rue de Varembè, Case postale 56, CH-1211 Geneve 20,~~ **ISO Central Secretariat, BIBC II, 8, Chemin de Blandonnet, CP 401, 1214 Vernier, Geneva, Switzerland** .

ISO 6184~~/~~ **-** 1, *Explosion Protection Systems — Part 1: Determination of Explosion Indices of Combustible Dust in Air,* 1985.

2.3.5 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Mandatory Sections.

NFPA 53, *Recommended Practice on Materials, Equipment, and Systems Used in Oxygen-Enriched Atmospheres,* 2011 edition.

NFPA 484, *Standard for Combustible Metals,* 2012 edition.

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids,* 2013 edition.

Statement of Problem and Substantiation for Public Input

Referenced current SDO names, addresses, standard names, numbers, and editions.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 2-NFPA 68-2015 [Chapter K]	

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Submittal Date: Wed Jun 17 02:04:51 EDT 2015

Public Input No. 16-NFPA 68-2016 [Section No. 7.7.1]

7.7.1

The ~~hazard zone~~ fireball length from a vented gas deflagration shall be calculated by the following equation:

$$D = 3.1 \cdot \left(\frac{V}{n}\right)^{0.402} \tag{7.7.1}$$

where:

D = axial distance (front-centerline) from vent (m)

V = volume of vented enclosure (m^3)

n = number of evenly distributed vents

Additional Proposed Changes

File Name	Description	Approved
fireball_formula_historic_comparison.pdf	Fireball Formula Illustration	

Statement of Problem and Substantiation for Public Input

The fireball dimension formula,10*V^(1/3) in 2002, changed in 2007 and carried into 2013 to a "hazard zone" of 3.1*(V/n)^0.402. This change reduced the result of the calculation to approximately 1/3 of the original dimensions. The supporting documents show that the new equation is closer to defining the actual fireball dimensions rather than a hazard zone since a thermal dose can be received some distance away from the actual fireball. See example of actual tests submitted with this input. I propose that the committee change the text 'hazard zone" to Fireball Length and replace D in the equation with the term FL. Add paragraph 7.7.2 moving existing 7.7.2 to 7.7.3.
7.7.2 The hazard zone D = 3 x FL.

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Public Input No. 7-NFPA 68-2015 [Chapter 8]

Chapter 8 Venting of Deflagrations of Dusts and Hybrid Mixtures

8.1 Introduction.

8.1.1

This chapter shall apply to all enclosures with *L/D* less than or equal to six handling combustible dusts or hybrid mixtures.

8.1.1.1

This chapter shall be used with the information contained in the rest of this standard.

8.1.1.2

In particular, Chapters 6, 7, 10, and 11 shall be reviewed before the information in this chapter is applied.

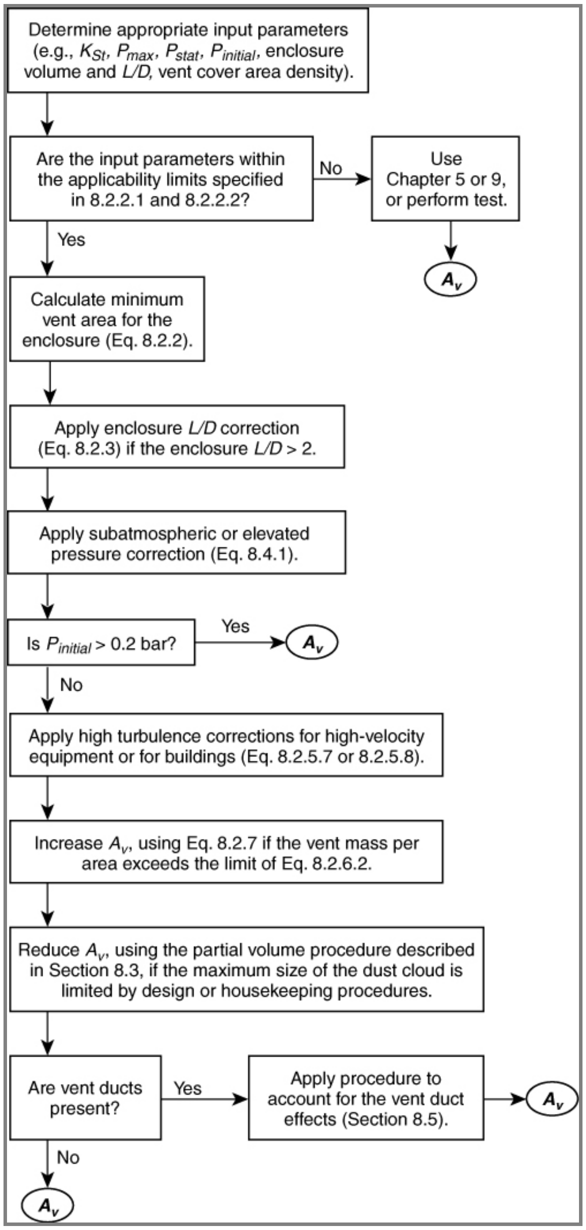
8.1.1.3

This chapter provides a number of equations and calculation procedures that shall be used to treat a variety of vent sizing applications.

8.1.1.4

The general flowchart given in Figure 8.1.1.4 shall be used to select applicable vent sizing methods.

Figure 8.1.1.4 Dust Explosion Vent Sizing Calculation Flowchart.



*****UPDATE FIGURE 8.1. 1.4 WITH BELOW SECTION AND EQUATION REFERENCE CHANGES*****

8.1. 2 *

Where actual material is not available for test, vent sizing shall be permitted to be based on K_{St} values for similar composition materials of particle size no greater than the specified particle size range per the chosen standard: ASTM E 1226, *Standard Test Method for Explosibility of Dust Clouds,* or ISO 6184-1, *Explosion Protection Systems — Part 1: Determination of Explosion Indices of Combustible Dust in Air*.

8.1.2.1

Where the actual material intended to be produced is smaller than the size determined by 8.1.2, tests shall be performed near the intended particle size.

8.1.2.2

When the actual material is available, the K_{St} shall be verified by test.

8.2 Venting by Means of Low-Inertia Vent Closures.

8.2.1

~~The *L/D* of the enclosure shall be determined according to Section 6.4 .~~

Minimum Vent Area Requirement

8.2. ~~2~~ 1.1

Equation 8.2.~~2~~ 1.1 shall be used to calculate the minimum necessary vent area, A_{v0}:

$$A_{v0} = 1 \cdot 10^{-4} \cdot \left(1 + 1.54 \cdot P_{stat}^{4/3}\right) \cdot K_{St} \cdot V^{3/4} \cdot \sqrt{\frac{P_{max}}{P_{red}} - 1}$$

(8.2.~~2~~ 1.1)

where:

A_{v0} = vent area (m^2)

P_{stat} = nominal static burst pressure of the vent (bar)

K_{St} = deflagration index (bar-m/s)

V = enclosure volume (m^3)

P_{max} = maximum pressure of a deflagration (bar-g)

P_{red} = reduced pressure after deflagration venting (bar) [115]

8.2. ~~2.~~ 1 –

~~Equation 8~~

.2

~~.2 shall apply to initial pressures before ignition of 1 bar-abs ± 0.2 bar.~~

~~8.2.2.2~~

The following limitations shall be applicable to Equation 8.2.~~2~~ 1.1 :

(1) 5 bar ≤ P_{max} ≤ 12 bar

(2) 10 bar-m/s ≤ K_{St} ≤ 800 bar-m/s

(3) 0.1 m^3 ≤ V ≤ 10,000 m^3

(4) P_{stat} ≤ 0.75 bar

8.2.

~~2.3~~

2 Effects of Elevated *L/D*

8.2.2.1

The *L/D* of the enclosure shall be determined according to Section 6.4 .

8.2.2.2

When *L/D* is less than or equal to 2, A_{v1} shall be set equal to A_{v0}.

8.2. 2. 3

For *L/D* values greater than 2 and less than or equal to 6, the required vent area, A_{v1}, shall be calculated as follows (where exp(*A*) = e^A , *e* is the base of the natural logarithm [114]):

$$A_{v1} = A_{v0} \cdot \left[1 + 0.6 \cdot \left(\frac{L}{D} - 2\right)^{0.75} \cdot \exp\left(-0.95 \cdot P_{red}^{2}\right)\right]$$

(8.2.2. 3)

8.2. ~~3~~ 2 . ~~1~~ 4 *

It shall be permitted to extend Equation 8.2.2. 3 to values of *L/D* of 8 for top-fed bins, hoppers, and silos, provided the calculated required vent area, after application of all correction factors, does not exceed the enclosure cross-sectional area.

8.2. 4 2.5

For situations where vents can be distributed along the major axis of the enclosure, Equation 8.2.~~2~~ 1.1 and Equation 8.2.2. 3 shall be permitted to be applied where *L* is the spacing between vents along the major axis.

8.2.

~~5 Three different general equations (Equations~~

3 Effects of Initially Elevated or Subatmospheric Pressure.

8.2.3 .1

When the initial pressure is between -0.2 bar and 0.2 bar , A_{vep} shall be set equal to A_{v1} .

8.2.

~~5.7, and~~

3.2 *

When enclosure pressure is initially greater than 0.2 bar (20 kPa) or less than -0.2 bar (-20 kPa), A_{vep}/A_{v0} shall be determined from the following equation:

$$A_{vep} = A_{v1} \cdot \frac{\left[1+1.54\cdot\left(\dfrac{P_{stat}-P_{initial}}{1+P_{effective}}\right)^{4/3}\right]\cdot\sqrt{\dfrac{1}{\Pi_{effective}}-1}}{\left[1+1.54\cdot P_{stat}^{4/3}\right]\cdot\sqrt{\dfrac{P_{max}}{P_{red}}-1}}$$

(8.2.

~~5~~

3 .

~~8) shall be applied to the determination of dust deflagration minimum required vent areas.~~

~~8.2.5.1~~

2)

where:

A_{vep} = vent area (m^2)
P_{stat} = static burst pressure of the vent (bar)
$P_{initial}$ = enclosure pressure at moment of ignition (bar)
$P_{effective}$ = $1/3\ P_{initial}$ (bar)
$\Pi_{effective}$ = $(P_{red} - P_{effective})/(P^{E}_{max} - P_{effective})$
P_{red} = reduced pressure
P^{E}_{max} = [(P_{max} 1) · ($P_{initial}$ 1)/(1 bar-abs) - 1] maximum pressure of the unvented deflagration at pressure (bar)
P_{max} = maximum pressure of an unvented deflagration initially at atmospheric pressure (bar)

8.2.3.3 *

When enclosure pressure is initially less than -0.2 bar, the vent area correction in Equation 8.2.3

~~, which produces the smallest required vent areas, shall apply to dust handling and storage equipment within which the average air axial velocity, v_{axial}, and the tangential velocity, v_{tan}, are both less than 20 m/s during all operating conditions.~~

~~8.2.5.2~~

.2 shall be evaluated over the range between operating pressure and atmospheric pressure and the largest vent area correction applied.

8.2.3.4

When enclosure pressure is initially less than -0.2 bar, it shall be permitted to use a value of 1.1 as the vent area correction for this section.

8.2.3.5

When enclosure pressure is initially greater than 0.2 bar, deflagration vents shall be permitted only when the following conditions are met:

(1) Vent duct length $L/D \leq 1$
(2) Panel density $M \leq M_T$ and ≤ 40 kg/m^2
(3) v_{axial} and v_{tan} < 20 m/s
(4) No allowance for partial volume
(5) Equation 8.4.1 used to calculate the necessary vent area adjustment

8.2.4 **Effects of Velocity Turbulence**

8.2.4.1 * _

For this application, average air axial velocity shall be calculated according to the following equation:

$$v = \frac{Q}{A}$$

(8.2.~~5~~ 4 .~~2~~ 1)

where:
v = average axial gas velocity (m/s)
Q = volumetric air flow rate (m^3/s)
A = average cross-sectional area of the flow path (m^2) [118,119]

8.2. ~~5~~ 4 . ~~3~~ 2 * _

If a circumferential (tangential) air velocity is in the equipment, v_{tan} shall be given by 0.5 v_{tan_max} , where v_{tan_max} is the maximum tangential air velocity in the equipment.

8.2. ~~5~~ 4 . 4 3

Values of Q, v_{axial} , v_{tan_max} , and v_{tan} shall be measured or calculated by engineers familiar with the equipment design and operation.

8.2. ~~5~~ 4 . ~~5~~ 4

The measurements or calculations shall be documented and made available to vent designers and the authority having jurisdiction.

8.2. 4. 5 ~~.6~~

When the maximum values derived for v_{axial} and v_{tan} are less than 20 m/s, A_{v2} shall be set equal to A_{vep} .

8.2. ~~5~~ 4 . ~~7~~ 6 * _

When either v_{axial} or v_{tan} is larger than 20 m/s, A_{v2} shall be determined from the following equation where *max* (*A, B*) = maximum value of either *A* or *B* [118,119]:

$$A_{v2} = \left[1 + \frac{max\left(v_{axial}, v_{\tan}\right) - 20}{36} \cdot 0.7\right] \cdot A_{vep}$$

(8.2.~~5~~ 4 .~~7~~ 6)

8.2. ~~5~~ 4 . ~~8~~ 7 * _

Vent areas for buildings in which there is a dust explosion hazard shall be determined from Equation 8.2.5.8 [118,119]:

$$A_{v2} = 1.7 \cdot A_{vep}$$

(8.2.~~5~~ 4 .~~8~~ 7)

8.2. ~~5~~ 4 . ~~9~~ 8

The required vent areas for these buildings shall be permitted to be reduced through use of the partial volume Equation 8.3.1.

8.2. ~~6~~ **5 *** – _ **Effects of Panel Inertia** ~~.~~

8.2.

~~6~~

5 .1

When the mass of the vent panel is less than or equal to 40 kg/m ^{2} , Equation 8.2. ~~6~~

5 .2 shall be used to determine whether an incremental increase in vent area is needed and the requirements of 8.2.

~~7~~

5.4 shall be used to determine the value of that increase.

8.2. ~~6~~ 5 .2

The vent area shall be adjusted for vent mass where the vent mass exceeds M_T as calculated in Equation 8.2.~~6~~ 5 .2:

$$M_T = \left[6.67 \cdot \left(P_{red}^{0.2}\right) \cdot \left(n^{0.3}\right) \cdot \left(\frac{V}{K_{St}^{0.5}}\right)\right]^{1.67} \qquad \textbf{(8.2.}\textbf{\sout{6}}\ \textbf{5 .2)}$$

where:

M_T = threshold mass (kg/m ^{2})

P_{red} = reduced pressure after deflagration venting (bar)

n = number of panels

V = volume (m ^{3})

8.2. ~~6~~ 5 .3

Where M is greater than 40 kg/m ^{2}, it shall be permitted to use the procedure provided in Annex G.

8.2. ~~7~~ 5.4

For $M > M_T$, the required vent area A_{v3}, shall be calculated as follows:

$$A_{v3} = F_{SH}\left[1 + (0.0075) \cdot M^{0.6} \cdot \left(\frac{K_{St}^{0.5}}{N^{0.3} V P_{red}^{\ 0.2}}\right)\right] \cdot A_{v2} \qquad \textbf{(8.2.}\textbf{\sout{7}}\ \textbf{5.4)}$$

where:

F_{SH} = 1 for translating panels or 1.1 for hinged panels

M = mass of vent panel (kg/m ^{2})

A_{v2} = vent area calculated by 8.2.4. 5~~.6~~ , Equation 8.2.~~5~~ 4 .~~7~~ 6 , or Equation 8.2.~~5~~ 4 .~~8~~ 7 , as applicable

8.2. ~~7~~ 5 . ~~1~~ 5

If K_{St} < 75 bar-m/s, K_{St} = 75 shall be used in Equation 8.2.~~7~~ 5 .4.

