**COMMITTEE ON HANDLING AND CONVEYING DUSTS,
VAPORS, AND GASES
November 15 – 17, 2010
NFPA Headquarters
Quincy, MA (George D. Miller Center, Lobby Level)
8:30 a.m.**

DRAFT AGENDA

1. Meeting opening, welcome members and guests, and introductions

2. Chair's remarks, Walt Frank

3. Review and approve minutes from July 12 – 14, 2010 meeting (NFPA 655 ROP meeting, Baltimore, MD)

4. Staff Liaison update (Committee Roster, schedule, advisory service)

5. NFPA 654 Report on Proposals (ROP)

    a. Public Proposals
    b. Committee Proposals (as appropriate)

7. NFPA 655 Report on Comments (ROC) – pre-ROC discussion

8. Other business

9. Review plans and schedule

10. Next meeting – ROC meeting (Closing date for Public Comments 3/4/11; last date for meeting 5/6/11; Committee has tentatively established March 28 – 29, 2011, as possible dates for meeting, no location specified). ROC meeting for NFPA 654 must occur prior to November 4, 2011; comment closing date is August 30, 2011.

11. Adjournment

654- Log #1 Final Action:
(6.1.2 and A.6.1.2)

Submitter: David C. Kirby, Baker Risk
Recommendation: The following is a reorganization and clarification of portions of paragraph 6.1.2 from the NFPA 654 Pre Rop meeting of June 17, 18, 2008. Succeeding paragraphs from the pre ROP should be included and renumber as applicable:

6.1.2 Room/Building Dust Explosion Hazard.

6.1.2.1 A dust explosion hazard shall be deemed to exist in those rooms or building volumes where a deflagration of the worst credible case explosible dust fill fraction, Xr, can result in a pressure exceeding the ultimate dynamic strength of the weakest structural element not intended to fail.

6.1.2.2* The dust layer control criterion shall be a maximum of 1 kg/m^2 (0.2 lbs/ft^2) accumulation for a nominal 3 meter high room/building, and shall be ratioed up or down as a function of room/building height to a maximum of 4 kg/m^2 (0.8 lbs/ft^2) for a 12 meter and higher (40 ft and higher) room/building. Where settled bulk density is known it shall be permissible to base dust layer control criterion on the following equation:

****Insert Equation 654-E__L1 Here****

6.1.2.3 Where dust accumulations exceed the dust layer control criterion over more than 5% of the surface area within the room/building, an engineering analysis shall be performed to determine acceptability of construction with respect to explosion protection in accordance with NFPA 68, Explosion Protection by Deflagration Venting, 2007 Edition, Section 8.3.4.

6.1.2.4* Small volume enclosures less than 100 m^3 (3,500 ft^3) or gallery-type enclosures with a length-to-diameter (L/D) ratio greater than 5 shall have lower limits of acceptable dust accumulation, based on an evaluation acceptable to the authority having jurisdiction.

A.6.1.2.2 A relatively small initial dust deflagration can disturb and suspend in air dust that has been allowed to accumulate on the surfaces of a building or equipment. When dispersed into a dust cloud and ignited, a deflagration can ensue, potentially causing damage. This is know as a secondary deflagration (explosion). Reducing significant additional dust accumulations is therefore a major factor in reducing the hazard in areas where a dust explosion hazard can exist. (See Annex D).

When structures are higher than 3 meters the meters the maximum allowable accumulation between cleaning (housekeeping) can be scaled upwards, not to exceed the dispersed limit of 330 grams/m3. For example, a 20 ft (6 m) high building could have a maximum allowable accumulation of 2 kg/m^2; -3.6 mm ($^3/_{16}$ in.) - if settled bulk density = 560 g/m3 (35 lbs/ft^3), but any building higher than about 40 ft (12 m) would have a maximum allowable accumulation of 3..5 kg/m^2, 6.25 mm ($^1/_4$ in.) — bulk density of 35 lbs/ft^3. However, for those high or unusually large structures, an engineering analysis should be performed to determine requirements for deflagration venting (see 6.2.3.4).

1 kg/m^2 accumulation (3.6 mm ($^1/_{16}$ in.) accumulation for a dust having a settled bulk density of 560 g/m^3 (35 lbs/ft^3) of a combustible dust in a 3 meter high enclosure, when totally and uniformly dispersed, represents a concentration of 333 grams/m^3. This is well above the minimum explosive concentration (MEC) for most dusts. In typical room-size, settled density, per cent moisture, room size, continuity of fuel loading, congestion, and strength of the ignition source. Flame-jet ignition from explosions within equipment that rupture and emit flame and pressure inside the room can result in a highly efficient entrainment factor. It is extremely important that processing/storage equipment be protected against venting flame/pressure into the room. This scenario can also eject unburned fuel into the room that can add to the secondary explosion violence.

A.6.1.2.4 Enclosures smaller than 100 m^3, or gallery-type enclosures that have a length to diameter ratio (hydraulic diameter) L/D greater than 5 are more efficient in entraining dust into a secondary explosion from shock or pressure waves from a primary explosion. When the enclosure is smaller than 100 m^3, acceptable maximum accumulations between cleaning cycle should be scaled down in ratio of the volume of the enclosure to a lower limit equal to 100% of the MEC for a 1 m^3 enclosure. For volumes between 1 m^3 and 100 m^3 direct scaling can be applied. Take for example a material having a MEC of 60 g/m^3 in a room 4.6 m (15 ft) × 6.1 m (20 ft) × 21. m (7 ft) high = 59 m^3 (2,100 ft^3). Solving from 1 m^3 @ 60g/m^3 to 100 m^3 @ 330/gm^3 at a point of 59 m^3, allowable accumulation is 220 g/m^3. This is a maximum allowable accumulation of 1.2 mm (3/64 in.) for a material having a bulk density of 560 kg/m^3 (35 lbs/ft^3).

Gallery-type enclosures with a length-to-diameter of 5 or less should be calculated on the basis of regular enclosures (typically these will be less than 100 m^3). Gallery-type enclosures with a length-to-diameter greater than 5 should have average accumulations, when totally entrained, less than the MEC. Galleries typically contain conveyors which are difficult to design to contain all fugitive emissions. Therefore, it is recommended that strong consideration be given controlling dust at transfer points, and providing means to wash down with water spray on a frequent basis. As noted below, keeping one side of a conveyor open along one side (aboveground) is highly recommended.

Gallery-type elongated enclosures where the L/D exceeds 5 shall be subject to smaller allowable accumulations between cleaning. This is especially important for underground tunnels where no explosion venting can occur (except from the ends). Unless testing is done to represent actual conditions, it is recommended that an L/D of 5 and greater, average accumulations of dispersible dust not exceed that which would, if dispersed, result in a cloud with a density greater than the MEC. Where it is not possible to maintain accumulations below the MEC, and where explosion effects can be communicated between work areas, or between equipment and work areas (such as between silos and processing rooms) consideration should be given to providing other explosion protection measures, such as deflagration isolation. Where feasible, gallery type construction (such as elevated conveyor structures) should have one side at least 25% open along the entire length. For this case an engineering analysis may determine that greater accumulations are not unsafe, but fire protection should still be a consideration. Note that testing has shown that very low combustible dust accumulations on gallery floors can propagate flame throughout the gallery, even at concentrations below the MEC if the dust is uniformly dispersed throughout the gallery, even at concentrations below the MEC if the dust is uniformly dispersed throughout the gallery volume. However, there is little pressure build-up for this (flash-fire) scenario. Experience has shown that railcar and truck unloading bunker-conveyor-tunnels that transition to above-ground galleries within a short distance (12 m (40 ft) can, in general, tolerate accumulations greater than the MEC (see 6.1.2.2 for recommended limitations).

Local combustible dust accumulations, such as localized dust accumulations as may accumulate in the upper structure of a high-bay building, may not constitute a building explosion hazard, but can pose a flash-fire risk. Cleaning should be performed prior to performing tasks that disturb the dust deposits and/or introduce ignition sources. The high-bay section should be considered a Hazardous Work Permit Area. The hazardous work permit should consider the need for personnel protective equipment (fire retardant clothing, face shields, etc.) as appropriate. Fire retardant personnel protection clothing can provide significant protection for credible scenarios of low explosion overpressure, and flash-fires. the use of clothing made from synthetic materials should be avoided.

Substantiation: None given.

Note: The following is a reorganization and clarification of portions of Paragraph 6.1.2. from the NFPA 654 Pre ROP Meting of June 17, 18, 2008. Succeeding paragraphs from the Pre ROP should be included and renumbered as applicable.

6.1.2 Room/Building Dust Explosion Hazard.

6.1.2.1 A dust explosion hazard shall be deemed to exist in those rooms or building volumes where a deflagration of the worst credible case explosible dust fill fraction, Xr, can result in a pressure exceeding the ultimate dynamic strength of the weakest structural element not intended to fail.

6.1.2.2* The dust layer control criterion shall be a maximum of 1 kg/m2 (0.2 lbs/ft2) accumulation for a nominal 3 meter (10 ft.) high room/building, and shall be ratioed up or down as a function of room/building height to a maximum of 4 kg/m2 (0.8 lbs/ft2) for a 12 meter and higher (40 ft. and higher) room/building. Where settled bulk density is known it hall be permissible to base dust layer control criterion on the following equation:

$$EquivalentDepth(mm) = \frac{1000 \bullet Accumulation(kg/m2)}{BulkDensity(kg/m3)}$$

6.1.2.3 Where dust accumulations exceed the dust layer control criterion over more than 5% of the surface area within the room/building, an engineering analysis shall be performed to determine acceptability of construction with respect to explosion protection in accordance with NFPA 68, Explosion Protection by Deflagration Venting, 2007 Edition, Section 8.3.4.

6.1.2.4* Small volume enclosures less than 100 m3 (3,500 ft3) or gallery-type enclosures with a length-to-diameter (L/D) ratio greater than 5 shall have lower limits of acceptable dust accumulation, based on an evaluation acceptable to the authority having jurisdiction.

A 6.1.2.2 A relatively small initial dust deflagration can disturb and suspend in air dust that has been allowed to accumulate on the surfaces of a building or equipment. When dispersed into a dust cloud and ignited, a deflgration can ensue, potentially causing damage. This is known as a secondary deflagration (explosion). Reducing significant additional dust accumulations is therefore a major factor in reducing the hazard in areas where a dust explosion hazard can exist. (See Annex D).

When structures are higher than 3 meters the maximum allowable accumulation between cleaning (housekeeping) can be scaled upwards, not to exceed the dispersed limit of 330 grams/m3. For example, a 20 ft. (6 m) high building could have a maximum allowable accumulation of 2 kg/m2; - 3.6 mm (3/16 inch) – if settled bulk density = 560 g/m3 (35 lbs/ft3), but any building higher than about 40 ft. (12 m) would have a maximum allowable accumulation of 3.5 kg/m2, 6.25 mm (1/4 inch) – bulk density of 35 lbs/ft^3. However, for those high or unusually large structures, an engineering analysis should be performed to determine requirements for deflagration venting (see 6.2.3.4).

1 kg/m2 accumulation (3.6 mm (1/16 in.) accumulation for a dust having a settled bulk density of 560 g/m3 (35 lbs/ft3)) of a combustible dust in a 3 meter high enclosure, when totally and uniformly dispersed, represents a concentration of 333 grams/m3. This is well above the minimum explosive concentration (MEC) for most dusts. In typical room-size enclosures 3 meters (10 ft) or more high, and ~ 36 m2 (400 ft2) and greater, the likelihood of entrainment of all of the dust from surfaces into an explosible dust cloud is generally low. The entrainment factor (efficiency) is a function of particle size, settled density, per cent moisture, room size, continuity of fuel

loading, congestion, and strength of the ignition source. Flame-jet ignition from explosions within equipment that rupture and emit flame and pressure inside the room can result in a highly efficient entrainment factor. It is extremely important that processing/storage equipment be protected against venting flame/pressure into the room. This scenario can also eject unburned fuel into the room that can add to the secondary explosion violence.

A 6.1.2.4 Enclosures smaller than ~ 100 m3, or gallery-type enclosures that have a length to diameter ratio (hydraulic diameter) L/D greater than ~ 5 are more efficient in entraining dust into a secondary explosion from shock or pressure waves from a primary explosion. When the enclosure is smaller than 100 m3, acceptable maximum accumulations between cleaning cycles should be scaled down in ratio of the volume of the enclosure to a lower limit equal to 100% of the MEC for a 1m3 enclosure. For volumes between 1 m3 and 100 m3 direct scaling can be applied. Take for example a material having a MEC of 60 g/m3 in a room 4.6 m (15 ft.) x 6.1 m (20 ft.) x 2.1 m (7 ft.) high = 59 m3 (2,100 ft3) Solving from 1m3 @60g/m3 to 100m3 @ 330 g/m3 at a point of 59m3, allowable accumulation is 220 g/m3. This is a maximum allowable accumulation of 1.2 mm (3/64 in.) for a material having a bulk density of 560 kg/m3 (35 lbs/ft3).

Gallery-type enclosures with a length-to-diameter of 5 or less should be calculated on the bases of regular enclosures (typically these will be less than 100 m3). Gallery-type enclosures with a length-to-diameter greater than 5 should have average accumulations, when totally entrained, less than the MEC. Galleries typically contain conveyors which are difficult to design to contain all fugitive emissions. Therefore, it is recommended that strong consideration be given to controlling dust at transfer points, and providing a means to wash down with water spray on a frequent basis. As noted below, keeping one side of a conveyor open along one side (aboveground) is highly recommended.

Gallery-type elongated enclosures where the L/D exceeds 5 shall be subject to smaller allowable accumulations between cleaning. This is especially important for underground tunnels where no explosion venting can occur (except from the ends),. Unless testing is done to represent actual conditions, it is recommended that at an L/D of 5 and greater, average accumulations of dispersible dust not exceed that which would, if dispersed, result in a cloud with a density greater than the MEC. Where it is not possible to maintain accumulations below the MEC, and where explosion effects can be communicated between work areas, or between equipment and work areas (such as between silos and processing rooms) consideration should be given to providing other explosion protection measures, such as deflagration isolation. Where feasible, gallery type construction (such as elevated conveyor structures) should have one side at least 25% open along the entire length. For this case an engineering analysis may determine that greater accumulations are not unsafe, but fire protection should still be a consideration. Note that testing has shown that very low combustible dust accumulations on gallery floors can propagate flame throughout the gallery, even at concentrations below the MEC if the dust is uniformly dispersed throughout the gallery volume. However, there is little pressure build-up for this (flash-fire) scenario.
Experience has shown that railcar and truck unloading bunker-conveyor-tunnels that transition to above-ground galleries within a short distance (12 m (40 ft) can, in general, tolerate accumulations greater than the MEC (see 6.1.2.2 for recommended limitations).

Local combustible dust accumulations, such as localized dust accumulations as may accumulate in the upper structure of a high-bay building, may not constitute a building explosion hazard, but can pose a flash-fire risk. Cleaning should be performed prior to performing tasks that disturb the dust deposits and/or introduce ignition sources. The high-bay section should be considered a Hazardous Work Permit Area. The hazardous work permit should consider the need for personnel protective equipment (fire retardant clothing, face shields, etc) as appropriate. Fire retardant personnel protection clothing can provide significant protection for credible scenarios of low explosion overpressure, and flash-fires. The use of clothing made from synthetic materials should be avoided.

