



National Fire Protection Association

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MEMORANDUM

TO: NFPA Technical Committee on Handling and Conveying of Dusts,
Vapors, and Gases

FROM: Joanne Goyette, Administrator, Technical Projects

DATE: November 18, 2011

SUBJECT: NFPA 654 ROC TC Letter Ballot (A2012)

The ROC letter ballot for NFPA 654 is attached. The ballot is for formally voting on whether or not you concur with the committee's actions on the comments. Reasons must accompany all negative and abstention ballots.

Please do not vote negatively because of editorial errors. However, please bring such errors to my attention for action.

Please complete and return your ballot as soon as possible but no later than **Friday, December 2, 2011**. As noted on the ballot form, please return the ballot to Joanne Goyette either via e-mail to jgoyette@nfpa.org or via fax to 617-984-7110. You may also mail your ballot to the attention of Joanne Goyette at NFPA, 1 Batterymarch Park, Quincy, MA 02169.

The return of ballots is required by the Regulations Governing Committee Projects.

Attachments:

Comments
Letter Ballot

654-1 Log #13 CMD-HAP
(3.3.x.2 Dust Flash Fire Hazard Area)

Final Action: Accept in Principle

Submitter: George Petino, Jr., Hazards Research Corporation, Inc.

Comment on Proposal No: 654-17

Recommendation: Revise text to read as follows:

An area where combustible dust accumulation on exposed or concealed surfaces, outside of equipment or containers, can result in personnel injury from thermal dose during a dust deflagration, as well as any areas, *outside of equipment or containers*, where dust clouds ~~of a hazardous~~ *at a* concentration *equal to or greater than the MEC* exist during normal operation. A propagating deflagration yields a flash fire through the hazard area. In the alternative, define the term "hazardous concentration" to mean a concentration equal to or greater than the MEC.

Substantiation: The undefined term "hazardous concentration" is ambiguous and needs to be defined or replaced to avoid unnecessary confusion. Given the conservative approach inherent in the combustible dust testing protocols, and the properties of combustible dust (as distinguished from a flammable gas), we do not believe any airborne combustible dust concentration below the minimum explosive concentration (MEC) should be considered hazardous. The reference to "dust clouds" appears to be adequate to ensure the determination will not be based on an insignificant volume.

Otherwise, one can, by applying a small enough boundary or perimeter, create a situation in which the presence of a small quantity of particles can exceed the MEC. While the minimum concentration for an explosion can be determined in the laboratory, there is no reliable instrument for measuring the instantaneous fugitive dust cloud concentration for explosion in the workplace with an acceptable degree of accuracy. This leaves one to use the general rule of thumb "if you can't see your hand at arm's length while standing in a dust cloud, it is a combustible cloud."

Committee Meeting Action: Accept in Principle

Revise Dust Flash Fire Hazard Area definition to read as follows:

3.3.x.2 Dust Flash Fire Hazard Area. An area where combustible dust accumulation on exposed or concealed surfaces, outside of equipment or containers, can result in personnel injury from thermal dose during a dust deflagration, as well as any areas, where ~~a~~ dust clouds of ~~a~~ hazardous concentrations~~s~~ exists~~s~~ ~~during normal operation~~. A propagating deflagration yields a flash fire through the hazard area.

Add annex to 3.3.x.2 Dust Flash Fire Hazard Area.

Where the dust cloud concentration is equal to or greater than the MEC it poses a dust explosion and dust flash fire hazard. Eckhoff has observed for coal dust that if the cloud obscures a 25 W light bulb over a 2 m (6.6 ft) length the concentration is probably close to the MEC (Eckhoff, R., *Dust Explosions in the Process Industries*, 3rd edition). It is customary to consider a dust cloud hazardous, when the concentration exceeds 25% of the MEC. It is recognized that it is often very difficult or impractical to measure airborne dust concentration in this range in an industrial setting. For this reason, it is often necessary to rely on subjective measures to determine the dust cloud concentration.

Committee Statement: The MEC is not able to be measured easily in the field, so the Committee did not accept the submitter's recommendation to include that as part of the definition. The Committee addressed the submitter's recommendation to define hazardous concentration by adding annex commentary to explain the basic condition - any time concentration in the dust cloud exceeds MEC - and to provide a commonly referenced example as provided in Rolf Eckhoff's text where visual obscurity is the reference point.

654-2 Log #21 CMD-HAP
(3.3.x Enclosureless Dust Collector and A.3.3.x)

Final Action: Accept in Principle in Part

Submitter: Marcelo M. Hirschler, GBH International

Comment on Proposal No: 654-15

Recommendation: Revise text to read as follows:

3.3.x Enclosureless Dust Collector. An air–material separator designed and used to remove dust from the transport air which is not enclosed or in a container, possessing ALL of the following: (1) The filtration is accomplished by passing dust-laden air through filter media, collecting the dust on the inside of the filter media, and allowing cleaned air to exit to the surrounding area. (2) The filter medium is not enclosed or in a container. (3) The filter medium is not mechanically shaken or pressure-pulsed. (4) The filter medium is under positive pressure. (5) Removal of the collected dust is not continuous or mechanical.

A.3.3.x Enclosureless dust collectors should have the following features: (1) the filtration should be accomplished by passing dust laden air through filter media and collecting the dust on the inside of the filter media, and allowing cleaned air to exit to the surrounding area; (2) the filter medium should not be enclosed or in a container; (3) the filter medium should not be mechanically shaken or pressure-pulsed; (4) the filter medium should be under positive pressure and (5) removal of the collected dust should not be continuous or mechanical.

Substantiation: The proposed revision to the definition is problematic since definitions need to be in single sentences and it contains multiple requirements. The proposed revision would fix this by eliminating requirements and placing them into the annex. An even better approach would be to incorporate all of the requirements somewhere in the body of the standard.

I am the chair of the Glossary committee on terminology, set up by NFPA Standards Council to obtain uniformity of definitions within NFPA.

Committee Meeting Action: Accept in Principle in Part

Revise the definition as shown:

3.3.x Enclosureless Dust Collector. An air–material separator designed and used to remove dust from the transport air where the filter medium is not enclosed or in a container.

Do not create an annex as recommended relocating the additional elements in the original definition.

Committee Statement: The Committee modified the recommended revision to the definition to clarify that it is the filter medium that is not enclosed or in a container. This action by the committee meets the intent of the first part of the submitter's recommendation to simplify the definition per NFPA Manual of Style. The Committee did not accept the recommendation as submitted to create an annex from the deleted text with the five elements contained in the original definition. The Committee believes those elements to be essential to defining what constitutes an enclosureless dust collector and what is required in order to be applicable within this standard. These items are addressed as part of the action by the Committee on Comment 654-1 (Log# 13). The submitter actually suggested this alternative as part of the substantiation.

654-3 Log #1 CMD-HAP
(3.3.4 Combustible Dust)

Final Action: Reject

Submitter: Brice Grinstead, Master Brand Cabinets

Comment on Proposal No: 654-6

Recommendation: None given.

Substantiation: Recommend removal of the addition of 420 micron diameter to 3.3.4. This requirement was removed in NFPA 664 ROP 3.3.24.1 and 3.3.24.2 - Deflagrable and Nondeflagrable wood dust. These definitions should be somewhat consistent.

Committee Meeting Action: Reject

Committee Statement: The submitter provided no technical recommendation on which to act. In addition, based on reading the substantiation, it appears the submitter is referring to an earlier edition of this definition as the reference to 420 microns is not currently contained in the 2006 edition of the standard.

654-4 Log #12 CMD-HAP
(3.3.4 Combustible Dust)

Final Action: Reject

Submitter: George Petino, Jr., Hazards Research Corporation, Inc.

Comment on Proposal No: 654-9

Recommendation: Replace the proposed definition with the following taken from Section 3.3.3 of NFPA 449:

“Combustible Dust. Any finely divided solid material that is 420 microns or smaller in diameter (material passing a U.S. No. 40 Standard Sieve) and presents a fire or explosion hazard when dispersed and ignited in air.”

Substantiation: While we recognize this issue was discussed, we believe the absence of a reference to a particle size in this definition is inappropriate and leaves the user with no meaningful or practical guidance other than to test everything. The inclusion of the undefined phrase “finely divided” is not helpful.” The possibility that a user may misinterpret the definition suggests that the standard provide some additional guidance rather than removing practical guidance.

Committee Meeting Action: Reject

Committee Statement: The Committee does not support including a particle size criterion in the definition. The 420 micron particle size was part of the definition prior to 2006, but starting with the revision to the 2006 edition, the Committee removed the particle size from the definition and included it only as supplemental information in the annex.

654-5 Log #17 CMD-HAP
(3.3.4 Combustible Dust)

Final Action: Reject

Submitter: John M. Cholin, Oakland, NJ

Comment on Proposal No: 654-9

Recommendation: Revise text to read as follows:

3.3.4* Combustible Dust. A finely divided combustible particulate solid that presents a flash fire or explosion hazard when suspended in air or the process specific oxidizing medium over a range of concentrations that has a mass-median particle size less than 1000 micron (1.0 mm).

Substantiation: The ROP language creates an obligation to test every particulate regardless of the particle size. There is ample industry experience that shows that particulates that are larger than a nominal 500 microns in mass median diameter are unlikely to pose a deflagration hazard. This comment doubles that number to err on the side of safety.

Without a size criterion if a facility operator had a silo full of golf balls she/he would be required to submit a sample for explosibility testing per ASTM E 1226. This example might seem ludicrous but it illustrates the point that most professionals knowledgeable in this segment of the fire protection industry recognize that many particulates are too large to pose a deflagration hazard in and of themselves. Consequently, there is no justification for testing them. The annex material covers the potentiality of particle attrition that produces a smaller, more hazardous particulate. The TC should address the economic burden the ROP language places on the operator and the fact that it establishes a requirement that is, in many cases, impossible to meet. This erodes the credibility of the entire standard.

Committee Meeting Action: Reject

Committee Statement: The Committee does not support the inclusion of a particle size criterion in the definition. The 420 micron particle size was part of the definition prior to 2006, but starting with the revision to the 2006 edition, the Committee removed the particle size from the definition and included it only as supplemental information in the annex.

654-6 Log #20 CMD-HAP
(3.3.5 Combustible Particulate Solid)

Final Action: Reject

Submitter: Marcelo M. Hirschler, GBH International

Comment on Proposal No: 654-9

Recommendation: Revise text to read as follows:

3.3.5* Combustible Particulate Solid. Any combustible solid material, composed of distinct particles or pieces, regardless of size, shape, or chemical composition ~~that presents a fire hazard~~ .

Substantiation: The revision to the definition causes a problem because a combustible solid material may well exist and be at such a low concentration so as not present a fire hazard and then be believed not to be a combustible particulate solid.

Note also that the term “combustible particulate solid” has as the preferred NFPA definition the following one: “A combustible solid material comprised of distinct particles or pieces, regardless of size, shape, or chemical composition, that is capable of being pneumatically conveyed.” from NFPA 1 and NFPA 69.

The technical committee might want to consider either adopting the preferred definition or adding a qualifier, such as “in terms of dust explosions” so that it becomes a unique definition. The definition would then read:

“3.3.5* Combustible Particulate Solid (in terms of dust explosions). Any combustible solid material, composed of distinct particles or pieces, regardless of size, shape, or chemical composition.

I am the chair of the Glossary committee on terminology, set up by NFPA Standards Council to obtain uniformity of definitions within NFPA.

Committee Meeting Action: Reject

Committee Statement: The recommendation does not correctly cite the version of the ROP approved definition per ROP 654-9 as it shows the word "combustible" in the definition for combustible particulate solid. In addition, the referenced preferred definition in the substantiation also uses this same incorrect form of using the term in the definition for the term. The Committee also notes that the proposed deletion of "that presents a fire hazard" would make the definition unclear.

654-7 Log #2 CMD-HAP Final Action: Accept in Principle
(3.3.11 Dust Collector, 7.3.2.x, 1.1.1, 10.2.2, 10.2.3.1, 9.1.2.1, 6.1.6, 7.3.3.x, 7.4.1, and 7.8.3.1, A.3.3.x, and A.7.3.2.x)

Submitter: Jack E. Osborn, Airdusco, Inc.

Comment on Proposal No: 654-12

Recommendation: Revise text to read as follows:

3.3.11* ~~Dust Collector~~ Dust Collection System: ~~See 3.3.2, Air-Material Separator (AMS).~~ A combination of equipment designed to contain, capture, pneumatically convey, collect, and filter airborne dusts.

(New) A.3.3.11 Dust Collection System. A typical dust collection system consists of the following:

(1) Hoods – devices designed to contain, capture, and control the airborne dusts by directing the induced air flow through the fugitive airborne dusts.

(2) Ducting – piping, tubing, fabricated duct, etc., used to provide the controlled pathway from the hoods to the dust collector (AMS). Maintaining adequate duct velocity (usually 4,000 fpm or higher) is a key factor in the proper functioning of the system.

(3) Dust collector – an AMS designed to typically filter the conveyed dusts from the conveying air stream. Usually these devices have automatic methods for cleaning the filters to allow extended use without blinding. In some systems a scrubber of similar device is used in place of the filter unit.

(4) Fan package – an AMD designed to induce the air flow through the entire system.

The system is design to only collect aerated dusts and not dusts at rest on surfaces. The system is also not designed to convey large amounts of dusts as the system design is based solely on the air friction losses. Thus, material loading must be minimal compared to the volume or mass of air flow.

3.3.19* Pneumatic Conveying System. An equipment system comprised of a material feeding device, an air-material separator, an enclosed ductwork, piping, or tubing system, and an air-moving device in which a combustible particulate solid is conveyed from one point to another with a stream of air or other gases used to transfer a controlled flow of solid particulate material from one location to another using air or other gases as the conveying medium.

3.3.19.1* Negative-Pressure Pneumatic Conveying System. A pneumatic conveying system that transports material by utilizing gas at less than atmospheric pressure (retained as before).

3.3.19.2* Positive-Pressure Pneumatic Conveying System. A pneumatic conveying system that transports material by utilizing gas at greater than atmospheric pressure (retained as before).

A.3.3.19 Pneumatic Conveying System. (Delete existing and revise with the following text): Generically, pneumatic conveying systems include a wide range of equipment systems utilizing air or other gases to transport solid particles from one point to another. A typical (there are variations) system is comprised of:

(1) A device used to meter the material into the conveying air stream.

(2) Piping, tubing, hose, etc., used to provide the closed pathway from the metering device to the AMS.

(3) AMS designed for the separation of comparatively large amounts of material from the conveying air/gas stream.

(4) An additional metering device (typically a rotary airlock valve or similar device) to allow discharge of the separated material from The conveying air stream without affecting the differential pressure of the system.

(5) AMD designed to produce the necessary pressure differential and air/gas flow in the system (positive or negative). This type of system requires the amount of material conveyed by the system to be considered as a major factor in the system calculations.

3.3.x * (New item) Centralized Vacuum Cleaning System. A fixed pipe system utilizing variable-volume induced air flows from remotely located hose connection stations to allow the vacuuming of dust accumulations from surfaces and conveying those dusts to an AMS.

A.3.3.x (new) Centralized Vacuum Cleaning System. This system normally consists of multiple locations, known as hose connection stations, hard-piped to an AMS located out of the hazardous area, using an AMD to provide the vacuum induced, variable volume, air flow. The hoses and vacuum cleaning tools utilized with the system are designed to be static dissipative in order to minimize any risk of generating an ignition source. Low MIE (minimum ignition energy) materials will require special consideration in the system design and use. A primary separator can be used if large quantities of materials are involved. However, most secondary AMS units (commonly called filter receivers) are capable of handling the high material loadings without the addition of the primary AMS (typically a cyclone).

7.3.2 ~~Pneumatic Conveying Systems.~~ Pneumatic Conveying, Dust Collection, and Centralized Vacuum Cleaning Systems.

7.3.2.1 No existing system shall be changed without considering the effects of those changes on the system performance. This requires a re-design of the system to incorporate the proposed changes. Such changes shall be fully

documented. The addition of branch lines shall not be made to an existing system without redesigning the entire system.

7.3.2.2 Branch lines shall not be disconnected and unused portions of the system shall not be blanked off without providing a means to maintain required and balanced airflow.

Delete the existing 7.3.2.3.

7.3.2.3 (new): The system shall be designed and maintained to assure that the air/gas velocity used shall at all times meet or exceed the minimum required to keep the interior surfaces of all duct free of accumulations.

Delete the existing 7.3.2.4.

7.3.2.4 (new): The system shall be equipped with adequate monitoring devices to allow continuous monitoring of the system performance.

7.3.2.5 (new – the existing will be renumbered) Specific Requirements for Dust Collection Systems

7.3.2.5.1 Each dust collection source or hood shall have a documented minimum air volume required for proper dust collection performance.