8.2. ~~8~~ 5.6

Where $M \le M_T$, A_{v3} shall be set equal to A_{v2}.

8.3 * Effects of Partial Volume .

8.3.1

When the volume fill fraction, X_r , can be determined for a worst-case explosion scenario, the minimum required vent area shall be permitted to be calculated from the following equation:

$$A_{v4} = A_{v3} \cdot X_r^{-1/3} \cdot \sqrt{\frac{X_r - \Pi}{1 - \Pi}} \qquad \textbf{(8.3.1)}$$

where:

A_{v4} = vent area for partial volume deflagration

A_{v3} = vent area for full volume deflagration as determined from Equation 8.2.~~7~~ 5.4 or from 8.2.~~8~~ 5.6

X_r = fill fraction > Π

$\Pi = P_{red} / P_{max}$

8.3.2 *

If $X_r \leq \Pi$, deflagration venting shall not be required.

8.3.2.1

Where partial volume is not applied, A_{v4} shall be set equal to A_{v3}.

8.3.3 * Process Equipment Partial Volumes.

Process equipment involving nonsolvent drying shall be permitted to use partial volume venting in accordance with Equation 8.3.1.

8.3.3.1

In applications involving dryers with recirculation of dry product, the fill fraction shall be taken as 1.0.

8.3.3.2

Furthermore, if the solvent is flammable, hybrid deflagration K_{St} values shall be determined.

8.3.3.3

In applications such as a spray dryer or fluidized bed dryer, the specific fill fraction to be used for vent design shall be based on measurements with representative equipment and process materials.

8.3.3.4

In applications involving spray dryers where a partial volume venting is calculated in accordance with Equation 8.3.1, the vent shall be mounted within the chosen partial volume zone of the dryer that contains the driest fraction of material.

8.3.3.5

In these applications, the determination of X_r shall be documented and submitted to the authority having jurisdiction for review and concurrence.

8.3.4 Building Partial Volumes.

(See Annex I.)

8.3.4.1

This subsection shall apply to large process buildings in which a dust explosion hazard is associated with combustible material deposits on the floor and other surfaces, and with the material contained in process equipment.

8.3.4.2

The minimum required deflagration vent area for the building dust explosion hazard shall be based either on the full building volume or on a partial volume determined as follows:

(1) Collect at least three representative samples of the floor dust from either the actual building or a facility with similar process equipment and materials. The samples shall be obtained from measured floor areas, A_{fs} , that are each 0.37 m^2 (4 ft^2) or larger.

(2) Weigh each sample and calculate the average mass, $\bar{M}_f$ (grams), of the floor samples.

(3) Collect at least two representative samples from measured sample areas, A_{ss} , on other surfaces with dust deposits. These surfaces on any plane could include beams, shelves, and external surfaces of process equipment and structures. Calculate the total area, A_{sur} , of these surfaces with dust deposits.

(4) Weigh each sample and calculate the average mass, $\bar{M}_f$ (grams), of the surface samples.

(5) Determine the total mass, M_e , of combustible dust that could be released from the process equipment in the building.

(6) Test the dust samples per ASTM E 1226, *Standard Test Method for Explosibility of Dust Clouds*, to determine P_{max} , K_{St} , and the worst-case concentration, c_w , corresponding to the largest value of K_{St} .

(7) Using the highest values of P_{max} and K_{St} , the building volume, V, and $\Pi = P_{red} / P_{max}$, use Equation 8.2.~~7~~ 5.4 or 8.2.~~8~~ 5.5 to calculate the vent area, A_{v3}, needed if the full building volume were filled with combustible dust.

(8) Calculate the worst-case building partial volume fraction, X_r , in accordance with 8.3.4.3.

(9) If the calculated $X_r > 1$, the minimum required vent area is equal to A_{v3} .

(10) If $X_r \leq \Pi$, no deflagration venting is needed.

(11) If $1 > X_r > \Pi$, the minimum required vent area, A_{v4} , is calculated from Equation 8.3.1 as follows:

$$A_{v4} = A_{v3} \cdot X_r^{-1/3} \cdot \sqrt{\frac{X_r - \Pi}{1 - \Pi}} \quad \textbf{(8.3.4.2)}$$

8.3.4.3

The worst-case building partial volume fraction, X_r , shall be calculated from the following equation:

8.3.4.3.1

If a measured value of c_W is available, the lowest value of c_W for the various samples shall be used in Equation 8.3.4.3.

$$X_r = \frac{\bar{M}_f \cdot A_{f\text{-}dusty} \cdot \eta_{Dfloor}}{A_{fs} \cdot V \cdot c_w} + \frac{\bar{M}_s \cdot A_{sur} \cdot \eta_{Dsur}}{A_{ss} \cdot V \cdot c_w} + \frac{M_e}{V \cdot c_w} \quad \textbf{(8.3.4.3)}$$

where:

X_r = worst-case building partial fraction
$\bar{M}_f$ = average mass of floor samples (g)
$A_{f\text{-}dusty}$ = total area of floor with dust deposits (m^2)
η_{Dfloor} = entrainment factor for floor accumulations
A_{fs} = measured floor areas (m^2)
V = building volume (m^3)
c_W = worst-case dust concentration (g/m^3)
$\bar{M}_s$ = average mass of surface samples (g)
A_{sur} = total area of surfaces with dust deposits (m^3)
η_{Dsur} = entrainment factor for surface accumulations
A_{ss} = measured sample areas of surfaces with dust deposits (m^2)
M_e = total mass of combustible dust that could be released from the process equipment in the building (g)

8.3.4.3.2

If a measured value of c_W is not available, a value of 200 g/m^3 shall be permitted to be used in Equation 8.3.4.3.

8.3.4.3.3 * _

If measured values of $\bar{M}_f / A_f$ and $\bar{M}_s / A_{ss}$ are not available, and if the facility is to be maintained with dust layer thickness in accordance with NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, an approximate value for these ratios shall be permitted to be used, based on a dust layer bulk density of 1200 kg/m^3 and a layer thickness of 0.8 mm (⅓₂ in.) over the entire floor area and other surfaces defined in 8.3.4.3.4.

8.3.4.3.4

The total mass of dust that could be released from process equipment in the building/room M_e , shall be determined as follows:

(1) Evaluate equipment with exposed dust accumulations, such as but not limited to screeners, open-top conveyors or conveyor belts, open packaging or shipping containers, and enclosureless dust collectors.

(2) Evaluate anticipated episodic spills from equipment in light of current housekeeping procedures and practices.

(3) Do not include material in closed packaging or shipping containers, material in enclosed silos or storage bins, or in otherwise explosion-protected equipment.

8.3.4.3.5

The entrainment factor, η_D for each representative area shall be determined by one of the following methods:

(1) Assume an entrainment factor of 1.

(2) Calculate the entrainment factor as follows:

(3) Determine the average particle density, ρ_p for each sampled dust layer.

(4) Determine the entrainment threshold velocity using the following equation:

$$U_t = 0.46 \cdot \rho_p^{1/3}$$ **[8.3.4.3.5**

where:

U_t = threshold velocity (m/s)

ρ_p = particle density (kg/m^3)

(5) Assume a maximum free-stream velocity, U, of 50 m/s or establish a different free-stream velocity calculated from a maximum credible initiating event.

(6) Determine a maximum entrainment rate using the following equation:

$$m'' = 0.002 \cdot \rho \cdot U \cdot \left(U^{1/2} - U_t^2 / U^{3/2}\right)$$ **[8.3.4.3.5**

where:

m'' = entrained mass flux (kg/m^2-s)

ρ = gas density (kg/m^3)

U = free-stream velocity (m/s) > U_t

U_t = threshold velocity (m/s)

(7) Determine initiating event time, t, by dividing the building or enclosure longest dimension by **1⁄2** the maximum free-stream velocity.

(8) Using the appropriate surface area, A, determine the maximum mass, M_{max}, from the presumed initiating event using the following equation:

$$M_{max} = m'' \cdot A \cdot t$$ **[8.3.4.3.5**

(9) Determine the entrainment factor using the following equation:

$$\eta_D = \begin{cases} \dfrac{M_{max}}{M}, \text{ if } \dfrac{M_{max}}{M} < 1 \\ 1, \text{ if } \dfrac{M_{max}}{M} \geq 1 \end{cases}$$ **[8.3.4.3.5**

where:

M = average mass of the sample (g)

8.4 – ~~Effects of Initially Elevated or Subatmospheric Pressure.~~ ~~8.4.1~~ *

~~When enclosure pressure is initially greater than 0.2 bar (20 kPa) or less than -0.2 bar (-20 kPa),~~ ~~A_{vep}/A_{v0} shall be determined from the following equation:~~

$$A_{vep} = A_{v1} \cdot \frac{\left[1 + 1.54 \cdot \left(\frac{P_{stat} - P_{initial}}{1 + P_{effective}}\right)^{4/3}\right] \cdot \sqrt{\frac{1}{\Pi_{effective}} - 1}}{\left[1 + 1.54 \cdot P_{stat}^{4/3}\right] \cdot \sqrt{\frac{P_{max}}{P_{red}} - 1}} \qquad \text{(8.4.1)}$$

~~where:~~

~~A_{vep} = vent area (m^2)~~

~~P_{stat} = static burst pressure of the vent (bar)~~

~~$P_{initial}$ = enclosure pressure at moment of ignition (bar)~~

~~$P_{effective}$ = $^1/_3$ $P_{initial}$ (bar)~~

~~$\Pi_{effective}$ = $(P_{red} - P_{effective})/(P^E_{max} - P_{effective})$~~

~~P_{red} = reduced pressure~~

~~P^E_{max} = [(P_{max} + 1) · ($P_{initial}$ + 1)/(1 bar-abs) - 1] maximum pressure of the unvented deflagration at pressure (bar)~~

~~P_{max} = maximum pressure of an unvented deflagration initially at atmospheric pressure (bar)~~

~~8.4.2~~ * –

~~When enclosure pressure is initially less than -0.2 bar, the vent area correction in Equation 8.4.1 shall be evaluated over the range between operating pressure and atmospheric pressure and the largest vent area correction applied.~~

~~8.4.3~~ –

~~When enclosure pressure is initially less than -0.2 bar, it shall be permitted to use a value of 1.1 as the vent area correction for this section.~~

~~8.4.4~~ –

~~When enclosure pressure is initially greater than 0.2 bar, deflagration vents shall be permitted only when the following conditions are met:~~

(1) ~~Vent duct length $L/D \leq 1$~~

(2) ~~Panel density $M \leq M_T$ and $\leq$ 40 kg/m^2~~

(3) ~~v_{axial} and v_{tan} < 20 m/s~~

(4) ~~No allowance for partial volume~~

(5) ~~Equation 8.4.1 used to calculate the necessary vent area adjustment~~

~~8.4.5~~ –

~~When the initial pressure is between -0.2 bar and 0.2 bar, A_{vep} shall be set equal to A_{v1}.~~

~~8.5~~ * – **Effects of Vent Ducts.**

8. ~~5~~ 4 .1 *

If there is no vent duct, $A_{vf} = A_{v\,4}$; otherwise, the effect of vent ducts shall be calculated from the following equations:

$$A_{vf} = A_{v4} \cdot \left(1 + 1.18 \cdot E_1^{0.8} \cdot E_2^{0.4}\right) \cdot \sqrt{\frac{K}{K_0}}$$

(8.~~5~~ 4 .1a)

$$E_1 = \frac{A_{vf} \cdot L_{duct}}{V}$$

(8.~~5~~ 4 .1b)

$$E_2 = \frac{10^4 \cdot A_{vf}}{\left(1 + 1.54 \cdot P_{stat}^{4/3}\right) \cdot K_{St} \cdot V^{3/4}}$$

(8.~~5~~ 4 .1c)

$$K \equiv \frac{\Delta P}{\frac{1}{2} \cdot \rho \cdot U^2} = K_{inlet} + \frac{f_D \cdot L_{duct}}{D_h} + K_{elbows} + K_{outlet} + \cdots$$

(8.~~5~~ 4 .1d)

where:

A_{vf} = vent area required when a duct is attached to the vent opening (m^2)
$A_{v\,4}$ = vent area after adjustment for partial volume (m^2), per Equation 8.3.1
K = overall resistance coefficient of the vent duct application
K_0 = 1.5, the resistance coefficient value assumed for the test configurations that generated the data used to validate Equations 8.2.~~2~~ 1.1 and 8.2.2. 3
L_{duct} = vent duct overall length (m)
V = enclosure volume (m^3)
P_{stat} = nominal static opening pressure of the vent cover (bar)
ΔP = static pressure drop from the enclosure to the duct exit at average duct slow velocity, U (bar)
ρ = gas density (kg/m^3)
U = fluid velocity (m/s)
K_{inlet}, K_{elbows}, K_{outlet} = resistance coefficients for fittings
f_D = D'Arcy friction factor for fully turbulent flow; see A.8.5 for typical formula [114]
D_h = vent duct hydraulic diameter (m)

8. ~~5~~ 4 .2

Under certain circumstances, in which there are two solutions for vent area, the smaller vent area shall be used.

8. ~~5~~ 4 .3

Where these equations do not produce a solution for vent area, the design shall be modified by decreasing the vent duct length, strengthening the vessel to contain a higher P_{red} , or both.

8. ~~5~~ 4 .4

Equation 8.~~5~~ 4 .1a shall not be used if the vent cover is not located at the entrance of the duct.

8. ~~5~~ 4 .5

Equation 8.~~5~~ 4 .1a shall not be used if the initial pressure exceeds ±0.2 bar-g.

8. ~~5~~ 4 .6

Equation 8.~~5~~ 4 .1a shall not be used if the vent duct cross-sectional area varies by more than 10 percent anywhere along the length.

8. ~~5~~ 4 .7

It shall be permitted to use Equation 8.~~5~~ 4 .1a for vent ducts equipped with elbows, bird screens, and rain covers as long as the obstructions are properly accounted for through the duct resistance coefficient *K*.

8. ~~5~~ 4 .8

It shall be permitted to use vent ducts outside the limitations of Equation 8.~~5~~ 4 .1(a) if designed in accordance with full-scale test data.

8. ~~5~~ 4 .9

The maximum length of the duct shall be limited to obey the following inequality, where min(*A*, *B*) = the minimum value of either *A* or *B*:

$$L_{eff} \le \min\left[\frac{10{,}000 \cdot D}{K_{St}}, \frac{11{,}000}{K_{St}}\right]$$

(8.~~5~~ 4 .9)

where:

$L_{eff} = \min(L_{duct}, L_{dusty})$

$L_{dusty} = (P_{max} - P_{red}) \cdot V/A_V$

8. ~~5~~ 4 .10

Table 8.~~5~~ 4 .10 shall be reviewed to determine the combination rules and limitations for application of various dust models in this chapter.