654- Log #2 **Final Action:**
(6.2.2.1)

Submitter: Marcelo M. Hirschler, GBH International
Recommendation: Revise text as follows:
6.2.2.1 Physical barriers that are erected to segregate dust hazards shall have all penetrations of floors, walls, ceilings, or partitions sealed dusttight, and, where structural assemblies have a fire resistance ~~endurance~~ rating, the seal shall maintain that rating.
Substantiation: The correct terminology is fire resistance rating. It is therefore recommended, in order to improve consistency within NFPA documents that the change gets made as shown.
I am the chairman of the NFPA Advisory Committee on the Glossary on Terminology. The committee was created by NFPA Standards Council to provide consistency in terminology throughout the NFPA documents. The committee not had an opportunity to review this recommendation on terms. Therefore, this proposal is being submitted in my name and not in the name of the committee.
This is not original material; its reference/source is as follows:
The text is used in other NFPA standards.

654- Log #3 **Final Action:**
(8.2.1)

Submitter: Mindy Wang, Ampco Safety Tools
Recommendation: Add new text as follows:
8.2.1.3 Tools for cleanup of fugitive dusts or collecting sweepings shall be non-sparking.
Substantiation:
- NFPA 654 can better mitigate the fire and explosions hazards by specifying the use of non-sparking tools. Without this specification, steel tools are likely to be used which can be an ignition source.
- NFPA 921, Guide for Fire and Explosion Investigations 2008 Edition, Chapter 5 Basic Fire Science Table 5.7.1.1 Reported Burning and Sparking Temperature of Selected Ignition Sources under Mechanical Sparks lists a Steel tool temperature at 2550°F. When working with flammable gases, liquids or vapors, a potential hazard arises because of the possibility that sparks produced by steel or iron tools can become an ignition source.
- Recognizing the potential for steel tools to be an ignition source in flammable environment, the Occupational Safety & Health Administration (OSHA) provides guidance in booklet 3080 Hand and Power Tools, 2002 revised, "iron and steel hand tools may produce sparks that can be an ignition source around flammable substances. Where this hazard exists, spark-resistant tools should be used."
- NFPA Fire Protection Handbook, Volume I, Chapter 8 Dusts states that ignition temperatures and ignition energies for dust explosions are much lower than the temperatures and energies of most common sources of ignition, it is not surprising that dust explosions have been caused by common sources of ignition. For this reason, the elimination of all possible sources of ignition is a basic principle of dust explosion prevention.
- On February 20, 2003, a dust explosion at the CTA Acoustics, Inc. (CTA) facility in Corbin, Kentucky, killed seven and injured 37 workers. In investigating this incident, the CSB determined that combustible resin dust that had accumulated throughout the facility fueled the explosion. Developed in 1997, job safety analyses for cleaning process line dust collectors and ducts list explosion as a potential hazard if the cleaning is done with tools capable of producing a spark. Employees reported that production line cleaning routinely created clouds of dust. They used compressed air, brooms, and metal tools to clean. The CSB concluded that the use of metal tools, brooms, compressed air, and fans during line cleaning is one of the root causes of explosion. One recommendation made by the CSB is using appropriate dust-cleaning methods and tools to minimize the dispersion of combustible dust.
- A dust explosion and fire on October 29, 2003 at the Hayes Lemmerz International-Huntington, Inc. killed one employee and injured six workers. Section 3.3.9.2 Impact Spark of the final Chemical Safety Board (CSB) investigation report stated when steel objects strike steel or an abrasive surface with enough momentum, the impact can generate a spark. A common example is the spark observed when a steel hammer strikes a steel nail. The report also stated for this reason, refineries and other workplaces that may have flammable atmospheres often use tools of bronze or other non-sparking metals. CSB investigations did not rule out an impact spark as a possible ignition source.
- As a result of catastrophic accident involving a combustible dust explosion at a sugar refinery, OSHA initiated a Combustible Dust National Emphasis Program in October 2007; reissued in March 2008. As a precautionary measure, OSHA requires Compliance, Safety and Health officers (CSHOs) uses non-sparking dust pans for collection settled dust and non-spark scoops for removing dust from cyclone containers or other ventilation equipment for the combustible dust hazards when conducting inspections under this program.
- FM Global, a large commercial and industrial property insurer, publishes guidelines to reduce or prevent dust fires and explosion. Data sheets are provided to customers and noncustomers. Data Sheet 6-9, Industrial Ovens and Dryers, addressed fire and explosion hazards from process combustibles (e.g. dust, debris), fuel, and flammable materials in industrial ovens and dryers and applies to operations such as those found at CTA. This data sheet states that scraping with non-sparking tools is probably the most widely used method for soft or easily removed deposits. Furthermore, the CSB final investigation report on explosion at CTA found that guidelines listed on FM data sheet 6-9 was not followed.
- A few more incidents:
    - OSHA inspection #127357804, employee #1 was working in an infrared flare composition mixing building. He completed installation of a metal vacuum filter table in Bay #1, permanently anchoring it to the concrete floor by drilling holes in the concrete floor, installing concrete anchor bolts, and bolting down the table. Employee #1 then removed the eight anchor bolts from the concrete floor at the old table location by hitting them with a ball peen hammer until they broke. On the last anchor bolt, some residual flare composition on the bolt threads or on the floor ignited due to the impact of the hammer. According to a company representative, room evidence indicated that the ignited flare material then probably ignited the flare composition-contaminated denim filter on the vacuum table next to Employee #1, causing an explosion or deflagration. Other composition-contaminated material in the building caught on fire, resulting in two to four more explosions. Employee #1 suffered second- and third-degree burns over 80 percent of his body and later died.

- OSHA inspection #110292604, employees #1 and #2 were mixing magnesium powder (metallic), calcium carbide, and sodium chloride. Employee #3 was bringing in drums of magnesium powder. Employees #1 and #2 were using a length of steel pipe to loosen a blockage in a magnesium batching hopper. The pipe caused a spark to ignite a magnesium powder flash fire and explosion. Employees #1 and 2 were killed and Employee #3 was injured.
- OSHA inspection #114997323, employee #1 was in an area between the dust collector and the air-lay machine on the 92 line preparing to dump a bag of resin into a hopper with a forklift when the resin reclaim unit blew out and burned him on his neck, back, and arms. The dust ignited in the duct system and traveled to the reclaim unit, where the blast engulfed the area. The initial spark may have occurred in the LaRouche machine from a steel-on-metal spark or in the air-lay machine from an overheated bearing. The employee was burned.
- Listed as accident #82 on dust incident data compiled by the CSB, an explosion resulted as a spark created by a worker with an allen wrench who was turning a screw to adjust a machine. The spark ignited some propellant dust and a vacuum system carried the fire another room where a barrel of dust exploded.
- Without the specification for non-sparking tools, steel tools are likely to be used which can be a source of ignition.

This is not original material; its reference/source is as follows:

OSHA Publication 3080; Hand and Power Tools, Revised: 2002
NFPA 921, Guide for Fire and Explosion Investigations, 2008
U.S. Chemical Safety and Hazard Investigation Board Investigation Report: Combustible Dust Fire and Explosions CTA Acoustics, Inc., Report No.2003-09-I-KY
February 2005, U.S. Chemical Safety and Hazard Investigation Board Investigation Report: Dust Explosion Hayes Lemmerz International, Inc, Report No. 2004-01-I-IN, September 2005
OSHA Directive Number CPL 03-00-008, Combustible Dust National Emphasis Program (Reissued)
Factory Global Property Loss Prevention Data Sheet 6-9 Industrial Ovens and Dryers, September 2003
NFPA Fire Protection Handbook, 20th edition, Volume 1, Section 6, Chapter 8 Dust, pg. 6-144
OSHA inspection #127357804, Employee Burned In Series Of Explosions, Later Dies, available:
http://www.osha.gov/pls/imis/accidentsearch.accident_detail?id=200620342
OSHA inspection #110292604, Two Employees Killed In Magnesium Dust Explosion, available:
http://www.osha.gov/pls/imis/accidentsearch.accident_detail?id=14387971
OSHA inspection #114997323, Employee Sustains Burns During Dust Explosion, available:
http://www.osha.gov/pls/imis/accidentsearch.accident_detail?id=975888
U.S. Chemical Safety and Hazard Investigation Board, Dust Incident Data File, incident # 82, data file available:
http://www.csb.gov/index.cfm?folder=completed_investigations&page=info&INV_ID=53

654- Log #4 Final Action:
(9.1.5)

Submitter: Mindy Wang, Ampco Safety Tools
Recommendation: Add new text as follows:
9.1.5 Equipment. Equipment with moving parts shall be installed and maintained so that true alignment is maintained and clearance is provided to minimize friction. Non-sparking tools shall be used to make repairs or adjustment on or around any machinery where combustible dust is present.
Substantiation: • NFPA 654 can better mitigate the fire and explosions hazards by specifying the use of non-sparking tools. Without this specification, steel tools are likely to be used which can be an ignition source.
• NFPA 921, Guide for Fire and Explosion Investigations 2008 Edition, Chapter 5 Basic Fire Science Table 5.7.1.1 Reported Burning and Sparking Temperature of Selected Ignition Sources under Mechanical Sparks lists a Steel tool temperature at 2550°F. When working with flammable gases, liquids or vapors, a potential hazard arises because of the possibility that sparks produced by steel or iron tools can become an ignition source.
• Recognizing the potential for steel tools to be an ignition source in flammable environment, the Occupational Safety & Health Administration (OSHA) provides guidance in booklet 3080 Hand and Power Tools, 2002 revised, “iron and steel hand tools may produce sparks that can be an ignition source around flammable substances. Where this hazard exists, spark-resistant tools should be used.”
• NFPA Fire Protection Handbook, Volume I, Chapter 8 Dusts states that ignition temperatures and ignition energies for dust explosions are much lower than the temperatures and energies of most common sources of ignition, it is not surprising that dust explosions have been caused by common sources of ignition. For this reason, the elimination of all possible sources of ignition is a basic principle of dust explosion prevention.
• On February 20, 2003, a dust explosion at the CTA Acoustics, Inc. (CTA) facility in Corbin, Kentucky, killed seven and injured 37 workers. In investigating this incident, the CSB determined that combustible resin dust that had accumulated throughout the facility fueled the explosion. Developed in 1997, job safety analyses for cleaning process line dust collectors and ducts list explosion as a potential hazard if the cleaning is done with tools capable of producing a spark. Employees reported that production line cleaning routinely created clouds of dust. They used compressed air, brooms, and metal tools to clean. The CSB concluded that the use of metal tools, brooms, compressed air, and fans during line cleaning is one of the root causes of explosion. One recommendation made by the CSB is using appropriate dust-cleaning methods and tools to minimize the dispersion of combustible dust.
• A dust explosion and fire on October 29, 2003 at the Hayes Lemmerz International-Huntington, Inc. killed one employee and injured six workers. Section 3.3.9.2 Impact Spark of the final Chemical Safety Board (CSB) investigation report stated when steel objects strike steel or an abrasive surface with enough momentum, the impact can generate a spark. A common example is the spark observed when a steel hammer strikes a steel nail. The report also stated for this reason, refineries and other workplaces that may have flammable atmospheres often use tools of bronze or other non-sparking metals. CSB investigations did not rule out an impact spark as a possible ignition source.
• As a result of catastrophic accident involving a combustible dust explosion at a sugar refinery, OSHA initiated a Combustible Dust National Emphasis Program in October 2007; reissued in March 2008. As a precautionary measure, OSHA requires Compliance, Safety and Health officers (CSHOs) uses non-sparking dust pans for collection settled dust and non-spark scoops for removing dust from cyclone containers or other ventilation equipment for the combustible dust hazards when conducting inspections under this program.
• FM Global, a large commercial and industrial property insurer, publishes guidelines to reduce or prevent dust fires and explosion. Data sheets are provided to customers and noncustomers. Data Sheet 6-9, Industrial Ovens and Dryers, addressed fire and explosion hazards from process combustibles (e.g. dust, debris), fuel, and flammable materials in industrial ovens and dryers and applies to operations such as those found at CTA. This data sheet states that scraping with non-sparking tools is probably the most widely used method for soft or easily removed deposits. Furthermore, the CSB final investigation report on explosion at CTA found that guidelines listed on FM data sheet 6-9 was not followed.
• A few more incidents:
• OSHA inspection #127357804, employee #1 was working in an infrared flare composition mixing building. He completed installation of a metal vacuum filter table in Bay #1, permanently anchoring it to the concrete floor by drilling holes in the concrete floor, installing concrete anchor bolts, and bolting down the table. Employee #1 then removed the eight anchor bolts from the concrete floor at the old table location by hitting them with a ball peen hammer until they broke. On the last anchor bolt, some residual flare composition on the bolt threads or on the floor ignited due to the impact of the hammer. According to a company representative, room evidence indicated that the ignited flare material then probably ignited the flare composition-contaminated denim filter on the vacuum table next to Employee #1, causing

an explosion or deflagration. Other composition-contaminated material in the building caught on fire, resulting in two to four more explosions. Employee #1 suffered second- and third-degree burns over 80 percent of his body and later died.

- OSHA inspection #110292604, employees #1 and #2 were mixing magnesium powder (metallic), calcium carbide, and sodium chloride. Employee #3 was bringing in drums of magnesium powder. Employees #1 and #2 were using a length of steel pipe to loosen a blockage in a magnesium batching hopper. The pipe caused a spark to ignite a magnesium powder flash fire and explosion. Employees #1 and 2 were killed and Employee #3 was injured.
- OSHA inspection #114997323, employee #1 was in an area between the dust collector and the air-lay machine on the 92 line preparing to dump a bag of resin into a hopper with a forklift when the resin reclaim unit blew out and burned him on his neck, back, and arms. The dust ignited in the duct system and traveled to the reclaim unit, where the blast engulfed the area. The initial spark may have occurred in the LaRouche machine from a steel-on-metal spark or in the air-lay machine from an overheated bearing. The employee was burned.
- Listed as accident #82 on dust incident data compiled by the CSB, an explosion resulted as a spark created by a worker with an allen wrench who was turning a screw to adjust a machine. The spark ignited some propellant dust and a vacuum system carried the fire another room where a barrel of dust exploded.
- Without the specification for non-sparking tools, steel tools are likely to be used which can be a source of ignition.

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OSHA Publication 3080; Hand and Power Tools, Revised: 2002, NFPA 921, Guide for Fire and Explosion Investigations, 2008, U.S. Chemical Safety and Hazard Investigation Board Investigation Report: Combustible Dust Fire and Explosions CTA Acoustics, Inc., Report No.2003-09-I-KY, February 2005, U.S. Chemical Safety and Hazard Investigation Board Investigation Report: Dust Explosion Hayes Lemmerz International, Inc, Report No. 2004-01-I-IN, September 2005, OSHA Directive Number CPL 03-00-008, Combustible Dust National Emphasis Program (Reissued), Factory Global Property Loss Prevention Data Sheet 6-9 Industrial Ovens and Dryers, September 2003, NFPA Fire Protection Handbook, 20th edition, Volume 1, Section 6, Chapter 8 Dust, pg. 6-144,
OSHA inspection #127357804, Employee Burned In Series Of Explosions, Later Dies, available:
http://www.osha.gov/pls/imis/accidentsearch.accident_detail?id=200620342,
OSHA inspection #110292604, Two Employees Killed In Magnesium Dust Explosion, available:
http://www.osha.gov/pls/imis/accidentsearch.accident_detail?id=14387971,
OSHA inspection #114997323, Employee Sustains Burns During Dust Explosion, available:
http://www.osha.gov/pls/imis/accidentsearch.accident_detail?id=975888,
U.S. Chemical Safety and Hazard Investigation Board, Dust Incident Data File, incident # 82, data file available:
http://www.csb.gov/index.cfm?folder=completed_investigations&page=info&INV_ID=53

654- Log #5 Final Action:
(10.5)

Submitter: Bill Stevenson, CV Technology, Inc.