7.3.2.5.2 The minimum acceptable duct air/gas velocity for the transport of combustible dusts in a ducting system for a dust collection system is 4000 fpm. The system shall be designed to maintain this conveying air/gas velocity at all times in all branch lines.

7.3.2.5.3 No system shall include manually adjustable control devices (e.g. slide gates, butterfly valves, etc.), except for exclusively maintenance purposes, or on/off purposes, that allow personnel to adjust the air flow into the system.

7.3.2.5.4 The rate of airflow at each hood or other pickup point shall be designed so as to convey and control the material.

7.3.2.5.5* All ductwork shall be sized to provide the air volume and air velocity necessary to keep the duct interior clean and free of residual material.

A.7.3.2.5.5. The typical minimum accepted velocity is 4,000 fpm. Some tacky, adhesive, and/or cohesive materials may require significantly higher duct velocities.

7.3.2.5.6. (retain as written) The design of the pneumatic conveyance system shall be documented, including the following information:

(1) Data on the range of particulate size

(2) Concentration in conveyance air stream

(3) Potential for reaction between the transported particulate and the extinguishing media used to protect process equipment

(4) Conductivity of the particulate

(5) Other physical and chemical properties that affect the fire protection of the Process

7.3.2.7 (new) Specific Requirements for Centralized Vacuum Cleaning Systems:

7.3.2.7.1. The system design shall be designed to assure proper conveying velocities at all times whether the system is used with a single or multiple simultaneous operators.

7.3.2.7.2. The hose length and diameter shall be sized for the application and operator.

7.3.2.7.3. Use only metal or conducting materials for vacuum tools.

7.3.2.7.4. The AMS shall be designed for continuous material discharge into a suitable enclosed container.

7.3.2.6.8.(retain as written) Pneumatic conveying systems that remove material from operations that generate flames, sparks, or hot material shall not be interconnected with pneumatic conveying systems that transport combustible particulate solids or hybrid mixtures.

7.12 Air-Moving Devices (Fans and Blowers).

7.12.1 Air-moving devices shall conform to the requirements of NFPA 91, Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids, except as amended by the requirements of this chapter.

7.12.2* (new) Air moving devices shall not be inside the clean air plenum of the dust collector.

A.7.12.2: Installing the air moving device (fan package) for an air-material separator (commonly called a dust collector or bin vent) inside the clean air plenum enclosure creates a significant and unnecessary explosion hazard. Filter failure is a common upset condition which will result in the accumulation of combustible dusts in the clean air plenum. If the air moving device (fan package) is located in the clean air plenum the combustible dust passing through the failed filter or filters is directly exposed to the drive and other ignition generating components of the air moving device (fan package). This combination produces an unnecessary explosion hazard that is avoided by not locating the device in the clean air plenum. This does not void the use of sound enclosures or similar enclosures which do not produce such hazards (not an integral part of the clean air plenum).

NOTE – the following items are included to “clean-up” the use of “pneumatic conveying” to include all three(3) types of systems.

1.1.1 This standard shall apply to all phases of the manufacturing, processing, blending, pneumatic conveying, dust collection, and centralized vacuum cleaning systems, repackaging, and handling of combustible particulate solids or hybrid mixtures, regardless of concentration or particle size, where the materials present a fire or explosion hazard.

4.4* Pneumatic Conveying, Dust Collection, and Centralized Vacuum System Design. (retain rest of text).

A.4.4 The design of the pneumatic conveying, dust collection, or centralized vacuum cleaning system should be coordinated with the architectural and structural designs. (Retain the rest).

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

7.3.3.1 Sequence of Operation. Pneumatic conveying, dust collection and Centralized vacuum cleaning 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, dust collection and centralized vacuum cleaning 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. Pneumatic conveying, dust collection and centralized vacuum cleaning systems shall be designed such that, on shutdown of the process, the system maintains design air velocity until material is purged from the system.

7.4.1 General. This section shall apply to facilities that operate pneumatic conveying, dust collection and centralized vacuum cleaning systems for metal particulates.

7.8.3.1 Airflow control valves that are installed in pneumatic conveying, dust collection and centralized vacuum cleaning systems shall be of both airtight and dusttight construction.

9.1.2.1 Where the process is configured such that the pneumatic conveying, dust collection or centralized vacuum cleaning system conveys materials that can act as an ignition source, means shall be provided to minimize the hazard.

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

10.2.3.1 Where fire detection systems are incorporated into the pneumatic conveying, dust collection or centralized vacuum cleaning system design, the fire detection systems shall be interlocked to shut down any active device feeding materials to the pneumatic conveying system on actuation of the detection system.

9.1.2.1 Where the process is configured such that the pneumatic conveying, dust collection or centralized vacuum cleaning system conveys materials that can act as an ignition source, means shall be provided to minimize the hazard.

Substantiation: Substantiation: 3.3.11. Dust Collection System. There are major operational and dust explosion hazard differences between “dust collection systems”, pneumatic conveying systems, and centralized vacuum cleaning systems. Also, there is substantial confusion created in the 654 document by the use of the term “pneumatic conveying” in a generic for these three(3) quite different systems since the industry accepted terminology for a Pneumatic Conveying System” refers to a system designed to convey comparatively large amounts of material (ranging from dusts to large particles) in comparatively small diameter pipes, using negative or positive pressure. The design parameters for the three(3) systems are quite different and require significantly different expertise to create a successful system design. In general a system that pneumatically conveys a combustible dust, when compared to a dust collection system handling the same dust, represents a **significantly reduced hazard**.

Substantiation: 3.3.19. Pneumatic Conveying System. Due to the method of conveying and the inherent design characteristics of a pneumatic conveying system (compared to a dust collection system or centralized vacuum system) this type of material transfer method is normally of less risk than either of the other types of “pneumatic-conveying” systems. Protecting this system against explosion hazards is inherently different than that of the other types (centralized vacuum system is similar, however). Separating this definition from that of the dust collection system and centralized vacuum cleaning system will eliminate the significant confusion created by “lumping” them together. They do not inherently share the same dust explosion hazard risks.

Substantiation: 3.3.x. Centralized Vacuum Cleaning System. This definition is included to provide clarification of the difference between a “dust collection system” and a “pneumatic conveying system” as used commonly in the industrial environment. This system presents a significantly greater risk than a typical pneumatic conveying system due to the inclusion of human operators and the reality that “trash” (e.g. welding rods, bolts, nuts, etc.) are often included in the material vacuumed off the floors, etc. Unique deflagration hazards exist with this type of system verses the typical pneumatic transfer and dust collection system.

Substantiation. 7.3.2.x... Multiple. These changes are to allow for the differentiation between the dust collection system, pneumatic conveying system and centralized vacuum cleaning system and the various specific items that relate

to them for this section.

Substantiation: Specific to 7.12.2. There is no functional reason for locating the fan package (air material separator) inside the clean air plenum. It is purely done for aesthetics and sales promotional reasons. When the fan is located in the clean air plenum it requires a larger-than-necessary enclosure resulting in additional, not less, construction costs for the unit. Most major dust collector (air-material separator) manufacturers do not locate the fan in this position for both cost and safety reasons. This situation is found almost exclusively in the “lower-end” cost, package units, which provide the enclosure strictly for aesthetics and sales reasons as it offers no known advantage over installing the relatively small fan package on top of the enclosure around the dirty air plenum or, if a clean air plenum is desired/required, on top of that enclosure. Thus, since there is no functional advantage to locating the fan package in the clean air plenum (over outside the same), it is logical to eliminate an explosion hazard by requiring the fan to be located external to the clean air plenum.

Substantiation for remainder (1.1.1., 4.4., 6.1.6, 7.3.3.1, & 2, & 3, 7.8.3.1, 9.1.2.1, 10.2.2, 10.2.3.1) is to “clean-up” or include the reference to the three(3) types of systems where only “pneumatic conveying systems” is located/used in the text.

Committee Meeting Action: Accept in Principle

Revise text as shown:

3.3.11* ~~Dust Collector~~ Dust Collection System: ~~See 3.3.2, Air-Material Separator~~

(AMS): A combination of equipment designed to capture, contain, pneumatically convey, collect, and remove airborne dusts from the airstream.

A.3.3.11 Dust Collection System. A typical dust collection system consists of the following:

(1) Hoods – devices designed to contain, capture, and control the airborne dusts by using an induced air flow in close proximity to the point of dust generation (local exhaust zone) to entrain directing the induced air flow through the fugitive airborne dusts.

(2) Ducting – piping, tubing, fabricated duct, etc., used to provide the controlled pathway from the hoods to the dust collector (AMS). Maintaining adequate duct velocity (usually 4,000 fpm or higher) is a key factor in the proper functioning of the system.

(3) Dust collector – an AMS designed to filter the conveyed dusts from the conveying air stream. Usually these devices have automatic methods for cleaning the filter media to allow extended use without blinding. In some systems a scrubber or similar device is used in place of the filter unit.

(4) Fan package – an Air Moving Device (AMD) designed to induce the air flow through the entire system.

The system is designed to only collect suspended aerated dusts at point of generation and not dusts at rest on surfaces. The system is also not designed to convey large amounts of dusts as the system design does not include friction loss due to solids loading in the pressure drop calculation is based solely on the pressure drop due to air only. Thus, material loading must be minimal compared to the volume or mass of air flow.

3.3.20* Pneumatic Conveying System. An equipment system comprised of a material feeding device, an air-material separator, an enclosed ductwork, piping, or tubing network, an air material separator, system, and an air-moving device in which a combustible particulate solid is conveyed from one point to another with a stream of air or other gases used to transfer a controlled flow of solid particulate material from one location to another using air or other gases as the conveying medium.

3.3.20.1& 2 remain are unchanged except for renumbering per ROP action.

A.3.3.20*~~19~~ Pneumatic Conveying System. Pneumatic conveying systems include ~~dust collection systems~~: a wide range of equipment systems utilizing air or other gases to transport solid particles from one point to another. A typical system is comprised of:

(1) A device used to meter the material into the conveying air stream.

(2) Piping, tubing, hose, etc., used to provide the closed pathway from the metering device to the AMS.

(3) AMS designed for the separation of comparatively large amounts of material from the conveying air/gas stream.

(4) An additional metering device (typically a rotary airlock valve or similar device) might be used to allow discharge of the separated material from the conveying air stream without affecting the differential pressure of the system.

(5) AMD designed to produce the necessary pressure differential and air/gas flow in the system (positive or negative).

This type of system requires the amount of material conveyed by the system to be considered as a major factor in the system pressure drop calculations.

Both positive and negative (i.e. vacuum) differential pressure is used for pneumatic conveying. The decision which is the best for a specific application should be based upon a risk analysis, equipment layout, and other system operational and cost factors.

Dense phase conveying may can also be considered for the application, especially with more hazardous materials (e.g. low MIE). The inherent design and operational features of this approach can provide significant safety and operational advantages over other types of pneumatic conveying systems.

~~A.3.3. 2019.1 Negative-Pressure Pneumatic Conveying System. These systems consist of a sequence of an air intake, a material feeder, an air-material separator, an air-moving device, and interconnecting ducts.~~

~~A.3.3. 2019.2 Positive-Pressure Pneumatic Conveying System. Such systems consist of a sequence of an air-moving device, a feeder for introducing materials into the system, an air-material separator, and interconnecting ducts.~~

3.3.x* Centralized Vacuum Cleaning System. A fixed pipe system utilizing variable-volume negative pressure (i.e. vacuum) air flows from remotely located hose connection stations to allow the removal of dust accumulations from surfaces and conveying those dusts to an AMS.

A.3.3.x Centralized Vacuum Cleaning System. This system normally consists of multiple hose connection stations hard-piped to an AMS located out of the hazardous area. Positive displacement or centrifugal AMDs can be used to provide the negative pressure air flow. The hoses and vacuum cleaning tools utilized with the system should be ~~are~~ designed to be conductive or static dissipative in order to minimize any risk of generating an ignition source. Low MIE (minimum ignition energy) materials should be given special consideration in the system design and use. A primary and secondary AMS separator combination (for example, cyclone and filter receiver) can be used if large quantities of materials are involved. However, most filter receivers ~~secondary AMS units (commonly called filter receivers)~~ are capable of handling the high material loadings without the addition of the use of a cyclone ~~primary AMS (typically a cyclone)~~.

~~7.3.2* Pneumatic Conveying Systems. Pneumatic Conveying, Dust Collection, and Centralized Vacuum Cleaning Systems.~~

~~7.3.2.1.5-6: The design of the pneumatic conveyance system shall be documented, and shall address including the following information:~~

- (1) Data on the range of particulate size
- (2) Concentration in conveyance air stream
- (3) Potential for reaction between the transported particulate and the extinguishing media used to protect process equipment
- (4) Conductivity of the particulate
- (5) Other physical and chemical properties that affect the fire protection of the

Process

~~7.3.2.2.* Existing systems shall not be modified without considering the effects of those changes on the system performance, including the re-design of the system to incorporate the proposed changes.~~

~~7.3.2.3.1-4 All system components that handle combustible particulate solids shall be designed to be dusttight, except for openings designed for intake and discharge of air and material.~~

~~7.3.2.4.* The system shall be designed and maintained to assure that the air/gas velocity during operation shall at all times meet or exceed the minimum required to keep the interior surfaces of all piping free of accumulations.~~

~~7.3.2.5* Pneumatic Conveying Systems. Where a pneumatic conveying system operates at a pressure of 15 psig (103 kPa) or greater, the components exposed to that pressure under normal or upset conditions shall be designed in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code or ASME B31.3, Process Piping.~~

~~7.3.2.1 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. (note – moved to a new location in this section).~~

~~7.3.2.2 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. [654-42 (CP#26)] (note – this item moved to a new location in this section).~~

~~7.3.2.31 The addition of branch lines shall not be made to an existing system without redesigning. (note – moved to the dust collection system section).~~

~~7.3.2.42 Branch lines shall not be disconnected and unused portions of the system shall not be blanked off without providing a means to maintain required and balanced airflow. (note – moved to the dust collection system section).~~

~~7.3.2.53 The rate of airflow at each hood or other pickup point shall be designed so as to convey and control the material. (note – moved to the dust collection section).~~

~~7.3.2.64* All ductwork shall be sized to provide the air volume and air velocity necessary to keep the duct interior clean and free of residual material. (note – moved to the dust collection section).~~

A.6.1.7.3.2 The design of a the pneumatic conveying, dust collection, or centralized vacuum cleaning system should be coordinated with the architectural and structural designs. The plans and specifications should include a list of all

equipment, specifying the manufacturer and type number, and the following information:

- (1) Name of owner and occupant
- (2) Location, including street address
- (3) Point of compass
- (4) Ceiling construction
- (5) Full height cross section
- (6) Location of fire walls
- (7) Location of partitions
- (8) Materials of construction

Plans should be drawn to an indicated scale and show all essential details as to location, construction, ventilation ductwork, volume of outside air at standard temperature and pressure that is introduced for safety ventilation, and control wiring diagrams.

Dust collection systems and centralized vacuum cleaning systems handling combustible dusts, usually use branched duct networks with multiple pick-up points and variable material loading. In contrast, dilute and dense phase pneumatic conveying systems are typically linear systems with controlled infeed and consistent material loading. Pneumatic conveying systems generally represent a lower deflagration risk. However, that does not mean there is not a deflagration risk present. Risk analysis should be used to determine the level of risk involved and the correct means to minimize that risk.

A.7.3.2.2. These systems are designed for specific safety and performance requirements. Modifications to the system can significantly change the ability of the system to provide the original design performance. An analysis of any proposed changes should be done in accordance with Section 4.3 (management of change) to assure the system will still be able to meet safety and performance requirements.

A.7.3.2.4. The minimum gas velocity to transport materials varies considerably due to the material characteristics, conveying rates, conveying distances, and other factors. If the velocity falls below the minimum requirement, plugging and other upset conditions could occur and lead to an unsafe operating condition. Typically the minimum gas velocities are established by testing or based upon existing data from the system designer and/or vendor.

~~A.6.4.57.3.2.5~~ Rotary valves and diverter valves are not addressed within the *ASME Boiler and Pressure Vessel Code* or *ASME B.31.3, Process Piping*, so they would not be required to comply with those codes.

~~A.7.3.2.4~~ For guidance on determining air volume and air velocity, refer to *Industrial Ventilation — a Manual of Recommended Practice*, published by the American Conference of Governmental Industrial Hygienists (ACGIH); (note – moved to the section on dust collection).

7.3.2.6* Dust Collection Systems

7.3.2.6.1* At each collection point, the system shall be designed to achieve the minimum required face velocity for dust capture over the entire opening of the hood or pick-up point.

7.3.2.6.2* The volumetric flow rate for each collection point shall be included in the system design documentation.

7.3.2.6.5 3* The rate of airflow at each hood or other pickup point for each dust source shall be designed so as to convey and control the material collected dust. (existing moved to this point and modified).