Table 8.~~5~~ 4 .10 Combination Rules and Limitations for NFPA 68 Dust Models

Vent ducts	P_{intial} ≤ 1.2 bar-abs 1 ≤ L/D ≤ 6 Allow turbulence Panel density ≤ 40 kg/m ^{2} Allow partial volume No elevated pressure (calculate vent duct effect last)
Partial volume	$P_{initial}$ ≤ 1.2 bar-abs 1 ≤ L/D ≤ 6 Allow turbulence Panel density ≤ 40 kg/m ^{2} Allow vent ducts No elevated pressure (calculate vent duct effect last)
Panel inertia	$P_{initial}$ ≤ 1.2 bar-abs 1 ≤ L/D ≤ 6 Allow turbulence Allow partial volume Allow vent ducts No elevated pressure (calculate vent duct effect last)
Elevated pressure	1.2 < $P_{initial}$ ≤ 5 bar-abs 1 ≤ L/D ≤ 6 Turbulence (v_{axial} and v_{tan}) < 20 m/s Panel density ≤ M_T and ≤ 40 kg/m ^{2} Full volume, no partial volume No vent ducts (calculate elevated pressure effect last)
Subatmospheric pressure	$P_{initial}$ ≤ 0.8 bar-abs 1 ≤ L/D ≤ 6 Allow turbulence Panel density ≤ 40 kg/m ^{2} Allow partial volume Allow vent ducts (calculate vent duct effect last)

8. ~~6~~ 5 Bins, Hoppers, and Silos.

8. ~~6~~ 5 .1

Deflagration venting for bins, hoppers, and silos shall be from the top or the upper side, above the maximum level of the material contained, and shall be directed to a safe outside location *(see Section 8.9)*.

8. ~~6~~ 5 .1.1 *

Deflagration venting shall be permitted to be through vent closures located in the roof or sidewall or by making the entire enclosure top a vent.

8. ~~6~~ 5 .1.2

In all cases, the total volume of the enclosure shall be assumed to contain a suspension of the combustible dust in question.

8. ~~6~~ 5 .1.3

No credit shall be taken for the enclosure being partly full of settled material.

8. ~~6~~ 5 .1.4

For a multiple application, the closures shall be placed symmetrically to minimize the effects of potential reaction forces *(see 6.3.5)*.

8. ~~6~~ 5 .1.5

Care shall be taken not to fill the enclosure above the bottoms of the vent panels, because large amounts of dust can blow out into the atmosphere, ignite, and form a large fireball.

8. ~~6~~ 5 .2

Deflagration venting shall be permitted to be accomplished by means of vent closures located in the roof of the enclosure.

8. ~~6~~ 5 .2.1

The vent operation procedures outlined in Section 6.5 shall be followed.

8. ~~6~~ 5 .3 *

The entire enclosure top shall be permitted to be used to vent deflagrations.

8. ~~6~~ 5 .3.1

Roof panels shall be as lightweight as possible and shall not be attached to internal roof supports.

8. ~~6~~ 5 .3.2

API 650, *Welded Steel Tanks for Oil Storage*, shall be referenced for guidelines for the design of a frangible, welded roof joint.

8. ~~6~~ 5 .3.3

Equipment, piping, and other process connections shall not restrict the roof's operation as a vent closure.

8. ~~6~~ 5 .3.3.1

Equipment, piping, and other process connections shall be included in the vent panel inertia evaluation per 8.2.~~6~~ 5 .

8. ~~6~~ 5 .3.4

The entire enclosure rooftop shall be labeled as an explosion vent in accordance with 11.3.4 .

8. ~~6~~ 5 .3.5

Access to the rooftop shall be restricted during operation of the protected enclosure.

8. ~~6~~ 5 .3.6

Initial inspection shall include the roof-wall connections.

8. ~~6~~ 5 .3.7

The remaining portions of the enclosure, including anchoring, shall be designed to resist the calculated P_{red} , based on the vent area provided. *(See Section 6.3.)*

8. ~~7~~ 6 Venting of Dust Collectors Using Bags, Filters, or Cartridges.

8. ~~7~~ 6 .1 *

It shall be permitted to remove the volume occupied by the filter elements, provided the filter elements would not obstruct the free flow of hot gases, unburned material, and flame during a deflagration. Methods for achieving this objective shall include but not be limited to the following:

(1) * Separating the vent closure from the filters, usually by locating the vent closure below the filters for standard vertical filters, but other configurations include, for example, horizontal cartridges and pleated flat panel filters, which could have side or top venting. If this methodology is used, the principle of separation of vent closure from filters shall be maintained regardless of filter design and orientation.

(2) * Shortening or removing a row of filters nearest the vent closure such that the area normal to and between the filters and the vent closure equals or exceeds the vent closure area. In this case, a restraining bar shall be installed to hold back the filters to prevent them from being deflected toward and obstructing the free flow of hot gases, unburned material, or flame through the vent during a deflagration.

8. ~~7~~ 6 .2

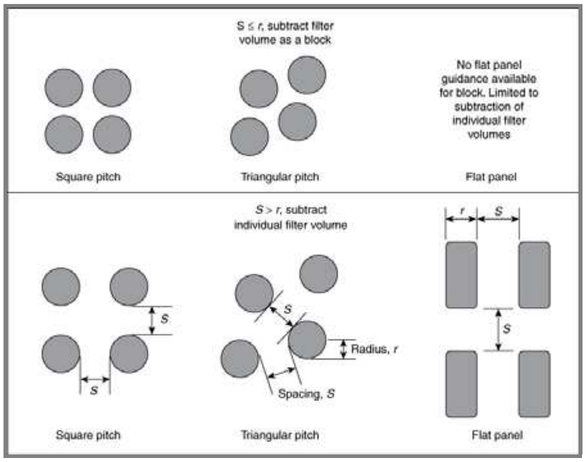
Where the volume occupied by the filter elements is removed according to 8.~~7~~ 6 .1 , the method for calculating the volume occupied by the filters shall be dependent on the distance between the filters as follows and as summarized in Figure 8.~~7~~ 6 .2 :

(1) For round or elliptical cross-section filters where the distance between the outer perimeters does not exceed the radius (or the minimus) of the filters, the volume can be calculated as a block to include the space between the filters.

(2) For round or elliptical cross-section filters where the distance between the outer perimeters is greater than the radius (or the minimus) of the filters, the volume can be calculated as the volume of each filter multiplied by the total number of filters.

(3) For flat panel filters (also called envelope, flat pocket filters), the volume of each filter can be calculated and multiplied by the total number of filters. Calculating the volume as a block is not permitted for flat panel filters.

Figure 8.~~7~~ 6 .2 Filter Element Spacing Criteria.



8. ~~7~~ 6 .3 *

Where the requirements of 8.~~7~~ 6 .1 are not met, vents are to be located such that the bottom of the vent(s) is below the bottom of the filtration media for standard vertical filters. In the case of horizontally installed filter media, locate the vent(s) as such that the filter media is not able to significantly block the vent opening. In both cases, the total dirty volume of the enclosure on the dirty side of the tube sheet, including the volume occupied by the filters, shall be calculated.

8. ~~7~~ 6 .4

If the clean air plenum contains dust, or if the material entering the dust collector is a hybrid mixture, one of the following protection measures shall be applied:

(1) A separate vent shall be provided on the clean air side, calculated based on the clean air side volume using the methodology in Chapter 7 .

(2) The clean air side gas concentration shall be evaluated for flammability and protected in accordance with NFPA 69, *Standard on Explosion Prevention Systems*.

8. ~~8~~ 7 Bucket Elevators.

8. ~~8~~ 7 .1 *

Bucket elevators shall be classified as single-casing (single leg) or double-casing (twin leg) design.

8. ~~8~~ 7 .2 * Head and Boot Vents.

8. ~~8~~ 7 .2.1

Vent areas shall be not less than the cross-sectional area of each leg and at a minimum shall be fitted both at the head and as close to the boot as practicable.

8. ~~8~~ 7 .2.2

Where a vent is not installed directly on the boot, a vent shall be installed on each casing at a distance from the boot less than or equal to the smaller of 6 m or the additional vent spacing distance per Table 8.~~8~~ 7 .3.3.

8. ~~8~~ 7 .3 Additional Casing Vents.

8. ~~8~~ 7 .3.1

The owner/operator shall be permitted to choose a design P_{red} of either 0.5 or 1.0 bar.

8. ~~8~~ 7 .3.2

The casing(s), head, and boot shall all be designed for the same P_{red} chosen from 8.~~8~~ 7 .3.1.

8. ~~8~~ 7 .3.3 *

Additional vents shall be installed in each casing at center-to-center spacing distance along the elevator axis based on the bucket elevator classification, the K_{St} of the material being handled, and the design P_{red} , as given in Table 8.~~8~~ 7 .3.3.

Table 8.~~8~~ 7 .3.3 Additional Vent Spacing

		Spacing (m)		
Bucket Elevator Classification	**K_{St} (bar-m/s)**	**P_{red} ≤ 0.2 bar**	**P_{red} ≤ 0.5 bar**	**P_{red} ≤ 1.0 bar**
Double-casing (twin leg)	<100	6	None required	None required
	100–150	3	10	19
	151–175	N/A	4	8
	176–200	N/A	3	4
	>200	N/A	N/A	3
Single-casing (single leg)	<100	N/A*	None required	None required
	100–150	N/A	7	14
	151–175	N/A	4	5
	176–200	N/A	3	4
	>200	N/A	N/A	3

N/A: Not allowed.

*For P_{red} ≤ 0.3 bar, vent spacing of 6 m is appropriate.

8. ~~8~~ 7 .3.4 *

At each vent location, the total vent area shall be not less than the cross-sectional area of each leg.

8. ~~8~~ 7 .3.5

For K_{St} values less than 100 bar-m/s where a P_{red} of 0.2 bar is selected, vents shall be placed at an interval not exceeding 6 m on the leg(s).

8. ~~8~~ 7 .4 *

Vent closures shall have P_{stat} less than or equal to 0.1 bar.

8. ~~9~~ 8 * Fireball Dimensions.

Measures shall be taken to reduce the risk to personnel and equipment from the effects of fireball temperature and pressure.

8. ~~9~~ 8 .1

A documented risk assessment shall be permitted to be used to reduce the hazard distances calculated in 8.~~9~~ 8 .2 and 8.~~9~~ 8 .3.

8. ~~9~~ 8 .2 *

In the case of dust deflagration venting, the distance, *D*, shall be expressed by Equation 8.9.2:

$$D = K \cdot \left(\frac{V}{n}\right)^{1/3}$$ **(8.~~9~~ 8 .2)**

where:

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

K = flame length factor: 10 for metal dusts, 8 for chemical and agricultural dusts

V = volume of vented enclosure (m^3)

n = number of evenly distributed vents

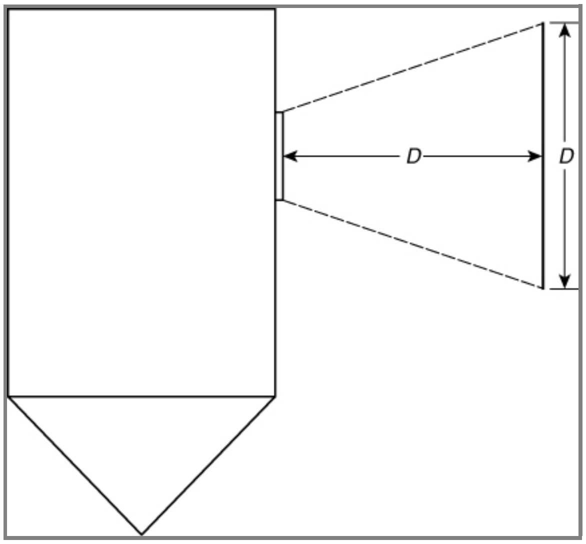
8. ~~9~~ 8 .2.1

Axial distance, calculated by Equation 8.~~9~~ 8 .2, shall be limited to 60 m [104].

8. ~~9~~ 8 .2.2

The maximum width and height of the projected flame shall be taken as *D* and shall be assumed to be equally distributed around the centerline of the vent discharge *(see Figure 8.~~9~~ 8 .2.2).*

Figure 8.~~9~~ 8 .2.2 Fireball Dimensions.



8. ~~9~~ 8 .3 *

Where venting is from a cubic vessel, the $P_{max,a}$ value shall be indicated approximately by Equation 8.9.3 [108]:

$$P_{max,a} = 0.2 \cdot P_{red} \cdot A_v^{0.1} \cdot V^{0.18}$$ **(8.~~9~~ 8 .3)**

where:

$P_{max,a}$ = external pressure (bar)

P_{red} = reduced pressure (bar)

A_v = vent area (m^2)

V = enclosure volume (m^3)

8. ~~9~~ 8 .4

For distances longer than α × D, the maximum external pressure, $P_{max,r}$, shall be indicated approximately by Equation 8.9.4:

$$P_{max,r} = P_{max,a}\left(\alpha \cdot D / r\right)$$

(8.~~9~~ 8 .4)

where:

$P_{max,r}$ = maximum external pressure

$P_{max,a}$ = external pressure (bar)

α = 0.20 for horizontal vents and 0.25 for vertical (upward directed) vents

D = maximum length of fireball (m)

r = distance from vent (m)

8. ~~9~~ 8 .5

Equation 8.~~9~~ 8 .2, Equation 8.~~9~~ 8 .3, and Equation 8.~~9~~ 8 .4 shall be valid for the following conditions:

(1) Enclosure volume: 0.3 $m^3 \leq V \leq$ 10,000 m^3

(2) Reduced pressure: $P_{red} \leq$ 1 bar

(3) Static activation pressure: $P_{stat} \leq$ 0.1 bar

(4) Deflagration index: $K_{St} \leq$ 200 bar-m/s

(5) $P_{max} \leq$ 9 bar

8. ~~10~~ 9 * **Venting Internal to a Building with Flame-Arresting and Particulate Retention Device** .

8. ~~10~~ 9 .1

Expected overpressure shall be compared to the building design, and building venting shall be considered to limit overpressures.

8. ~~10~~ 9 .1.1

The resulting pressure increase in an unvented building shall be permitted to be estimated from the following:

(1) $\Delta P = 1.74\, P_0\, (V_1/V_0)$

(2) V_0 = free volume of building

(3) V_1 = volume of protected equipment

(4) P_0 = ambient pressure [14.7 psia (1.013 bar-abs)]

(5) ΔP = pressure rise in the building (in same units as P_0)

8. ~~10~~ 9 .1.2

It shall be permitted to use a lower value of the coefficient than that shown in 8.~~10~~ 9 .1.1 (1) where experimental data are available to substantiate the lower value.

8. ~~10~~ 9 .2

The deflagration venting area provided for the protected enclosure shall be adjusted to compensate for the venting efficiency as determined by test for the device.

8. ~~11~~ 10 * Venting Silos or Other Storage Vessel Provided with Integral Bin Vents.

8. ~~11~~ 10 .1

Where bin vents (air material separators) are installed in common with a silo or any other storage vessel, they shall be protected as follows:

(1) The protected volume shall be calculated as the sum of the volume of the silo and the volume of the collector in accordance with Section 8.~~7~~ 6 .

(2) The *L/D* of the combination shall be calculated based on the dimensions of the silo alone in accordance with Section 6.4.

(3) Vent panels shall be located on the silo top surface or on the side walls above the maximum level of the contents of the silo.

(4) It shall be permitted to locate a portion of the venting on the bin vent surface in accordance with the following proportions:

$$A_{v,bin\ vent} = A_{v,\ total} - A_{v,silo\ min}$$

$$A_{v,silo\ min} = \left(\frac{V_{silo}}{V_{total}}\right)^{2/3} A_{v,\ total}$$

where:

$A_{v,bin\ vent}$ = vent area of the bin vent/collector

$A_{v,total}$ = total vent area calculated for the bin vent–silo combination

$A_{v,silo,min}$ = minimum explosion venting area required to be on the silo

$A_{v,silo}$ = actual explosion venting area installed on the silo

8. ~~11~~ 10 .2

Where the open area of the connection between the bin vent and the silo is greater than or equal to the vent area required for the combined volume, it shall be permitted to locate all or any portion of the venting on the bin vent surface.

8. ~~11~~ 10 .2.1

When 8.~~11~~ 10 .2 is applied, the clear path requirements of Section 8.~~7~~ 6 shall apply.