Recommendation: New wording needs to be crafted in committee to require automatic sprinklers for areas handling combustible dust to be compatible with the IBC and IFC.

Substantiation: This explanation was developed by a client and is presented here as the basis for consideration of a proposal to require automatic sprinklers for facilities handling combustible dust under paragraph 10.5.

You remember correctly that we did an exhaustive study this year of both the IBC and IFC, as they relate to Combustible Dust Manufacturing. In both cases we employed the 2006 editions. Based upon this analysis, our view is that facilities employed for Combustible Dust Manufacturing that are in excess of 12,000 sq ft (pretty much all our plants) are required to have Automatic Sprinkler Systems. Our logic is as follows:

(1) Both the IBC and the IFC rely heavily on "Control Tables", which list the maximum allowable quantities of hazardous materials allowed per control area. In the case of the IFC, Article 2703.1.1 states as follows:

"The maximum allowable quantity of hazardous materials per control area shall be as specified in Tables 2703.1.1(1) through 2703.1.1(4)". The companion table in the IBC is Table 307.1(1).

(2) In both cases (the IBC and the IFC), the tables do not list combustible dust at all. In other words, this class of materials literally does not exist in the table. Our Senior Code Specialist has confirmed that this means there is no requirement for combustible dusts at all, at least as the requirement is related to any and all Articles in the IBC and the IFC that refer specifically to the respective tables.

(3) Anecdotally, there are multiple cases in both the IBC and the IFC where Combustible Dust is suggested to be a hazardous material that may be required (by implication) to reside in an H-2 area. That said, the firm requirement does not exist.

(4) In Chapter 2 of the IFC (Definitions), it indicates the following:

High-hazard Group H. High-hazard Group H occupancy includes, among others, the use of a building or structure, or a portion thereof, that involves the manufacturing, processing, generation or storage of materials that constitute a physical or health hazard in quantities in excess of quantities allowed in control areas constructed and located as required in Section 2703.8.3. Hazardous uses are classified in Groups H-1, H-2, H-3, H-4 and H-5 and shall be in accordance with this code and the requirements of Section 415 of the International Building Code.

Exceptions: The following shall not be classified in Group H, but shall be classified in the occupancy that they most nearly resemble:

1. Buildings and structures that contain not more than the maximum allowable quantities per control area of hazardous materials as shown in Tables 2703.1.1(1) and 2703.1.1(2), provided that such buildings are maintained in accordance with this code.

(5) Logically, since the exception applies (Combustible Dust doesn't exceed the amount in the table since it is not listed in the table), so the bottom line is this: Combustible Dust Manufacturing, Processing and Handling should be classified in the occupancy that it most nearly resembles.

(6) A quick read of the Occupancy Classes in Chapter 2 of the IFC (Definitions) confirms that the only choice is Factory Industrial Group F, the "Factory Industrial Group". The description reads as follows:

F occupancy includes, among others, the use of a building or structure, or a portion thereof, for assembling, disassembling, fabricating, finishing, manufacturing, packaging, repair or processing operations that are not classified as a Group H high-hazard or group S storage occupancy.

(7) Factory Industrial Group F is further sub-divided into F-1 (Moderate Hazard) and F-2 (Low Hazard). It is reasonable to classify Combustible dust Manufacturing, Processing and Handling as F-1.

(8) All of the logic thus far was necessary to construct a frame work for determining the requirement for Automatic Sprinkler Systems (a sub-set of Fire Protection systems, found in the IFC Chapter 9).

(9) Chapter 9, Section 903, Article 903.2.3 states the following:

903.2.3 Group F-1. An automatic sprinkler system shall be provided throughout all buildings containing a Group F-1 occupancy where one of the following conditions exists:

1. Where a Group F-1 fire area exceeds 12,000 sq ft (1115 m^2);
2. Where a Group F-1 fire area is located more than three stories above grade plane; or
3. Where the combined area of all Group F-1 fire areas on all floors, including any mezzanines, exceeds 24,000 sq ft (2230 m^2).

654- Log #6 **Final Action:**
(7.13.1.1.2)

Submitter: Bill Stevenson, CV Technology, Inc.
Recommendation: Add new text as follows:
7.13.1.1.1 Where an explosion hazard exists, air-material separators larger than 8 ft^3 shall be located outside of buildings.
Substantiation: The exemption for air-separators that have a volume of less than 8 ft^3 from the need for protection is not entirely clear to all users of the current edition of the document.

654- Log #7 **Final Action:**
(Various)

Submitter: Bill Stevenson, CV Technology, Inc.
Recommendation: Add new text as follows:
This is not suggested wording, rather it is a suggested approach. Could we add annex material to help users determine where an explosion hazard exists?
Substantiation: The phrase "where an explosion hazard exists..." is found in several places in the document. Nowhere in the document can be found information on how to determine where an explosion hazard exists.

654- Log #8 **Final Action:**
(7.2.3.3.4)

Submitter: Bill Stevenson, CV Technology, Inc.
Recommendation: Add new text as follows:
This is not suggested wording, rather it is a suggested approach. Could we add annex material to explain the rationale for the exclusion of transportable containers from the requirement for protection?
Substantiation: The rationale for the exemption from protection requirements for transportable containers is not clear.

654- Log #9 **Final Action:**
(9.3.3)

Submitter: Bill Stevenson, CV Technology, Inc.

Recommendation: Add new text as follows:

9.3.3 Intermediate Bulk Containers. Re-write in committee will be required. N.B. we will also need to add similar information in the air-material separator section of the new document.

Substantiation: It is now known (published findings of Martin Glor) that a brush discharge is not capable of igniting pure dust (he tried and failed using sulfur dust). Since a brush discharge is the only credible discharge from an FIBC, for pure dusts Type A and Type B containers are suitable and even preferred. This whole section needs to be revamped. Also, the composition of the bag is not the only issue, we also need to address bag liners.

Note: A brush discharge is also the only credible discharge from a filter in an air-separator. Groundable filters have been known to fail due to repeated air pulsation and once continuity to ground is lost between the filter element and the housing an isolated conductor is created. If the potential difference gets great enough, a spark would jump the gap from the filter to the housing. This usually occurs at a sharp point and has been identified as the source of ignition in filter air-separators. Using groundable filters for pure dusts is not a good idea.

654- Log #10 **Final Action:**
(3.3.13 Explosion Hazard)

Submitter: John M. Cholin, J. M. Cholin Consultants Inc.
Recommendation: Add new text as follows:
Explosion Hazard. Any vessel, duct, building compartment, room or other enclosure containing a deflagration hazard.
Substantiation: Section 6.2.3 has been used to define where an explosion hazard exists, in lieu of actually defining the term in Chapter 3. This proposal, along with a companion proposal, defines both deflagration hazard as well as explosion hazard in a manner that is consistent with the manual of style, and NFPA 69.

Many sections of NFPA 654 begin with the phrase “Where and explosion hazard exists…” Yet no where in NFPA 654 does the document establish what constitutes an "explosion hazard". This proposal along with its companion proposal provide the necessary definitions to make the rest of the document meaningful.

Furthermore, the definition of "explosion" requires the rupture or bursting of an enclosure. Yet we know that personnel injuries can occur in buildings where deflagrations occur that do not cause the building enclosure to fail. The 14 employees injured in the Malden Mills explosion and fire were all in a portion of the building that did NOT suffer rupture of the enclosure envelop! Since one objective of NFPA 654 is life safety, NFPA 654 should address the distinction between the deflagration and the explosion. The proposed definitions assist in drawing this distinction.

654- Log #11 **Final Action:**
(1.5.1)

Submitter: John M. Cholin, J. M. Cholin Consultants Inc.
Recommendation: Revise text as follows:
1.5.1 Unless otherwise specified, where used as a reference document for building code enforcement, the provisions of this standard shall not apply to facilities, equipment, structures.....retroactive.
Substantiation: The general duty clause of the OSH Act of 1970 requires employers to provide employees with a work place free of know recognized hazards that can cause injury or death. There is no "grandfather clause" in the OSH Act of 1970. The apparent intent of Congress was to have in law a requirement that kept pace with the times; as knowledge increased and our recognition of hazards increased that the obligation to protect employees from those hazards would also increase.
Where OSHA has not already written its own standard it looks to nationally recognized concensus standards to establish what is deemed to be a hazard and what are the feasible abatement methods. Thus OSHA looks to NFPA 654 as the nationally recognized consensus standard to establish what constitutes a hazard and what are the feasible abatement methods. Without the proposed revision to section 1.5.1 employees working in old facilities are deserving of less protection from hazards in employment than those that work in newer facilities. The proposed revision makes it clear that the retroactivity provisions are ONLY relevant to building code enforcement and that NFPA standards are not intended to establish a "grandfather provision" into federal workplace safety law.
Furthermore, there is no hope of ever having NFPA standards adopted as federally recognized safety standards as long section 1.5.1 remains as it is currently stated.

654- Log #12 **Final Action:**
(6.1.3)

Submitter: John M. Cholin, J. M. Cholin Consultants Inc.
Recommendation: Revise text as follows:
6.1.3 Recycling of Air-Material Separator Exhaust. Cleaned, exhaust air from air material separators shall not be returned back into the facility unless provision are in place to divert the return air flow to the building exterior in the event of a fire in the air-material separator.
This language is to replace the text of 6.1.3. The text in 6.1.3.1 and 6.1.3.2 is to remain.
Substantiation: The proposed text removes an industrial hygiene requirement that the TC is not qualified to establish and clarifies the intent of the TC.

654- Log #13 **Final Action:**
(3.3.8 Deflagration Hazard)

Submitter: John M. Cholin, J. M. Cholin Consultants Inc.
Recommendation: Add new text as follows:
Deflagration Hazard. Any location where either of the following conditions exist as a normal part of operations, during routine maintenance or as a result of production upset:
a.) a combustible dust exists in suspension in the atmosphere at a concentration above 25% of the Minimum Explosible Concentration (MEC) or
b.) a layer of accumulated combustible dust in excess of the threshold depth exists.
The threshold depth shall be:
a.) 1/32nd inch (0.8mm) for dusts of unknown bulk density, or
b.) Calculated form the following relation:
Threshold Depth = [(1/32) (75)] / (bulk density)
Where bulk density is expressed in pounds per cubic foot.
Delete Section 6.2.3.1 and Section 6.2.3.2. Attach A.6.2.3.1 to the new definition.
Substantiation: Section 6.2.3 has been used to define where an explosion hazard exists, in lieu of actually defining the term in Chapter 3. This proposal, along with a companion proposal, defines both "deflagration hazard" as well as "explosion hazard" in a manner that is consistent with the manual of style, and NFPA 69.
A deflagration can occur where a combustible dust exists in suspension in the atmosphere at concentration above the MEC and a competent igniter is present. Personnel injuries can occur in buildings where deflagrations occur even when the deflagration does not cause the building enclosure to fail. The 14 employees injured in the Malden Mills explosion and fire were all in a portion of the building that did NOT suffer rupture of the enclosure envelop! Other examples exist. Since one objective of NFPA 654 is life safety NFPA 654 should identify clearly where the hazard to life from a deflagration exists so that other sections of the standard can be brought to bear to manage the hazard. Since NFPA 69 requires that the concentration be controlled to 25% of the MEC where concentration monitoring is not in place this definition adopts that concentration criterion for the sake of internal consistency. By placing this definition in Chapter 3, NFPA 654 will begin to clearly establish where measures to manage the deflagration hazard must be in place.
Furthermore, many sections of NFPA 654 begin with the phrase "Where and explosion hazard exists..." yet no where in NFPA 654 does the document clearly state what constitutes and "explosion hazard". This proposal along with its companion proposal provide the necessary definitions to make the rest of the document meaningful.

654- Log #14 Final Action:
(Annex D)

Submitter: Robert G. Zalosh, Firexplo
Recommendation: Revise text as follows:

This Appendix is intended to explain and quantify how the potential ignition of a localized dust cloud can lead to significant pressure and flame injury hazards. It also provides a derivation of the maximum allowable accumulated dust as specified in the body of NFPA 654.

D.1 If a fraction of the accumulated combustible dust in an enclosure of volume V is dispersed so as to form a local dust cloud of optimum concentration, c_{opt}, in a part of the enclosure, the mass of dust in the cloud is equal to $c_{opt}f_{pv}V$, where f_{pv} denotes the fraction of the volume occupied by the dust cloud. If the dispersed fraction of the accumulated dust is designated as $_{disp}$, the accumulated mass corresponding to the mass in the dust cloud is given by $c_{opt}f_{pv}V/ _{disp.}$ The value of c_{opt} can be obtained from ASTM E1226 tests with the value corresponding to concentration at which the maximum-rate-of-pressure occurs. If there is a plateau rather than a well defined maximum in the plot of rate-of-pressure-rise versus dust concentration, the value of c_{opt} would be the concentration at the beginning of the plateau. Typical values are in the range 500 to 1000 g/m^3.

D.2 According to Paragraph 8.3.4 of NFPA 68-2007, no deflagration venting is needed if f_{pv} is less than or equal to P_{red}/P_{max} because the deflagration pressure will not exceed P_{red}, the maximum allowable deflagration pressure in the enclosure to preclude damage. The value of P_{red} per NFPA 68 is usually taken as 2/3[rd] of the enclosure yield strength for low strength enclosures. If we set $f_{pv} = P_{red}/P_{max}$ for unoccupied enclosures, then the maximum allowable accumulated dust in the enclosure, m_{Dmax}, is given by

Insert Equation #1 (E654-12) Here

The volume of enclosures with a uniform height, H, and floor area, A_{floor}, is equal to HA_{floor}. If we assume that $\chi_{disp} = ¼$, then

Insert Equation #2 (E654-13) Here

D.3 If the dusty enclosure is normally occupied, then the primary personnel hazard is burn injury due to contact or proximity with the burning dust in the dust cloud. The burned dust cloud will be larger than the unburned original dust cloud because of the gas expansion associated with the flame temperature. In the absence of any compression or pressure development, the gas expansion ratio is roughly equal to the temperature ratio, which is approximately equal to $(P_{max} + P_a)/P_a$, assuming the cloud was ignited at atmospheric pressure, P_a. Therefore, the volume of burned gas due to ignition of a cloud of volume $f_{pv}V$, is equal to $(P_{max} + P_a)f_{pv}V/P_a$. In order to have at most a 5% chance of the being immersed in the dust cloud, the burned gas volume should be at most 0.05V.

The corresponding maximum mass of dust in the enclosure in this case is

Insert Equation #3 (E654-14) Here

If we make the same assumption as in D.2, i.e. that $\chi_{disp} = ¼$, and express V in terms of height multiplied by floor area, then

Insert Equation #4 (E654-15) Here

D.4 The maximum allowable dust accumulation can also be expressed as the product of dust surface area, A_{dust}, and the dust maximum allowable surface mass density, m''_{Dmax}. The value of m''_{Dmax} corresponding to the equation for m_{Dmax} in D.2 is

Insert Equation #5 (E654-16) Here

and the associated maximum allowable average dust layer thickness, t_{Dmax}, is

Insert Equation #6 (E654-17) Here

where t_{Dmax} is in the same units as H, c_{opt} is in the same units as the accumulated dust bulk density, ρ_{bulk}, and the areas and pressures are in consistent units.