7.3.2.6.2 4* Branch lines shall not be disconnected and unused portions of the system shall not be blanked off without providing a means to maintain required and balanced air flow.

7.3.2.6.2 5* The addition of branch lines shall not be added made to an existing system without redesigning reviewing the design of the entire system. (existing moved to this location).

7.3.2.6.2 6* All ductwork shall be sized to provide the air volume and air velocity necessary to keep the duct interior clean and free of residual material. (existing and moved to this point).

7.3.2.6.2 7 Dust collection ~~Pneumatic conveying~~ systems that remove material from operations that generate flames, sparks, or hot material shall not be interconnected with ~~pneumatic conveying dust collection~~ systems that transport combustible particulate solids or hybrid mixtures. (existing moved to this point and modified)

7.3.2.6.8* HVAC systems shall not be used as the means to collect dusts from localized sources.

A.7.3.2.6.8 Where combustible dust emissions are likely, they should be managed with a dust collection system. The operator should not rely on the HVAC system to prevent dust accumulations. It is recognized that dust collection systems might not capture 100% of the dusts released from localized sources. It is not the intent of this requirement to prohibit the use of HVAC systems where incidental amounts of airborne dust is present and the HVAC system has been designed to address this hazard. Special attention should be given to areas where low air velocity exists and dust can settle out, such as the return air plenum.

A.7.3.2.6.4 Dust collection systems and centralized vacuum cleaning systems handling combustible dusts, usually use branched duct networks with multiple pick-up points and variable material loading. In contrast, dilute and dense phase pneumatic conveying systems are typically linear systems with controlled infeed and consistent material loading. Dust collection systems for combustible dusts represent a significant increase in deflagration risk compared to most

pneumatic conveying systems. A properly designed system is critical to minimizing that risk. For guidance on determining proper dust collection system design air volume and air velocity, refer to *Industrial Ventilation – a Manual of Recommended Practice*, published by the American Conference of Governmental Industrial Hygienists (ACGIH). (part is new, part is modified existing)

A.7.3.2.6.1 Proper dust collection design requires that a minimum air volume flow be maintained for each dust collection source point (such as a hood). This value should be determined as part of the design process. This is the value that should be documented to allow for field testing to determine if the system is providing that flow and operating properly.

A.7.3.2.6.2 The *Industrial Ventilation – a Manual of Recommended Practice* has extensive information on the design basis for dust collection hoods and the necessary minimum air volumes and velocities to assure the containment, capture (i.e. collection), and control of the aerated dusts being generated.

A.7.3.2.6.3 Proper system design requires that air flows in the various branch lines be balanced to assure minimum air volume flow at each dust source collection point. When a branch line is disconnected, blanked off, or otherwise modified it changes the air flows in all the other branches of the system. This can lead to an imbalance of air flows that result in flows below the minimum required to keep the dust from accumulating in the ducts.

A.7.3.2.6.4 Adding additional branch lines for additional dust sources to an existing dust collection system will result in lower air volumes and duct velocities for the existing portions of the system. Without providing for additional system performance this may result in a system performing below the minimum required for keeping the ducts free from material accumulations. It is also possible that modifications could result in failure of the main equipment items. (new)

A.7.3.2.6.5 As per *Industrial Ventilation – a Manual of Recommended Practice* the duct air velocity can range from a minimum of 3,500 fpm (18 m/s) to significantly higher levels. However, that document is for all dusts including non-combustible dusts. 4,000 fpm (20 m/s) is recommended as a minimum value for the conveying of combustible dusts. Also, there are some combustible dusts which have material characteristics (e.g., cohesiveness, adhesiveness, particle shape and size, particle density) that may require significantly higher duct velocities to minimize the possibility of accumulations in the ducts. For instance, NFPA 484 requires a minimum duct velocity of 4500 fpm (23 m/s) for metal dusts.

7.3.2.7* Centralized Vacuum Cleaning Systems.

7.3.2.7.1* The system shall be designed to assure minimum transport velocities at all times.

7.3.2.7.2* The system shall be operated only with the hoses and tools that have been designated in the design documentation for the specific hose connection station.

7.3.2.7.3* Vacuum hose, couplings, and tools shall be made of conductive or static-dissipative materials that are bonded and grounded in accordance with 9.3.1.3.

7.3.2.7.4* Controls shall be provided to prevent overfilling the AMS, which could disable the system.

7.3.2.7.5 The maximum number of hose connection stations that can be simultaneously used shall be included in the system documentation.

A.7.3.2.7 Centralized vacuum cleaning systems represent a significant deflagration risk due to the fact that the system is designed to both collect and convey combustible dusts and that tramp metals and other foreign materials that could create an ignition source can enter the system through the vacuuming process. However, through proper design and protection of the system against deflagration, this system can provide for the removal of combustible dusts from plant areas where dust accumulations represent a risk to personnel and property. Furthermore, the dust once removed through the vacuuming process will now be located in an area where it can be properly handled with minimal risk.

A.7.3.2.7.1 No more than two simultaneous hose connection stations should be allowed on any one line to the AMS. This is to assure that adequate transport velocity can be maintained with just a single operator on the same line. Multiple lines to the AMS can be used to allow for more than two simultaneous operators on the whole system (with no more than two simultaneous operators allowed on each line).

The minimum conveying velocity will vary with the typical combustible dusts being conveyed. Usually, the minimum conveying velocities will be the same as the minimum required for pneumatic conveying of the same material.

A.7.3.2.7.2 Hose diameters of 1.5"(38 mm) and/or 2.0"(50 mm) i.d. are usually used for housekeeping purposes. Hoses should be 25 ft.(7.6m) or less in length. In most systems the pressure losses (i.e. energy losses) through the hose represents as much as 50% of the overall system differential pressure requirements. If the hose diameter is too large, the flow may be insufficient to maintain transport velocity through the hose. Conversely, if the hose diameter is too small, the flow restriction of the hose can produce a low velocity in the branch line. Shorter hose lengths can be used to improve system performance, but should be long enough to accomplish the intended tasks while avoiding the need for field modifications such as splicing or coupling hoses.

A.7.3.2.7.3 The accumulation of static electrical charge on conductive or static-dissipative vacuum cleaning tools, hoses, and couplings will be prevented through grounding of these system components. However, there is a potential for the accumulation of static electrical charge on particulate solids that are transported through these components.

Often this can pose an electrostatic ignition concern in the AMS, which would then warrant the application of appropriate control measures. Creation of static charges is of greater concern when low MIE combustible dusts are being vacuumed.

A.7.3.2.7.4 The AMS should not be used as a combustible dust storage device due to the potential of bridging and plugging of the discharge. A rotary airlock valve can be used to provide for continuous discharge of the separated dusts; alternatively, a slide valve can be used where dust loadings are light, provided that the material is removed frequently enough to prevent bridging and plugging. The container below the rotary valve, or other continuous discharge device, should be designed for the type of material collected, the typical rates of material collected, and to minimize the creation of aerated dusts during the discharge of the material from the AMS into the container. It is also important to maintain a regular emptying or replacement of the collected material container to minimize the risk of overfilling.

8.2.3 Portable Vacuum Cleaners.

NOTE – the following items are included to “clean-up” the use of “pneumatic conveying” to include all three(3) types of systems.

1.1.1 This standard shall apply to all phases of the manufacturing, processing, blending, ~~pneumatic~~ conveying, repackaging, and handling of combustible particulate solids or hybrid mixtures, regardless of concentration or particle size, where the materials present a fire or explosion hazard.

~~4.45*~~ Pneumatic Conveying, Dust Collection, and Centralized Vacuum Cleaning System Design.

A.4.45 The design of the pneumatic conveying, dust collection, and centralized vacuum cleaning systems should be coordinated with the architectural and structural designs. (remaining text is not changed).

7.3.3.1 Sequence of Operation. Pneumatic conveying, dust collection, and centralized vacuum cleaning 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, dust collection, and centralized vacuum cleaning 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.

7.3.3.3.1 Pneumatic conveying, dust collection, and centralized vacuum cleaning 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.

7.4.1.1 This section shall apply to facilities that operate pneumatic conveying, dust collection, and centralized vacuum cleaning systems for metal particulates.

7.8.3.1 Airflow control valves that are installed in pneumatic conveying, dust collection, and centralized vacuum cleaning systems shall be of both airtight and dusttight construction.

9.1.2.1 Where the process is configured such that the pneumatic conveying, dust collection, or centralized vacuum cleaning system conveys materials that can act as an ignition source, means shall be provided to minimize the hazard.

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

~~10.2.43.1~~ 10.2.43.1 Where fire detection systems are incorporated into the pneumatic conveying, dust collection, or centralized vacuum cleaning system, the fire detection systems shall be interlocked to shut down any active device feeding materials to the pneumatic conveying, dust collection, or centralized vacuum cleaning system on actuation of the detection system.

Committee Statement: The Committee cleaned up some of the numbering and use of unenforceable terms in the submitter's recommendation.

654-8 Log #CC2 CMD-HAP
(3.3.14 and 9.3.1)

Final Action: Accept

Submitter: Technical Committee on Handling and Conveying of Dusts, Vapors, and Gases,
Comment on Proposal No: 654-14
Recommendation: 2.3.x IEC Publication.

IEC 61340-4-4, *Electrostatics – Part 4-4: Standard Test Methods for Specific Applications – Electrostatic Classification of Flexible Intermediate Bulk Containers (FIBC)*, 2005.

2.3.y ASTM Publication

ASTM E2019-03, “*Standard Test Method for Minimum Ignition Energy of a Dust Cloud in Air*,” 2007

3.3.15.1* Flexible Intermediate Bulk Container (FIBC) . Large bags typically made from non-conductive woven fabric which are used for storage and handling of bulk solids.

3.3.15.1.1 Type A FIBC. ~~A standard insulating flexible intermediate bulk container (FIBC):~~
An FIBC made from non-conductive fabric with no special design features for control of electrostatic discharge hazards.

3.3.15.1.2 Type B FIBC. An FIBC made from non-conductive fabric where the fabric or the combination of the fabric shell, coating, and any loose liner has a breakdown voltage of less than 6000 volts.

3.3.15.1.3 Type C FIBC. ~~A flexible intermediate bulk container (FIBC) where the fabric is interwoven with an electrically interconnected conductive fiber and provided with a tab for connection to grounding systems:~~
An FIBC made from conductive material or non-conductive woven fabric incorporating interconnected conductive threads of specified spacing with all conductive components connected to a grounding tab.

3.3.15.1.4 Type D FIBC. An FIBC made from fabric and/or threads with special static properties designed to control electrostatic discharge energy, without a requirement for grounding the FIBC.

A.3.3.15.1 FIBCs are usually made from non-conductive materials and the electrostatic charges developed as FIBCs are filled or emptied may result in electrostatic discharges which may pose an ignition hazard for combustible dust or flammable vapor atmospheres within or outside of the bag. There are currently four types of FIBCs, Type A, Type B, Type C, and Type D, based on their characteristics for control of electrostatic discharges from the FIBC.

3.3.x* Minimum Ignition Energy (MIE). The lowest capacitive spark energy capable of igniting the most ignition sensitive concentration of a flammable vapor/air or combustible dust/air mixture as determined by a standard test procedure

A.3.3.x The standard test procedure for MIE of combustible particulate solids is ASTM E2019, “Standard Test Method for Minimum Ignition Energy of a Dust Cloud in Air,” and the standard test procedure for MIE of flammable vapors is ASTM E582, “Standard Test Method for Minimum Ignition Energy and Quenching Distance in Gaseous Mixtures”

Add and renumber 9.3.1 (renumber 9.3.1 and after)

9.3.1 For electrostatic hazard assessment purposes MIE determination of dust clouds shall be based on a purely capacitive discharge circuit in accordance with ASTM E2019.

9.3.3 Flexible Intermediate Bulk Containers (FIBCs). FIBCs shall be permitted to be used for the handling and storage of combustible particulate solids in accordance with the requirements in 9.3.3.x to 9.3.3.y.

A.9.3.3 A more detailed description of FIBC ignition hazards can be found in IEC 61340-4-4, “*Electrostatics – Part 4-4: Standard Test Methods for Specific Applications – Electrostatic Classification of Flexible Intermediate Bulk Containers*”

(FIBC)”

9.3.3.1* Electrostatic ignition hazards associated with the particulate and objects surrounding or inside of the FIBC shall be included in the process hazard analysis required by 4.2.

A.9.3.3.1 Induction charging of ungrounded conductive objects, including personnel, should be addressed as part of the process hazard analysis. The process hazard analysis should also consider that higher rates of transfer into and out of the FIBC increases the rate of charge generation. Consideration should also be given to the possibility of surface (cone) discharges while filling the FIBC, regardless of FIBC type. For additional information on these phenomena refer to NFPA 77. The use of internal liners in FIBCs may introduce additional electrostatic ignition hazards and should be subject to expert review prior to use

9.3.3.2 Type A FIBCs shall be limited to use with non-combustible particulate solids or combustible particulate solids having MIE >1000 mJ.

9.3.3.2.1 Type A FIBCs shall not be used in locations where flammable vapors are present.

9.3.3.2.2* Type A FIBCs shall not be used with conductive particulate solids.

A.9.3.3.2.2 For this application, conductive particulate solids are typically those materials having bulk resistivity 10^6 ohm-m.

9.3.3.3 Type B FIBCs shall be permitted to be used where combustible dusts having MIE >3 mJ are present.

9.3.3.3.1 Type B FIBCs shall not be used in locations where flammable vapors are present.

9.3.3.3.2* Type B FIBCs shall not be used for conductive particulate solids.

A.9.3.3.3.2 See A.9.3.3.2.2.

9.3.3.4 Type C FIBCs shall be permitted to be used with combustible particulate solids and in locations where flammable vapors having MIE >0.14 mJ are present.

9.3.3.4.1 Conductive FIBC elements shall terminate in a grounding tab and resistance from these elements to the tab shall be 10^8 ohms.

9.3.3.4.2 Type C FIBCs shall be grounded during filling and emptying operations with a resistance to ground of less than 25 ohms.

9.3.3.4.3 Type C FIBCs shall be permitted to be used for conductive particulate solids.

9.3.3.5 Type D FIBCs shall be permitted to be used with combustible particulate solids and in locations where flammable vapor atmospheres having MIE >0.14 mJ are present.

9.3.3.5.1 Type D FIBCs shall not be permitted to be used for conductive particulate solids.

9.3.3.6* Type B, C, and D FIBCs shall be tested and verified as safe for their intended use by a recognized testing organization in accordance with the requirements and test procedures specified in standard IEC 61340-4-4 before being used in hazardous environments.

A.9.3.3.6 Table A.9.3.3.6 provides a useful guide for selection and use of FIBCs based on the MIE of product contained in the FIBC and the nature of the atmosphere surrounding it:

Insert Table A.9.3.3.6

9.3.3.6.1 Intended use shall include both the product being handled and the environment in which the FIBC will be used.

9.3.3.6.2 Materials used to construct inner baffles, other than mesh or net baffles, shall meet the requirements for the bag type in which they are to be used.

9.3.3.6.3 Documentation of test results shall be made available to the authority having jurisdiction

9.3.3.6.4 FIBCs which have not been tested and verified for type in accordance with IEC 61340-4-4 shall be not be used for combustible dusts or in flammable vapor atmospheres.

9.3.3.7* Deviations from the above requirements for safe use of FIBCs shall be permitted upon expert review and a documented risk assessment acceptable to the authority having jurisdiction.

A.9.3.3.7 In special cases it may be necessary to use an type of FIBC which is not permitted for the intended application based on the requirements of Section 9.3.3. For such cases it may determined that the FIBC is safe to use provided that filling or emptying rates are restricted in order to limit electrostatic charging. In the case of conductive combustible particulate solids the use of a Type A FIBC may be acceptable provided that the maximum ignition energy from the FIBC or charged product within it is less than the MIE of the combustible particulate solids

9.3.4 Rigid Intermediate Bulk Containers (RIBC)

9.3.4.1* Conductive RIBC shall be permitted to be used for dispensing into any flammable vapor, gas, dust, or hybrid atmospheres provided that the RIBC is electrically grounded

A.9.3.4.1 Conductive containers are generally made from either metal or carbon-filled plastic having a volume resistivity $<10^6$ ohm-m.

9.3.4.2* Non-conductive RIBCs shall not be permitted to be used for applications, processes, or operations involving combustible particulate solids or where flammable vapors or gases are present unless a documented risk evaluation assessing the electrostatic hazards is acceptable to the authority having jurisdiction.

A.9.3.4.2 Induction charging of ungrounded conductive objects, including personnel, should be addressed as part of the risk evaluation and process hazard analysis when considering the use of non-conductive RIBC. The risk evaluation should also consider that higher rates of transfer into and out of the RIBC increases the rate of charge generation which could result in propagating brush discharges or surface (cone) discharges while filling the RIBC. For additional information on these phenomena refer to NFPA 77.