8. ~~12~~ 11 * – Deflagration Venting of Enclosures Interconnected with Pipelines.

8. ~~12~~ 11 .1 *

For interconnecting pipelines with inside diameters no greater than 0.3 m (1 ft) and lengths no greater than 6 m (20 ft), the following requirements shall apply [104]:

(1) The venting device for the enclosure shall be designed for $P_{stat} < 0.2$ bar.

(2) Enclosures of volumes within 10 percent of each other shall be vented as determined by Equation 8.2.~~2~~ 1.1 and Equation 8.2.2. 3.

(3) If enclosures have volumes that differ by more than 10 percent, the vents for both enclosures shall be designed as if P_{red} were equal to 1 bar or less. The enclosure shall be designed with P_{es} equal to a minimum of 2 bar.

(4) If it is not possible to vent the enclosure with the smaller volume in accordance with this standard, the smaller enclosure shall be designed for the maximum deflagration pressure, P_{max} , and the vent area of the larger enclosure with the larger volume shall be doubled.

(5) The larger enclosure shall be vented or otherwise protected as described in NFPA 69, *Standard on Explosion Prevention Systems*, in order for the deflagration venting of smaller enclosures to be effective.

8. ~~12~~ 11 .2 *

For enclosures outside the scope of 8.~~12~~ 11 .1 , explosion isolation or suppression shall be provided in accordance with NFPA 69, *Standard on Explosion Prevention Systems*, unless a documented risk assessment acceptable to the authority having jurisdiction demonstrates that increased vent area prevents enclosure failure.

Statement of Problem and Substantiation for Public Input

Though Figure 8.1.1.4 is intended to guide the user through the vent sizing process, the text and order of equations make it quite difficult to navigate the actual calculation procedure. By organizing the sections by order of intended execution, the user will be able to follow the flow of section 8.2 without needing to jump through the chapter. There are also currently several sections that add some amount of confusion as to applicability. Sections 8.2.2.1 and 8.2.5.1 for example are intending to advise that where the conditions fall outside of those listed, additional corrections will be required. These sections can also be interpreted to mean that the referenced equations would not be applicable for conditions outside of those listed, which puts the user in a position where venting does not appear to be allowed in those cases. 8.7.3 is another section which is vague and requires some amount of interpretation by the user. This section should include some reference or direction as to where the vent opening(s) should be located relative to the filtration media. Figure 8.1.1.4 will need to be updated if the recommended section and equation numbers are altered as recommended.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 8-NFPA 68-2015 [Section No. 8.4.1]	
Public Input No. 9-NFPA 68-2015 [Section No. 8.5.1]	
Public Input No. 12-NFPA 68-2015 [Sections A.8.7.1(1), A.8.7.1(2)]	

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Public Input No. 8-NFPA 68-2015 [Section No. 8.4.1]

8.4.1 *

When enclosure pressure is initially greater than 0.2 bar (20 kPa) or less than -0.2 bar (-20 kPa), A_{vep}~~/A_{v0}~~ - shall be determined from the following equation:

$$A_{vep} = A_{v1} \cdot \frac{\left[1+1.54\cdot\left(\frac{P_{stat}-P_{initial}}{1+P_{effective}}\right)^{4/3}\right]\cdot\sqrt{\frac{1}{\Pi_{effective}}-1}}{\left[1+1.54\cdot P_{stat}^{4/3}\right]\cdot\sqrt{\frac{P_{max}}{P_{red}}-1}} \qquad \textbf{(8.4.1)}$$

*****Review equation 8.4.1 against committee intent to assure values are accurate.*****

where:

A_{vep} = vent area (m^2)

P_{stat} = static burst pressure of the vent (bar)

$P_{initial}$ = enclosure pressure at moment of ignition (bar)

$P_{effective}$ = $^1/_3$ $P_{initial}$ (bar)

$\Pi_{effective}$ = (P_{red} - $P_{effective}$)/(P^E $_{max}$ - $P_{effective}$)

P_{red} = reduced pressure

P^E $_{max}$ = [(P_{max} - ~~+~~ 1) · ($P_{initial}$ - ~~+~~ 1)/(1 bar-abs) - 1] maximum pressure of the unvented deflagration at pressure (bar)

P_{max} = maximum pressure of an unvented deflagration initially at atmospheric pressure (bar)

Additional Proposed Changes

File Name	Description	Approved
8.4.1_example.pdf	8.4.1 Example Problem	

Statement of Problem and Substantiation for Public Input

The scenarios that I have run to date where an initially elevated pressure was being evaluated, the correction actually resulted in a reduction of vent area requirement. It is my understanding that this would not have been the intent of the correction and I would expect an increase of vent area would be warranted. I have attached an example problem with notes. I believe that there may be a missing component in the denominator of the equation as, to the best of my knowledge, there is a remaining unit which carries through without cancelling. The description of 8.4.1 also indicates that "Avep/Av0" is being determined, but the equation 8.4.1 only indicates "Avep" is being determined.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 7-NFPA 68-2015 [Chapter 8]	Input #7 covered general section organizational issues, where input #8 is specific to issues being experienced in the calculation process.

Submitter Information Verification

schenck process

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Project #: ________ Date: 10-28-2015
By: Nathan Egbert
Ch'k: ________
Customer: ________
Project: NFPA 68 Public Input
Subject: Initially Elevated Pressure

$$A_{vep} = A_{v1} \cdot \frac{\left[1 + 1.54\left(\frac{P_{stat} - P_{initial}}{1 + P_{effective}}\right)^{4/3}\right] \cdot \sqrt{\frac{1}{\Pi_{effective}} - 1}}{\left[1 + 1.54 \cdot P_{stat}^{4/3}\right] \cdot \sqrt{\frac{P_{max}}{P_{red}} - 1}} \qquad (8.4.1)$$

Example

$P_{stat} = 0.5$ Bar
$P_{initial} = 0.3$ Bar
$P_{red} = 1$ Bar
$P_{max} = 8.5$ Bar

$P_{effective} = \frac{1}{3}(0.3\text{ Bar}) = 0.1$ Bar

$$P^{E}_{max} = \frac{(8.5\text{ Bar} + 1)(0.3\text{ Bar} + 1)}{1\text{ Bar abs}} - 1 = 11.35\text{ Bar}$$

$$\Pi_{effective} = \frac{(1\text{ Bar} - 0.1\text{ Bar})}{(11.35\text{ Bar} - 0.1\text{ Bar})} = 0.08$$

$$A_{vep} = A_{v1} \cdot \frac{\left[1 + 1.54 \cdot \left(\frac{0.5\text{ Bar} - 0.3\text{ Bar}}{1 + 0.1\text{ Bar}}\right)^{4/3}\right] \cdot \sqrt{\frac{1}{0.08} - 1}}{\left[1 + 1.54 \cdot (0.5\text{ Bar})^{4/3}\right] \cdot \sqrt{\frac{8.5\text{ Bar}}{1\text{ Bar}} - 1}} = A_{v1} \cdot \frac{[1.159] \cdot (3.39)}{\underset{\uparrow ?}{[1.611\text{ Bar}]} \cdot (2.739)}$$

$$A_{vep} = A_{v1} \cdot \left(\frac{0.89}{1\text{ Bar}}\right)$$

* I would assume that it was not intended to have a unit (Bar) left in the denominator. Is there a missing component of the equation which would have made the correction factor unit-less?

* I have not run an exhaustive number of scenarios, but all that I have run to date which include $P_{initial} > 0.2$ Bar have resulted in a correction factor that would reduce the venting requirement.

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Public Input No. 9-NFPA 68-2015 [Section No. 8.5.1]

8.5.1 *

If there is no vent duct, $A_{vf} = A_{v4}$; otherwise, the effect of vent ducts shall be calculated from the following equations:

$$A_{vf} = A_{v4} \cdot \left(1 + 1.18 \cdot E_1^{0.8} \cdot E_2^{0.4}\right) \cdot \sqrt{\frac{K}{K_0}} \qquad \textbf{(8.5.1a)}$$

$$E_1 = \frac{A_{vf} \cdot L_{duct}}{V} \qquad \textbf{(8.5.1b)}$$

$$E_2 = \frac{10^4 \cdot A_{vf}}{\left(1 + 1.54 \cdot P_{stat}^{4/3}\right) \cdot K_{St} \cdot V^{3/4}} \qquad \textbf{(8.5.1c)}$$

$$K \equiv \frac{\Delta P}{\frac{1}{2} \cdot \rho \cdot U^2} = K_{inlet} + \frac{f_D \cdot L_{duct}}{D_h} + K_{elbows} + K_{outlet} + \cdots \qquad \textbf{(8.5.1d)}$$

where:

A_{vf} = vent area required when a duct is attached to the vent opening (m^2)

A_{v4} = vent area after adjustment for partial volume (m^2), per Equation 8.3.1

K = overall resistance coefficient of the vent duct application.

K_0 = 1.5, the resistance coefficient value assumed for the test configurations that generated the data used to validate Equations 8.2.2 and 8.2.3

L_{duct} = vent duct overall length (m)

V = enclosure volume (m^3)

P_{stat} = nominal static opening pressure of the vent cover (bar)

ΔP = static pressure drop from the enclosure to the duct exit at average duct slow velocity, U (bar)

ρ = gas density (kg/m^3)

U = fluid velocity (m/s)

K_{inlet}, K_{elbows}, K_{outlet} = resistance coefficients for fittings

f_D = D'Arcy friction factor for fully turbulent flow; see A.8.5 for typical formula [114]

D_h = vent duct hydraulic diameter (m)

Equation 8.5.1a is only valid where resistance coefficient K≥1.5.

Statement of Problem and Substantiation for Public Input

In the case of short, straight duct the duct inlet loss generally dominates the resistance coefficient. Where a Kinlet is taken from Figure A.8.5(a), the resulting total K can be less than 1.5 which, when placed in equation 8.5.1a, results in a correction factor less than 1.0 and a reduction in total vent area requirement. It would be my assumption that the committee would not intend for the vent duct correction to reduce the required vent area under any circumstance. Because K0=1.5 has been used to validate equations 8.2.2 and 8.2.3, I would recommend stating that the minimum value of K that is acceptable for use in equation 8.5.1a would be 1.5.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 7-NFPA 68-2015 [Chapter 8]	Input #7 generally commented on the workflow through chapter 8 while input #9 specifically addresses issues with the equations found in section 8.5.
Public Input No. 11-NFPA 68-2015 [Section No. A.8.5]	

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Public Input No. 10-NFPA 68-2015 [Section No. 8.5.5]

8.5.5

Equation 8.5.1a shall not be used if the initial pressure exceeds ~~±0~~ 0 .2 bar-g.

Statement of Problem and Substantiation for Public Input

The limitation given in 8.5.5 includes both positive and negative pressure limitations where the limitation indicated in Table 8.5.10 is only relevant for positive pressures above 0.2 bar. Equation 8.5.1a should still be available for vacuum conditions.

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Public Input No. 15-NFPA 68-2015 [Section No. 8.7]

8.7 Venting of Dust Collectors Using Bags, Filters, or Cartridges.

8.7.1*

It shall be permitted to remove the volume occupied by the filter elements, provided the filter elements would not obstruct the free flow of hot gases, unburned material, and flame during a deflagration. Methods for achieving this objective shall include but not be limited to the following:

(1)* Separating the vent closure from the filters, usually by locating the vent closure below the filters for standard vertical filters, but other configurations include, for example, horizontal cartridges and pleated flat panel filters, which could have side or top venting. If this methodology is used, the principle of separation of vent closure from filters shall be maintained regardless of filter design and orientation.

(2)* Shortening or removing a row of filters nearest the vent closure such that the area normal to and between the filters and the vent closure equals or exceeds the vent closure area. In this case, a restraining bar shall be installed to hold back the filters to prevent them from being deflected toward and obstructing the free flow of hot gases, unburned material, or flame through the vent during a deflagration.

8.7.2

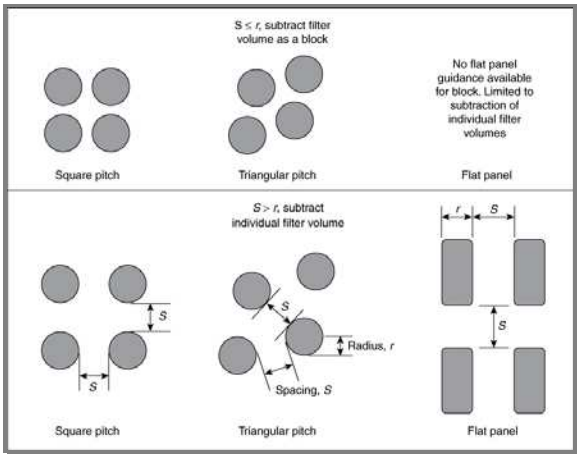
Where the volume occupied by the filter elements is removed according to 8.7.1, the method for calculating the volume occupied by the filters shall be dependent on the distance between the filters as follows and as summarized in Figure 8.7.2:

(1) For round or elliptical cross-section filters where the distance between the outer perimeters does not exceed the radius (or the minimus) of the filters, the volume can be calculated as a block to include the space between the filters.

(2) For round or elliptical cross-section filters where the distance between the outer perimeters is greater than the radius (or the minimus) of the filters, the volume can be calculated as the volume of each filter multiplied by the total number of filters.

(3) For flat panel filters (also called envelope, flat pocket filters), the volume of each filter can be calculated and multiplied by the total number of filters. Calculating the volume as a block is not permitted for flat panel filters.

Figure 8.7.2 Filter Element Spacing Criteria.



8.7.3*

Where the requirements of 8.7.1 are not met, the total dirty volume of the enclosure on the dirty side of the tube sheet, including the volume occupied by the filters, shall be calculated.

8.7.4

If the clean air plenum contains dust, or if the material entering the dust collector is a hybrid mixture, one of the following protection measures shall be applied:

(1) A separate vent shall be provided on the clean air side, calculated based on the clean air side volume using the methodology in Chapter 7.

(2) The clean air side gas concentration shall be evaluated for flammability and protected in accordance with NFPA 69, *Standard on Explosion Prevention Systems*.

Additional Proposed Changes

File Name	Description	Approved
NFPA_68_Venting_Issue_Document_Dec_15.docx	photographs pre- and post explosion	

Statement of Problem and Substantiation for Public Input

NFPA 68 (2013) includes a discussion of vent placement with regard to the parameters to be used in calculating the vent area and, in addition, provides recommendations with regard to modifying sock locations. In situations where the bottom of the socks is below the bottom of the lowest vent, Section 8.7 provides guidance for venting of dust collectors using bags, filters or cartridges. It is permitted to remove, for the purposes of the calculations, the volume occupied by the filter elements or a block of filter elements, if the spacing of the elements is less than the diameter of the element, provided the filter elements would not obstruct the free flow of hot gases, unburned material and flame during a deflagration. Examples of this include (Section 8.7.1 (2)) shortening or removing a row of filters near the vent closure such that the area normal to and in between the filters and the vent closure equals or exceeds the vent closure area. In this case, a restraining bar must be installed to hold back the filters to prevent them from being deflected towards and obstructing the free flow of hot gases, unburned material, or flame through the vent during a deflagration.

Drawings in the Annex of the standard are provided to help the user comply with this caveat. If these modifications are not undertaken, then the entire dirty side volume must be considered (Section 8.7.3) in the vent calculations.