D.5 The maximum allowable surface mass density and layer thickness corresponding to the occupied enclosure as described in D.3 are

Insert Equation #7 (E654-18) Here

Insert Equation #8 (E654-19) Here

D.6 As an example, consider an enclosure with dust accumulated on equipment, structures, and the floor, such that the dust area is equal to 10% of the floor area, i.e. $A_{floor}/A_{dust} = 10$. Let us assume that the value of c_{opt} is equal to 500 g/m^3 and the bulk density is 1200×10^3 g/m^3. If we take P_a to be 1 bar abs, and P_{max} = 9 barg, then the equation in D.5 produces $m''_{Dmax} = 0.2(500\ g/m^3)H$. If H = 4 m, $m''_{Dmax} = 400\ g/m^2$. The corresponding value of t_{Dmax} is 400/1200 mm = 0.33 mm. Alternatively, if the dusty area is only equal to 5% of the floor area and the bulk density is 600 kg/m^3, the allowable layer thickness is 1.32 mm.

Continue with current C.2 (5), (6), and (7).

Substantiation: The current Annex D does not account for explosibility properties of the dust material in question. The proposed revision accounts for pertinent explosibility properties and provides an explanation and derivation of the equations being proposed to replaced the current specified maximum allowable dust layer thickness in the body of NFPA 654.

$$m_{D\max} = \frac{c_{opt} V \mathrm{P}_{red}}{\chi_{disp} P_{\max}}$$

654/L14 /A2010/ROP

E654-12

$$m_{D\max} = \frac{4 c_{opt} H A_{floor} P_{red}}{P_{\max}}$$

$$m_{D\max} = \frac{c_{opt} V (0.05 P_a)}{\chi_{disp} (P_{\max} + P_a)}$$

$$m_{D\max} = \frac{c_{opt} 4HA_{floor} (0.05P_a)}{(P_{\max} + P_a)}$$

654/L14/A2010/ROP

E654-15

$$m''_{D\max} = \frac{4c_{opt} H A_{floor} P_{red}}{(A_{dust} P_{\max})}$$

654/L14/A2010/RDP
E654-16

$$t_{D\max} = \frac{4 c_{opt} H A_{floor} P_{red}}{\rho_{bulk} A_{dust} P_{\max}}$$

654/L19/A2010/ROP
E654-17

$$m''_{th max} = \frac{4c_{opt} H A_{floor} (0.05 P_a)}{A_{dust} (P_{max} + P_a)}$$

654/L14/A2010/ROP

E654-18

$$t_{D\max} = \frac{4c_{opt}HA_{floor}(0.05P_a)}{\rho_{bulk}A_{dust}(P_{\max} + P_a)}$$

654/L19/A2010/ROP
E654-19

654- Log #15 **Final Action:**
(1.1.3)

Submitter: Peter Levitt, Sternvent Company, Inc.
Recommendation: Add new text as follows:
1.1.2 This standard shall apply to operations that occupy areas of more than 465m2 (5000 ft2) or where dust-producing equipment requires an aggregate dust collection flow rate of more than 2549 m3/hr (1500 ft3/min).
(Re-number existing 1.1.2 to 1.1.3)
Substantiation: There are many small companies that polish jewelry, dental labs that polish dental items, bakeries that mix flour, shipping departments that cut cardboard tubes, antique sellers who buff metal, etc. & have a small dust collector, typically 1500 cfm or less. Sternvent's experience is that, historically there have been few incidents of fires or explosions, in small dust collectors. Sternvent has been selling small dust collectors for over thirty years. If small dust collectors are "accidents waiting to happen", then Grainger, McMaster Carr & Sternvent would have stopped selling them years ago. Often the dust collector is located near the work area and not near an exterior wall & can not be located outdoors. The concept of exempting small dust collectors, from the standard, comes from my committee work on NFPA 664.
This is not original material; its reference/source is as follows:
NFPA 664-2007 1.1.2

654- Log #16 **Final Action:**
(4.5.4)

Submitter: Peter Levitt, Sternvent Company, Inc.

Recommendation: Revise text as follows:

4.5.4 Mitigation of Fire Spread and ~~Explosions~~ Deflagrations

Substantiation: I believe deflagration is the correct term. It needs to be changed in the text of this section & others in both the front & appendix.

NFPA 664 made a similar edit in recent years.

654- Log #17 **Final Action:**
(7.6.2)

Submitter: Peter Levitt, Sternvent Company, Inc.
Recommendation: Add new text as follows:
7.6.2 Ductwork shall be metallic. Non-conductive ducts, such as PVC pipes shall not be permitted.
(Re-number existing 7.6.2 to 7.6.3, 7.6.3 to 7.6.4, etc.)
Substantiation: Many people are not aware that ducts that convey combustible dust should be conducive. PVC is used because it is readily available & easy to install.
This is not original material; its reference/source is as follows:
NFPA 664, 8.2.2.2.1.1 and 8.2.2.2.1.2 have similar requirements

654- Log #18 **Final Action:**
(7.6.2)

Submitter: Peter Levitt, Sternvent Company, Inc.
Recommendation: Revise text as follows:
7.6.2 Flexible hose ~~and~~ connections shall be permitted to be used for material pickup and isolation. Hose length should be kept to a minimum. To prevent static electricity discharge, hose shall be static dissipative or duct before and after the hose shall be electrically bonded and have a resistance of 1 ohm or less.
Substantiation: “And” does not seem necessary.
Flexible hoses can be a source of ignition, especially fine powders with a low MIE. This is similar to the requirement for sight glasses in 7.7.7

654- Log #19 **Final Action:**
(7.13.1.1.2(3))

Submitter: Peter Levitt, Sternvent Company, Inc.
Recommendation: Revise text as follows:
~~(3) Air-material separators that have a volume of less than 8 ft3 (0.2 m3)~~
Substantiation: I believe this section serves no purpose.
8 cu ft = 2'X2'X2' I am not aware of any air-material separator (dust collector) that is this small. This is the size of a vacuum cleaner & covered in 8.2.3
Also, basing the exception on the physical size of the dust collector, instead of air flow (cfm) is unusual.

654- Log #20 **Final Action:**
(7.17.1)

Submitter: Peter Levitt, Sternvent Company, Inc.
Recommendation: Revise text as follows:
7.17.1 Mixers and blenders shall be airtight, with the exception of the fill area that shall have a suction hood or hinged cover with duct connection for an air-material separator to capture the nuisance & prevent it from forming a dust cloud.
Substantiation: Mixers & blenders can not be 100% airtight. The new text provides instructional information.

654- Log #21 **Final Action:**
(A.1.1)

Submitter: Peter Levitt, Sternvent Company, Inc.
Recommendation: Revise text as follows:

A.1.1 Examples of industries and materials, covered by this standard, that handle combustible particulate solids, either as a process material or as a fugitive or nuisance dust, include but are not limited to the following:

(1) ~~Agricultural~~, Chemicals ~~and food commodities~~, fibers and textile materials.
~~(2) Forest and furniture products industries~~
~~(3) Metals processing~~
(2) Paper products
(3) Pharmaceuticals
(4) Resource recovery operations (tires, municipal solid waste, metal, paper or plastic recycling operations)
(5) ~~Wood, metal or~~ Plastic fabricators

Substantiation: I have excluded materials that are covered by other NFPA standards, called out in 1.4.1.
The emphasis in A.1.1 should be on the materials, products or industries covered by 654.
Possibly the list can be improved by including other examples.

654- Log #22 **Final Action:**
(7.13.2.1.2)

Submitter: Robert L. Gravell, E. I. duPont de Nemours & Company, Inc.
Recommendation: Revise text as follows:

7.13.2.1.2 Filter media <u>and supporting frames</u> shall be permitted to be constructed of combustible material.

Substantiation: Induction charging of ungrounded conductive filter support cages can create a potential capacitive spark ignition source that has been shown to be the cause of dust explosions. The use of support cages fabricated from non-conductive material can be advantageous in preventing such a hazard. Based on current knowledge low level brush discharges from such a nonconductor will not pose an ignition hazard for a combustible dust cloud. Further, the advantage of using a non-conductive support cage outweighs the small additional fuel loading posed by such a structure in the event of an internal fire.

654- (9.7) Log #23 **Final Action:**

Submitter: Robert L. Gravell, E. I. duPont de Nemours & Company, Inc.

Recommendation: Revise text as follows:

9.7 The temperature of external surfaces, such as compressors; steam, water, or process piping; ducts; and process equipment in an area containing a combustible dust shall be maintained below ~~80 percent of~~ the minimum ignition temperature of the dust layer as determined by recognized test methods acceptable to the authority having jurisdiction ~~or 329° F (165° C), whichever is lower.~~ <u>For organic dusts which may dehydrate or carbonize the temperature shall not exceed the lower of the ignition temperature or 165° C.</u>

Substantiation: The suggested rewording is consistent with Section 500.8 (D)(2) of NFPA-70, “National Electrical Code,” 2008 edition, which states that when establishing maximum surface temperature for electrical equipment “The temperature marking specified in 500.8 (C) shall be less than the ignition temperature of the specific dust to be encountered. For organic dusts that may dehydrate or carbonize the temperature marking shall not exceed the lower of either the ignition temperature or 165° C.” The use of 165° C as an upper temperature limit is not justified in situations where carbonization is not an issue. It is suggested that the explanatory note for this section found in Annex A also be modified to be consistent with Section A.4.3.1.2 of NFPA-499, 2008 edition.

654- Log #24 **Final Action:**
(9.3.1.3)

Submitter: Robert L. Gravell, E. I. duPont de Nemours & Company, Inc.
Recommendation: Revise text as follows:
9.3.1.3 Bonding and grounding with a resistance of less than 1.0 x 10^6 ohms to ground shall be provided for conductive components; <u>however, resistance to ground in metal systems is typically less than 10 ohms and values well in excess of this may be indicative of problems such as loose or corroded grounding components</u>
Substantiation: While a resistance of less than 10^6 ohms is considered adequate for static charge dissipation the use of such a criterion for evaluating the adequacy of metal-to-ground connections can be misleading since the resistance of such grounds should be orders of magnitude below this value. The suggested rewording is consistent with sections 7.4.1.3 and 7.4.1.3.1 of NFPA-77, “Recommended Practice on Static Electricity,” 2007 edition

654- Log #25 Final Action:
(9.3.1, 9.3.1.1, and 9.3.1.2)

Submitter: Robert L. Gravell, E. I. duPont de Nemours & Company, Inc.
Recommendation: Revise text as follows:

9.3.1 Conductive Components

9.3.1.1 ~~All system components shall be conductive~~Non-conductive components having potential exposure to combustible dust clouds are permitted provided that the MIE of the dust being handled is >3 mJ; it must also be ensured that use of non-conductive components will not result in isolation of conductive components which could be exposed to combustible dust clouds

9.3.1.2 ~~Where the use of conductive components is not practical, nonconductive equipment shall be permitted shere one of the following criteria is met:~~

~~(1) A documented engineering analysis that is acceptable to the authority having jurisdiction has determined that no electrostatic ignition potential exists~~

~~(2) Materials being conveyed are not compatible with metal ductwork, and other means of explosion protection are provided in accordance with 7.1.2.1(1), 7.1.2.1(3), 7.1.2.1(4), or 7.1.2.1(5)~~

Due to the potential for propagating brush discharges non-conductive sheets, coatings, or layers must not be used in high surface charging processes such as pneumatic conveying unless the breakdown strength across such materials is less than 4 kV.

Substantiation: In the absence of high surface charging processes such as pneumatic conveying surface charge densities are limited to 27 microcolumbs per square meter on non-conductive surfaces in air and only corona and brush discharges are possible. According to Section 9.5.2 of NFPA-77, , "Recommended Practice on Static Electricity," 2007 edition "No evidence is available, however, that a corona discharge is capable of igniting a dust cloud. Likewise, no evidence is available that a brush discharge can ignite dusts with MIEs greater than 3 mJ, provided that no flammable gas or vapor is present in the dust cloud." Similarly Section 7.2.5.3 of CENELEC TR50404, , "Electrostatics—Code of Practice for the Avoidance of Hazards Due to Static Electricity," 2003 edition, states that "…In the absence of flammable atmospheres with MIE less than 3 mJ, brush and corona discharges may be tolerated." Special consideration must be given to situations in which high surface charging processes are present since these can result in creation of so-called "propagating brush discharges." In such cases only non-conductive components having breakdown voltages <4 kV should be used (ref. Section 10.1.4.6 of NFPA-77 and Section 7.2.5.3 of CENELEC TR50404)

654- Log #26 **Final Action:**
(9.3.2)

Submitter: Robert L. Gravell, E. I. duPont de Nemours & Company, Inc.
Recommendation: Revise text as follows:

9.3.2 ~~Where belt drives are used, the belts shall be electrically conductive and have a resistance of less than 1.0x106 ohms to ground~~ Significant electrostatic charging can occur during operation of conveyor belts used to transport materials or transmission belts used to drive rotating components. Belts used in Class II locations must meet the following requirements:

9.3.2.1 Conveyor belts operating at less than 5 m/s must have a surface resistivity less than 10^9 ohm/square on both surfaces or a resistance less than 10^9 ohms through the belt when measured at 20-25° C and 50% relative humidity; they must also be grounded by conductive pulleys. Guidelines provided in Section 9.3.2.2 must be followed where speed exceeds 5 m/s

9.3.2.2 Power transmission belts and high-speed conveyor belts must meet the following requirements:

1. Velocity not to exceed 30 m/s
2. Belt must meet the criterion that RxB < 10^5 ohm-m where R is the resistance measured at the inner side of the mounted transmission belt between an electrode halfway between the two pulleys and ground (ohms) and B is the width of a flat belt or twice the depth of the side face of a V belt (meters); alternatively resistance through the belt must be less than 10^9 ohms when measured at 20-25° C and 50% relative humidity
3. Belt must be grounded by conductive pulleys

Substantiation: The universal requirement for 'conductive belts' in any location where a combustible dust is handled is not justified. Per Section 10.4.1 of NFPA-77, "Recommended Practice on Static Electricity," 2007 edition, potential static charging on belts and conveyors should be addressed "…if a possibility exists that ignitable concentrations of flammable gases or vapors or combustible dusts or fibers might be present;" per NFPA-499 guidelines this means Class II locations. The changes suggested are consistent with guidelines presented in Section 10.4 of NFPA-77 and Section 4.5 of CENELEC TR50404, "Electrostatics—Code of Practice for the Avoidance of Hazards Due to Static Electricity," 2003 edition.

654- Log #27 **Final Action:**
(9.3.3.1(3))

Submitter: Robert L. Gravell, E. I. duPont de Nemours & Company, Inc.

Recommendation: Revise text as follows:

9.3.3.1(3) A Type C FIBC shall be permitted to be used for dispensing into any flammable vapor, gas, dust, or hybrid atmosphere for which the FIBC has been tested and found suitable, provided the FIBC is electrically grounded with a resistance of less than ~~1~~ 100 megaohms to ground.

Substantiation: A resistance of <100 megaohms to ground from any point on the surface of a Type C FIBC is considered sufficient for static charge dissipation per IEC 61340-4-4, “Electrostatics Part 4-4: Standard Test Methods for Specific Applications—Electrostatic Classification of Flexible Intermediate Bulk Containers (FIBC)” . This higher resistance is also consistent with requirements for personnel grounding via static dissipative footwear per ASTM F2413-05. It is also recommended that a reference to IEC 61340-4-4 be added to both Section A.9.3.3.1 of Annex A and to the references listed in Annex G.