Substantiation: This represents the work of a task group formed by the Chair at the ROP meeting in regards to ROP 654-14. The recommended changes to both the FIBC definitions and the requirements regarding use or application limitations for FIBC types and static electrical ignition precautions are based on industry practices throughout the world based on the most current IEC requirements contained in the reference publication addressing test methods and electrostatic classification for FIBCs.

Committee Meeting Action: Accept

Use of different types of FIBCs

<u>Bulk product in FIBC</u>	<u>Surroundings</u>		
<u>MIE of solids^a</u>	<u>Non-flammable atmosphere</u>	<u>Class II, Divisions 1 & 2</u> <u>(1 000 mJ ≥ MIE ≥ 3 mJ)^a</u>	<u>Class I, Divisions 1 & 2</u> <u>(Gas Group C & D)</u> <u>or</u> <u>Class II, Divisions 1 & 2</u> <u>(MIE ≤ 3 mJ)^a</u>
<u>MIE > 1 000 mJ</u>	<u>A,B,C,D</u>	<u>B,C,D</u>	<u>C,D^b</u>
<u>1 000 mJ ≥ MIE > 3 mJ</u>	<u>B,C,D</u>	<u>B,C,D</u>	<u>C,D^b</u>
<u>MIE ≤ 3 mJ</u>	<u>C,D</u>	<u>C,D</u>	<u>C,D^b</u>
<p><u>NOTE 1 Additional precautions are usually necessary when a flammable gas or vapour atmosphere is present inside the FIBC, e.g. in the case of solvent wet solids.</u></p>			
<p><u>NOTE 2 Non-flammable atmosphere includes combustible particulate solids having a MIE > 1 000 mJ.</u></p>			
<p><u>NOTE 3 FIBC Types A, B, and D are not suitable for use with conductive combustible particulate solids</u></p>			
<p>^a <u>Measured in accordance with ASTM E2019, capacitive discharge circuit (no added inductance).</u></p>			
<p>^b <u>Use of Type C and D shall be limited to Gas Groups C & D with MIE > 0,14 mJ.</u></p>			

654-9 Log #19 CMD-HAP
(3.3.14.1.1 Type A FIBC)

Final Action: Accept in Principle

Submitter: Marcelo M. Hirschler, GBH International

Comment on Proposal No: 654-14

Recommendation: Revise text to read as follows:

3.3.14.1.1 Type A FIBC. ~~A standard insulating flexible intermediate bulk container (FIBC); A flexible intermediate bulk container (FIBC) made from fabric or plastic sheet without any measures against the build up of static electricity; Any FIBC that does not meet the requirements specified in IEC/FDIS 61340-4-4:2005(E); or which has not been tested against the requirements is classified as Type A.~~

Substantiation: The proposed revision to the definition (as rejected) is problematic since definitions need to be in single sentences, cannot contain requirements and cannot refer to standards (and even less to proposed standards).

The proposed revision is a way forward for the technical committee, and it would read as follows:

3.3.14.1.1 Type A FIBC. A flexible intermediate bulk container (FIBC) made from fabric or plastic sheet without any measures against the build up of static electricity or which has not been tested against the requirements is classified as Type A.

Note that an FDIS is not a published standard.

I am the chair of the Glossary committee on terminology, set up by NFPA Standards Council to obtain uniformity of definitions within NFPA.

Committee Meeting Action: Accept in Principle

See Committee Action on Committee Comment 654-8 (Log# CC2).

Committee Statement: See Committee Action and Substantiation on Committee Comment 654-8 (Log# CC2).

654-10 Log #22 CMD-HAP
(3.3.14.1.3 Type C FIBC and A.3.14.1.3)

Final Action: Accept in Principle

Submitter: Marcelo M. Hirschler, GBH International

Comment on Proposal No: 654-14

Recommendation: Revise text to read as follows:

3.3.14.1.3* Type C FIBC. A flexible intermediate bulk container (FIBC) ~~where the fabric is interwoven with an electrically interconnected conductive fiber and provided with a tab for connection to grounding systems; made from conductive fabric or plastic sheet, or interwoven with conductive threads or filaments and designed to prevent the occurrence of incendiary sparks, brush discharges and propagating brush discharges.~~

A.3.14.1.3 Type C FIBC are designed to be connected to earth during filling and emptying operations.

Substantiation: The proposed revision to the definition (as rejected) is problematic since definitions need to be in single sentences.

The proposed revision is a way forward for the technical committee, and it would read as follows:

3.3.14.1.1 Type A FIBC. A flexible intermediate bulk container (FIBC) made from conductive fabric or plastic sheet, or interwoven with conductive threads or filaments and designed to prevent the occurrence of incendiary sparks, brush discharges and propagating brush discharges.

The second sentence can be made into an Annex note, as proposed here, or placed somewhere in the body of the standard.

I am the chair of the Glossary committee on terminology, set up by NFPA Standards Council to obtain uniformity of definitions within NFPA.

Committee Meeting Action: Accept in Principle

See Committee Action on Committee Comment 654-8 (Log# CC2).

Committee Statement: See Committee Action and Substantiation on Committee Comment 654-8 (Log# CC2).

654-11 Log #14 CMD-HAP
(4.2.3)

Final Action: Accept in Principle

Submitter: George Petino, Jr., Hazards Research Corporation, Inc.

Comment on Proposal No: 654-18

Recommendation: This provision should be deleted.

Substantiation: Scope: The scope and intent of this provision is unclear. On its face, it appears that this provision would apply to both areas inside process equipment and areas external to process equipment.

Application: As written, this requirement is neither appropriate nor practical. As a general principle, manufacturing plants are not designed with the expectation that they will generate significant dust deposits. Rather our experience is that the generation of dust deposits results from changes such as the evolution of a process (e.g., moving from granular to powdered materials) and the aging of equipment that still has a remaining useful life. This proposed provision does not have any apparent limitations. It appears to impose an unnecessary and impractical burden, requiring the ability to see into the future, for the person performing a PHA to specify, in advance, the allowable layer thickness and deposit surface area for each exposed or concealed surface in a facility. The reality is that one designs a facility to avoid the generation of fugitive dust and then re-assesses the situation after the plant is up and running. At that point, one then determines whether any process or equipment modifications are appropriate and what cleaning frequency and methods are required or appropriate to avoid or eliminate any dust explosion hazard areas that may exist. Any attempt to do this in advance is wholly impractical. As a general principle, any suggestion that one would design a plant with residual dust explosion hazard areas and then plan for the use of PPE is fundamentally wrong.

Committee Meeting Action: Accept in Principle

Revise 4.2.3 as shown:

4.2.3* If the process, equipment, or the operation does not prevent accumulation ~~permit elimination~~ of dust deposits outside of equipment 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.

Committee Statement: The modifications to the ROP language in paragraph 4.2.3 address the submitter's scope issues by establishing boundaries or limitations as called for in the substantiation so that it is clear that it is the intent for this requirement to apply to outside of equipment. With respect to the concerns highlighted in the "application" section of the substantiation, the Committee notes that there is a potential for release of combustible dusts and the requirement intends to establish controls to ensure that intolerable accumulations of dust are prevented. PHAs are updated on a periodic basis, which allows operating experience and changes implemented in the facility/equipment/process to be reflected and controls to be adjusted as warranted.

654-12 Log #15 CMD-HAP
(4.4.1)

Final Action: Reject

Submitter: George Petino, Jr., Hazards Research Corporation, Inc.

Comment on Proposal No: 654-19

Recommendation: Revise this provision to read as follows:

4.4.1* Incidents that result in a fire or explosion of a magnitude that causes *significant* property damage, *significant* production shutdown time, or *serious* injury shall be investigated.

Substantiation: The scope of Section 4.4.1 is unnecessarily broad and burdensome, and would result in excessive micromanagement of the user. Clearly, it is important not to overburden operators by having to conduct an incident investigation of every event regardless of its character. This is a point on which we believe it is preferable to narrow the scope to what is practical rather than being over-inclusive and expecting the user to discount the requirement to an appropriate degree.

Committee Meeting Action: Reject

Committee Statement: The recommended language changes would introduce unenforceable terms into this requirement. The Committee also notes that the Annex to this requirement provides explanation for how the user could apply the provision.

654-13 Log #23 CMD-HAP
(4.6.2)

Final Action: Reject

Submitter: George Petino, Jr., Hazards Research Corporation, Inc.

Comment on Proposal No: N/A

Recommendation: Delete Section 4.6.2.

Substantiation: We believe it is important to comment on this provision, although it was not part of a proposed change, because it relates to our comment on Section 4.2.3. This section provides:

The facility shall be designed, constructed, and equipped to maintain its structural integrity in spite of the effects of fire or explosion for the time necessary to evacuate, relocate, or defend in place occupants not in the immediate proximity of the ignition. As a general principle, a new manufacturing plant is not designed with the expectation that it will have unprotected AMS and generate significant fugitive dust deposits that present fire and explosion hazards. Rather our experience is that the generation of dust deposits results from changes such as the evolution of a process (e.g., moving from granular to powdered materials) and the aging of equipment that still has a remaining useful life. This proposed provision does not have any apparent limitations. It appears to impose an unnecessary and impractical burden, requiring the designer to have the ability to see into the future and specify, in advance, the design criteria that will ensure that the facility complies with this provision for events that could not have been foreseen or planned for at the time of the initial design of the facility. The reality is that one generally designs a facility to avoid the generation of fugitive dust and then re-assesses the situation after the plant is up and running. At that point, one then determines whether any process or equipment modifications are appropriate and what cleaning frequency and methods are required or appropriate to avoid or eliminate any dust explosion hazard areas that may exist. Any attempt to do this in advance is wholly impractical.

Committee Meeting Action: Reject

Committee Statement: First, it should be noted that this section of NFPA 654 was not revised and is therefore not open to Public Comment for revision. In addition, the Life Safety Objective in 4.6.2 of the ROP draft is an essential element of the document, whether the prescriptive or performance-based approach is followed, and for that reason the Committee does not support the recommendation for deletion.

654-14 Log #24 CMD-HAP
(5.1.1)

Final Action: Reject

Submitter: George Petino, Jr., Hazards Research Corporation, Inc.

Comment on Proposal No: N/A

Recommendation: This provision should be deleted or amended in a way that provides some meaningful, objective criteria for evaluating the qualifications of the person preparing the performance-based design.

Substantiation: This provision currently reads as follows:

The performance-based design shall be prepared by a person with qualifications acceptable to the owner/operator." This provision lacks credibility, reflects negatively on the organization and should be amended so as to provide a credible definition of a qualified person that is based on reasonable, objective criteria that would not inappropriately exclude qualified individuals from this role, or it should be dropped.

Committee Meeting Action: Reject

Committee Statement: First, it should be noted that this section of NFPA 654 was not revised and is therefore not open to Public Comment for revision. The submitter has not provided any specific language on which to evaluate any proposed technical revision to the current requirement. One option provided by this comment is to delete the provision, however, no clear basis has been provided to take that action and since the other option suggested is to amend, the Committee is not able to act as no specific language has been provided.

654-15 Log #25 CMD-HAP
(5.3.2.1 and 5.3.2.2)

Final Action: Reject

Submitter: George Petino, Jr., Hazards Research Corporation, Inc.

Comment on Proposal No: 654-2

Recommendation: Revise these provisions to read as follows:

5.3.2.1 Each duct, enclosed conveyor, silo, bunker, ~~cyclone, air-material separator dust collector~~, or other vessel containing a combustible dust in sufficient quantity ~~or and under conditions to that would~~ support the propagation of a flame front during startup, normal operating conditions, or shutdown shall be included as an explosion scenario.

5.3.2.2 Each duct, enclosed conveyor, silo, bunker, ~~cyclone, air-material separator dust collector~~, or other vessel containing a combustible dust in sufficient quantity ~~or and under conditions to that would~~ support the propagation of a flame front under credible conditions of production upset or single equipment failure shall be included as an explosion scenario.

Substantiation: A cyclone is one type of AMS; to use both terms suggests that a cyclone is not an AMS. The original language "or conditions" was unclear and would lead to misunderstandings and confusion. We inserted the word "credible" because the risk evaluation needs to be based on credible conditions rather than any theoretically possible conditions.

Committee Meeting Action: Reject

Committee Statement: The Committee already deleted "cyclone" and "dust collector" per ROP 654-2 and so the recommendation in this comment to make that amendment is redundant. The proposed inclusion of the word "credible" introduces an unenforceable term. The other proposed edits in both paragraphs do not add clarity to the objective in this section.

654-16 Log #CC3 CMD-HAP
(6.1)

Final Action: Accept

Submitter: Technical Committee on Handling and Conveying of Dusts, Vapors, and Gases,
Comment on Proposal No: 654-22
Recommendation: Revise 6.1 as shown:

Include 654_LCC3_R here

Substantiation: The proposed amendments in this Committee Comment are based on the work of a Task Group established at the ROP meeting to further develop the requirements applicable for hazard determination and use of separation. The revised requirements provide the user of the standard with sufficient enhanced options by which to determine the existence of hazardous conditions for dust flash fires or dust explosions. The revisions now provide the four options as equal to each other so that the user is able to select one based on particular applications. The revisions to this section of the standard also address three specific issues in the 2006 edition of NFPA 654: determination of where a deflagration hazard exists in a room or building, determination of where an explosion hazard exists in equipment, and thermal exposure protection for personnel exposed to a deflagration hazard. The proposed revision of 6.1 presented in this Committee Proposal also reflects the Committee's action in the TIA 1020 to the 2006 edition of NFPA 654 that was issued by the Standards Council March 1, 2011 (see Decision D#11-4). The options are Layer Depth Criterion Method, Mass Method A, Mass Method B, and Risk Evaluation Method.

While many people use the 1/32 in. dust layer thickness criterion as a basis for determining the presence of a dust deflagration hazard, the existing text in the body of NFPA 654-2006 does not currently provide sufficient guidance on the proper use of this criterion. In fact, the only reference to this layer thickness in the current body text is in a section that specifically addresses hazardous area separation distances. The committee's intent for the application of the 1/32 in. criterion is presented in Annex D. This annex clearly describes how a 1/32 in. dust layer throughout an entire room could create an explosible cloud 10 feet high throughout the entire room. It also states that the dust layer should not be allowed to accumulate over more than 5% of the building floor area or 1000 ft², whichever is less. However, this section is often overlooked when applying the 1/32 in. criterion. The result of this misapplication is that a user may fail to recognize a significant dust explosion hazard. The proposed changes to 6.1.1 and 6.2.3 move the 1/32 in. threshold to a general section of the document to clearly establish where a deflagration hazard exists. These changes also incorporate the critical factors from Annex D into the body text so that they must be considered as part of the hazard analysis. Additional annex material has also been prepared to provide examples of the proper application of this requirement. Dust deflagration events produce both pressure-related hazards and thermal exposure hazards. The existing text does not specifically address thermal exposure hazards to personnel from a dust flash fire or deflagration. Note that even with the proposed limitations on combustible dust (1/32 in. over 5% of the floor area), as much as 50% of the room volume could be filled with a burning dust cloud. The proposed addition of sections 6.1.1.10 and 11.2.3 requires users to address flash fire personal protective equipment (PPE) as part of the operating and maintenance procedures, including the use of flame-resistant garments for all personnel exposed to a deflagration hazard. The current edition also lacks a definitive statement establishing what constitutes an "explosion hazard", which establishes the basis for numerous requirements in the document. A new section 6.1.1.3 has been added to remedy this omission. Without this new section there is no basis in the standard for the user to determine where many of the prescriptive criteria are applicable. The proposed changes address omissions in the 2006 edition of NFPA 654. The application of the 1/32 in. dust layer limit without regard to an area limitation presents a dangerous condition in which a secondary dust explosion could produce widespread damage and multiple injuries or fatalities. In addition, the thermal exposure hazard from a flash fire is a recognized hazard that is not addressed in the current edition.

The changes included also have made the entrainment fraction, η_D (Greek symbol "eta" subscript D) equal to 0.25 and permits the use of alternative values based on a risk evaluation. A new requirement for enclosed process equipment has also been added as a new 6.1.7 to be consistent with the amendment of the standard that came from the TIA action.

Committee Meeting Action: Accept

6.1 General. The facility and process shall be designed and operated in accordance with this section.

~~provisions of this section. shall apply to the overall design of systems that handle combustible dusts.~~

6.1.1 Hazard Assessment. The facility and process equipment shall be evaluated for dust flash fire and dust explosion hazards in accordance with this section. ~~The provisions of this section shall apply to the assessment of the hazards associated with the overall design of systems that handle combustible dusts.~~

6.1.1.1 Those portions of the process and facility interior where dust accumulations exist outside of equipment in sufficient depth to prevent discerning the underlying surface color shall be evaluated to determine if a dust explosion hazard or flash fire hazard exists. ~~s, unless the dust layer depth is 1/64" or less or the underlying surface colors are readily discernible.~~

6.1.1.2 Areas where dust clouds of a hazardous concentration exist shall be deemed to be a dust flash fire and dust explosion hazard area.