I recently investigated an incident where there was an explosion in a dust collector collecting metal powder. The Kst of the powder was tested and reported to be 186 bar ·meter/sec and Pmax was 7.2 bar. This dust collector was vented using three hinged explosion doors each measuring 35 in. by 28 in. (6.81 ft2) with Brixon latches designed for a Pstat of 0.04 barg. The vents were mounted one on top of the other tethered with chains to prevent the doors from detaching from the body of the dust collector. There were 81 socks inside in a nine by nine array. Each sock was provided with a sock cage measuring 6 in. in diameter and 10 ft long. The bottoms of the socks were at the same horizontal plane as the top of the hopper. The design was such that the bottom of the bottom vent was about one (1) foot above the bottom of the socks. The manufacturer of the vent panels calculated the vent area based on the entire volume of the dust collector, below the tube sheet, which in this case was 775 ft3 (21.96 m3). See the Appendix for dust collector dimensions, vent calculations and pictures. Performing the calculation using a Pred value of 0.2 bar (3.0 psig) and an L/D of 2.81 yielded a required vent area of 17.9 ft², compared to the actual amount of vent area which was 20.4 ft².

I have reviewed the calculation and determined it to be compliant with the intent of the standard, where the bottom of the socks are below the bottom of the lowest vent. During the course of the investigation it became quite evident that the position of the socks adversely affected the pressure relief dynamics of the dust collector with regard to safely venting the deflagration. Structural damage occurred in this case.

I have attached some photographs pre- and post-explosion to show the condition of the dust collector. You can clearly see that the first row of socks, closest to the vent, were forced into the bottom vent opening. There was also evidence of significant sidewall deformation and damage to the access doors above the tube sheet but it is difficult to see in these pictures.

So as a result of this investigation I am curious about the genesis of the current NFPA 68 requirements which recognize that the vent opening can be compromised as a result of sock placement and recommend using the entire dirty side volume but, at the same time, do not require shortening or removal of the socks to essentially provide equivalent vent opening, when compared to the amount of venting in place. Under the current configuration essentially the unrestricted vent area would have been limited to an area equivalent to the perimeter of the openings 35 in. x (3)*28 in. multiplied by the distance from the face of the vent to the first row of socks (6 in). This is equivalent to a vent area of 35*84*6/144 in2/ft2 = 9.92 ft2. I cannot understand how one can expect that a simple increase in the volume to be protected can compensate for a wide range of blockage scenarios, ranging from partial to complete blockage, especially considering that the increase in volume to be protected relative to the dirty side volume will vary depending on the details of the dust collector.

Venting of Dust Collectors Using Bags Where the Bottom of the Filters are Below the Bottom of the Vents

Submitted by Steven J Luzik PE, CFEI (732-921-3830) NFPA Member No. 2529399

on December 18, 2015

STATEMENT OF THE PROBLEM

NFPA 68 (2013) includes a discussion of vent placement with regard to the parameters to be used in calculating the vent area and, in addition, provides recommendations with regard to modifying sock locations. In situations where the bottom of the socks is below the bottom of the lowest vent, **Section 8.7** provides guidance for venting of dust collectors using bags, filters or cartridges. It is permitted to remove, for the purposes of the calculations, the volume occupied by the filter elements or a block of filter elements, if the spacing of the elements is less than the diameter of the element, provided the filter elements would not obstruct the free flow of hot gases, unburned material and flame during a deflagration. Examples of this include (**Section 8.7.1 (2)**) shortening or removing a row of filters near the vent closure such that the area normal to and in between the filters and the vent closure equals or exceeds the vent closure area. In this case, a restraining bar must be installed to hold back the filters to prevent them from being deflected towards and obstructing the free flow of hot gases, unburned material, or flame through the vent during a deflagration.

Drawings in the Annex of the standard are provided to help the user comply with this caveat. If these modifications are not undertaken, then the entire dirty side volume must be considered (**Section 8.7.3**) in the vent calculations.

I recently investigated an incident where there was an explosion in a dust collector collecting metal powder. The K_{st} of the powder was tested and reported to be 186 bar ·meter/sec and P_{max} was 7.2 bar. This dust collector was vented using three hinged explosion doors each measuring 35 in. by 28 in. (6.81 ft^2) with Brixon latches designed for a P_{stat} of 0.04 barg. The vents were mounted one on top of the other tethered with chains to prevent the doors from detaching from the body of the dust collector. There were 81 socks inside in a nine by nine array. Each sock was provided with a sock cage measuring 6 in. in diameter and 10 ft long. The bottoms of the socks were at the same horizontal plane as the top of the hopper. The design was such that the bottom of the bottom vent was about one (1) foot above the bottom of the socks. The manufacturer of the vent panels calculated the vent area based on the entire volume of the dust collector, below the tube sheet, which in this case was 775 ft^3 (21.96 m^3). See the Appendix for dust collector dimensions, vent calculations and pictures. Performing the calculation using a P_{red} value of 0.2 bar (3.0 psig) and an L/D of 2.81 yielded a required vent area of 17.9 ft^2, compared to the actual amount of vent area which was 20.4 ft^2.

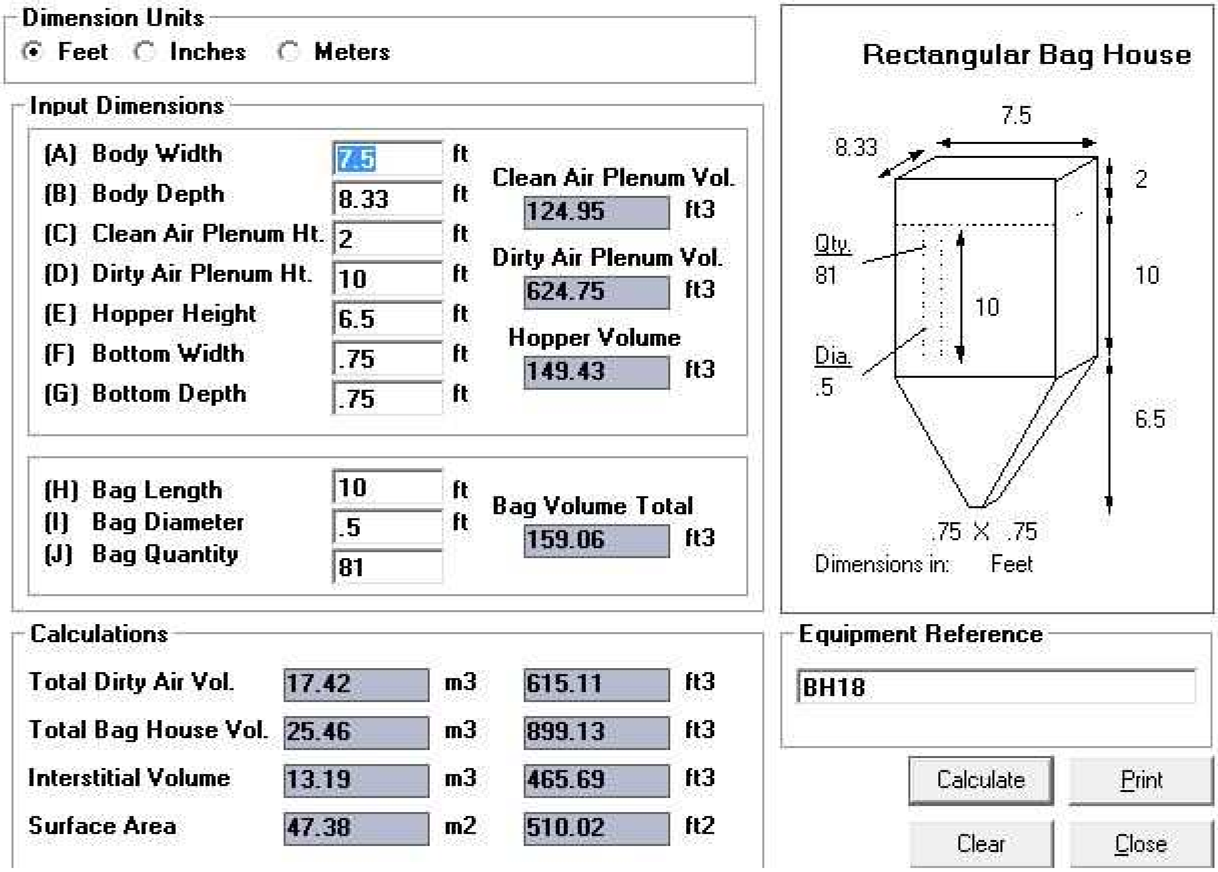
I have reviewed the calculation and determined it to be compliant with the intent of the standard, where the bottom of the socks are below the bottom of the lowest vent. During the course of the investigation it became quite evident that the position of the socks adversely affected the pressure relief dynamics of the dust collector with regard to safely venting the deflagration. Structural damage occurred in this case.

I have attached some photographs pre- and post-explosion to show the condition of the dust collector. You can clearly see that the first row of socks, closest to the vent, were forced into the bottom vent opening. There was also evidence of significant sidewall deformation and damage to the access doors above the tube sheet but it is difficult to see in these pictures.

So as a result of this investigation I am curious about the genesis of the current NFPA 68 requirements which recognize that the vent opening can be compromised as a result of sock placement and recommend using the entire dirty side volume but, at the same time, do not require shortening or removal of the socks to essentially provide equivalent vent opening, when compared to the amount of venting in place. Under the current configuration essentially the unrestricted vent area would have been limited to an area equivalent to the perimeter of the openings 35 in. x (3)*28 in. multiplied by the distance from the face of the vent to the first row of socks (6 in). This is equivalent to a vent area of 35*84*6/144 in^2/ft^2 = 9.92 ft^2. I cannot understand how one can expect that a simple increase in the volume to be protected can compensate for a wide range of blockage scenarios, ranging from partial to complete blockage, especially considering that the increase in volume to be protected relative to the dirty side volume will vary depending on the details of the dust collector.

The question for the committee is whether or not testing has been performed on a design where the bottoms of the socks are below the bottom of the lowest vent, where shortening or removal of the socks does not occur, to validate the recommendation to use the total dirty side volume to calculate the vent area required, as the only adjustment need to assure that P_{red} will not be exceeded during a deflagration. If such validation tests have not been performed then I believe the committee needs to reevaluate the current requirements to develop a solution that will ensure that dust collectors are adequately protected where the installation is such that the deflagration vent placement is compromised by the presence of the socks/cartridges that can block the opening(s) of the vents.

APPENDIX:
DUST COLLECTOR DIMENSIONS, VENT CALCULATIONS AND PICTURES



Dimension Units

● Feet ○ Inches ○ Meters

Input Dimensions

(A) Body Width	7.5	ft
(B) Body Depth	8.33	ft
(C) Clean Air Plenum Ht.	2	ft
(D) Dirty Air Plenum Ht.	10	ft
(E) Hopper Height	6.5	ft
(F) Bottom Width	.75	ft
(G) Bottom Depth	.75	ft

Clean Air Plenum Vol. 124.95 ft3

Dirty Air Plenum Vol. 624.75 ft3

Hopper Volume 149.43 ft3

(H) Bag Length	10	ft
(I) Bag Diameter	.5	ft
(J) Bag Quantity	81	

Bag Volume Total 159.06 ft3

Calculations

Total Dirty Air Vol.	17.42	m3	615.11	ft3
Total Bag House Vol.	25.46	m3	899.13	ft3
Interstitial Volume	13.19	m3	465.69	ft3
Surface Area	47.38	m2	510.02	ft2

Equipment Reference

BH18

NFPA 68 Venting Calculations 2013 Edition	BH 18	BH 18
	*	**
Volume	21.96	8.43
L/D	2.78	2.78
Kst (bar•m/sec)	183.00	183.00
P max (bar)	7.20	7.20
P stat (bar)	0.04	0.04
P red (bar)	0.20	0.20
Vent Mass (kg/m2)	29.00	29.00
Vent Area Avo M^2	1.66	0.81
Vent Area Avo FT^2	17.9	8.71
Area square inches	2571.59	1253.68
n = no of vents	3	3
Air Quantity Entering (CFM)	0	0
Duct Diameter (inches)	20	20
Tang velocity (m/sec)	0.0	0.0
Vent Area Av2 (m2) Correction for Velocity	1.66	0.81
Vent Area Av2 (ft2) Correction for Velocity	17.9	8.7
Effect of Panel Mass Mt	54.11	10.94
Vent area Av3 (m2) with Correction for mass	1.66	0.97
Vent area Av3 (ft2) with Correction for mass	17.9	10.5
FSH	1.100	1.100
1 for translating panel 1.1 for hinged		
Diameter of a circular vent (in)	57.32	43.83
Number of 28* 35 in panel req'd	2.63	1.54
Airex calcs No panels req'd	3.00	8.00
* bottom of vent above bottom of socks - no		
modification of socks		
** bottom of vent above bottom of socks -		
socks removed as per 8.7.1 (2)		

** Volume is the volume of the hopper - 149.43 ft^3 plus the volume occupied by the rectangular portion of the dust collector around the perimeter of the block of socks

V = 149.43 + 10 ft*(8.33 ft*2*0.5 + 6.5*2*0.5) = 297.6 ft^3 or 8.43 m^3.

Figure 1 - Rectangular Baghouse pre-Explosion

Figure 2 - Close-up of Middle Explosion Panel

Figure 3 - View of all Three Panels. Note Congestion; Bottom Panel has Sock Cages Pushed out of Opening

Figure 4 - Side Wall of Collector - Deformation Damage Even Though Reinforced

Figure 5 - Bottom Vent Showing Pushed-out Sock Cages

Figure 6 - Top of Dust Collector. Note Deformed Access Doors

The question for the committee is whether or not testing has been performed on a design where the bottoms of the socks are below the bottom of the lowest vent, where shortening or removal of the socks does not occur, to validate the recommendation to use the total dirty side volume to calculate the vent area required, as the only adjustment need to assure that Pred will not be exceeded during a deflagration. If such validation tests have not been performed then I believe the committee needs to reevaluate the current requirements to develop a solution that will ensure that dust collectors are adequately protected where the installation is such that the deflagration vent placement is compromised by the presence of the socks/cartridges that can block the opening(s) of the vents.

Submitter Information Verification

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Public Input No. 14-NFPA 68-2015 [Section No. 8.7.3]

8.7.3 *

~~Where~~

Where the requirements of 8.7.1

~~are~~

and 8.7.2 are not met ***the requirement for a free flow path , separation of filter elements per 8.7.2, and/or retrains (to prevent obstructed flow) may be disregarded if (1) test data is found that validates the exceptions taken, and (2)*** the total dirty volume of the enclosure on the dirty side of the tube sheet, including the volume occupied by the filters, shall

~~be calculated~~

be ***used as the enclosure volume "V" for the calculation of vent area .***

Statement of Problem and Substantiation for Public Input

The committee was given assurance that data existed to validate taking exception to the requirements for (1) a free flow path, (2) separation of elements from each other, (3) restraints to prevent clogging the vent. The committee has seen examples of successful venting even with filters clogging the vent. The data I've seen does not validate the worst case explosion for every credible situation. For example: close packing of filters prevents the volume between filters from increasing Pred, except if this dense packing obstructs the venting flow path by reducing the superficial flow area or by moving and clogging the flow path.

Submitter Information Verification

Submitter Full Name:	Mitchel Rooker
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Submittal Date:	Thu Dec 17 09:52:30 EST 2015

Public Input No. 13-NFPA 68-2015 [Section No. 8.8.3.3]

8.8.3.3 *

Additional vents shall be installed in each casing at center-to-center spacing distance along the elevator axis based on the bucket elevator classification, the K_{St} of the material being handled, and the design P_{red} , as given in Table 8.8.3.3.