654- Log #28 **Final Action:**
(Chapter 3 Various Definitions (New))

Submitter: Mark L. Holcomb, Kimberly-Clark Corporation
Recommendation: Add new text to read as follows:
Hazardous Dust Cloud – a dust cloud composed of a combustible dust suspended in air or other oxidizing medium that exceeds a concentration of 25% of the minimum explosive concentration (MEC).
Maximum Allowable Dust Accumulation – The amount of dust accumulation in a manufacturing environment that creates a fire or explosion hazard. Exceeding the maximum allowable dust accumulation level triggers cleaning as determined by section 6.2.3.2. The maximum allowable dust accumulation is determined by the characteristics of the dust, the size of the room, and the amount of the area within the room where dust accumulates.
Ignition sources and hot surfaces capable of igniting a dust cloud or dust layer – Ignition sources of sufficient energy to ignite a dust cloud (>75% of the MIE for the dust cloud or dust layer) or hot surfaces with temperatures hot enough to ignite a dust cloud or layer (>75% of the minimum ignition temperature of the dust cloud or dust layer).

Substantiation: The hazardous dust cloud, maximum allowable dust accumulation, and Ignition sources and hot surfaces concepts are referred to in the standard but are not defined.

654- Log #29 **Final Action:**
(6.2.3.2)

Submitter: Mark L. Holcomb, Kimberly-Clark Corporation
Recommendation: Add new text to read as follows:
The following equation is an alternative method for determining the maximum allowable dust accumulation for combustible dust density is less than 15 lbs/ft^3:

$$M_{dmax} = (0.031 * C_{opt} * 20,000 * H)/A_{dust}$$

Where:

- x_{disp} - fraction of accumulated dust that is actually suspended to form a dust cloud.
- F_{pv} - maximum allowable partial room volume fraction
- $x_{disp} F_{pv} = 15.5/ C_{opt} = 15.5/500 = 0.031$
- $M_{dmax,}$ g/m^2 is the maximum allowable mass accumulation over the dust collection surface area. Not to exceed 3.5 kg/m^2, regardless of the room dimensions and dust parameters.
- C_{opt} , g/m^3 is the dust concentration that produces the maximum pressure rise in the ASTM 1226 test. Default value is 500 g/m^3.
- H, meters is the room height in meters
- A_{dust} , ft^2 is the area of the surfaces where dust collects

Substantiation: Existing equations do not apply to combustible dusts with densities below 15 lb/ft^3. Determination of bulk density can be difficult to measure for some low-density materials that agglomerate when disturbed. This method relies instead on maximum mass accumulations. The method also factors in the optimum concentration which is an important parameter for determining the hazard a specific dust presents.

654- Log #30 Final Action:
(Chapter 8)

Submitter: Mark L. Holcomb, Kimberly-Clark Corporation
Recommendation: Add new text to read as follows:
Chapter 8 - Fugitive Dust Control and Housekeeping
8.1 – Fugitive Dust Control
8.1.1
Equipment and processes shall be designed, maintained and operated in a manner that minimizes the release of fugitive dust into the building environment.
8.1.2 – Control Equipment Design
Processes shall be designed to minimize or eliminate the release of combustible dust. Engineering controls shall be provided for processes where combustible dust is liberated during normal operation. Ventilation controls shall be designed in accordance with criteria specified in the current edition of the American Conference of Governmental Industrial Hygienists (ACGIH) Industrial Ventilation Manual. Dust collectors or other types of air material separators, including wet collectors, shall be used to collect dust. To the extent possible, dust collector designs shall eliminate explosion hazards by reducing dust concentrations inside collector housings below the MEC. Ducts used to convey air containing dust shall be designed to maintain air transport velocities that are high enough to prevent dust from accumulating inside ducts.
8.1.3 – Control Equipment Maintenance
Engineering controls shall be maintained to the original design specifications and the performance of these systems must be initially validated after installation and periodically validated thereafter. Written operating and maintenance procedures must be developed and maintained for all engineering controls and related equipment. The frequency and method used to validate system performance should be based manufactures recommendations, operating experience, and the severity of the consequence of system or individual component failure. Both real-time instrumentation and visual inspections should be considered. A corrective action system must be implemented that prioritizes corrective actions based on risk. The corrective action system must specify closure schedules and track closure status.
8.2 – House Keeping. All housekeeping requirements shall be applied retroactively.
8.2.1 – Control of Fugitive Dust Accumulations through building structure design and ventilation.
To the extent possible, overhead building structures, process and electrical equipment, lighting and other overhead surfaces should be configured to minimize or prevent the accumulation of fugitive dust. Active methods of reducing fugitive dust accumulations in overhead building surfaces, including high-velocity HVAC and fans mounted in the overheads may also be deployed where practical. Active control methods must be operated frequently enough to ensure that accumulated dust levels that are removed by these systems never exceed 50% of the maximum allowable dust accumulation.
8.2.2 – Housekeeping Frequency
The housekeeping frequency shall be established to ensure that the accumulated dust levels on walls, floors, and horizontal surfaces do not exceed the maximum allowable dust accumulation. A planned inspection process must be implemented to periodically evaluate dust accumulation rates and determine changes in the rate that change housekeeping frequency. Factors that should be considered in establishing the housekeeping frequency include:
· Variability of fugitive dust emissions.
· Impact of process changes and non-routine activities.
· Variability of accumulations on different surfaces within the room (walls, floors, overheads).
Un-scheduled housekeeping must be conducted to clean localized dust accumulations that exceed 1 kg/m^2 in any area greater than 200 square feet (19 square meters). These accumulations may result from spills, process leaks, and other process upsets. The un-scheduled housekeeping must be conducted within 24 hours.
8.2.3 – Housekeeping Methods
Combustible dust accumulations from surfaces shall be cleaned in a manner that minimizes the risk of generating a hazardous dust cloud. A written housekeeping procedure must be developed that addresses the following aspects:
1. A risk analysis that considers the specific characteristics of the dust being cleaned (particle size, moisture content, MEC, MIE) and other safety risks introduced by the cleaning methods used.
2. Personal Safety procedures and personal protective equipment (PPE)
3. Cleaning sequence.
4. Cleaning methods to be used.
5. Equipment, including lifts, vacuum systems, attachments, etc.

Compressed air must not be used to clean confined spaces, including vessels, process equipment or small rooms whose volume is less than 2000 ft^3 (57 m^3). Compressed air may be used to clean if the following conditions are met:

1. Vacuum cleaning or wet cleaning methods are used to clean surfaces that can be safely accessed prior to using compressed air.
2. Dust accumulations in the area being cleaned are less than 50% of the maximum allowable dust accumulation and no localized accumulations exceed 0.5 kg/m^2.
3. Compressed air use is limited to cleaning inaccessible surfaces or surfaces where other methods of cleaning result in a greater personal safety risk to those performing the cleaning.
4. The lowest air pressure that provides effective cleaning is used.
5. All electrical equipment potentially exposed to airborne dust in the area meets NEMA 12 (dust tight) requirements.
6. Ignition sources and hot surfaces capable of igniting a dust cloud or dust layer are shut down or removed from the area.

8.2.4 – Vacuum Cleaners

Central vacuum systems (fixed pipe suction system with remotely located exhauster and dust collector) shall be installed in conformance with Section 7.13.

Portable vacuum systems shall be certified by the manufacturer to meet the hazard classification of the area where they will be used (non-classified, class I, II, or III). Portable vacuum systems must be used in accordance with the manufacturers' requirements to ensure that the hazard classification is maintained.

Substantiation: Chapter 8, sections 8.1.1 and 8.1.2 need to be revised to align with accepted industrial hygiene control hierarchy and ventilation system design criteria.

Section 8.1.3: This change provides practical guidance for applying recognized ventilation system design and maintenance criteria.

Section 8.2.2 - The 200 sq ft area limit is identified in FM 7-76.

Section 8.2.3 – This section was revised to provide guidance for dust accumulations that result from spills or leaks.

Section 8.2.4 - All equipment used in hazardous locations must meet the hazard class of the location. There is no technical reason to require classified vacuums for combustible dust unless it is being used in a hazardous location. Vacuuming does not generate a hazardous dust cloud in the room environment

654- (9.8) Log #31 **Final Action:**

Submitter: Brice Chastain, Georgia-Pacific

Recommendation: Revise text to read as follows:

9.8 Industrial Trucks. In areas ~~containing a combustible dust~~ <u>where a deflagration hazard exists</u>, only industrial trucks listed or approved for the electrical classification of the area, as determined by Section 6.6, <u>where commercially available</u>, shall be used in accordance with NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations*.

Substantiation: Diesel-powered front-end loaders suitable for use in hazardous locations have not been commercially available. See exact text contained in NFPA 664, paragraph A.7.5 addressing provisions to reduce the fire hazard from diesel-powered front-end loaders used in Class II hazardous areas as defined in Article 500 of NFPA 70. Recommend Annex material associated with paragraph 9.8 include these provisions.

This is not original material; its reference/source is as follows:

NFPA 664, Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities, 2007 Edition.

654- Log #32 **Final Action:**
(6.2.3)

Submitter: Brice Chastain, Georgia-Pacific
Recommendation: Revise text to read as follows:
This proposal is directed to paragraph 6.2.3.2 dust accumulations-bulk density equation. The present equation does not address accumulations allowed for tall buildings (e.g. 70 feet in height). Bob Zalosh equation does include building height.
Substantiation: There is no technical requirement to use Class II vacuum cleaners in an area not electrically classified as a Class II, Division 1, Group locations as defined in Article 502 of NFPA 70, National Electric Code.

654- Log #33 **Final Action:**
(6.2.3)

Submitter: Brice Chastain, Georgia-Pacific
Recommendation: Revise text to read as follows:
New paragraph 6.2.3.3 An alternative method to 6.2.3.2 for determining allowable thickness that addresses large, tall buildings is provided in the following equation.

$$M_{dmax} = (0.031 * C_{opt} * 20,000 * H)/A_{dust}$$

Where:

- x_{disp} - fraction of accumulated dust that is actually suspended to form a dust cloud.
- F_{pv} - maximum allowable partial room volume fraction
- $x_{disp} F_{pv} = 15.5/C_{opt} = 15.5/500 = 0.031$
- M_{dmax}, g/m^2 is the maximum allowable mass accumulation over the dust collection surface area. Not to exceed 3.5 kg/m^2, regardless of the room dimensions and dust parameters.
- C_{opt}, g/m^3 is the dust concentration that produces the maximum pressure rise in the ASTM 1226 test. Default value is 500 g/m^3.
- H, meters is the room height in meters

A_{dust}, ft^2 is the area of the surfaces where dust collects

Substantiation: Present paragraph 6.2.3.2 does not address building height (e.g. 70 feet in height) or large buildings (110 ft width x 340 ft long) in determination of allowable dust accumulation thickness. Suggest an alternative equation developed by Bob Zalosh be considered in addition to the bulk density equation present.

*****Additionally, the present 6.2.3.2 equation or the proposed alternative equation above does not addresses dust "dispersibility" or dust cohesiveness. This factor should also be addressed and included in the revised 654 standard for determining allowable dust accumulation thickness due to some dust propensity to clump together and not disperse easily into individual particles as compared to other dusts. (e.g. tissue paper dusts compared to wood flour or starch; tissue dust is not as easily dispersed into suspension as is wood flour or starch due to its cohesiveness. Tissue dust tends to clump together when suspended or lifted off a horizontal surface; wood flour and starch separates into thousands of discrete particles).

This is not original material; its reference/source is as follows:
Settlement agreement by OSHA and competitor Paper Industry corporation in establishing paper accumulation allowance in a paper converting facility.

654- Log #34 **Final Action:**
(7.1.4)

Submitter: Erdem A. Ural, Loss Prevention Science & Technologies, Inc.
Recommendation: Revise text to read as follows:

7.1.4.2 Isolation devices shall include, but shall not be limited to, the following:

(1)*Chokes

(2)*Rotary valves <u>in accordance with NFPA 69, Standard on Explosion Prevention Systems</u>

(3)*Automatic fast-acting valve systems in accordance with NFPA 69, Standard on Explosion Prevention Systems

~~(4)*Flame front diverters in accordance with NFPA 69, Standard on Explosion Prevention Systems~~

(5)*Chemical isolation systems in accordance with NFPA 69, Standard on Explosion Prevention Systems

A.7.1.4.2(4) Figure A.7.1.4.2(4) illustrates an example of deflagration propagation using flame front diversion. <u>This device provides relief against pressure build-up, but does not count as an explosion isolation device.</u>

7.1.4.3 Isolation devices shall not be required when oxidant concentration <u>in pieces of equipment and connecting ductwork</u> has been reduced <u>below the inerting concentration</u> or when the dust has been rendered noncombustible in accordance with 7.1.2.1(1) or 7.1.2.1(5).

Substantiation: * New edition of NFPA 69 provides a greatly expanded section on isolation devices

* New edition of NFPA 69 specifies requirements for rotary valves being used as isolation devices

* NFPA 69 precludes use of flame front diverters as explosion isolation devices.

654- Log #35 **Final Action:**
(4.2 and 8.2.1.2)

Submitter: Erdem A. Ural, Loss Prevention Science & Technologies, Inc.

Recommendation: Revise text to read as follows:

4.2 Process Hazard Analysis.

4.2.1* The design of the fire and explosion safety provisions shall be based on a process hazard analysis of the facility, the process, and the associated fire or explosion hazards.

4.2.2 The results of the process hazard analysis shall be documented and maintained for the life of the process.

4.2.3 If the process, equipment, or the operation does not permit elimination of dust deposits at all times, then the process hazard analysis shall specify and document maximum allowable layer thickness (or area density), maximum allowable deposit surface area, and minimum PPE requirements

4.2.4 It shall be permitted to use the partial volume deflagration analysis method described in NFPA 68 to satisfy the requirements of Section 4.2.3(NEW) for enclosure or building heights of up to 30 ft (BLDG HEIGHT SUBJECT TO COMMITTEE CONSENSUS).

4.2.5 ~~4.2.3~~ The process hazard analysis shall be reviewed and updated at least every 5 years.

8.2.1.2 Regular cleaning frequencies shall be established for walls, floors, and horizontal surfaces, such as equipment, ducts, pipes, hoods, ledges, beams, and above suspended ceilings and other concealed surfaces, to ensure ~~minimize~~ dust accumulations never exceed the maximum quantities specified in process hazard analysis (see Section 4.2.3(NEW)) ~~within operating areas of the facility.~~

Substantiation: Note: Supporting material is available for review at NFPA Headquarters.

654- Log #36 **Final Action:**
(7.1.4)

Submitter: Erdem A. Ural, Loss Prevention Science & Technologies, Inc.

Recommendation: Insert the following new text before current section 7.1.4.3, renumber current 7.1.4.3 and 7.1.4.4 accordingly:

7.1.4.3 (NEW) Active (as opposed to passive) explosion isolation system design package shall specify the data or correlation used to determine the maximum speed the explosion flame front travels from the point of detection to the isolation device.

7.1.4.4 (NEW) The equation proposed in section 3.1.15 of Reference G.1.2.5 (FMGR Publication 7-76 dated May 2008) shall not be used for active isolation system design.

7.1.4.5 (NEW) Active explosion isolation system design package shall also specify the maximum time required for deflagration detection and that for the full operation of the isolation device.

Substantiation: These are key parameters which decide the success or failure of active isolation devices.

If permitted to be used, the equation proposed in FMDS 7-76 will result in unsafe active isolation system designs.

Note: Supporting material is available for review at NFPA Headquarters.