6.1.1.3* Dust flash fire or dust explosion hazard areas shall additionally be determined in accordance with any one of the four methods established below:

- (1) Layer Depth Criterion Method in Section 6.1.3
- (2) Mass Method A in Section 6.1.4
- (3) Mass Method B in Section 6.1.5,
- (4) Risk Evaluation Method in Section 6.1.6.

~~Building, rooms, compartments and other interior spaces shall be assessed in accordance with Sections 6.1.2, 6.1.3, 6.1.4 or 6.1.5.~~

A.6.1.1.3 For many situations the layer depth method is the easiest to use and can be used for any application or ceiling height. Either of the Mass Methods can be used for any ceiling height. Mass Method A does not require specific material properties or building strength data. Using Method A for buildings with greater than 12 meter ceiling height does not allow the user increased dust accumulation, compared to Mass Method B. Mass Method B allows the owner operator the greatest flexibility in addressing dust accumulations and takes into account specific building and material properties. However, this requires more detailed information about the building construction that might not be available for some buildings. When calculating dust loads by any method, include dust on mezzanines. When calculating the allowable volume or mass of dust, the area of the mezzanine is not added to the footprint of the building or room.

6.1.1.4 Each of the methods in Sections 6.1.3, 6.1.4, 6.1.5, and 6.1.6 shall be deemed to provide equivalent levels of safety.

6.1.1.5* It shall be permitted to determine the accumulated mass and bulk density on a dry weight basis by drying the sample to less than or equal to 5 weight percent moisture. (existing 6.1.9 of ROP moved here)

A.6.1.1.5 In some cases, such as fine particulates generated from hardwoods, it is advisable to correct for a settled bulk density in excess of the 20 lb/ft³ (320 kg/m³), used in this requirement.

The measurement of bulk density is very dependent upon the particle, size, shape, and chemical content. Settled bulk density is not the same as tapped bulk density. Settled bulk density is the density as the material has settled in the facility under normal operating conditions. Tapped bulk density is the maximum density that can be achieved without intentional compression. Tapped bulk density measurement numbers are almost always higher than settled bulk density measurement numbers.

Moisture content is a factor that has a profound effect on dust deflagration propagation. Moisture in dust particles raises the minimum ignition temperature (MIT), minimum ignition energy (MIE), and minimum explosible concentration (MEC) by increasing agglomeration of particles.

Moisture content can be determined using the following method:

- (1) Weigh the material of which a moisture content is to be determined in the moist, as-received state.
- (2) Then dry it for 24 hours in a drying oven set at 75°C (167°F).
- (3) Then reweigh the sample.

Calculate the moisture content from the following relation:

$$\% \text{ MC} = [(\text{moist weight}) - (\text{dry weight})](100)/\text{moist weight}$$

While no ASTM method currently exists for determining settled bulk density, the following method has been utilized to produce usable results. Since the use of bulk density measurements is to determine the permissible dust layer depth for hazard assessment, bulk density should be based upon the dried weight, not moist weight; the water in the moist sample does not add combustible material to the mixture.

Recommended Tools: Neoprene or other similar plastic-type gloves, ruler, two natural bristle brushes [100 mm (4 in.) width], scales (that measure grams), pre-weighed container (weighed in grams to nearest tenth of a gram), and a drying oven.

Recommended Procedure:

- (1) Pre-weigh and record container weight.
- (2) Locate horizontal surface area where dust is present and is evenly distributed across a flat surface. This is an important criterion.

(3) Mark off a 1 ft² (0.09 m²) area. (It is easier if one of the four sides is the horizontal surface ledge). If one square foot is not available due to size of surface use: 1/2 ft × 2 ft; 1/4 ft × 4 ft, etc.

(4) Using the ruler as a guide, carefully scrape the other dust surrounding the marked 1 ft² (0.09 m²) (or other established one square foot dimension) back away from the dust square (or rectangle) to at least 8–12 in. Use the first brush if needed to clean dust away from the 1 ft² (0.09 m²) selected for density measurement [ensuring that the 1 ft² (0.09 m²) area does not receive any of the dust being brushed away].

(5) Measure and record the height (to the nearest 1/32 in.) of the dust layer as it sits on the horizontal layer. Take a minimum of three to five measurements along the edge of the dust layer to establish an average height (to the nearest 1/32 in.) of the dust layer.

(6) Take the second clean, natural bristle brush and carefully brush the dust contained inside the 1 ft² (0.09 m²) area into the pre-weighed container.

(7) At this time, the dust sample must be dried as outlined above.

(8) Weigh the dried dust sample and the container together and record the weight in grams.

(9) Subtract the weight of the container from the weight of the dried dust-filled container to obtain the weight of the dried dust in grams. Record the dust weight.

(10) Calculate volume of the dust layer using average height measured (in inches) × length (12 in.) × height (12 in.) to obtain cubic inches of volume.

(11) Convert cubic inches to cubic feet.

(12) Convert grams of dust measured to pounds. (Note: 453.6 g = 1 lb).

(13) Divide pounds of dust by cubic feet to establish estimated density in pound per cubic feet (lb/ft³).

Example:

Container pre-weight is 500 g.

Average dust height measured is 2 1/32 in.

Container plus dust weight is 660 g.

Dust Volume Determination in cubic feet (ft³):

2 1/32 in. = 65/32 in., or 2.03125 in. (51.6 mm)

Volume (in.³) = L × W × H = 12 in. × 12 in. × 2.03125 in. = 292.5 cubic in.³

Convert cubic inches to cubic feet: There are 1728 in.³ in 1 ft³.

Volume (ft³) = Volume (in.³) ÷ 1728 = 292.5 ÷ 1728 = 0.169 ft³ (0.0048 m³)

(305 mm × 305 mm × 51.6 mm) = (0.305 m × 0.305 m × 0.0516 m = 0.0048 m³)

Dust Weight Determination in pounds (lb):

To obtain the weight of the dust, subtract container weight in grams from weight of the container containing the dried sample:

660 g – 500 g = 160 g

Convert grams to pounds. There are 453.6 g in 1 lb, therefore:

160 g ÷ 453.6 g/lb = 0.353 lb (of dust)

Dust Density Determination:

Divide pounds of dust by volume of dust in cubic feet:

$$0.353 \text{ lb} \div 0.169 \text{ ft}^3 = 2.087 \text{ lb/ft}^3.$$

Round off to nearest tenth of a pound = 2.1 lb/ft³

$$[0.16 \text{ kg} \div 0.0048 \text{ m}^3] (33.43 \text{ kg/m}^3).$$

6.1.1.6 Dust accumulations are deemed non-separated unless segregation, separation, or detachment is used to limit the hazard area in accordance with section 6.2

6.1.1.7 All dust accumulated on structures above the lowest footprint shall be evaluated as if accumulated on the lowest footprint.

6.1.1.8 Dust accumulation amounts shall reflect the conditions that exist just prior to routinely scheduled cleaning, and shall not include short term accumulations cleaned in accordance with Chapter 8.

6.1.1.9 The process equipment shall be assessed in accordance with Section 6.1.7.

6.1.1.10 Personnel exposed to a dust flash fire hazard shall be protected in accordance with Section 11.2.2.

6.1.2 Those portions of the facility and process where a dust explosion hazard or flash fire hazard exists shall be protected from the effects of these hazards in accordance with this section as well as Sections 6.2, 6.3, and 6.4 and Chapter 7.

6.1.3* Layer Depth Criterion Method.

A dust flash fire or dust explosion hazard area exists when the dust layer thickness measured outside of process equipment exceeds the quantity determined below.

A.6.1.3 See Annex D for example calculations applying the layer depth criterion method.

6.1.3.1 The layer depth criterion is 1/32" and shall be permitted to be increased according to equation 6.1.3.1 for materials with bulk density less than 75 lb/ft³

*****Insert Equation 6.1.3.1 (from ROP Eq 6.1.6.1) Here*****

6.1.3.2* A dust explosion hazard and dust flash fire hazard shall be deemed to exist in any building or room where any of the following conditions exist:

~~(1) For any buildings or rooms with footprint areas smaller than 20,000 ft² either~~

(1)(a) the total area of non-separated dust accumulations exceeding the layer depth criterion is greater than 5% of the footprint area, or

(2)(a) the area of any single non-separated dust accumulations exceeding the layer depth criterion is greater than 1000 ft², or

$$\text{Layer Depth Criterion (in)} = \frac{\left(\frac{1}{32} \text{ in}\right) \left(75 \frac{\text{lb}}{\text{ft}^3}\right)}{\text{Bulk Density} \frac{\text{lb}}{\text{ft}^3}}$$

~~(2) For buildings or rooms with footprint areas greater than or equal to 20,000 ft² either
(3)(b) the total volume of non-separated dust accumulations is greater than the layer depth criterion multiplied by 5% of the footprint area, or
(4)(b) the total volume of any single non-separated dust accumulation is greater than the layer depth criterion multiplied by 1000 ft².~~

~~(1) For buildings or rooms with footprint areas smaller than 20,000 ft²
(a) the area of dust accumulations exceeding the layer depth criterion is greater than 5% of the footprint area, or
(b) the total volume of dust accumulations is greater than the layer depth criterion multiplied by 5% of the footprint area.
(2) For buildings or rooms with footprint areas greater than or equal to 20,000 ft²
(a) the area of dust accumulations exceeding the layer depth criterion is greater than 1000 ft², or
(b) the total volume of dust accumulations is greater than the layer depth criterion multiplied by 1000 ft². [654-22 (CP#4)]~~

A.6.1.3.2 See D.2 for example of how to apply this method.

6.1.4* Mass Method A. A dust flash fire or dust explosion hazard area exists when the total accumulated dust outside of process equipment exceeds the quantities determined from the equations below.

A.6.1.4 Mass per unit area derived from these mass determination methods can be used to derive a measurable layer depth using the fact that mass divided by settled bulk density equals layer depth. See D.3 for an example of how to apply this method.

6.1.4.1 The threshold dust mass establishing a building or room as a dust explosion hazard area, $M_{\text{basic-exp}}$, shall be determined per equation 6.1.4.1.

Eqn 6.1.4.1 (existing equation 6.1.3.1 from ROP)

6.1.4.2 The threshold dust mass establishing a building or room as a dust flash fire hazard area ~~dust deflagration hazard area~~, $M_{\text{basic-fire}}$, shall be determined per equation 6.1.4.2.

Eqn 6.1.4.2 (existing equation 6.1.3.2 from ROP)

Where, for both equations 6.1.4.1 and 6.1.4.2:

$M_{\text{basic-exp}}$ is the threshold dust mass (kg) based upon building damage criterion

$M_{\text{basic-fire}}$ is the threshold dust mass (kg) based upon personnel fire exposure criterion

A_{floor} is the lesser of the enclosure floor area (m²) or 2000 m²

H is the lesser of the enclosure ceiling height (m) or 12 m

A.6.1.34 Because fugitive dust could accumulate in a localized area of the building or room (localized area less than 10% of the total floor area), the floor area limit (A_{floor})

$$M_{(basic-cxp)} = 0.004 \cdot A_{floor} \cdot H$$

654_Log#CC3_Eq 6.1.4.1

$$M_{base-fur} = 0.02 \cdot A_{floor}$$

654_Log#CC3_Eq 6.1.4.2

used in equations 6.1.34.1 or 6.1.34.2 has been set to 2000 m². For an example of the calculation of threshold dust mass see Annex D.

6.1.5* Mass Method B. A dust flash fire or dust explosion hazard area exists when the total accumulated dust outside of process equipment exceeds the quantities determined from the equations below.

A.6.1.5 See D.3 for an example of how to apply this method.

6.1.5.1* The threshold dust mass establishing a building or room as a dust explosion hazard area, M_{exp} , shall be determined per equation 6.1.5.1.

A.6.1.5.41 The Dust Explosion Hazard Area equation originates from the NFPA-68 Partial Volume equation, which adjusts the amount of venting needed when the design scenario presumes the combustible mixture fills only a part of the enclosure. NFPA-68 uses the ratio of P_{red} to P_{max} and the fill fraction to make this adjustment. P_{red} is the maximum pressure predicted to be developed during a vented deflagration and should be less than the strength of the weakest building structural element not intended to vent or fail. Windows, for instance, might be intended to fail. NFPA-68 sets an upper bound for P_{red} , ensuring that the calculated pressure during the event does not exceed the strength of the enclosure. This upper bound is P_{es}/DLF , the dynamic strength of the weakest building structural element not intended to vent or fail. In the implementation here, the goal is to see if any explosion venting is needed to prevent damage to the main building structural components, thus P_{red} is equated to its maximum allowable value, based on the building/room design.

In a deflagration, the pressure developed changes with the dust concentration. Equation 6.1.54.1 uses the so-called worst case concentration of dust in a combustible mixture, C_w , as defined in NFPA-68. A conservative way to evaluate the pressure attained at lower average dust concentration is to assume that all of the dust available is concentrated in a smaller volume to the worst case concentration. This smaller volume is a fraction of the total volume, the fill fraction. In Equation 6.1.45.1, the threshold dust mass, M_{exp} , divided by the product of worst case concentration and building volume is the fill fraction. When accumulated dust mass is larger than the threshold for the Explosion Hazard, then the fill fraction is greater than the ratio of P_{es}/DLF to P_{max} , and an Explosion Hazard exists.

*****Insert Eqn 6.1.5.1 (existing equation 6.1.4 from ROP) Here*****

where:

M_{exp} = the threshold dust mass (kg) based upon building damage criterion,

P_{es} = the enclosure strength evaluated based on static pressure calculations for the weakest building structural element not intended to vent or fail (bar g) per NFPA 68,

DLF = the dynamic load factor, the ratio of maximum dynamic deflection to static deflection per NFPA 68,

$$M_{\text{exp}} = \left[\frac{PeS}{DLF} \right] \cdot \left[\frac{C_w}{P_{\text{max}}} \right] \cdot \frac{A_{\text{flot}} \cdot H}{\eta_D}$$

654_Log#CC3_Eq 6.1.5.1

C_w = the worst case dust concentration (kg/m^3) at which the maximum rate-of-pressure-rise results in tests conducted per ASTM E1226,

P_{max} = the maximum pressure (bar g) developed in ASTM E1226 tests with the accumulated dust sample,

A_{floor} = the enclosure floor area (m^2),

H = the enclosure ceiling height (m).

ηD = the entrainment fraction = 0.25

6.1.5.1.1 In the absence of detailed structural response analysis, it shall be permitted to assume a worst-case value of $\text{DLF} = 1.5$ and design based on the weakest structural element of the enclosure.

6.1.5.1.2* It shall be permitted to use an alternative value of ηD ~~less than 0.25~~, based on a risk evaluation that is acceptable to the authority having jurisdiction.

A.6.1.45.1.2 See FPRF Report Towards Estimating Entrainment Fraction for Dust Layers, 2011. See NFPA 68 for additional information.

~~A higher value for ηD is more appropriate for ducts and small enclosures less than 100 m^3 and for enclosures with L/D ratios greater than 5, such as galleries. Research activities are currently in progress to define a technical basis for estimating ηD .~~

6.1.5.2* The threshold dust mass establishing a building or room as a dust flash fire hazard area, M_{fire} , shall be determined per equation 6.1.5.2.

A.6.1.5.2 The Dust Flash Fire Hazard Area equation estimates the fraction of the volume that could be filled by an expanded fireball from burning dust. The room or building volume up to person height is taken as the total volume for this hazard, regardless of actual building height. The threshold for the Flash Fire Hazard is based on allowing the accumulated dust mass to reach the worst case concentration in an unburnt volume which, when expanded in a fireball, is only a fraction of the volume described by the product of person height and floor area. The relation in 6.1.5.2 uses a probability (p) of an occupant being in the same location as the deflagration flame as its risk tolerance criterion. This choice implies that some residual risk remains.

*****Insert Eqn 6.1.5.2 (existing equation 6.1.5 from ROP) Here*****

Where:

M_{fire} = the threshold dust mass (kg) based upon personnel fire exposure criterion.

P_{initial} = 1 bar absolute

D = the nominal height of a person (m)

p = the probability of flame impingement on a person.

6.1.5.2.1 The value of D in equation 6.1.5.2 shall be 2 m.

$$M_{fire} = \rho \cdot C_w \cdot \left[\frac{P_{initial}}{P_{initial} + P_{max}} \right] \cdot \frac{A_{floor} \cdot D}{\eta_D}$$

654_Log#CC3_Eq 6.1.5.2

6.1.5.2.2 The value of p shall not exceed 0.05 (5% probability).

6.1.5.2.3* It shall be permitted to use an alternative value of ηD ~~less than 0.25~~, based on a risk evaluation that is acceptable to the authority having jurisdiction.