Table 8.8.3.3 Additional Vent Spacing

		Spacing (m) for Elevator Design Strength P es		
Bucket Elevator Classification	***K St*** **(bar-m/s)**		***P***	
~~***red***~~				
		es		
≤				
		0.2		
~~bar~~				
	bar & Greater			***P***
~~***red***~~				
		es		
≤				
		0.5		
~~bar~~				
	bar & Greater			***P***
~~***red***~~				
		es		
≤				
1.0 bar & Greater				
Double-casing (twin leg)	<100	6	None required	None required
	100–150	3	10	19
	151–175	N/A	4	8
	176–200	N/A	3	4
	>200	N/A	N/A	3
Single-casing (single leg)	<100	N/A*	None required	None required
	100–150	N/A	7	14
	151–175	N/A	4	5
	176–200	N/A	3	4
	>200	N/A	N/A	3

N/A: Not allowed.

*For *P*~~*red*~~ ~~≤~~ *es* 0.3 to 0.49 bar, vent spacing of 6 m is appropriate.

Statement of Problem and Substantiation for Public Input

The Design pressure Pred signs of "less than or equal to" are wrong. For example: if the elevator is made of tissue paper with a design pressure of .001 Bar, then any of the 3 vent spacing values could be used (for Kst X). Obviously with a vent Pstat of 0.1 Bar the design pressure must be at least greater than 0.1 Bar. I could not type in the "greater than or equal to" symbol in my proposal. We could label columns as "0.2 to 0.49 Bar" or ".02 greater than or equal to Pred less than 0.5 Bar". Pred should be Pes, since were not referring to the explosion pressure but the design enclosure pressure. And it would be helpful to put "elevator design strength" in the table and text.

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Public Input No. 5-NFPA 68-2015 [Section No. A.6.3.1.1]

A.6.3.1.1

~~If the enclosure is intended to be reused following an event, the owner or operator should design the system to prevent permanent deformation of the enclosure.~~ This is also referred to as ~~“explosion~~ "explosion pressure shock resistant ~~design”~~ " design in European documents such as ~~VDI 3673, *Pressure Venting of Dust Explosions* , and EN 13237, “Potentially explosive atmospheres — Terms and definitions for equipment and protective systems intended for use in potentially explosive atmospheres.”~~ EN 14460, "Explosion Resistant Equipment."

Statement of Problem and Substantiation for Public Input

The descriptions given in A.6.3.1.1 and A.6.3.1.2 are reversed when referencing the standard text in sections 6.3.1.1 and 6.3.1.2. 6.3.1.1 describes a design scenario allowing deformation, not rupture. The description in 6.3.1.1 is equivalent to "Explosion pressure shock resistant" design in the EU harmonized standards such as EN 14460 "Explosion Resistant Equipment." Section 5 of that document states "Explosion pressure shock resistant equipment shall be so constructed that they can withstand the maximum or reduced explosion pressure without rupturing, but may become permanently deformed."

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 6-NFPA 68-2015 [Section No. A.6.3.1.2]	

Submitter Information Verification

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Submittal Date: Tue Oct 27 10:44:55 EDT 2015

Public Input No. 6-NFPA 68-2015 [Section No. A.6.3.1.2]

A.6.3.1.2

If the enclosure is intended to be reused following an event, the owner or operator should design the system to prevent permanent deformation of the enclosure. This is also referred to as ~~“explosion~~ "explosion pressure ~~shock~~ resistant ~~design”~~ " design in European documents such as EN 14460, "Explosion Resistant Equipment ."

Statement of Problem and Substantiation for Public Input

A.6.3.1.1 and A.6.3.1.2 appear to have been switched when compared to their referenced text in 6.3.1.1 and 6.3.1.2. A.6.3.1.2 should describe the design scenario where no deformation is allowed, which is equivalent to "explosion pressure resistant" design as defined in EU harmonized standard EN 14460, "Explosion Resistant Equipment."

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 5-NFPA 68-2015 [Section No. A.6.3.1.1]	

Submitter Information Verification

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Public Input No. 11-NFPA 68-2015 [Section No. A.8.5]

A.8.5

The flow resistance coefficient *K* for the vent duct correlation is defined on the static pressure drop, Δ*P*, from the enclosure to the duct exit at a given average duct flow velocity, *U*:

$$K \equiv \frac{\Delta P}{\frac{1}{2}\cdot \rho \cdot U^2}$$

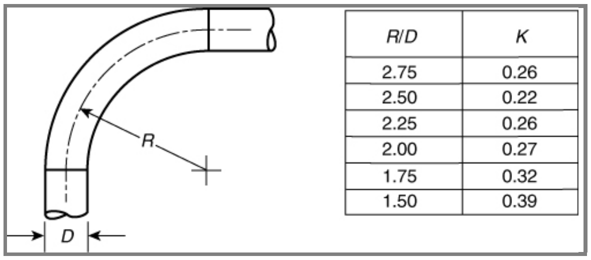
Another convention used by some reference books is to define *K* on the total pressure drop or on another velocity scale. The user should ensure that the loss coefficients used in the calculations are consistent with the definition of *K* adopted for the vent duct calculations. See Ural [114] for additional information.

The user should note that inlet loss can vary depending on the shape of the vent closure inlet; however, most typically a flanged inlet would be appropriate. Figure A.8.5(a) shows the loss coefficient for two different inlet designs.

Figure A.8.5(a) Loss Coefficients for Inlets.

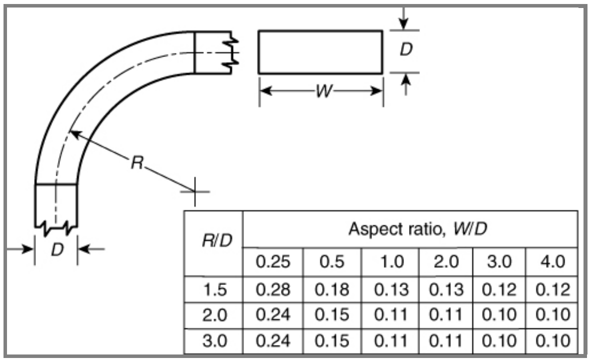
Figure A.8.5(b) shows a round elbow and loss coefficents for various radii of curvature. Figure A.8.5(c) shows a rectangular elbow and loss coefficients for various duct aspect ratios and radii of curvature. Loss coefficients for 45 degree bends and 30 degree bends are proportionally less than the tabulated 90 degree bends. Figure A.8.5(d) provides loss coefficients for a typical rain hat design.

Figure A.8.5(b) Loss Coefficients for Round Elbows.



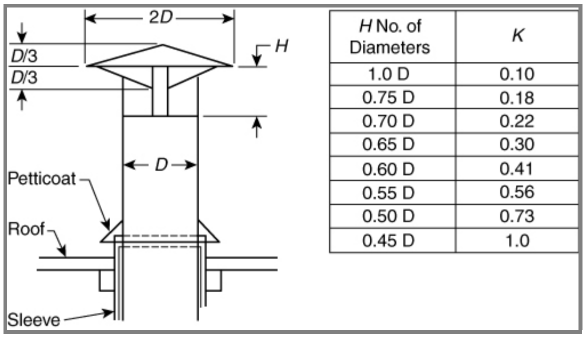
R/*D*	*K*
2.75	0.26
2.50	0.22
2.25	0.26
2.00	0.27
1.75	0.32
1.50	0.39

Figure A.8.5(c) Loss Coefficients for Square and Rectangular Elbows.



R/*D*	Aspect ratio, *W*/*D*					
	0.25	0.5	1.0	2.0	3.0	4.0
1.5	0.28	0.18	0.13	0.13	0.12	0.12
2.0	0.24	0.15	0.11	0.11	0.10	0.10
3.0	0.24	0.15	0.11	0.11	0.10	0.10

Figure A.8.5(d) Loss Coefficients for Rain Hats.



H No. of Diameters	*K*
1.0 D	0.10
0.75 D	0.18
0.70 D	0.22
0.65 D	0.30
0.60 D	0.41
0.55 D	0.56
0.50 D	0.73
0.45 D	1.0

The equations are nonlinear and, under certain combinations of input values, result in two possible solutions for vent area for a given P_{red} . The lower value of vent area is the meaningful solution, and the upper value is an artifact of the form of the equation set. There are certain combinations of P_{red} and vent duct length where no vent area is large enough and no solution is obtainable. When that occurs, it could be possible to vary P_{red} or vent duct length to converge to a solution. If that solution is not satisfactory, NFPA 69, *Standard on Explosion Prevention Systems*, can provide alternatives.

There is a minimum value for P_{red} as vent area increases, beyond which solutions are not meaningful. That value occurs approximately when the volume of the duct exceeds a fraction of the volume of the vessel. When solving the equations, constraining A_{vf} as follows will typically isolate the smaller root:

$$\frac{A_{vf} \cdot L}{V} \leq 1$$

For the following input values, Figure A.8.5(e) illustrates the potential solutions:

V = 500 m^3

P_{max} = 8.5 bar

K_{St} = 150 bar-m/s

P_{stat} = 0.05 bar

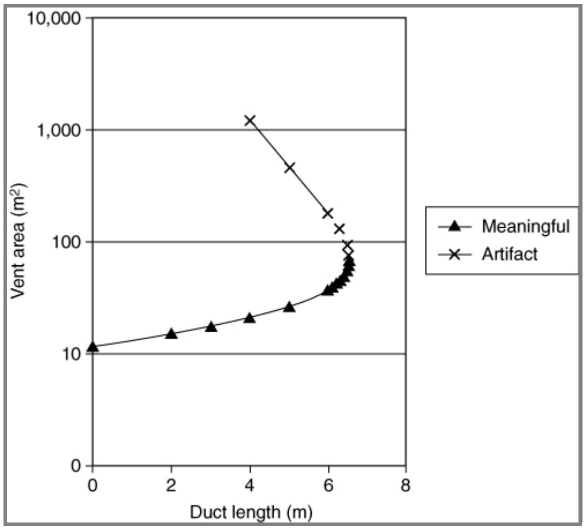
P_{red} = 0.5 bar

Vessel L/D = 4

~~ε~~ ? = 0.26 mm

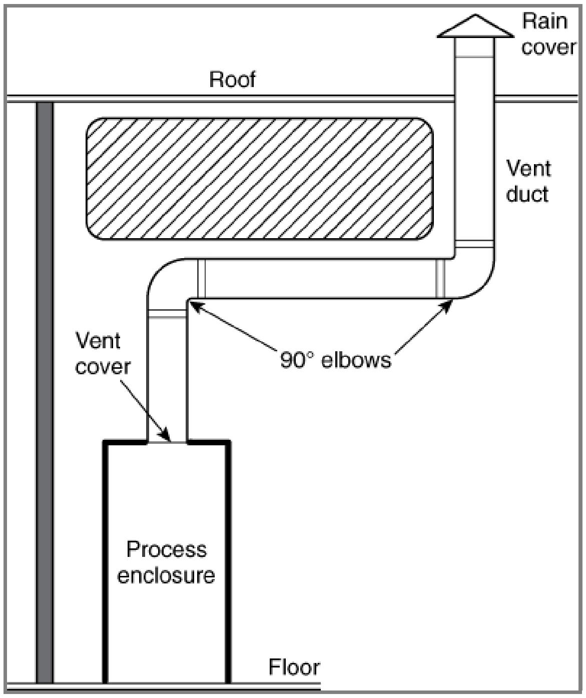
Straight duct, no elbows, fittings, or rain hats.

Figure A.8.5(e) A_v vs. Duct Length.



Example problem. Given Figure A.8.5(f) and the following conditions, calculate P_{red} :

Figure A.8.5(f) Example Vent Duct Installation.



Enclosure volume, V = 25 (m^3)

Enclosure L/D = 4

Vent diameter, D_v = 1.5 (m)

Duct diameter, D_h = 1.5 (m)

A_v = 1.77 (m^2)

P_{stat} = 0.25 (bar-g)

K_{St} = 200 (bar-m/s)

P_{max} = 8 (bar)

Duct length = 12 (m)

Duct effective roughness, ~~ε~~ ? = 0.26 (mm)

Elbows = 2 × 90 degrees

Elbow flow resistance = 2 × 1.2 = 2.4

Rain hat flow resistance = 0.75

While Section 8.5 provides the equations in a form to calculate the vent area based on an allowable P_{red} , this example shows how to determine the resulting P_{red} for a given vent area. In general, such calculations will be iterative. These input parameters are provided for demonstration purposes. Ural [114] can be referenced for additional discussion on how they were selected.

Solution:

(1) Compute the friction factor for the problem. For practically all vent ducts, the Reynolds number is so large that a fully turbulent flow regime will be applicable. In this regime, the friction factor is only a function of the ratio of the internal duct surface effective roughness (~~ε~~ ?) to duct diameter. The duct friction factor can thus be calculated using a simplified form of the Colebrook equation:

$$f_D = \left\{ \frac{1}{\left[1.14 - 2\log_{10}\left(\frac{\varepsilon}{D_h} \right) \right]} \right\}^2$$

(A.8.5a)

The effective roughness for smooth pipes and clean steel pipes is typically 0.0015 mm and 0.046 mm, respectively. Recognizing that the pipes used repeatedly in combustion events could be corroded, a value of ~~ε~~ ? = 0.26 mm is assumed.

From Equation A.8.5a, f_D = 0.013:

$$\text{then } \frac{f_D \cdot L}{D_h} = \frac{0.013 \cdot 12}{1.5} = 0.107\text{, and}$$
$$K = K_{inlet} + \frac{f_D \cdot L}{D_h} + K_{elbows} + K_{outlet}$$
$$K = 1.5 + 0.107 + 2.4 + 0.75 = 4.757$$

(A.8.5b)

where:

K = 4.757

K_{inlet} = 1.5

K_{elbows} = 2.4

K_{exit} = 0.75

(2) Assume a P_{red} value of 1 bar-g. The solution is iterative, where the assumed value of P_{red} is replaced with the calculated value of P_{red} until the two values substantially match. A 1 percent difference between iterations is typically considered acceptable convergence.

(3) From Equation 8.2.2:

$$A_{v0} = 1 \cdot 10^{-4} \cdot \left[1 + 1.54 \cdot (0.25)^{4/3} \right] \cdot 200 \cdot (25)^{3/4} \cdot \sqrt{\frac{8}{P_{red}} - 1}$$
$$A_{v0} = 0.735 \text{ m}^2$$

(A.8.5c)

(4) From Equation 8.2.3:

$$A_{v1} = 0.735 \cdot \left[1 + 0.6 \cdot (4-2)^{0.75} \cdot \exp(-0.95 \cdot P_{red}^2) \right]$$
$$A_{v1} = 1.02 \text{ m}^2$$

(A.8.5d)

(5) From Equation 8.5.1(b), and using the intended vent area of 1.77 m^2:

$$E_1 = \frac{1.77 \cdot 12}{25}$$
$$E_1 = 0.85$$

(A.8.5e)

(6) From Equation 8.5.1(c), and using the installed vent area of 1.77 m^2:

$$E_2 = \frac{10^4 \cdot 1.77}{\left[1 + 1.54 \cdot (0.25)^{4/3} \right] \cdot 200 \cdot (25)^{3/4}}$$
$$E_2 = 6.37$$

(A.8.5f)

(7) From Equation 8.5.1(a), with A_{v4} equal to A_{v1}, assuming no increase for turbulence, inertia, or partial volume:

$$A_{vf} = (1.02)\cdot\left[1+1.18\cdot(0.85)^{0.8}\cdot(6.37)^{0.4}\right]\cdot\sqrt{\frac{4.757}{1.5}}$$
$$A_{vf} = 5.77\ \text{m}^2$$
(A.8.5g)

(8) Because the calculated value of A_{vf} is not equal to the installed vent area, go back to Step 2, and change P_{red} until the A_{vf} calculated in Step 7 is equal to the specified vent area of 1.77 m^2. A trial-and-error process (or the goal seek button in Excel) satisfies the requirement in Step 8 when P_{red} = 3.52 bar-g.