654- Log #37 **Final Action:**
(A.6.6.2)

Submitter: Erdem A. Ural, Loss Prevention Science & Technologies, Inc.
Recommendation: Revise Table A.6.6.2 to account for the MIE, LAYER AIT, CLOUD AIT, AND DUST RESISTIVITY.
Substantiation: Subject table is too conservative for some dusts and not nearly conservative enough for others.

654- Log #38 **Final Action:**
(10.2)

Submitter: Thomas C. Scherpa, E. I. DuPont de Nemours & Company

Recommendation: Revise text to read as follows:

10.2 System Requirements.

Fire protection systems required by this standard shall comply with 10.2.1 <u>through</u>~~and~~ 10.2.9.

10.2.1* Fire-extinguishing agents shall be compatible with the conveyed materials.

10.2.2 Where fire detection systems are incorporated into pneumatic conveying systems, an analysis shall be conducted to identify safe interlocking requirements for air-moving devices and process operations.

<u>10.2.3 Where firefighting water or wet product can accumulate in the system, vessel and pipe supports shall be designed to support the additional water weight.</u>

Substantiation: Large amounts of firefighting water can be used in extinguishing activities, both from fixed suppression systems and from manual application of hose streams. Wet product can plug vessel outlets, allowing the water to accumulate in the system. Vessel and pipe supports should be designed to withstand the additional gravity load to prevent structural collapse. Collapsing equipment could endanger emergency response crews.

654- Log #39 **Final Action:**
(7.1.2)

Submitter: Thomas C. Scherpa, E. I. DuPont de Nemours & Company
Recommendation: Revise text to read as follows:
7.1.2 Explosion Protection for Equipment.
7.1.2.1 The design of explosion protection for equipment shall incorporate one or more of the following methods of protection:
(1) Oxidant concentration reduction in accordance with NFPA 69, Standard on Explosion Prevention Systems
(a) Where oxygen monitoring is used, it shall be installed in accordance with ISA 84.00.01, Functional Safety: Application of Safety Instrumented Systems for the Process Industry Sector.
(b)* Where the chemical properties of the material being conveyed require a minimum concentration of oxygen to control pyrophoricity, that level of concentration shall be maintained.
(2)* Deflagration venting <u>in accordance with NFPA 68, Standard on Explosion Protection by Deflagration Venting</u>
(3) Deflagration pressure containment in accordance with NFPA 69, Standard on Explosion Prevention Systems
(4) Deflagration suppression systems in accordance with NFPA 69, Standard on Explosion Prevention Systems
(5)* Dilution with a noncombustible dust to render the mixture noncombustible (See 7.1.2.2.)
(6)* Deflagration venting through a listed dust retention and flame-arresting device
7.1.2.2 If the method in 7.1.2.1(5) is used, test data for specific dust and diluent combinations shall be provided and shall be acceptable to the authority having jurisdiction.
<u>7.1.2.3* A risk evaluation in accordance with 7.1.1 shall be permitted to determine the appropriate level of protection. This evaluation may supersede the requirements of 7.1.2.1.</u>

Substantiation: Several sections in this chapter reference section 7.1.2 for protection requirements, yet in the current edition the provision for a risk evaluation is not explicitly included in section 7.1.2. This revision adds a reference to the risk evaluation statement into 7.1.2, so that it is incorporated by reference in other sections in this chapter.
Also, NFPA 68 has become a standard and so it can now be referenced directly from the body of the document rather than in the appendix.

654- Log #40 **Final Action:**
(7.1.4.4)

Submitter: Thomas C. Scherpa, E. I. DuPont de Nemours & Company
Recommendation: Revise text to read as follows:
7.1.4.4 Isolation devices shall not be required if a documented risk evaluation that is acceptable to the authority having jurisdiction determines that the risk from deflagration propagation is acceptable. ~~deflagration propagation will not occur.~~
Substantiation: The purpose of a risk assessment is not to determine that an event will not occur; rather, the purpose is to determine the appropriate controls necessary to reduce the risk to an acceptable value.

654- Log #41 **Final Action:**
(7.1.4)

Submitter: Thomas C. Scherpa, E. I. DuPont de Nemours & Company
Recommendation: Add new text to read as follows:
7.1.4.1 Where an explosion hazard exists, isolation devices shall be provided to prevent deflagration propagation between pieces of equipment connected by ductwork.
7.1.4.2 The requirement of 7.1.4.1 shall not apply where all of the following conditions are met:
(1) The material being conveyed is not a metal dust or hybrid mixture
(2) The connecting ductwork is smaller than 4 inches in diameter
(3) The maximum concentration of dust conveyed through the duct is less than 25% of the MEC of the material
(4) The conveying velocity is high enough to prevent accumulation of combustible dust in any portion of the duct
(5) All connected equipment is properly designed for explosion protection.
Substantiation: The current requirement applies to all connecting ductwork regardless of size. The AIChE CCPS Guidelines for Safe Handling of Powders and Bulk Solids states that the probability of propagation is low if the first three criteria above are met. The fourth criteria is supported by text in the FM Global datasheet FM 7-76. The fifth criteria is supported by the current Appendix E.3.1
By adding this exemption, users would be able to exclude some ductwork from the isolation requirement without requiring the risk assessment per section 7.1.4.4

654- Log #42 Final Action:
(7.1.5.3)

Submitter: Thomas C. Scherpa, E. I. DuPont de Nemours & Company
Recommendation: Revise text to read as follows:
7.1.5.3 Isolation devices shall not be required if a documented risk evaluation that is acceptable to the authority having jurisdiction determines that the risk from deflagration propagation is acceptable. ~~deflagration propagation will not occur.~~
A.7.1.5.3 Several common design factors can reduce the risk of explosion propagation, such as:
(1) The material being conveyed is not a metal dust or hybrid mixture
(2) The connecting ductwork is smaller than 4 inches in diameter
(3) The maximum concentration of dust conveyed through the duct is less than 25% of the MEC of the material
(4) The conveying velocity is high enough to prevent accumulation of combustible dust in any portion of the duct
(5) The air-material separator is properly designed for explosion protection by means other than explosion containment
(6) The upstream work areas do not contain large quantities of dust that can be entrained by a pressure pulse from an explosion in the dust collector.
Substantiation: The purpose of a risk assessment is not to determine that an event will not occur; rather, the purpose is to determine the appropriate controls necessary to reduce the risk to an acceptable value.
The proposed appendix material gives examples of some conditions that can yield a low probability of explosion propagation. The AIChE CCPS "Guidelines for Safe Handling of Powders and Bulk Solids" states that the probability of propagation is low if the first three criteria above are met. The fourth criteria is supported by text in the FM Global datasheet FM 7-76. The fifth criteria is supported by the current Appendix E.3.1. The sixth criteria highlights the increased risk of secondary explosions in and around work areas where significant quantities of entrainable dust are present.

654- Log #43 Final Action:
(7.2.3)

Submitter: Thomas C. Scherpa, E. I. DuPont de Nemours & Company

Recommendation: Revise text to read as follows:

7.2.3 Explosion Hazards.

7.2.3.1 Where an explosion hazard exists, intertank or interbin venting shall not be permitted.

~~7.2.3.2 Fixed Bulk Storage Location.~~

~~7.2.3.2.1 Where an explosion hazard exists, fixed bulk storage containers shall be located outside of buildings.~~

~~7.2.3.2.2 Fixed bulk storage containers shall be permitted to be located inside of buildings where one of the following applies:~~

~~(1) Fixed bulk storage containers are protected in accordance with 7.1.2.1(1), 7.1.2.1(3), 7.1.2.1(4), 7.1.2.1(5), or 7.1.2.1(6).~~

~~(2)* Fixed bulk storage containers meet all of the following criteria:~~

~~(a) They are equipped with deflagration vents that are vented through ducts to the outside.~~

~~(b) The reduced venting efficiency due to the duct has been taken into account.~~

~~(c) The ducts are designed to withstand the effects of the deflagration.~~

~~(3)* Fixed bulk storage containers are 8 ft3 (0.2 m3) or less.~~

7.2.3.3 Fixed Bulk Storage Protection.

7.2.3.3.1 Where an explosion hazard exists, fixed bulk storage containers shall be protected in accordance with 7.1.2.

~~7.2.3.3.2 For fixed bulk storage containers that are located outside of buildings, a risk evaluation shall be permitted to be conducted to determine the level of explosion protection to be provided.~~

7.2.3.3.3* The explosion protection requirements of 7.1.2 shall not be required provided that the volume of the fixed bulk storage container is less than 8 ft3 (0.2 m3).

7.2.3.3.4 The requirements of 7.2.3.3 shall not apply to storage and receiving containers that are used for transportation of the material.

Substantiation: The deleted text in this section will not be necessary if NFPA 68 is included by reference in section 7.1.2.1(2). In the current edition, NFPA 68 is included in the appendix because it was a guideline document at the time the current edition was written. Now that it is a standard, it can be referenced in the body of the text. NFPA 68 provides requirements for vent ducts, and so it would be redundant to provide those requirements here. By removing the vent duct requirements from the current 7.2.3.2.2, the requirements in this section would become identical to section 7.1.2 and so the entire section 7.2.3.2 can be deleted.

If a new risk evaluation statement is added to 7.1.2 (per a separate proposal), then it would be incorporated by reference and therefore section 7.2.3.3.2 would become redundant.

654- Log #44 Final Action:
(7.3.3)

Submitter: Thomas C. Scherpa, E. I. DuPont de Nemours & Company

Recommendation: Revise text to read as follows:

7.3.3 Operations

7.3.3.1 Sequence of Operation. Pneumatic conveying systems shall be designed with the operating logic, sequencing, and timing outlined in 7.3.3.2 and 7.3.3.3.

7.3.3.2* Startup. Pneumatic conveying systems shall be designed such that, on startup, the system achieves and maintains design air velocity prior to the admission of material to the system.

7.3.3.3 Shutdown.

7.3.3.3.1 Pneumatic conveying systems shall be designed such that, on normal shutdown of the process, the system maintains design air velocity until material is purged from the system.

7.3.3.3.2 The requirements of 7.3.3.3.1 shall not apply during emergency shutdown of the process, such as by activation of an emergency stop button or by activation of an automatic safety interlocking device. The system shall be designed such that, upon restart after an emergency shutdown, residual materials can be cleared and design air velocity can be achieved prior to admission of new material to the system.

Substantiation: Depending on the reason for activation of an emergency shutdown device, maintaining design air velocity could potentially cause or contribute to a hazard. For example, in the event of a fire in or around the pneumatic conveying system, all material movement should be stopped immediately so as to avoid introducing more fuel into the area of the fire.

654- Log #45 **Final Action:**
(7.4)

Submitter: Thomas C. Scherpa, E. I. DuPont de Nemours & Company
Recommendation: Add new text to read as follows:
7.4.1 General. This section shall apply to facilities that operate pneumatic conveying systems for metal particulates.
7.4.2 Systems handling metal particulates shall be designed in accordance with NFPA 484, Standard for Combustible Metals, and the requirements of this section.
Substantiation: NFPA 484 provides additional requirements for systems handling metal particulates which should be included by reference.
This proposal would require renumbering of the subsequent sections in 7.4 and updates to any references in the remainder of the document.

654- Log #46 **Final Action:**
(7.10.1)

Submitter: Thomas C. Scherpa, E. I. DuPont de Nemours & Company
Recommendation: Revise text to read as follows:
7.10.1* Deflagration Venting.
7.10.1.1 Where an explosion hazard exists, bucket elevators shall be protected in accordance with 7.1.2. ~~provided with deflagration venting.~~
~~7.10.1.2 When bucket elevators are located inside the building, deflagration vents shall be ducted to the outside.~~
~~7.10.1.3 As an alternative to deflagration venting, bucket elevators shall be permitted to be protected in accordance with 7.1.2.1(1), 7.1.2.1(3), 7.1.2.1(4), 7.1.2.1(5), 7.1.2.1(6), or 7.1.4.2(5).~~
Substantiation: The deleted text in this section will not be necessary if NFPA 68 is included by reference in section 7.1.2.1(2). In the current edition, NFPA 68 is included in the appendix because it was a guideline document at the time the current edition was written. Now that it is a standard, it can be referenced in the body of the text. NFPA 68 provides requirements for vent ducts, and so it would be redundant to provide those requirements here. By removing the vent duct requirements from 7.10.1.2, the requirements in this section would become identical to section 7.1.2.

654- Log #47 **Final Action:**
(7.13.1)

Submitter: Thomas C. Scherpa, E. I. DuPont de Nemours & Company
Recommendation: Revise text to read as follows:

7.13.1 General.

~~7.13.1.1 Location.~~

~~7.13.1.1.1 Where an explosion hazard exists, air–material separators shall be located outside of buildings.~~

~~7.13.1.1.2* The requirement of 7.13.1.1.1 shall not apply to the following:~~

~~(1) Air–material separators that are protected in accordance with 7.1.2.1(1), 7.1.2.1(3), 7.1.2.1(4), 7.1.2.1(5), or 7.1.2.1(6)~~

~~(2) Air–material separators that meet all of the following criteria:~~

~~(a) They are equipped with deflagration vents that are vented through ducts to the outside.~~

~~(b) The reduced venting efficiency due to the duct has been taken into account.~~

~~(c) The ducts are designed to withstand the effects of the deflagration.~~

~~(3) Air–material separators that have a volume of less than 8 ft3 (0.2 m3)~~

7.13.1.2 Where both an explosion hazard and a fire hazard exist in an air–material separator, provisions for protection for each type of hazard shall be provided.

7.13.1.3 Protection.

7.13.1.3.1 Where an explosion hazard exists, a~~A~~ir–material separators shall be protected in accordance with 7.1.2.

~~7.13.1.3.2 For air–material separators that are located outside of buildings, a risk evaluation shall be permitted to be conducted to determine the level of explosion protection to be provided.~~

Substantiation: The deleted text in this section will not be necessary if NFPA 68 is included by reference in section 7.1.2.1(2). In the current edition, NFPA 68 is included in the appendix because it was a guideline document at the time the current edition was written. Now that it is a standard, it can be referenced in the body of the text. NFPA 68 provides requirements for vent ducts, and so it would be redundant to provide those requirements here. By removing the vent duct requirements from 7.13.1.1.2, the requirements in this section would become identical to section 7.1.2.

If a new risk evaluation statement is added to 7.1.2 (per a separate proposal), then it would be incorporated by reference and therefore section 7.2.3.3.2 would become redundant.

654- Log #48 **Final Action:**
(8.2.3.1)

Submitter: Thomas C. Scherpa, E. I. DuPont de Nemours & Company
Recommendation: Revise text to read as follows:
8.2.3 Vacuum Cleaners.
8.2.3.1 Portable vacuum cleaners used with combustible dusts shall meet the following minimum requirements:
(1) All metal components, including wands, attachments, and hose reinforcing wires, shall be bonded and grounded
(2) Dust-laden air shall not pass over the fan or motor
(3) When liquids or wet material are picked up by the vacuum cleaner, paper filter elements shall not be used
A8.2.3(3) Liquids or wet material can weaken paper filter elements causing them to fail, which can allow combustible dust to reach the fan and motor.
(4) Vacuum cleaners used for metal dusts shall meet the requirements of NFPA 484, Standard for Combustible Metals
(5) General purpose vacuum cleaners shall not be used to pick up bulk quantities of combustible dust
A8.2.3(5) If a large quantity of material is spilled in an unclassified area, the bulk material should be collected by sweeping, shoveling, or with a Class II listed vacuum cleaner. General purpose vacuum cleaners can be used to clean up residual material after the bulk of the spill has been collected.
8.2.3.21 When used in Class II areas as determined in accordance with 6.6.2, Vvacuum cleaners shall be listed for use in Class II hazardous locations or shall be a fixed-pipe suction system with remotely located exhauster and dust collector installed in conformance with Section 7.13.
8.2.3.32 Where flammable vapors or gases are present in hazardous concentrations, vacuum cleaners shall be listed for Class I ~~and Class II~~ hazardous locations in addition to meeting the requirements in 8.2.3.1 or 8.2.3.2.
Substantiation: The current wording requires the use of Class II vacuum cleaners in all areas, including general purpose areas with low quantities of combustible dust. This requirement presents an undue burden on users, and may cause some users to resort to other means of housekeeping that are more hazardous (such as compressed air blowdowns).
While vacuum cleaners can present a potential ignition source, and a combustible dust cloud may be present in the collection drum, the proposed minimum requirements stated in this proposal should minimize the risk of ignition of a dust cloud.