~~A.6.1.5.3 See A.6.1.4.2.~~

A.6.1.5.2.3 See A.6.1.5.1.2

6.1.6* Risk Evaluation Method. A documented risk evaluation acceptable to the AHJ shall be permitted to be conducted to determine whether or where a dust explosion hazard or dust flash fire hazard area exists.

A.6.1.6 The risk evaluation method in 6.1.6 supplements the process hazard analysis required in Chapter 4. It is intended to focus on material properties and inherent design features of the equipment and facility necessary to determine the extent of the hazard areas.

6.1.7 An explosion hazard shall be deemed to exist in enclosed process equipment where all of the following conditions are possible:

(1) Combustible dust is present in sufficient quantity to cause enclosure rupture if suspended and ignited.

(2) A means of suspending the dust is present, ~~and~~

654-17 Log #18 CMD-HAP
(6.1 and 6.2)

Final Action: Accept in Principle

Submitter: Samuel A. Rodgers, Honeywell International

Comment on Proposal No: 654-22, 654-25

Recommendation: Revise text to read as follows:

6.1.6.2* A dust explosion hazard and dust flash fire hazard shall be deemed to exist in any building or room where dust clouds of a hazardous concentration exist or where any of the following conditions exist:

~~(1) For any buildings or rooms with footprint areas smaller than 20,000 ft² either~~

(1) ~~(a)~~ the total area of non-separated dust accumulations exceeding the layer depth criterion is greater than 5% of the footprint area, or

(2) ~~(a)~~ the area of any single non-separated dust accumulations exceeding the layer depth criterion is greater than 1000 ft², or

~~(2) For buildings or rooms with footprint areas greater than or equal to 20,000 ft² either~~

(3) ~~(b)~~ the total volume of non-separated dust accumulations is greater than the layer depth criterion multiplied by 5% of the footprint area, or

(4) ~~(b)~~ the total volume of any single non-separated dust accumulations is greater than the layer depth criterion multiplied by 1000 ft².

6.1.6.2.1 Dust accumulations are deemed non-separated unless segregation, separation, or detachment is used to limit the hazard area in accordance with section 6.2.

6.2.3 Use of Separation.

6.2.3.1* Separation shall be permitted to be used to limit the dust explosion hazard or dust flash fire hazard area where supported by a documented risk evaluation acceptable to the authority having jurisdiction.

6.2.3.1.1 The required separation distance between the dust explosion hazard or flash fire hazard area identified in 6.1 and surrounding exposures shall be determined by a risk evaluation that addresses the following:

(1) ~~Engineering evaluation that addresses the p~~ Properties of the materials

(2) Type of operation

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

(4) Building and equipment design

(5) Nature of surrounding exposures

6.2.3.1.2 Within the separation area shall be free of dust or where dust accumulations on any surfaces do not exceed 1/64" or such that surface colors are shall be readily discernible.

6.2.3.1.3 When separation is used to limit the dust flash fire hazard area determined in 6.1, the minimum separation distance shall not be less than 30 ft (9 m).

6.2.3.2 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 explosion hazard or flash fire hazard area.

6.2.3.3* Where separation is used to limit a dust explosion hazard or dust flash fire hazard area, Equation 6.1.3.2 or 6.1.5 dust thresholds determined in Section 6.1 shall be applied to based on this limited area such that the parameter, A_{floor} , in the equations is consistent with the limited area under consideration.

6.2.3.4 Separation shall not be permitted to be used to limit the dust explosion hazard area.

Substantiation: Section 6.1.6.2 of CP#4 is currently not clear as to whether separation can be used to limit the dust accumulations that are included in the 5% criterion. Separation by distance should be permitted for explosion hazard if the dust accumulations are far enough separated to prevent propagation from one accumulation to the next. Currently Section 6.2.3 on Use of Separation prohibits the use of separation for explosion hazard.

Committee Meeting Action: Accept in Principle

See Committee Action on Committee Comments 654-16 (Log# CC3) and 654-24 (Log# CC5).

Committee Statement: See Committee Action and Substantiation on Committee Comments 654-16 (Log# CC3) and 654-24 (Log# CC5).

654-18 Log #16 CMD-HAP
(6.1.2)

Final Action: Reject

Submitter: John M. Cholin, Oakland, NJ

Comment on Proposal No: 654-22

Recommendation: Revise text to read as follows:

Include 654_L16_Include_REC here

Substantiation: While there is considerable potential in the computational method that has been proposed it does not have sufficient foundation to be mandatory text at this time.

The calculations rely on a parameter η_D , the entrainment factor, for which there is currently no test method for determining its numerical value nor is there sufficient research supporting the notion that a single value is applicable to all facilities under all scenarios. Until this supporting material is available this method should not be in the mandatory portion of the document.

By placing it in the Annex, it is available for use by practitioners who can justify their selection of the numerical values for the parameters upon which the calculations rely, under the criteria established for performance-based design in Chapter 5.

The limits on applying the simple layer criteria were returned to the Annex by including the old Annex D test because there is simply no loss history suggesting that the simpler layer depth criteria without these limits are inadequate. The removed language in the ROP draft 6.1.6.2 was initially derived from the old Annex D text. The Annex D calculations were developed as a bounding value hypothetical case. It was written to inform users of the hypothetical worst-case scenario so the users would take the layer depth criteria in the body of the standard seriously. The conclusions drawn from the hypothetical case should not be made mandatory text unless there is some form of substantiation. The hypothetical case does not consider flame quenching by the building and the equipment, heat losses to noncombustible impingement surfaces, losses due to compression of the air ahead of the dust cloud, etc. It assumes a uniform dust suspension, something that is unlikely, at best. It is inappropriate to take a bounding value hypothetical case and use it as the basis for mandatory criteria.

The TC has made great strides in establishing a section that now effectively defines what constitutes an explosion hazard and what constitutes a flash-fire hazard. This was desperately needed. But there is simply no evidence that the simple, easy to enforce layer depth criterion has led to problems or has allowed personnel injuries in facilities that complied with it.

There is a cost associated with excessively restrictive criteria. We know that dust layers measured in inches are sufficient to put the occupants at serious risk. We have experience data that suggests that deflagrations were unable to propagate in facilities where the layer depth criteria were essentially compliant with the 1/32nd inch criterion that has been in this document for the past decade. What we don't know is at what layer depth the building compartment transitions from acceptable to unacceptable. This is an area for research but not hypotheation. Excessively restrictive criteria increase operating costs for facility operators with no demonstrable benefit. That is NOT "good engineering". Who would buy a car fabricated from 1/4" steel plate? Sure, it would be safe but the mileage might be disappointing.

Committee Meeting Action: Reject

Committee Statement: See Committee Action and Substantiation on Committee Comment 654-16 (Log# CC3).

6.1.2 Hazard Assessment. The provisions of this section shall apply to the assessment of the hazards associated with the overall design of systems that handle combustible dusts.

6.1.2.1 Those portions of the process and facility where dust accumulations exist outside of equipment shall be evaluated to determine if a dust explosion hazard or flash fire hazard exists, unless the dust layer depth is 1/64" or less or the underlying surface colors are readily discernible.

6.1.2.2 Building, rooms, compartments and other interior spaces shall be assessed in accordance with Sections 6.1.2, 6.1.3 or 6.1.4 or 6.1.5.

6.1.2.3 The process equipment shall be assessed in accordance with Section 6.1.7

6.1.3* It shall be permitted to use performance-based methods in accordance with Chapter 5 to identify dust explosion and dust flash fire hazard areas. ~~Unless supported by calculations per 6.1.4 and 6.1.5, or using the method in 6.1.6, Dust explosion hazard areas and dust flash fire hazard areas shall be deemed to exist when the total accumulated dust on any surfaces exceeds the thresholds calculated in 6.1.3.1 or 6.1.3.2, respectively.~~

A.6.1.3 The threshold dust mass establishing a building or room as a dust explosion hazard volume, $M_{basic-exp}$, should be determined per equation A.6.1.3.1.

$$M_{basic-exp} = 0.004 \cdot A_{floor} \cdot H \quad \text{Eqn A.6.1.3.1}$$

The threshold dust mass establishing a building or room as a dust deflagration hazard volume, $M_{basic-fire}$, shall be determined per equation 6.1.3.2.

$$M_{basic-fire} = 0.02 \cdot A_{floor} \quad \text{Eqn A.6.1.3.2}$$

Where, for both equations A.6.1.3.1 and A.6.1.3.2:

$M_{basic-exp}$ is the threshold dust mass (kg) based upon building damage criterion

$M_{basic-fire}$ is the threshold dust mass (kg) based upon personnel fire exposure criterion

A_{floor} is the lesser of the enclosure floor area (m^2) or 2000 m^2

H is the lesser of the enclosure ceiling height (m) or 12 m

Because fugitive dust could accumulate in a localized area of the building or room (localized area less than 10% of the total floor area), the floor area limit (A_{floor}) used in equations A.6.1.3.1 or A.6.1.3.2 has been set to 2000 m^2 . For an example of the calculation of threshold dust mass see Annex D.

It shall be permitted to evaluate the threshold dust mass establishing a building or room as a dust explosion hazard area, m_{exp} , per equation A.6.1.3.3.

$$M_{exp} = \left[\frac{P_{es}}{DLF} \right] \cdot \left[\frac{C_w}{P_{max}} \right] \cdot \frac{A_{floor} \cdot H}{\eta_D} \quad \text{Eqn A.6.1.3.3}$$

where:

M_{exp} = the threshold dust mass (kg) based upon building damage criterion,

P_{es} = the enclosure strength evaluated based on static pressure calculations for the weakest building structural element not intended to vent or fail (bar g) per NFPA 68,

DLF = the dynamic load factor, the ratio of maximum dynamic deflection to static deflection per NFPA 68,

C_w = the worst case dust concentration (kg/m^3) at which the maximum rate-of-pressure-rise results in tests conducted per ASTM E1226,

P_{max} = the maximum pressure (bar g) developed in ASTM E1226 tests with the accumulated dust sample,

A_{floor} = the enclosure floor area (m^2),

H = the enclosure ceiling height (m),

η_D = the entrainment fraction

In the absence of detailed structural response analysis, it shall be permitted to assume a worst-case value of DLF = 1.5 and design based on the weakest structural element of the enclosure.

The Dust Explosion Hazard Area equation originates from the NFPA-68 Partial Volume equation, which adjusts the amount of venting needed when the design scenario presumes the combustible mixture fills only a part of the enclosure. NFPA-68 uses the ratio of P_{red} to P_{max} and the fill fraction to make this adjustment. P_{red} is the maximum pressure predicted to be developed during a vented deflagration and should be less than the strength of the weakest building structural element not intended to vent or fail. Windows, for instance, might be intended to fail. NFPA-68 sets an upper bound for P_{red} , ensuring that the calculated pressure during the event does not exceed the strength of the enclosure. This upper bound is P_{es}/DLF , the dynamic strength of the weakest building structural element not

intended to vent or fail. In the implementation here, the goal is to see if any explosion venting is needed to prevent damage to the main building structural components, thus P_{red} is equated to its maximum allowable value, based on the building/room design.

In a deflagration, the pressure developed changes with the dust concentration. Equation 6.1.3.3 uses the so-called worst case concentration of dust in a combustible mixture, C_w , as defined in NFPA-68. A conservative way to evaluate the pressure attained at lower average dust concentration is to assume that all of the dust available is concentrated in a smaller volume to the worst case concentration. This smaller volume is a fraction of the total volume, the fill fraction. In Equation 6.1.3.3, the threshold dust mass, M_{exp} , divided by the product of worst case concentration and building volume is the fill fraction. When accumulated dust mass is larger than the threshold for the Explosion Hazard, then the fill fraction is greater than the ratio of P_{es}/DLF to P_{max} , and an Explosion Hazard exists.

Users should ~~it shall be permitted to~~ assume a default value of 0.25 to 1 for the entrainment fraction (η_D). A higher value for η_D is more appropriate for ducts and small enclosures less than 100 m³ and for enclosures with L/D ratios greater than 5, such as galleries. Research activities are currently in progress to define a technical basis for estimating η_D .

~~6.1.4.3~~ It shall be permitted to use an alternative value of η_D less than 0.25, based on a risk evaluation that is acceptable to the authority having jurisdiction.

~~6.1.5*~~ It shall be permitted to evaluate the threshold dust mass, M_{fire} , establishing an area as a dust flash fire hazard area, per equation A.6.1.3.4.

$$M_{fire} = p \cdot C_w \cdot \left[\frac{P_{initial}}{P_{initial} + P_{max}} \right] \cdot \frac{A_{floor} \cdot D}{\eta_D} \quad \text{Eqn A.6.1.3.4}$$

Where:

M_{fire} = the threshold dust mass (kg) based upon personnel fire exposure criterion.

$P_{initial}$ = 1 bar absolute

D = the nominal height of a person (m)

p = the probability of flame impingement on a person.

~~6.1.5.1~~ The value of D in equation 6.1.5 should ~~shall~~ be 2 m.

~~6.1.5.2~~ The value of p shall should not exceed 0.05 (5% probability).

~~6.1.5.3*~~ It ~~shall~~ should be permitted to assume a default value of 0.25 to 1 for the entrainment fraction (η_D).

The Dust Flash Fire Hazard Area equation estimates the fraction of the volume that could be filled by an expanded fireball from burning dust. The room or building volume up to person height is taken as the total volume for this hazard, regardless of actual building height. The threshold for the Flash Fire Hazard is based on allowing the accumulated dust mass to reach the worst case concentration in an unburnt volume which, when expanded in a fireball, is only a fraction of the volume described by the product of person height and floor area. The relation in 6.1.5 uses a probability (p) of an occupant being in the same location as the deflagration flame as its risk tolerance criterion. This choice implies that some residual risk remains.

~~6.1.5.4~~ It ~~shall~~ should be permitted to use an alternative value of η_D less than 0.25, based on a risk evaluation that is acceptable to the authority having jurisdiction.

6.1.6.4* Layer Depth Criterion Method.

6.1.6.1 The layer depth criterion establishing the presence of a dust flash fire and dust explosion hazard shall be of 1/32". This layer depth shall be permitted to be increased according to equation 6.1.6.1 for materials with bulk density less than 75 lb/ft³

$$\text{Allowable thickness (in.)} = \frac{(1/32)(75)}{\text{bulk density (lb/ft}^3\text{)}} \quad 6.1.6.1$$

6.1.6.2* A dust explosion hazard and dust flash fire hazard shall be deemed to exist where dust clouds of a hazardous concentration exist or where the accumulated dust layer exceeds the layer depth criterion in 6.1.6.1. any of the following conditions exist:

- (1) For buildings or rooms with footprint areas smaller than 20,000 ft²
 - (a) the area of dust accumulations exceeding the layer depth criterion is greater than 5% of the footprint area, or
 - (b) the total volume of dust accumulations is greater than the layer depth criterion multiplied by 5% of the footprint area.
- (2) For buildings or rooms with footprint areas greater than or equal to 20,000 ft²
 - (a) the area of dust accumulations exceeding the layer depth criterion is greater than 1000 ft², or

~~(b) the total volume of dust accumulations is greater than the layer depth criterion multiplied by 1000 ft².~~

A.6.1.6.1 Calculations suggest that surprisingly small dust layers could be capable of propagating a dust deflagration through a room or building. When bounding value assumptions are used one can calculate the following.

(Insert old Annex D here)

Renumber subsequent sections in this chapter

654-19 Log #9 CMD-HAP
(6.1.2.1 through 6.1.6.2)

Final Action: Reject

Submitter: Hugh D. Castles, Entergy Services, Inc.

Comment on Proposal No: 654-22

Recommendation: Add new text to read as follows:

6.1.2.1 Those portions of the process and facility where dust accumulations exist outside of equipment shall be evaluated to determine if a dust explosion hazard ~~or flash fire hazard~~ exists, unless the dust layer depth is 1/64" or less or the underlying surface colors are readily discernible.

6.1.2.2 Building, rooms, compartments and other interior spaces shall be assessed in accordance with Sections 6.1.2, 6.1.3, 6.1.4 or 6.1.5.

6.1.2.3 Determination of exposure to personnel and protection from a dust flash fire. shall be in accordance with NFPA 2113 Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire.

~~6.1.2.3~~ 4 The process equipment shall be assessed in accordance with Section 6.1.10.

6.1.3* Unless supported by calculations per 6.1.4 and 6.1.5, or using the method in 6.1.6, dust explosion hazard areas ~~and dust flash fire hazard~~ areas shall be deemed to exist when the total accumulated dust on any surfaces exceeds the thresholds calculated in 6.1.3.1 or 6.1.3.2, respectively.