(9) From 8.5.9, Equation A.8.5h and Equation A.8.5i show that there is no deflagration-to-detonation-transition (DDT) propensity for this particular application:

$$L_{eff} \le \min\left[\frac{10{,}000\cdot 1.5}{200}, \frac{11{,}000}{200}\right]$$
$$L_{eff} \le \min\ [75, 55]$$
$$\le 55$$
(A.8.5h)

$$L_{dusty} = (8-3.52)\cdot\frac{25}{1.77}$$
$$= 63\ \text{m}$$
(A.8.5i)

Because L_{duct} = 12 m, L_{eff} = min [12, 63] = 12 m ≤ 55 m. Therefore, DDT is not expected.

Statement of Problem and Substantiation for Public Input

K factor values provided in Figures A.8.5(a), A.8.5(b) and A8.5(c) do not appear to be consistent with the values referenced in the example problem from A.8.5, borrowed from Erdam Ural's "Dust Explosion Venting through Ducts." My specific concerns are that the values listed in the given Figures appear to be much lower than the values Ural pulled from references by Lunn and Idelchik and may result in inaccurate results when used in equation 8.5.1a. Also reference Public Input #9 for discussion on use of total K factors less than 1.5 in equation 8.5.1a.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 9-NFPA 68-2015 [Section No. 8.5.1]	

Submitter Information Verification

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Submittal Date: Wed Oct 28 12:03:52 EDT 2015

Public Input No. 12-NFPA 68-2015 [Sections A.8.7.1(1), A.8.7.1(2)]

Sections A.8.7.1(1), A.8.7.1(2)

A.8.7.1(1)

One way to provide a clear path is to separate the vent closure from the filter elements. Figure A.8.7.1(1)(a) shows the vent closure below the filter elements for standard vertical bags, while Figure A.8.7.1(1)(b) shows the vent closure equivalently separated for horizontal cartridges by the vent area being located under the cartridges (Version 1) or to the side (Version 2). The figures provided here are representative of current practices.

Figure A.8.7.1(1)(a) Vent Area Separated from Vertical Filter Elements.

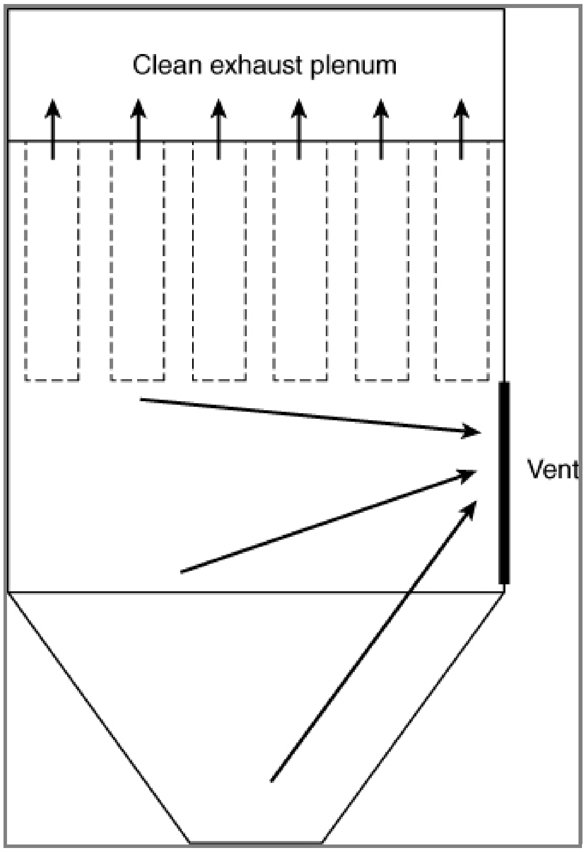
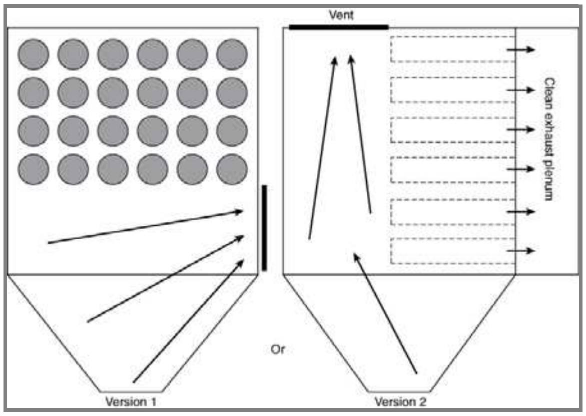


Figure A.8.7.1(1)(b) Vent Area Separated from Horizontal Filter Elements.



Version 2 should be modified or removed

A.8.7.1(2)

Another approach to provide a clear path is to provide a flow area equivalent to the vent area immediately adjacent to the vent. Figure A.8.7.1(2)(a) and Figure A.8.7.1(2)(b) show a side view and a plan view, respectively, for vertical elements. Figure A.8.7.1(2)(c) and Figure A.8.7.1(2)(d) show an end view and a side view, respectively, for Version 1 of the horizontal elements, while Figure A.8.7.1(2)(e) shows an end view for Version 2 of the horizontal elements.

Figure A.8.7.1(2)(a) Free Area Normal to Vent for Vertical Filter Elements — Side View.

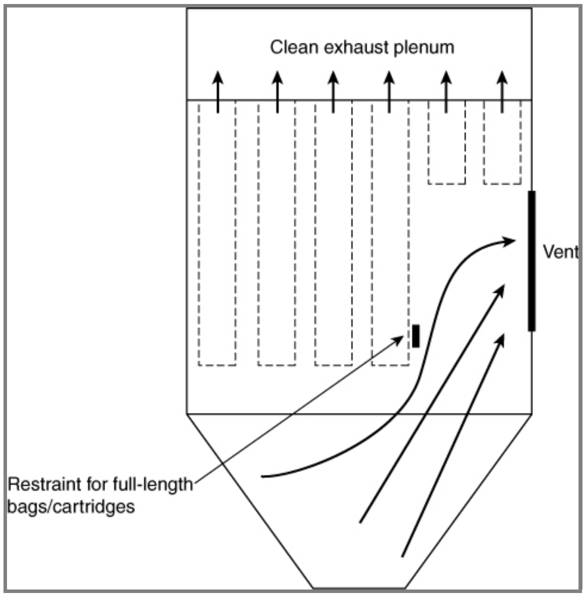


Figure A.8.7.1(2)(b) Free Area Normal to Vent for Vertical Filter Elements — Plan View.

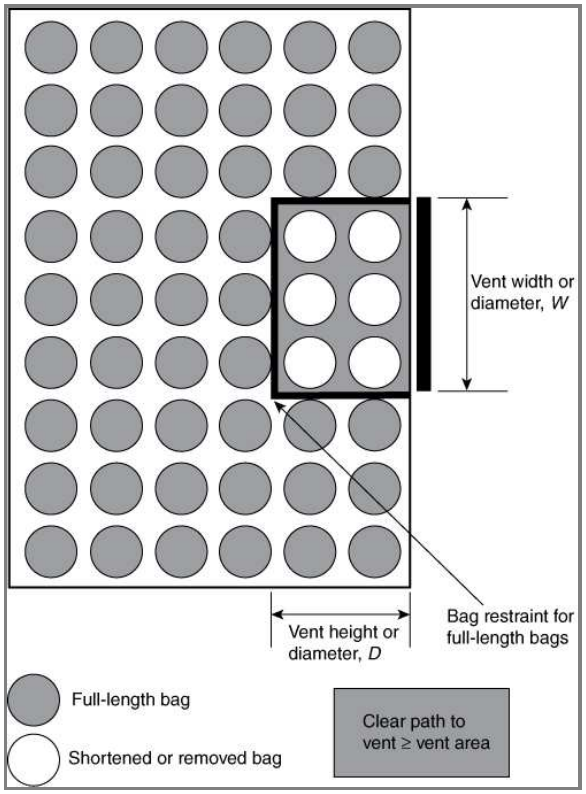
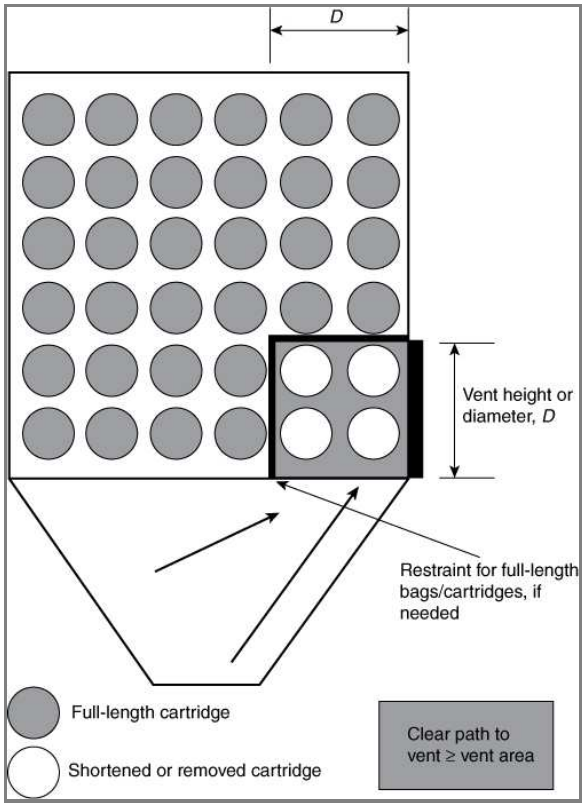
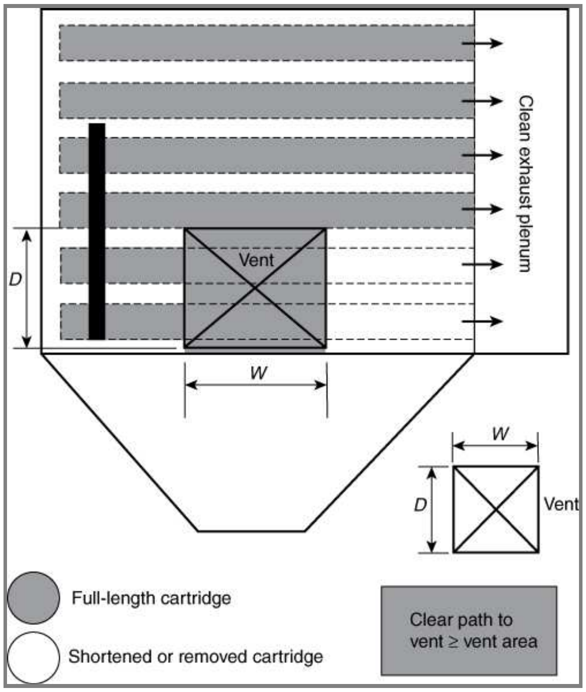


Figure A.8.7.1(2)(c) Free Area Normal to Vent for Horizontal Elements — Version 1, End View.



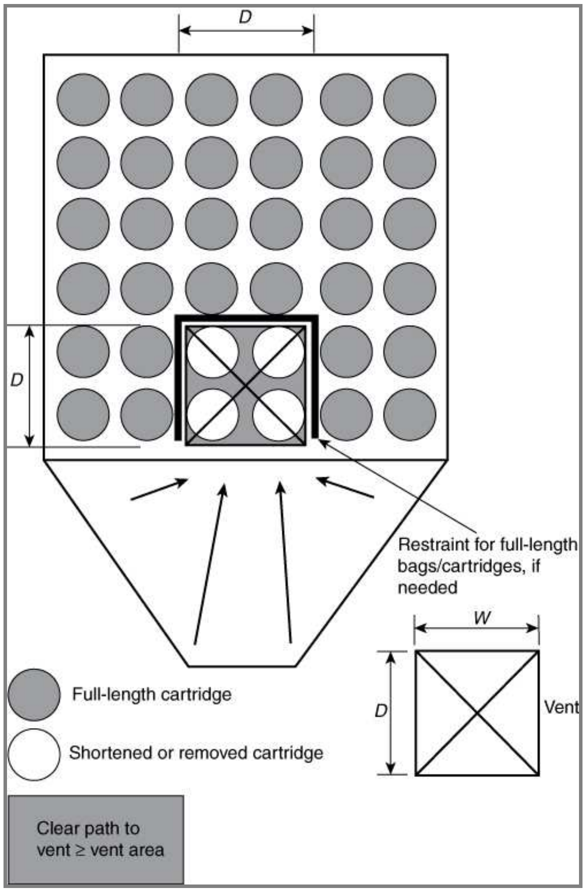
Remove reference to shortened horizontal cartridge

Figure A.8.7.1(2)(d) Free Area Normal to Vent for Horizontal Filter Elements — Version 1, Side View.



Remove reference to shortened cartridge and show "clear path" area without filter media

Figure A.8.7.1(2)(e) Free Area Normal to Vent for Horizontal Filter Elements — Version 2, End View.



Remove reference to shortened cartridge

Additional Proposed Changes

File Name	Description	Approved
A8.7.1_Drawing_Notes.pdf	A.8.7.1 Drawing Notes for Horizontal/Downflow filters	

Statement of Problem and Substantiation for Public Input

I don't know that there is a high level of risk associated with using the existing graphics for horizontal filters, but there is a bit on inaccuracy related to how these filters function. Ideally these graphics would be revised in a way that indicates more realistic applications or removed entirely.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 7-NFPA 68-2015 [Chapter 8]	

Submitter Information Verification

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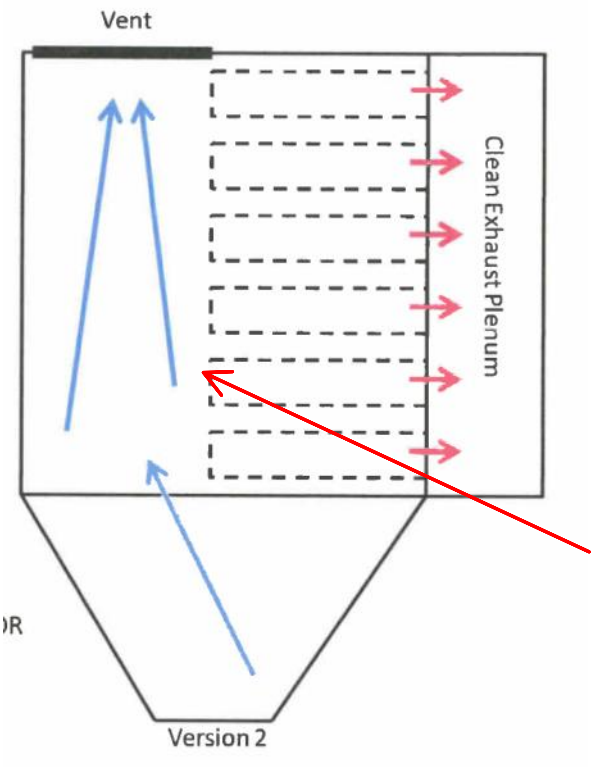
Public Input notes