654- Log #49 **Final Action:**
(7.14.1.4)

Submitter: Tony L. Thomas, Flamex, Inc.
Recommendation: Add new text to read as follows:
The abort gate should be a high speed device with a reaction time of less than one second.
Substantiation: We occasionally see motorized dampers used as abort dampers on return air ducts. The reaction time of a motorized damper may be in excess of five seconds. A significant amount of burning material may be blown into the building before the damper fully diverts.

654- Log #50 **Final Action:**
(7.14.2.1)

Submitter: Tony L. Thomas, Flamex, Inc.
Recommendation: Revise text to read as follows:
The abort gate or abort damper shall be installed downstream of the air-moving device so that it diverts airflow to a restricted area to safely discharge combustion gases, flames, burning solids or process gases or fumes.
Substantiation: If the abort damper is installed upstream of the air-moving device it is impossible to discharge the burning material from the duct. It is the air-moving device that "blows" the burning material from the duct to a safe area.

654- Log #51 **Final Action:**
(7.14.2.2.3)

Submitter: Tony L. Thomas, Flamex, Inc.
Recommendation: Add new text to read as follows:
A powered reset is acceptable if it can only be activated manually at the damper.
Substantiation: We have seen confusion in the past of what a manual reset actually is. Large abort dampers are very heavy, and a powered reset makes it much easier to reset the damper.

654- Log #52 **Final Action:**
(10.2.9.3)

Submitter: Tony L. Thomas, Flamex, Inc.
Recommendation: Add new text to read as follows:
The requirements of 10.2.9.1 shall not apply when the abort damper circuit and releasing device are fail-safe and the damper automatically diverts airflow upon a failure of the releasing device or circuit.
Substantiation: A typical abort gate has an electromagnet as the releasing device. When the releasing circuit opens, the electromagnet loses power and the damper falls into the divert position. One or more 110 VDC magnets are used because there would be additional power supply considerations if low voltage devices were used.

654- Log #53 **Final Action:**
(Figure C.2.1)

Submitter: Tony L. Thomas, Flamex, Inc.
Recommendation: Revise Figure C.2.1 as follows:
Move location of spark detectors from outlet of air-material separator to inlet of air-material separator.
Substantiation: C.2.2 states that "the detectors are usually situated on the inlet to the collector as shown in Figure C.2.1". However, the detectors are shown on the outlet of the collector.

654- Log #54 **Final Action:**
(Figure C.2.1 and C.2.2)

Submitter: Tony L. Thomas, Flamex, Inc.
Recommendation: Revise text to read as follows:
The detectors are usually located on the inlet <u>and outlet</u> of the collector.
Substantiation: We believe that the highest level of protection would be achieved with an additional detection location on the outlet of the air-material separator. We have seen dust collector fires and deflagrations in the past that were not caused by a spark entering the dust collector through the inlet duct.

654- Log #55 Final Action:
(9.3.5 (New))

Submitter: Albert I. Ness, Rohm and Haas Company
Recommendation: Add new text to read as follows:
9.3.5 Manual additions of solids through an open port or a manway into a vessel containing flammable vapors shall be permitted to be done in 50 lb (25 kg) batches or smaller.
9.3.5.1 The bags shall be constructed of paper, plies of paper and plastic in which the nonconductive plastic film is covered by paper on both sides, or antistatic plastic.
9.3.5.1.1 Direct emptying of powders from nonconductive plastic bags into a vessel that contains a flammable atmosphere shall be strictly prohibited.
9.3.5.1.2 Powder shall not be emptied from a nonconductive container in the presence of a flammable atmosphere.
9.3.5.1.3 Fiber drums or packages shall not have a loose plastic liner that can leave the package and behave like a plastic bag.
9.3.5.1.4 Metal chimes shall be grounded.
9.3.5.2 Personnel in the vicinity of openings of vessels that contain flammable liquids should be grounded, and special attention shall be paid to housekeeping, because accumulation of nonconductive residues (e.g., resins) on the floor or on items such as grounding clips can impair electrical continuity.
9.3.5.3 Bulk quantities shall be permitted to be charged in 50 lb (25 kg) batches with a ½ minute interval between charges.

Substantiation: The current requirements in NFPA 654 for manual addition of solids into a vessel containing flammable vapors is insufficient. This is a hazardous operation and the requirements are not sufficiently protective. They are less than the guidance in NFPA 77 Recommended Practice on Static Electricity. This proposal adds the advice from NFPA 77 as requirements as well as an open literature source, referenced below.
This is not original material; its reference/source is as follows:
NFPA 77, Recommended Practice on Static Electricity Section 9.11. Static Electricity: Rules for Plant Safety, Expert Commission for Safety in the Swiss Chemical Industry (ESCIS), SUVA, Flu hmattstrasse 1, CH6002, Switzerland, Plant/Operations Progress, Vol. 7, No. 1, January, 1988, pp. 1-22.

654- Log #56 Final Action:
(6.2.3.1 and 6.2.3.2)

Submitter: Robert G. Zalosh, Firexplo
Recommendation: Replace current 6.2.3.1 and 6.2.3.2 with wording in the following:
6.2.3.1 When the separate area is normally unoccupied and is enclosed by physical barriers per 6.2.2.2, the allowable total accumulated combustible dust mass in the enclosure, m_{Dmax} (in grams), is given by

Insert Equation E654-4 Here

where
c_{opt} is the optimum dust concentration (g/m^3) at which the maximum rate-of-pressure-rise results in tests conducted per ASTM E1226,
P_{red} is the allowable pressure (bar g) developed during a deflagration per NFPA 68 (normally equal to 2/3rd the enclosure strength),
P_{max} is the maximum pressure (bar g) developed in ASTM E1226 tests with the accumulated dust sample,
A_{floor} is the enclosure floor area (m^2), and H is the enclosure ceiling height (m).

6.2.3.2 When the separate area is normally occupied, m_{Dmax} is given by

Insert Equation E654-5 Here

where P_a is the atmospheric pressure in bar.
6.2.3.3 When the total amount of dust in the room, m_{Dmax}, cannot be reliably estimated but representative accumulated dust samples can be collected from measured areas and then weighed to obtain the dust surface mass density m_D" = $m_{Dsample}/A_{Dsample}$, the maximum allowable value of m_D" in g/m^2 is given by

Insert Equation E654-6 Here

where

m_{Dmax} is obtained from the equations in either 6.2.3.1 for unoccupied enclosures or 6.2.3.2 for occupied areas,
A_{Dust} is the estimated total surface area (m^2) in the enclosure on which dust has accumulated,
$m_{Dsample}$ is the average measured mass (g) of the collected samples, and $A_{Dsample}$ is the average surface area (m^2) from which the samples were collected.
6.2.3.4 When representative dust samples cannot reliably be collected and weighed, but the dust bulk density is known and reliable measurements of dust layer thickness can be made, the maximum allowable dust layer thickness, t_{Dmax} (mm), can be calculated from

Insert Equation E654-7 Here

where ρ_{bulk} is the bulk density in g/m^3, and m"$_{Dmax}$ is obtained from 6.2.3.3
Substantiation: The current requirements to limit combustible dust layer thicknesses to 0.8 mm for bulk densities of 1200 kg/m3 or greater, and to allow larger thicknesses for lighter dusts by the ratio of 75 lb/ft3 to the actual dust bulk density in lb/ft3, is difficult to implement because of highly non-uniform dust layers and difficulty in accurate measurements of layer thickness. Furthermore, it does not account for the explosibility properties of the combustible dust.
The proposed revision provides a way to estimate the total allowable accumulated mass of dust based either on the maximum allowable pressure developed in an unoccupied enclosure or the maximum allowable flame volume for a deflagration or flash fire in an unoccupied area. The basis and derivation of the equations can be shown in a revised Appendix D. For now, the key assumptions are that 25% of the accumulated dust gets disperse as a dust cloud of optimal concentration, and that the allowable flame volume after accounting for expansion due to burning, is about 5%

of the room volume.

NFPA Technical Committee Document Proposal Form

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Date 12/1/2008 **Name** Robert Zalosh **Tel. No.** 781-237-3430

Company Firexplo **Email** bob@firexplo.com

Street Address 20 Rockland St. **City** Wellesley **State** MA **Zip** 02481

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1. (a) NFPA Document Title Prevention of Fire and Dust Explosions … **NFPA No. & Year** 654 - 2006

(**b) Section/Paragraph**

2. Proposal Recommends (check one): ☐ new text **X** revised text ☐ deleted text

3. Proposal (include proposed new or revised wording, or identification of wording to be deleted): [Note: Proposed text should be in legislative format; i.e., use underscore to denote wording to be inserted (<u>inserted wording</u>) and strike-through to denote wording to be deleted (~~deleted wording~~).]

Replace current 6.2.3.1 and 6.2.3.2 with wording in Attachment 1.

4. Statement of Problem and Substantiation for Proposal: (Note: State the problem that would be resolved by your recommendation; give the specific reason for your Proposal, including copies of tests, research papers, fire experience, etc. If more than 200 words, it may be abstracted for publication.)

The current requirements to limit combustible dust layer thicknesses to 0.8 mm for bulk densities of 1200 kg/m^3 or greater, and to allow larger thicknesses for lighter dusts by the ratio of 75 lb/ft^3 to the actual dust bulk density in lb/ft^3, is difficult to implement because of highly non-uniform dust layers and difficulty in accurate measurements of layer thickness. Furthermore, it does not account for the explosibility properties of the combustible dust.

The proposed revision provides a way to estimate the total allowable accumulated mass of dust based either on the maximum allowable pressure developed in an unoccupied enclosure or the maximum allowable flame volume for a deflagration or flash fire in an unoccupied area. The basis and derivation of the equations can be shown in a revised Appendix D. For now, the key assumptions are that 25% of the accumulated dust gets disperse as a dust cloud of optimal concentration, and that the allowable flame volume after accounting for expansion due to burning, is about 5% of the room volume.

5. Copyright Assignment

(a) x

I am the author of the text or other material (such as illustrations, graphs) proposed in this Proposal.

(b) ☐ **Some or all of the text or other material proposed in this Proposal was not authored by me. Its source is as follows** (please identify which material and provide complete information on its source)**:**

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12/1/2008

Attachment 1

6.2.3.1 When the separate area is normally unoccupied and is enclosed by physical barriers per 6.2.2.2, the allowable total accumulated combustible dust mass in the enclosure, m_{Dmax} (in grams), is given by

$$m_{D\max} = \frac{4c_{opt}\, P_{red}\, A_{floor}\, H}{P_{\max}}$$

where
c_{opt} is the optimum dust concentration (g/m^3) at which the maximum rate-of-pressure-rise results in tests conducted per ASTM E1226,
P_{red} is the allowable pressure (bar g) developed during a deflagration per NFPA 68 (normally equal to 2/3rd the enclosure strength),
P_{max} is the maximum pressure (bar g) developed in ASTM E1226 tests with the accumulated dust sample,
A_{floor} is the enclosure floor area (m^2),
and H is the enclosure ceiling height (m).

6.2.3.2 When the separate area is normally occupied, m_{Dmax} is given by

$$m_{D\max} = \frac{4c_{opt}\,(0.05\,P_a)\,A_{floor}\,H}{P_{\max} + P_a}$$

where P_a is the atmospheric pressure in bar.

6.2.3.3 When the total amount of dust in the room, m_{Dmax}, cannot be reliably estimated but representative accumulated dust samples can be collected from measured areas and then weighed to obtain the dust surface mass density $m_D'' = m_{Dsample}/A_{Dsample}$, the maximum allowable value of m_D'' in g/m^2 is given by

$$m''_{D\max} = m_{D\max} / A_{Dust}$$

where
m_{Dmax} is obtained from the equations in either 6.2.3.1 for unoccupied enclosures or 6.2.3.2 for occupied areas,
A_{Dust} is the estimated total surface area (m^2) in the enclosure on which dust has accumulated,
$m_{Dsample}$ is the average measured mass (g) of the collected samples,
and $A_{Dsample}$ is the average surface area (m^2) from which the samples were collected.

6.2.3.4 When representative dust samples cannot reliably be collected and weighed, but the dust bulk density is known and reliable measurements of dust layer thickness can be made, the maximum allowable dust layer thickness, t_{Dmax} (mm), can be calculated from

$$t_{D\max} = 1000\,(m''_{D\max} / \rho_{bulk})$$

where ρ_{bulk} is the bulk density in g/m^3, and m''_{Dmax} is obtained from 6.2.3.3,

654- Log #57 **Final Action:**
(Chapter 6, 7, and 8)

Submitter: Samuel A. Rodgers, Honeywell, Inc.
Recommendation:

Include-L57-Rec

Substantiation: This proposal clarifies when a Dust Explosion Hazard and a Dust Fire Hazard exist in an operation handling combustible dust. The current text mentions these situations but provides no quantitative method to determine how much dust or what distribution of dust results in the hazard. In addition, the current text does not clearly differentiate between dust accumulations requiring electrical classification or those presenting a dust explosion hazard.

This proposal does not set a maximum amount of dust accumulation in a facility. Instead, just as for other materials, it establishes additional protection requirements when a certain amount of accumulation is exceeded.

The proposal includes prior additions and seeks to clarify the question of initial dust accumulation estimates for new installations.

The current building codes do not establish when a building or room must be protected against a dust explosion. Nor do they set the allowable quantity of a hazardous (combustible) dust in a control area, above which automatic fire suppression is required. Similar to NFPA-30 for liquids, NFPA-654 should establish these limits for dusts. Also, similar to NFPA-30, NPFA-654 should establish an acceptable amount of material in process, in this case, escaped dust.

This proposal clarifies when a Dust Explosion hazard and a Dust Fire Hazard exist in an operation handling combustible dust. The current text mentions these situations but provides no quantitative method to determine how much dust or what distribution of dust results in the hazard. In addition, the current text does not clearly differentiate between dust accumulations requiring electrical classification or those presenting a dust explosion hazard.

This proposal does not set a maximum amount of dust accumulation in a facility. Instead, just as for other materials, it establishes additional protection requirements when a certain amount of accumulation is exceeded.

The criteria for a dust explosion hazard is based on the ability to produce overpressure sufficient to cause building structural failure in the absence of some explosion protection method, typically venting. This is based on the worst case dust concentration, meaning that concentration and its associated maximum deflagration pressure, P_{max}, which give the largest building fill fraction. The worst case fill fraction would come from NFPA-68, section 8.3.4.