Delete all of 6.1.5 and associated Annex material

6.1.6.2* A dust explosion hazard ~~and dust flash fire hazard~~ shall be deemed to exist where dust clouds of a hazardous concentration exist or where any of the following conditions exist:

Substantiation: The proposed wording has criteria for determining when an individual is subject to a potential flash fire. The equations and factors provided in the proposal are in conflict with the guidance provided in NFPA 2113 which was established in OSHA Combustible Dust National Emphasis Program (Reissued) CPL-03-00-008 page 20 item g as the document industry should use. In NFPA 2113, the criteria given as determining if a dust presents a flash fire (particle size, minimum ignition temperature, and moisture) are not included in the equations in the proposal. NFPA should ensure that there is no confusion in which NFPA document should be utilized by the user.

Committee Meeting Action: Reject

Committee Statement: See Committee Action and Substantiation for Committee Comment 654-16 (Log# CC3). The Committee does not support the recommendation to rely on NFPA 2113 for the determination of a flash fire hazard area as it is not as comprehensive as the elements to be considered as defined in the proposed requirements for NFPA 654-2013. The Committee also notes that Chapter 11 per the ROP already requires use of NFPA 2113 for selecting flash fire protective clothing for protection of personnel.

654-20 Log #10 CMD-HAP
(6.1.4)

Final Action: Reject

Submitter: Hugh D. Castles, Entergy Services, Inc. / Rep. Edison Electric Institute, Fire Protection and Loss Prevention Task Force

Comment on Proposal No: 654-22

Recommendation: Delete 6.1.4 entirely.

Substantiation: The Committee has made a simple process much more difficult to enforce and evaluate by using equations that are insufficiently demonstrated or substantiated. Specifically it continues to use the "entrainment factor" which has been neither clearly defined, nor proven by experimental data. Data to assign to it cannot be found in any readily available reference. The entrainment factor issue was one of the main reasons the document was voted by the Fall 2010 Annual convention to return the document to committee. As proposed, it appears to be unworkable or unenforceable in the real world. The fact that none of the frequently cited tragic outcomes conformed to NFPA 654 in its original form clearly shows a lack of enforcement--- not requirements that were too lax. To echo the words of John Cholin, the outcomes "do not indicate a need to make the document more stringent-they indicate a need to make the document more useable."

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

John Cholin, Explanation of Negative, Proposal 654-22, A2012 ROP

Committee Meeting Action: Reject

Committee Statement: See Committee Action and Substantiation on Committee Comment 654-16 (Log# CC3).

654-21 Log #26 CMD-HAP
(6.1.4)

Final Action: Reject

Submitter: George Petino, Jr., Hazards Research Corporation, Inc.

Comment on Proposal No: 654-22

Recommendation: We are troubled by the proposed adoption of formulas based on an entrainment fraction for which, per A.6.1.4.2, "research activities are currently in progress to define a technical basis for estimating [its values]."

Substantiation: The research should be completed, peer reviewed and published before reliance on this model is incorporated into an NFPA standard.

Committee Meeting Action: Reject

Committee Statement: The submitter provided no specific language. In addition, see Committee Action and Substantiation on Committee Comment 654-16 (Log# CC3). The action in Comment 654-16 (Log# CC3) has now established a fixed value for the entrainment fraction as described in the substantiation.

654-22 Log #27 CMD-HAP
(6.1.7)

Final Action: Reject

Submitter: George Petino, Jr., Hazards Research Corporation, Inc.

Comment on Proposal No: 654-22

Recommendation: This provision should be revised to read as follows:

An explosion hazard shall be deemed to exist in enclosed process equipment where, based on a risk evaluation, a determination is made that the existence of all of the following conditions in the process equipment is credible ~~are possible~~:

- (1) Combustible dust is present in sufficient quantity to cause enclosure rupture if suspended and ignited.
- (2) A means of suspending the dust is present, and
- (3) An ignition source at the minimum ignition energy or the minimum ignition temperature.

Substantiation: The revision recognizes that the required determination can be made only by performing a risk evaluation. That assessment should include an assessment of potential ignition sources rather than assuming the existence of an ignition source. The appropriate test criterion is "credible" rather than "possible." Anything with a probability greater than zero is possible.

Committee Meeting Action: Reject

Committee Statement: The Committee notes that while the absence of an ignition source might be an element in establishing risk, the intent of this section is to determine whether an explosion hazard exists. It was the Committee's intent that the presence of an ignition source is assumed. If a risk based assessment is desired, it can be conducted in accordance with 7.1.3.

654-23 Log #11 CMD-HAP
(6.1.8)

Final Action: Reject

Submitter: Hugh D. Castles, Entergy Services, Inc.

Comment on Proposal No: 654-22

Recommendation: Delete new section 6.1.8.

Substantiation: Personal protective equipment (PPE) is addressed in Proposal 654-85 in new section 11.2.2 (accepted by TC). The wording in proposed new section 6.1.8 forces a decision regarding PPE per the NFPA 654 criteria for "dust flash fire hazard" per new section 6.1.6.2 which is incomplete as printed in the ROP. NFPA 2113 addresses PPE and is referenced in the text included in Proposals 654-85 (new section 11.2.2) and 654-62 (new A.8.2.2.5).

Section 6.1.6.2 is incomplete as there are no conditions listed.

Section 6.1.7 appears to be incomplete as subsection (2) ends with "and".

Committee Meeting Action: Reject

Committee Statement: See Committee Action and Substantiation on Committee Comment 654-16 (Log# CC3). The submitter's statement that proposed paragraph 6.1.8 forces a decision regarding PPE is not accurate; Section 6.1 deals with determination of hazards - dust explosion and dust flash fire hazards. If, based on the conditions, it is determined that a dust flash fire hazard area exists, then 6.1.8 requires an evaluation whether personnel need to be protected according to the flash fire protective garment selection requirements in NFPA 2113 as stated by reference to paragraph 11.2.2.

654-24 Log #CC5 CMD-HAP
(6.2.3)

Final Action: Accept

Submitter: Technical Committee on Handling and Conveying of Dusts, Vapors, and Gases,

Comment on Proposal No: 654-25

Recommendation: Revise as follows:

6.2.3 Use of Separation.

6.2.3.1 Separation shall be permitted to be used to limit the dust explosion hazard or dust flash fire hazard area where supported by a documented engineering evaluation acceptable to the authority having jurisdiction.

6.2.3.1.1* The required separation distance between the dust explosion hazard or flash fire hazard area identified in 6.1 and surrounding exposures shall be determined by an engineering evaluation that addresses the following:

- (1) Properties of the materials
- (2) Type of operation
- (3) Amount of material likely to be present outside the process equipment
- (4) Building and equipment design
- (5) Nature of surrounding exposures

A.6.2.3.1.1 Separation distance is the distance between the outer perimeter of a primary dust accumulation area and the outer perimeter of a second dust accumulation area. Separation distance evaluations should include the area and volume of the primary dust accumulation area as well as the building or room configuration. One approach begins by determining the expanded volume of the deflagration, the so-called burnt volume, from equation A.6.2.3.1.1. M_{dust} is the kg of dust or equally the accumulation area multiplied by depth and bulk density. In this equation the parameters are consistent with section 6.1 and V_{burnt} is in units of m^3 .

*****Insert 654_LCC5_Eq A.6.2.3.1.1*****

The burning dust volume will expand to fill the available building or room area and this expansion could be approximately 1-dimensional in a corridor, 2-dimensional in a low-ceiling height room, or 3-dimensional in a large, tall building. By understanding the potential burnt volume of the primary accumulation and comparing that to the building or room, the user can determine an appropriate separation distance.

Example:

A primary dust accumulation area of 1000 ft^2 , approximately round, has a dust accumulation of just less than 1/32 inch and a bulk density of 75 lb/ft^3 . This is a limiting case of 195 lb (89 kg) of dust beyond which the primary accumulation would result in a dust deflagration hazard area. For a round accumulation area, the initial radius of the dust accumulation is approximately 17.8 ft. For a typical dust with P_{max} of 8 barg and c_w of 0.5 kg/m^3 , V_{burnt} would be 400 m^3 . For 3-dimensional expansion, hemispherical above the floor, the 400 m^3 burnt volume would have a radius of 18.8 ft. The separation distance would be the difference between the initial accumulation radius and the burnt volume radius, or about 1 ft. The necessary separation is the larger of the determined separation or the prescribed minimum separation. In this case the necessary separation distance would be 30 ft per 6.2.3.1.3.

If the same 89 kg of dust accumulation was instead in one end of an 8 ft tall by 8 ft wide corridor, the expansion would be approximately 1-dimensional. For the case where the initial dust was 1/8 inch thick, the accumulation would initially cover an area 8 ft wide by 31 ft long. The same burnt volume would expand along the corridor for a length of 220 ft. In this case the separation distance would be approximately $220 - 31$ ft or 189 ft.

6.2.3.1.2 The separation area shall be free of dust or where dust accumulations exist on any surface, the surface colors below shall be readily discernible.

6.2.3.1.3 When separation is used to limit the dust flash fire or dust explosion hazard area determined in 6.1, the minimum separation distance shall not be less than 35 ft (11m), consistent with NFPA 51B, *Standard for Fire Prevention during Welding, Cutting, and other Hotwork*.

6.2.3.2* 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 explosion hazard or flash fire hazard area.

A.6.2.3.2 The assertion of separation must recognize the dust accumulation on all surfaces in the intervening distance, including floors, beam flanges, piping, ductwork, equipment, suspended ceilings, light fixtures and walls. Process

equipment or ductwork containing dust can also provide a connecting conduit for propagation between accumulation areas. The National Grain and Feed Association study [A] has shown that a layer as thin as 1/100 inch is sufficient to propagate flame in a limited expansion connection, such as an exhaust duct or a hallway. In the subject study the flame propagated for at least 80 feet.

[A] Tamanini, F., "Dust Explosion Propagation in Simulated Grain Conveyor Galleries," ESV-83-067, National Grain and Feed Association Fire and Explosion Research Report, prepared by Factory Mutual Research Corporation, Norwood, MA, July 1983.

6.2.3.3 Where separation is used to limit a dust explosion hazard or dust flash fire hazard area, dust thresholds in Section 6.1 shall be determined for this limited area such that the parameter, A_{floor} , in the equations is consistent with the limited area under consideration.

Substantiation: The updated to the revisions to Section 6.2 introduced at the ROP stage, are required to make this section consistent with the updated changes to Section 6.1 made by Comment 654-16 (Log# CC3) and the introduction of the four methods for determining that a hazard exists in terms of dust flash fire or dust explosion hazard areas. Paragraph 6.2.3 was modified to clarify the use of separation within the standard.

The proposed revision of 6.2 presented in this Committee Comment also reflects the Committee's action in the TIA 1020 to the 2006 edition of NFPA 654 that was issued by the Standards Council March 1, 2011 (see Decision D#11-4).

Committee Meeting Action: Accept

NFPA 654 Log CC5 Equation A.6.2.3.1.1

$$V_{burnt} = \frac{M_{dust} \bullet \eta_D}{c_w} \bullet \left[\frac{P_{initial} + P_{max}}{P_{initial}} \right]$$

Eqn A.6.2.3.1.1

654-25 Log #6 CMD-HAP
(7.1.4)

Final Action: Accept in Principle

Submitter: Thomas C. Scherpa, The DuPont Company, Inc.

Comment on Proposal No: 654-35

Recommendation: Insert new 7.1.4.2 as follows:

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 (100 mm) nominal 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 sufficient to prevent accumulation of combustible dust in the duct
- (5) All connected equipment is properly designed for explosion protection.

Substantiation: This text was rejected at the proposal stage with a recommendation that it be modified and resubmitted at the comment stage. The first three requirements are still substantiated by text in the AICHE CCPS Guidelines for Safe Handling of Powders and Bulk Solids. Additionally, the second requirement is substantiated by text in Holbrow et al, 1999: "The experimental trials have shown that if the pipe diameter is less than 0.1 m the probability of transmission would seem to be very low, and may be ignored for design purposes."

The fourth requirement is necessary to ensure that deposited material does not contribute to an abnormally high concentration at the moment of the primary explosion. A properly designed system should satisfy this requirement anyway, and so this should not be an onerous requirement.

The fifth requirement is based on the existing text in Annex E.3.1, which has not been modified at the ROP stage.

If the committee does not consider the fourth and fifth requirements to be adequately substantiated, then one or both of these requirements could be removed and the other requirements could stand.

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

Substantiation text includes a quote from P. Holbrow, G. A. Lunn, A. Tyldesley, Dust explosion protection in linked vessels: guidance for containment and venting, Journal of Loss Prevention in the Process Industries, Volume 12, Issue 3, May 1999, Pages 227-234

Committee Meeting Action: Accept in Principle

Insert new 7.1.4.2 as follows:

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 (100 mm) nominal 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 sufficient to prevent accumulation of combustible dust in the duct
- (5) All connected equipment is properly designed for explosion protection by means other than deflagration pressure containment.

Committee Statement: Item 5 was modified to exclude deflagration pressure containment from the explosion protection methods because ducts could be subjected to excessive flame extension that could lead to pressure piling.

654-26 Log #28 CMD-HAP
(7.2.3.3.3)

Final Action: Hold

Submitter: George Petino, Jr., Hazards Research Corporation, Inc.

Comment on Proposal No: 654-31

Recommendation: This provision should be revised as follows:

The explosion protection requirements of 7.1.4~~2~~ shall not be required provided that the volume of the fixed bulk storage container is less than 8 ft³ (0.2 m³), and the fixed bulk storage container does not serve metal grinders, hot work processes, or machinery that can produce sparks.

Substantiation: We believe this provision should be consistent with the proposed enclosureless AMS provision in 7.13.1.1.2(4).

Committee Meeting Action: Hold

Committee Statement: The recommendation proposes new material that was not addressed for change during the ROP phase of this revision, so per the NFPA regulations, the Committee believes the appropriate action is to Hold this comment.

654-27 Log #33 CMD-HAP
(7.10.9.4)

Final Action: Hold

Submitter: Jason Krbec, CV Technology, Inc.

Comment on Proposal No: N/A

Recommendation: Delete text as follows:

~~7.10.9.4 The requirement of 7.10.9.1 shall not apply to elevators that have belt speeds below 500 ft/min (150 m/min) or capacities less than 3750 ft³/hr (106 m³/hr).~~

Substantiation: The belt speed or capacity has no influence on the reduced explosion pressure or the likely hood of an event occurring in a bucket elevator. The Health and Safety Executive (HSE) published a paper by Holbrow, P., Lunn, G. A., Tyldesley, A. titled Explosion Venting of Bucket Elevators in the *Journal of Loss Prevention in the Process Industries*, 15 (2002), 373-383. The article provides extensive test data for the design of explosion venting with regards to bucket elevators.

The paper concludes that belt speed had no noticeable effect on the reduced explosion pressure. Belt misalignment, hot bearing temperatures and excessive vibration should all be monitored as they are credible ignition sources independent of the capacity of a bucket elevator.

Committee Meeting Action: Hold

Committee Statement: The recommendation proposes new material that was not addressed for change during the ROP phase of this revision, so per the NFPA regulations, the Committee believes the appropriate action is to Hold this comment.

654-28 Log #7 CMD-HAP
(7.12.2)

Final Action: Accept in Principle

Submitter: Thomas C. Scherpa, The DuPont Company, Inc.

Comment on Proposal No: 654-48

Recommendation: Revise text to read as follows:

7.12.2.2* The requirement of 7.12.2.1 shall not apply to systems designed to operate at a combustible particulate solids concentration or hybrid mixture concentration of less than ~~25%~~ 10% of the MEC or the lower of the MEC or LFL for the hybrid mixture where hybrid mixtures are present.

7.12.2.3* The requirement of 7.12.2.1 shall not apply to systems meeting both of the following criteria:

(1) Systems operating at a combustible particulate solids concentration or hybrid mixture concentration equal to or greater than ~~25%~~ 10% of the MEC or the LFL for the hybrid mixture where hybrid mixtures are present.

(2) Systems protected by an approved explosion prevention or isolation system to prevent the propagation of the flame front from the fan to other equipment in accordance with 7.1.2.1(1), 7.1.2.1(4), 7.1.2.1(5), 7.1.4.2(3), 7.1.4.2(4), or 7.1.4.2(5).

7.12.2.4 Where the MEC value is unknown, it shall be permitted to assume a value of 0.03 oz/ft³ (30 g/m³)

7.12.2.5 Where an air moving device is located in the dirty air stream and the dust/air stream concentration is higher than ~~25%~~ 10% of the MEC, fans and blowers shall be of Type A or B spark-resistant construction per AMCA 99-0401-86, Classifications for Spark Resistant Construction.