Wednesday, October 28, 2015
11:29 AM

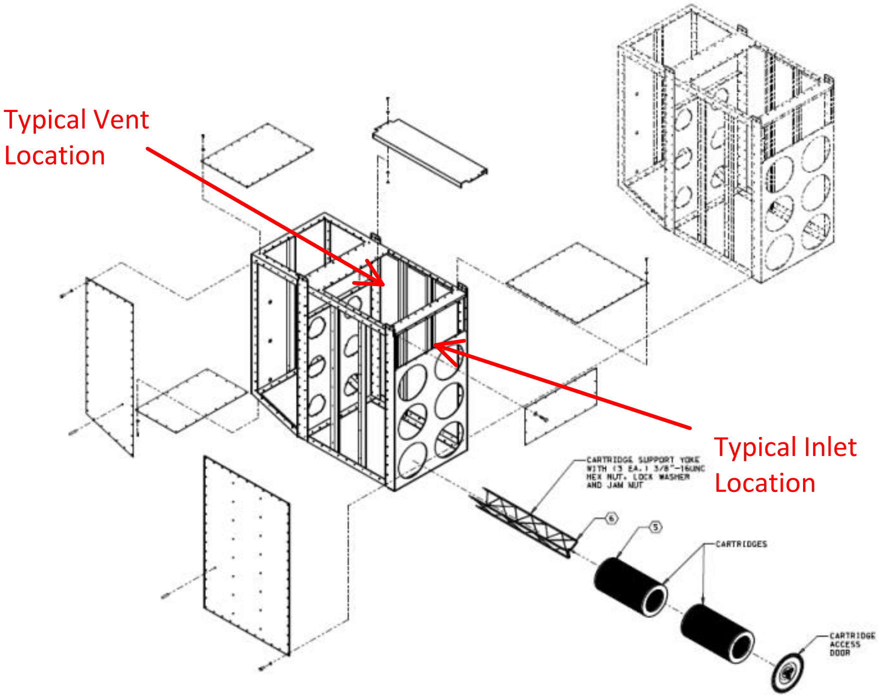
Drawing Notes:

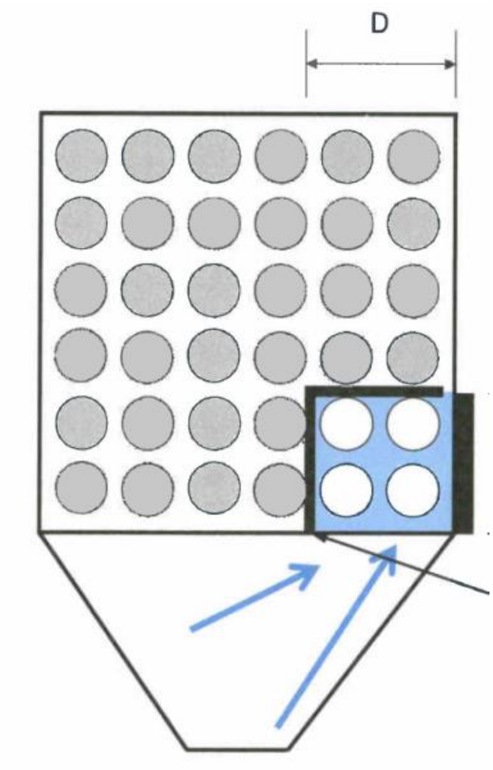
- Drawing comments that I have are related to the horizontal cartridge depictions and how one of these filter types are assembled and operate.
- Figure A.8.7.1(1)(b)



How is this side of the cartridge sealed?

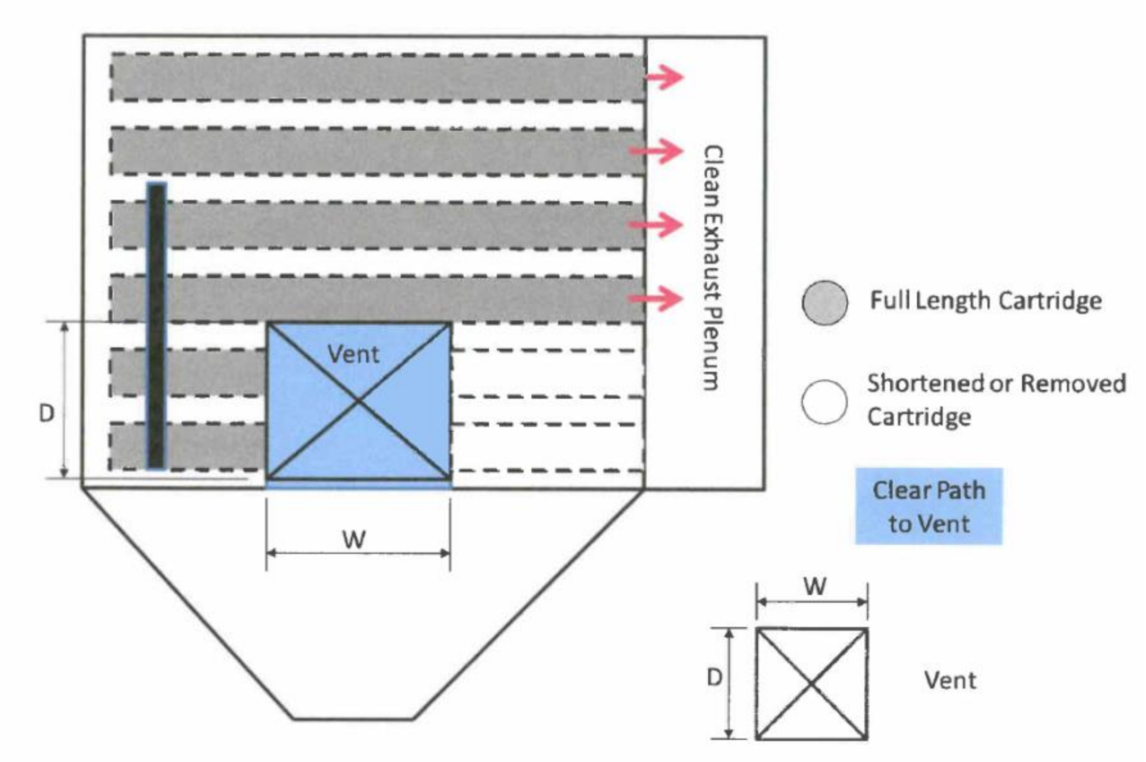
  - No comment on version 1
  - Version 2 does not fit any horizontal element design that I am aware of. The issue with this type of filter is that the cartridge is inserted through a round door opening in the front of the unit (left side of version 2 drawing) over a support yoke of some sort, followed by another cartridge, then the cartridges are sealed to each other, the tubesheet, and the access door by tightening the door down from outside. I have included a rough diagragm on how this goes together below. The drawing for version 2 would not seem to allow for the cartridge to be tightened down to anything as the yoke would still be running through it, so there would be no seal to the tubesheet and nothing sealing the dirty side from the clean side on the left end of the cartridge element.



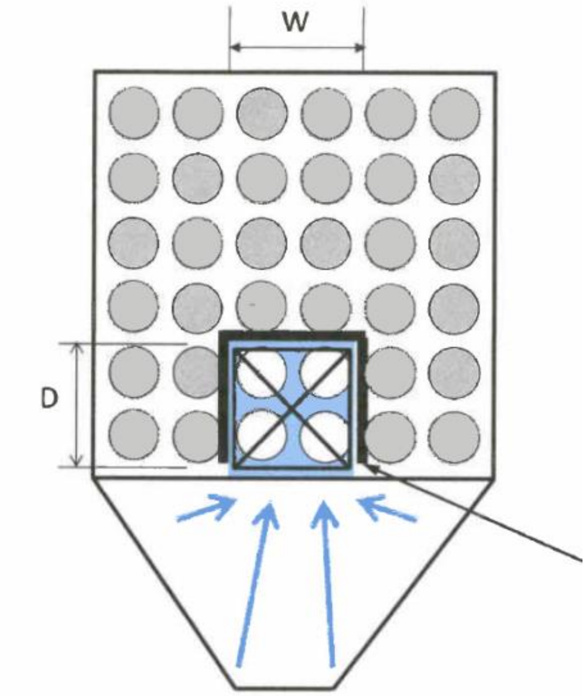


- Figure A.8.7.1(2)(c)
  - This figure would probably work, assuming that the entire row of cartridges in the vent area are removed. Reasoning for this statement is the same as above.
  - One general note that I would make relative to restraint on this type of filter is that this type of filter arrangement will typically be used as depicted above where the cartridge yoke is anchored to both the tubesheet and at the access door. In my opinion, this in and of itself would be adequate restraint for the filters which remain in place.
  - Another comment related to this type of filter is that a very typical vent closure location is out the top of the unit. As you can see, the above drawing has an area below where the vent panel would fit that is free area used for an inlet section and the cartridges would not interfere. What does not

occur, however, is a full width pathway from the hopper (not shown) to the vent panel. Because these units are generally used as shown above and are utilized because of their small footprint, I'm not sure that adding another filter module, except without cartridges, would be feasible.



- Figure A.8.7.1(2)(d)
  - This view would include much the same comment as above, except this time it would be the tubesheet side of the filter elements that would not be sealed. The only way that I can see this arrangement working is by removing the entire row of cartridges and adding a seal plate to both the access door and to the tubesheet.
  - Restraint-wise, my comments are the same for all of the horizontal filter drawings.



- Figure A.8.7.1(2)(e)
  - Same comments as for Figure A.8.7.1(2)(c)

Submittal Date:	Wed Oct 28 12:24:31 EDT 2015

Public Input No. 2-NFPA 68-2015 [Chapter K]

Annex K Informational References

K.1 Referenced Publications.

The documents or portions thereof listed in this annex are referenced within the informational sections of this standard and are not part of the requirements of this document unless also listed in Chapter 2 for other reasons.

K.1.1 NFPA Publications.

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 30, *Flammable and Combustible Liquids Code*, 2012 edition.

NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products*, 2011 edition.

NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*, 2011 edition.

NFPA 35, *Standard for the Manufacture of Organic Coatings*, 2011 edition.

NFPA 52, *Vehicular Gaseous Fuel Systems Code*, 2013 edition.

NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*, 2013 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2008 edition.

NFPA 400, *Hazardous Materials Code*, 2013 edition.

NFPA 484, *Standard for Combustible Metals*, 2012 edition.

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, 2013 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2010 edition.

NFPA 5000 ®, *Building Construction and Safety Code* ®, 2012 edition.

Fire Protection Guide to Hazardous Materials, 2001 edition.

K.1.2 Other Publications.

K.1.2.1 ANSI Publications.

American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036.

ANSI Z535**.4** , *Product Safety Signs and Labels,* ~~1998~~ **2011** .

K.1.2.2 API Publications.

American Petroleum Institute, 1220 L. Street, N.W., Washington, DC 20005-4070.

~~API 752~~ API **RP** 752 , *Management of Hazards Associated with Location of Process Plant* ~~Buildings~~ **Permanent** *Buildings* , ~~2003~~ **2009** .

K.1.2.3 ASCE Publications.

American Society of Civil Engineers, 1801 Alexander Bell Drive, Reston, VA 20191–4400.

ASCE, *Design of Blast-Resistant Buildings in Petrochemical Facilities*, 2010.

ASCE/SEI 7, *Minimum Design Loads for Buildings and Other Structures*, 2010.

K.1.2.4 ASTM Publications.

ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM ~~D 5680a~~ D5680 , *Standard Practice for Sampling Unconsolidated Solids in Drums or Similar Containers,* ~~2001~~ **2014** .

ASTM ~~E 502~~ E502 , *Standard Test Method for Selection and Use of ASTM Standards for the Determination of Flash Point of Chemicals by Closed Cup Methods,* ~~2000~~ **2007, reapproved 2013** .

ASTM ~~E 582~~ E582 , *Standard Test Method for Minimum Ignition Energy and Quenching Distance in Gaseous Mixtures,* ~~2004~~ **2007, (2013 e1)** .

ASTM ~~E 681~~ E681 , *Standard Test Method for Concentration Limits of Flammability of Chemicals (Vapors and Gases),* ~~2004~~ **2009, reapproved 2015** .

ASTM ~~E 1226~~ E1226 , *Standard Test Method for Explosibility of Dust Clouds*, ~~2010~~ **2012A** .

ASTM ~~E 1515~~ E1515 , *Standard Test Method for Minimum Explosible Concentration of Combustible Dusts*, ~~1998~~ **2014** .

ASTM ~~E 2019~~ E2019 , *Standard Test Method for Minimum Ignition Energy of a Dust Cloud in Air,* 2003**, reapproved 2013** .

K.1.2.5 CCPS Publications.

Center for Chemical Process Safety, 3 Park Avenue, 19th Floor, New York, NY 10016.

Guidelines for Safe Handling of Powders and Bulk Solids, 2004.

K.1.2.6 ISO Publications.

International Organization for Standardization, ~~1, rue de Varembé, Case postale 56, CH-1211 Geneve 20,~~ **ISO Central Secretariat, BIBC II, 8, Chemin de Blandonnet, CP 401, 1214 Vernier, Geneva, Switzerland** .

ISO 6184~~/~~ **-** 1, *Explosion Protection Systems — Part 1: Determination of Explosion Indices of Combustible Dust in Air,* 1985.

K.1.2.7 NACE Publications.

NACE International, 1440 South Creek Drive, Houston, TX 77084-4906.

National Association of Corrosion Engineers Handbook, 2nd edition, 1991.

K.1.2.8 U.S. Government Publications.

U.S. Government ~~Printing~~ **Publishing Office, 732 North Capitol Street, NW, Washington, DC** ~~20402~~ **20401-0001** .

TM5-1300, *Structures to Resist the Effects of Accidental Explosions,* Department of Defense Explosives Safety Board, 1990.

K.1.2.9 Other Publications.

Biggs, J. M., *Introduction to Structural Dynamics*, New York: McGraw-Hill, 1964.

Darby, R., *Chemical Engineering Fluid Mechanics*, 2nd Edition, New York: Marcel Dekker, 2001.

Holbrow, P., S. Andrews, and G. A. Lunn, “Dust explosions in interconnected vented vessels,” *Journal of Loss Prevention in the Process Industries*, Vol. 9, No. 1, pp. 91–103 (1996).

Holbrow, P., G. A. Lunn, and A. Tyldesley, “Dust explosion protection in linked vessels: Guidance for containment and venting,” *Journal of Loss Prevention in the Process Industries*, Vol. 12, No. 3, pp. 227–234 (1999).

Krishna, K., W., Rogers, and M. Sam Mannan, “The use of aerosol formation, flammability, and explosion information for heat-transfer fluid selection,” *Journal of Hazardous Materials* 104, 2003.

Lees, F. P., *Lees' Loss Prevention in the Process Industries,* 2nd Edition, Oxford, U.K.: Butterworth–Heinemann, 1996.

Lunn, G. A., P. Holbrow, S. Andrews, and J. Gummer, “Dust Explosions in Totally Closed Interconnected Vessels,” *Journal of Loss Prevention in the Process Industries*, Vol. 9, No. 1, pp. 45–58 (1996).

Moore, P. E., and J. A. Senecal, “Industrial Explosion Protection — How Safe Is Your Process?” Dust Explosion Symposium, Fire Protection Research Foundation, Baltimore, MD, May 13–14, 2009. See http:www.nfpa.org/assets/files/PDF/Foundation%20proceedings/Industrial_Explosion_Protection.pdf.

Roser, M., “Investigation of dust explosion phenomenon in interconnected process vessels,” Forschungsgesellschaft fur angewandle Systemsicherheit und Arbeitsmedizin PhD Thesis, University of Loughborough.

Roser, M., A. Vogel, S. Radant, W. Malalasekera, and R. Parkin, “Investigations of flame front propagation between interconnected process vessels. Development of a new flame front propagation time prediction model,” *Journal of Loss Prevention in the Process Industries*, Vol. 12, Issue 5, pp. 421–436 (1999).

Yu, X., and Young, K.-J., The Dynamic Load Factor of Pressure Vessels in Deflagration Events.

K.2 Informational References. (Reserved)

K.3 References for Extracts in Informational Sections. (Reserved)

Statement of Problem and Substantiation for Public Input

Referenced current SDO names, addresses, standard names, numbers, and editions.

Related Public Inputs for This Document

Related Input	Relationship
Public Input No. 1-NFPA 68-2015 [Chapter 2]	Referenced current SDO names, addresses, standard names, numbers, and editions.

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