Insert E654-8 Here

Where:

X_r = worst-case building partial fraction

****Insert Symbol E654-9 Here**** = average mass (gram) of floor samples

A_{fs} = measured floor areas

c_w = worst-case dust concentration

H = ceiling height of the building

****Insert Symbol E654-10 Here**** = average mass (gram) of surface samples

A_{sur} = total area of surfaces with dust deposits

A_{ss} = measured sample areas of surfaces with dust deposits

V = building volume

M_e = total mass of combustible dust that could be released from the process equipment in the building

Use of this NFPA-68 equation should be clarified in order that unopened shipping containers or bags are not counted in the “process equipment”. This should also be clarified to mean the dust accumulation between routine scheduled cleaning. Therefore, if the elevated and concealed surfaces are cleaned less frequently than the floor, these higher amounts would be included in the calculation. NFPA-68 then includes a method to determine P_{red} as a function of P_{max} and the fill fraction, X_r.

The committee should be aware that this analytical approach includes dust in process equipment and, therefore, housekeeping alone can not prevent the installation of an explosion vent. However, housekeeping can prevent the need for extensive fire protection and classified electrical equipment.

The criteria for a dust fire hazard area is based on local fugitive dust accumulation exceeding a mass of 1 kg/m^2 on a single square meter of surface between routine scheduled cleaning. This amount of dust, if dispersed, could create an explosible dust cloud to 2 to 4 meters height in a local area. Such a cloud would present a potential for a flash fire with personnel injury as well as ignition of other combustibles. Engineered dust collection and a sufficient routine housekeeping schedule can minimize dust fire hazard areas. When fugitive equipment leaks, then a local accumulation exceeding the 1 kg/m^2 criteria between scheduled general cleaning would be cleaned up in shorter times as the local accumulation rate increases.

A small dust fire hazard area would require manual fire protection. If the process results in more than 5% of the fire-separated area (room or floor) exceeding the criteria between routine cleaning, effectively a minimum average of 0.05 kg/m2 or 10%-20% of the MEC, the entire area would protected with automatic fire suppression. This includes all the areas which experience short term accumulations beyond 1 kg/m^2 in a typical 24 hour operation, the longest allowed local cleaning period.

The need for electrically classified equipment for ignition prevention is clearly separated from the explosion and fire hazards. The dust layer thickness, that is accumulation, used to determine electrical classification, is different than those for provision of automatic fire suppression or explosion protection.

My suggestion for inserted text is as follows:

Definitions:

<u>Fill Fraction, Xr: Fraction of the building or enclosure volume which could reach the dust concentration associated with the maximum explosion pressure, Pmax, in an unvented explosion.</u>

6.1 General.

The provisions of this section shall apply to the overall design of systems that handle combustible ~~particulate solids~~ <u>dusts.</u>

6.1.1* Those portions of the process and facility where a dust <u>explosion</u> ~~deflagration~~ hazard <u>or fire hazard</u> exists shall be protected from the effects <u>of these hazards</u> ~~dust deflagrations~~ in accordance with <u>this section as well as</u> Sections 6.2, 6.3, and 6.4 and

Chapter 7.

6.1.2* Dust Explosion Hazard Volume. (all of Kirby annex)

6.1.2.1 Dust explosion hazard volumes shall include those room or building volumes where an unvented deflagration of the worst case explosible dust fill fraction, Xr, can result in a reduced pressure, P_{red}, exceeding the ultimate dynamic strength of the weakest structural element not intended to fail.

6.1.2.x Dust quantities used to evaluate the dust fill fraction shall include all combustible dusts in the room or building volume, including that in open and closed containers, except as modified by 6.1.2.2 to 6.1.2.4.

6.1.2.2 Where dust accumulations exceed the dust layer control criterion over more than 0.5% of the surface area within the room/building, an engineering analysis shall be performed to determine acceptability of construction with respect to explosion protection in accordance with NFPA 68, Explosion Protection by Deflagration Venting, 2007 Edition, Chapter 8.3.4.

6.1.2.3 Quantities of dust in otherwise explosion-protected equipment or in sealed shipping containers shall not be included in the determination of the fill fraction for the room or building.

6.1.2.4 Dust accumulation amounts shall reflect the worst case for routinely scheduled cleaning, and not include short term accumulations cleaned within the times allowed in Chapter 8.

6.1.2.x For existing installations, the actual dust accumulation between routinely scheduled cleaning shall be documented.

6.1.2.x For new installations, the anticipated dust accumulation shall be permitted to be estimated for purposes of determining dust fill fraction.

6.1.2.x.1 If dust accumulation is initially estimated, the owner/operator shall document the actual dust accumulation within one month after the new installation is operational

6.1.2.x.2 If dust accumulation is initially estimated, the owner/operator shall either adjust routine cleaning schedule or modify dust containment methods to achieve at most the estimated dust accumulation within 6 months after the new installation is operational.

6.1.2.5 Small volume enclosures or gallery-type enclosures shall have lower limits of acceptable dust accumulation, based on an evaluation acceptable to the authority having jurisdiction (see A.6.1.2)

6.1.2.5 Dust explosion hazard volumes shall be segregated or detached from other volumes in the same occupancy.

6.1.3 Dust Fire Hazard Area.

6.1.3.1* Dust fire hazard areas shall include those areas where combustible dust accumulation on exposed or concealed surfaces, outside of equipment or containers, exceeds the dust layer control criterion, as well as areas where dust clouds of a hazardous concentration exist during normal operation.

6.1.3.2* The dust layer control criterion shall be 1 kg/m^2 of horizontal floor area beneath the accumulation for a nominal 3 meter room/building height and shall be ratioed up or down as a function of room/building height to a maximum of 4 kg/m^2 for a 12 meter room/building height.

A6.1.3.2 The following equation provides a means to estimate an equivalent depth from a known value of settled bulk density.

Eqn A.6.1.3.2

Insert E654-11 Here

6.1.3.3 Dust fire hazard areas shall be segregated or separated from other areas in the same occupancy.

6.1.3.4 The extent of fire protection and control that is provided for those portions of a facility containing a dust fire hazard area shall be determined by means of an engineering evaluation of the facility and application of sound fire/explosion protection and process engineering principles. This evaluation shall include, but not be limited to, the following:

- Analysis of the fire hazards of the operation and dust accumulations
- Analysis of facility and system designs and special fire protection in other parts of this chapter, and in Chapter 10
- Analysis of the emergency response capabilities of the local emergency services.

6.1.4- Recycling of Air–Material Separator Exhaust. Recycling of air–material separator exhaust to buildings shall be permitted if the system is designed to prevent both return of dust with an efficiency of 99.9 percent at 10 m and transmission of energy from a fire or explosion to the building.

6.1.4.1 Recycling of air–material separator exhaust to the building shall not be permitted under any circumstances when combustible gases or vapors or hybrid mixtures are involved.

6.1.4.2* Recycling of air–material separator exhaust to the building shall not be permitted when the recycled stream reduces the concentration of oxygen below 19.5 percent by volume in the work area.

A6.1.4.2 (renumbered A6.1.3.2)

(Repeated in Chapter 10)

6.1.5* Where a pneumatic conveying system or any part of such systems operates as a positive-pressure-type system and the air-moving device's gauge discharge pressure is 15 psi (103 kPa) or greater, the system shall be designed in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code or ASME B31.3, Process Piping.

6.1.6 All components of pneumatic conveying systems that handle combustible particulate solids shall be designed to be dusttight, except for openings designed for intake and discharge of air and material.

6.2 Segregation, Separation, or Detachment of Combustible Dust Handling and Processing Areas.

6.2.1 General. Areas in which combustible dusts are produced, processed, handled, or collected shall be detached, segregated, or separated from other occupancies to minimize damage from a fire or explosion.

6.2.2 Use of Segregation.

6.2.2.1 Physical barriers that are erected to segregate dust fire hazard areas shall be a minimum 1 hour fire separation assembly, including seals at all penetrations of floors, walls, ceilings, or partitions.

6.2.2.2 Physical barriers that are erected to segregate dust explosion hazard volumes shall be designed to preclude failure of those barriers during a dust explosion per NPFA-68, Standard on Explosion Protection by Deflagration Venting.

6.2.2.3 Doors and openings shall not be permitted in physical barriers unless they are normally closed and have at least the strength and fire endurance rating required of ~~as~~ the physical barrier.

6.2.3 Use of Separation.

6.2.3.1* When separation is used to limit the dust fire hazard area, the required separation distance between the fire hazard area identified in 6.1.3 and surrounding exposures shall be determined by the following:

(1) Engineering evaluation that addresses the properties of the materials

(2) Type of operation

(3) Amount of material likely to be present outside the process equipment

(4) Building design

(5) Nature of surrounding exposures

6.2.3.2 In no case shall the separation distance be less than 30 ft (9 m).

6.2.3.3 When separation is used, housekeeping, fixed dust collection systems employed at points of release, and compartmentation shall be permitted to be used to limit the extent of the dust fire hazard area.

6.3 Building Construction.

6.3.1 All buildings shall be of Type I or Type II construction, as defined in NFPA 220, Standard on Types of Building Construction.

6.3.2 Where local, state, or national building codes are more restrictive, modifications shall be permitted for conformance to those codes.

6.3.3* Interior surfaces where dust accumulations can occur shall be designed and constructed so as to facilitate cleaning and to minimize combustible dust accumulations.

6.3.4 Spaces inaccessible to housekeeping shall be sealed to prevent dust accumulation.

6.3.5 Interior walls erected for the purpose of limiting fire spread shall have a minimum 1-hour fire resistance rating and shall be designed in accordance with NFPA 221, Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls.

6.3.6 Fire Doors.

6.3.6.1 Openings in fire walls and in fire barrier walls shall be protected by self-closing fire doors that have a fire resistance rating equivalent to the wall design.

6.3.6.2 Fire doors shall be installed according to NFPA 80, Standard for Fire Doors and

Fire Windows, and shall normally be in the closed position.

6.3.7 Egress. Means of egress shall comply with NFPA 101, Life Safety Code.

6.3.8 Penetrations. Where floors, walls, ceilings, and other partitions have been erected to control the spread of fire or deflagrations, penetrations in these structures shall be sealed to maintain their fire endurance rating and maintain physical integrity in a deflagration. (See 7.6.5.)

6.3.9 Fire Resistance Rating.

6.3.9.1 Interior stairs, elevators, and manlifts shall be enclosed in dusttight shafts that have a minimum fire resistance rating of 1 hour.

6.3.9.2 Doors that are the automatic-closing or self-closing type and have a fire resistance rating of 1 hour shall be provided at each landing.

6.3.9.3 Stairs, elevators, and manlifts that serve only open-deck floors, mezzanines, and platforms shall not be required to be enclosed.

6.3.10* Floors and load-bearing walls that are exposed to dust explosion hazards volumes shall be designed to preclude failure during a dust explosion as determined according to NFPA-68, Standard on Explosion Protection by Deflagration Venting.

6.4* Explosion Protection.

6.4.1* A dust hazard explosion volume, as specified in 6.1.2, shall be provided with explosion protection in accordance with NPFA-69, Standard on Explosion Prevention Systems

A.6.4.1 For buildings or rooms, the typical explosion protection method is deflagration venting. The need for building deflagration venting is a function of equipment design, particle size, deflagration characteristics of the dust, and housekeeping results. As a rule, deflagration venting is recommended unless there can be reasonable assurance that hazardous quantities of combustible and dispersible dusts will not be permitted to accumulate outside of explosion-protected equipment.

Where building explosion venting is needed, detaching the operation to an open structure or to a building of damage-limiting construction is the preferred method of protection. Damage-limiting construction involves a room or building that is designed such that certain interior walls are pressure resistant (can withstand the pressure of the deflagration) to protect the occupancy on the other side and some exterior wall areas are pressure relieving to provide deflagration venting. It is preferable to make maximum use of exterior walls as pressure-relieving walls (as well as the roof wherever practical), rather than to provide the minimum recommended. Further information on this subject can be found in NFPA 68, Standard on Explosion Protection by Deflagration Venting.

Deflagration vent closures should be designed such that, once opened, they remain open to prevent failure from the vacuum following the pressure wave.

Updates are suggested here to be in compliance with NFPA 69, which recently eliminated chokes as an acceptable isolation device and introduced design limitations for rotary valves alone, as opposed to rotary valves with an additionally maintained material layer above the valve.

7.1.4* Isolation of Equipment.

7.1.4.1 Where an explosion hazard exists, isolation devices shall be provided to prevent deflagration propagation between pieces of equipment connected by ductwork.

7.1.4.2 Isolation devices shall include, but shall not be limited to, the following:

~~(1)* Chokes~~

(2)* Rotary valves in accordance with NFPA 69, Standard on Explosion Prevention Systems

(3)* Automatic fast-acting valve systems in accordance with NFPA 69, Standard on Explosion Prevention Systems

Updates here are to provide clear instructions for suitable routine housekeeping and spill cleanup.

8.2 Housekeeping.

The requirements of 8.2.1 through 8.2.3 shall be applied retroactively.

8.2.1* General.

8.2.1.1 Equipment shall be maintained and operated in a manner that minimizes the escape of dust.

8.2.1.2 Regular cleaning frequencies shall be established for walls, floors, and horizontal surfaces, such as equipment, ducts, pipes, hoods, ledges, beams, and above suspended ceilings and other concealed surfaces, to minimize dust accumulations within operating areas of the facility.

8.2.1.3 Wherever a local spill or short-term accumulation of combustible dust on the surfaces listed in 8.2.1.2 exceeds the dust layer control criterion between regular cleaning, determined on the basis of a single square meter of surface collecting the accumulation, un-scheduled housekeeping shall be performed according to 8.2.1.4.

8.2.1.4* Un-scheduled housekeeping shall be performed in accordance with Table 8.2.1.4 to limit the time that a local spill or short-term accumulation of dust is allowed to remain before cleaning the local area to less than the dust layer control criterion.

Table 8.2.1.4 Un-Scheduled Housekeeping

Accumulation on the worst single square meter of surface	Longest Time to Complete Un-scheduled Local Cleaning of Floor-Accessible Surfaces	Longest Time to Complete Un-scheduled Local Cleaning of Remote Surfaces
>1 to 2 times dust layer control criterion	8 hours	24 hours
>2 to 4 times dust layer control criterion	4 hours	12 hours

> 4 times dust layer control criterion	1 hour	3 hours

A8.2.1.4 Table A8.2.1.4 shows approximate equivalent depths for the accumulation values in Table 8.2.1.4 when the dust layer control criterion is 1 kg/m^2. The owner/operator can use an approximate depth to facilitate communication of housekeeping needs.

Table A8.2.1.4 Un-Scheduled Housekeeping

Accumulation on the worst single square meter of surface	Average Depth	Average Depth
	at 75 lb/ft^3	at 30 lb/ft^3
>1 to 2 kg/m^{2f}	>1/32-1/16 in. (0.8-1.7 mm)	>5/64-5/32 in. (2.1-4.2 mm)
>2 to 4 kg/m^2	>1/16 -1/8 in. (1.7-3.3 mm)	>5/32 -5/16 in. (4.2-8.3 mm)
> 4 kg/m^2	> 1/8 in. (>3.3 mm)	> 5/16 in. (>8.3 mm)

654- Log #CP1 **Final Action: Accept**
(Entire Document)

Submitter: Technical Committee on Handling and Conveying of Dusts, Vapors, and Gases,
Recommendation: Review entire document to: 1) Update any extracted material by preparing separate proposals to do so, and 2) review and update references to other organizations documents, by preparing proposal(s) as required.
Substantiation: To conform to the NFPA Regulations Governing Committee Projects.

Committee Meeting Action: Accept