A.7.12.2.2 Some systems are designed to operate at solids concentrations that pose no fire or deflagration risk. Such systems include nuisance dust exhaust systems and the downstream side of the last air-material separator in the pneumatic conveying system.

A threshold concentration limit of ~~25%~~ 10% of the MEC has been set to discriminate between such systems and other systems designed to operate at a significant combustible solid loading. This limit ensures that normal variations in processing conditions do not result in the combustible particulate or hybrid mixture concentration approaching the MEC.

A.7.12.2.5 The production of mechanical sparks is only one possible ignition mechanism from a fan or blower. Frictional heat due to contact between moving parts (misalignment) or bearing failure can present an ignition source both in the fan and downstream. Additionally, these failure mechanisms can result in a decrease in airflow through the air moving device which can result in an increase in the combustible dust concentration coincident with the creation of an ignition source.

Substantiation: At the proposal stage, the concentration threshold for requiring additional protection on fans and blowers in dirty air streams was raised from nominally 1% of MEC to 25% of MEC. One of the justifications for this change was for consistency with the 25% LEL operating limit for ovens and dryers processing flammable vapors. I disagree with the notion of equating the dust concentration limit with that of flammable vapors and gases because 1) many dust handling operations produce transient and nonuniform dust concentrations making it difficult to apply an 'average' design concentration concept as is often done with flammable vapors, and 2) unlike flammable vapors, combustible dusts can settle out of an airflow, creating deposits within the system that can be disturbed to create a dust concentration higher than the design concentration. This is supported by text in the CCPS Guidelines for Safe Handling of Powders and Bulk Solids, which states "Combustible concentration reduction is more feasible for equipment containing gases and vapors than for systems containing combustible solids because the dust concentration inside process equipment very often varies in unpredictable and uncontrollable ways. Often there is a tendency for the dust to fall out of suspension and settle on internal surfaces, later to be thrown into suspension, forming an ignitable concentration."

For these reasons, additional conservatism is warranted, and so I have proposed changing the threshold to 10% of MOC. This is an order of magnitude higher than the previous limit, yet still an order of magnitude below the MOC.

Annex material was also added to caution against other ignition sources that are possible with spark resistant fans.

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

A quote in the substantiation was taken from the book "Guidelines for Safe Handling of Powders and Bulk Solids", 2005, Center for Chemical Process Safety of the American Institute of Chemical Engineers, Three Park Avenue, New York, New York, 10016.

Committee Meeting Action: Accept in Principle

Revise text to read as follows:

7.12.2.2* The requirement of 7.12.2.1 shall not apply to systems designed to operate at a combustible particulate solids concentration or hybrid mixture concentration of less than ~~25%~~ 10% of the MEC or for a hybrid mixture, the lower of ~~the 10% of the MEC of the dust or 10% of the LFL of the vapor~~ for the hybrid mixture where hybrid mixtures are

present.

7.12.2.3* The requirement of 7.12.2.1 shall not apply to systems ~~meeting both of the following criteria:~~

~~(1) Systems operating at a combustible particulate solids concentration or hybrid mixture concentration equal to or greater than 25% 10% of the MEC or for a hybrid mixture, the greater of 10% of the MEC or the LFL for the hybrid mixture where hybrid mixtures are present.~~

~~(2) Systems protected by an approved explosion prevention or isolation system to prevent the propagation of the flame front from the fan to other equipment in accordance with 7.1.2.1(1), 7.1.2.1(4), 7.1.2.1(5), 7.1.4.2(3), 7.1.4.2(4), or 7.1.4.2(5).~~

7.12.2.4 Where the MEC value is unknown, it shall be permitted to assume a value of 0.03 oz/ft³ (30 g/m³)

7.12.2.5* Where an air moving device is located in the dirty air stream and the dust/air stream concentration is higher than ~~25%~~ 10% of the MEC, fans and blowers shall be of Type A or B spark-resistant construction per AMCA 99-0401-86, Classifications for Spark Resistant Construction, or Type C spark-resistant construction protected with spark detection and extinguishment located downstream of the fan.

A.7.12.2.2 Some systems are designed to operate at solids concentrations that pose no fire or deflagration risk. Such systems include nuisance dust exhaust systems and the downstream side of the last air-material separator in the pneumatic conveying system.

A threshold concentration limit of ~~25%~~ 10% of the MEC has been set to discriminate between such systems and other systems designed to operate at a significant combustible solid loading. This limit ensures that normal variations in processing conditions do not result in the combustible particulate or hybrid mixture concentration approaching the MEC.

A.7.12.2.5 The production of mechanical sparks is only one possible ignition mechanism from a fan or blower. Frictional heat due to contact between moving parts (misalignment) or bearing failure can present an ignition source both in the fan and downstream. Additionally, these failure mechanisms can result in a decrease in airflow through the air moving device which can result in an increase in the combustible dust concentration coincident with the creation of an ignition source.

Committee Statement: The Committee accepted the primary element of the submitter's recommendation which was to reduce the 25% MEC or 25% LFL value to 10% MEC and LFL depending on whether applicable to hybrid mixtures, dust, or vapor. The Committee modified the requirement to make the specific provisions more clear depending on which component applies. The Committee believed, that as written, it was confusing which provision applied and now, as modified, there are only 2 conditions applicable.

654-29 Log #29 CMD-HAP
(7.12.2.5)

Final Action: Reject

Submitter: George Petino, Jr., Hazards Research Corporation, Inc.

Comment on Proposal No: 654-48

Recommendation: This provision should be eliminated. References in the standard to 25% of the MEC should be replaced with the MEC.

Substantiation: Our experience is that use of spark-resistant construction can lead to metal-to-metal surface contact and friction generating temperatures in excess of 600°C, which exceeds the ignition temperature of most combustible dusts. Therefore, this is not a recommended design for dirty air streams.

Committee Meeting Action: Reject

Committee Statement: The submitter's recommendation does not match the substantiation. The submitter has proposed relaxing a requirement, although the substantiation cautions that a hazard exists that would not be protected if the committee acted to accept this comment.

654-30 Log #3 CMD-HAP
(7.13.1.1.2(4))

Final Action: Accept in Principle

Submitter: Jack E. Osborn, Airdusco, Inc.

Comment on Proposal No: 654-53

Recommendation: Add new text to read as follows:

7.13.1.1.2(4) Enclosureless air-material separator meeting all the following criteria shall be permitted to be used:

(a)* The AMS is used only for wood and wood products including paper.

(b) The AMS is not used to vent or serve metal grinders, hot work processes, or machinery that can produce sparks.

(c)* Each collector has a maximum air-flow handling capacity of 2.4 cu. meters (5,000 cfm) with a maximum filter volume of 8 cu. ft.

(d) The fan motor is suitable for Class II, Division 2, or Class III, as appropriate (for example, totally enclosed, fan-cooled design).

(e) The collected dust is removed daily or more frequently if necessary to ensure efficient operation and to limit the collected dust to less than 10 kg.

(f) The collector is located at least 6.1 m (20 ft.) from any means of egress or area routinely occupied by personnel.

(g)* Multiple collectors in the same room are separated from each other by at least 6.1 m (20 ft.).

(h) The MIE of the collected materials is greater than 1000 mJ.

(i)* If the fabric for the bag is demonstrated to meet Type B, C, or D FIBC properties, it shall not be required to meet 7.13.1.1.2(4)(g).

(j) The fan construction must be spark resistant and meet the criteria in 7.12.2.

(k)* The AMS is not used to vent or serve sanders, abrasive planers, or similar sanding process equipment.

A.7.13.1.1.2(4)(a) Enclosureless dust collectors are not meant for use with most dusts created during the venting of process equipment or other aerated dust sources. Fine dust will rapidly blind the filter which results in reduced performance and a significant increase in deflagration hazards associated with the system operation and performance. Use of the enclosureless AMS for typical sawdust, paper dust, and similar particles has been proven to be effective, within the conditions listed, when applied properly.

A.7.13.1.1.2(4)(c) Many of the enclosureless dust collectors are manifolded into multiple bags with containers. The 5,000 cfm limit refers to the overall airflow through the assembly and not just to a single bag with collected material container.

A.7.13.1.1.2(4)(g) Enclosureless dust collectors are often manifolded into multiple bags (with collected material containers). Each such manifolded assembly must be separated by the requires 6.1 m or 20 ft.

A.7.13.1.1.2(4)(i) Refer to 9.3.3 for more information.

Substantiation: The Committee has provided new test to permit the use of enclosureless dust collectors under a list of conditions. These units have been used extensively in the wood industry and have proven safe under the listed conditions. They are also permitted for use in NFPA 664 under similar conditions.

Also, by placing limits on these units for use only with certain materials and conditions, the risks involved with incorrectly applying enclosureless dust collectors for fine dust emissions is specifically avoided.

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

NFPA 654 Task Group on this section.

Committee Meeting Action: Accept in Principle

Add new text to read as follows:

7.13.1.1.2(4)* Enclosureless air-material separator meeting all the following criteria shall be permitted to be used:

(a) The filter medium is not shaken or pressure-pulsed to dislodge dust during operation.

(a)* The AMS is used only for wood and wood products including paper.

(b) The AMS is not used to vent or serve metal grinders, hot work processes, or machinery that can produce sparks.

(c) The AMS is not used to vent or serve sanders, abrasive planers, or similar sanding process equipment.

(d)* Each collector system has a maximum air-flow handling capacity of 3,000 cfm (1.4 m³/sec) with a total filter volume of 8 cu. ft.

(e) The fan motor is suitable for Class II, Division 2, or Class III, as appropriate.

(f) The collected dust is removed daily or more frequently if necessary to ensure efficient operation and to limit the collected dust to less than 10 kg.

(g) The collector is located at least 6.1 m (20 ft.) from any means of egress or area routinely occupied by personnel.

(h)* Multiple collectors in the same room are separated from each other by at least 6.1 m (20 ft.).

(i)* The MIE of the collected materials is greater than ~~10~~500 mJ.

~~(j)* If the fabric for the bag is demonstrated to meet Type B, C, or D FIBC properties, it shall not be required to meet 7.13.1.1.2.(4)(i):~~

~~(i) The fan construction is spark resistant and meets the criteria in 7.12.2.5.~~

~~(k) The filter medium are not located within 35 ft (m) of any open flame or hot surface capable of igniting a dust cloud of the material it contains.~~

~~A.7.13.1.1.2(4) Enclosureless dust collectors are not meant for use with most dusts created during the venting of process equipment or other aerated dust sources. Fine dust will rapidly blind the filter which results in reduced performance and a significant increase in deflagration hazards associated with the system operation and performance. Use of the enclosureless AMS for typical sawdust, paper dust, and similar particles has been proven to be effective, within the conditions listed, when applied properly.~~

~~A.7.13.1.1.2(4)(d) Many of the enclosureless dust collectors are manifolded into multiple bags with containers. The 3,000 cfm limit refers to the overall airflow through the assembly and not just to a single bag with collected material container.~~

~~A.7.13.1.1.2(4)(h) Enclosureless dust collectors are often manifolded into multiple bags (with collected material containers). Each such manifolded assembly must be separated by the required 6.1 m or 20 ft.~~

~~A.7.13.1.1.2(4)(i) MIE is determined by testing the material as received with respect to particle size.~~

~~A.7.13.1.1.2(4)(i) Refer to 9.3.3 for more information.~~

Committee Statement: The Committee's modifications include: a change in the MIE value from 1000 mJ to 500 mJ which establishes a more conservative value; a removal of the restriction that the AMS is used only for wood as the Committee intent for including them in NFPA 654 is to expand the application under controlled, limited conditions beyond those already established for wood within NFPA 664; and the Committee modified the air-flow handling requirements to be consistent with limits recognized for typical systems.

654-31 Log #30 CMD-HAP
(7.13.1.2.1)

Final Action: Reject

Submitter: George Petino, Jr., Hazards Research Corporation, Inc.

Comment on Proposal No: 654-49, 654-50, 654-53

Recommendation: This provision should be revised to read as follows:

Where both an explosion hazard and a fire hazard exist in an air-material separator, *other than an enclosureless AMS meeting the criteria of 7.13.1.1.2(4)*, provisions for protection for each type of hazard shall be provided.

Substantiation: Section 7.13.1.1 appears to go to a significant effort to create an exemption from the location requirements for enclosureless AMS with a filter volume of less than 8 cubic feet, but we did not see a comparable exemption in the protection requirements of 7.13.1.2, which would appear to render the exemption in 7.13.1.1 ineffective.

Committee Meeting Action: Reject

Committee Statement: The recommended change would remove a requirement for fire protection for enclosureless AMS and the Committee does not support this potential reduction in safety.

654-32 Log #4 CMD-HAP
(8.2.1.3)

Final Action: Reject

Submitter: Mindy Wang, Ampco Safety Tools

Comment on Proposal No: 654-63

Recommendation: Add new text to read as follows:

8.2.1.3 Tools for cleanup of fugitive dusts or collecting sweepings shall be spark resistant.

Substantiation: In response to the original proposal the Committee expressed multiple concerns. The following is intended to discuss each of these concerns:

1. The Committee cites “published literature from API Recommended Practice 2214, Bureau of Mines, and Eckhoff, “Dust Explosions in the Process Industries, 3rd Edition that does not support the need for non-sparking tools in the application recommended.”

- API Recommended Practice 2214 has been withdrawn, effective May 1 2011. API announced the withdrawal of API RP 2214 on June 3 of API SmartBrief, “The withdrawal of RP 2214 is in recognition of a forthcoming revision in the 2012 edition of NFPA 30, Flammable and Combustible Liquid Code. New explanatory material provided in Annex A of NFPA 30 discusses the need to control sources of ignition, including mechanical sparks from hand tools that might have sufficient energy to ignite flammable vapors. The API Safety and Fire Protection Group determined that the new language in NFPA 30 recognizes that there is a potential for hand tool sparks to ignite flammable vapors for a limited number of chemicals and under certain unique conditions.” API now recognizes the need to control mechanical sparks from hand tools and withdraws API RP 2214.

- Bureau of Mines, “Frictional Ignition of Gas by Mining Machines”, concluded that “...Although the presence of frictional sparks is a warning of potential danger, it should be remembered that hot spots on the contacting surfaces can cause ignitions without visual sparking. To avoid ignitions, gas accumulation and frictional heating or frictional sparks must be prevented.” Although Bureau of Mines did not recommend of spark resistant tools in this report, Bureau of Mines recognized the fact that frictional sparks can ignite flammable gas. Published by OSHA, Occupational Safety and Health Guideline for Coal Dust (< 5% SiO₂) summarizes pertinent information about coal dust for workers and employers as well as for physicians, industrial hygienists, and other occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. One of the steps for undertaking of coal dust spills and leaks is to use non-sparking tools.

- In “Dust Explosions in the Process Industries” 3rd Edition, Rolf K. Eckhoff concluded that “...up to net impact energies of 20J, tangential accidental single impacts between various types of steel and between steel and rusty steel or concrete are unable to ignite clouds of grain and feed dust or flour, even if the dusts are dry....However, for net impact energies > 20J the situation may be different.” Eckhoff’s conclusion on impact sparks ignition is limited to power density of 20J. Eckhoff does not come to clear conclusion that impact sparks greater than 20J will not pose an ignition hazard. In fact, power density from steel impact sparks can generate energy greater than 20J and is illustrated in Section 3 below.

2. The Committee stated that “The submitter’s incident citations are not applicable to the operation of cleaning or sweeping as proposed in the recommendation; the incidents cited all involve use of hand tools in a maintenance application.”

- We are perplexed by the Committee’s statement. Although the incident citations are not in cleaning operation, the combustible nature of dusts and risk for ignition from steel tools are present as evidenced by the incidents cited. The Report of the BP U.S. Refineries independent Safety Review Panel, also known as the Baker Panel Report, states that “Preventing process accidents requires vigilance. The passing of time without a process accident is not necessarily an indicator that all is well and may contribute to a dangerous and growing sense of complacency.” In a testimony to the Congress, Jordan Barab, Assistant Secretary for the Occupational Safety and Health Administration U.S. Department of Labor states that conventional injury and illness rates are not adequate indicators of the risk of fires, explosions, or other catastrophic accidents, and companies need to develop better leading indicators to assess risks in their workplaces.

3. The Committee stated that “The submitter has not provided calculations showing that the power density produced by tool impact in probable scenarios is sufficient to ignite the particulates encompassed in the scope of NFPA 654.” Calculations of power density of mechanical sparks and hot surfaces from steel hand tools can have enough energy to ignite dust/air mixture.

- Dust Explosions in the Process Industries, by Rolf K. Eckhoff, table A.1 Ignitability and Explosibility of Dusts, lists minimum ignition energy (MIE) and minimum ignition temperature(MIT) for various dust layers, a few examples:

INSERT TABLE 654_L4 here

Mechanical sparks include impact sparks and friction sparks. In his study, Initiation of Grain Dust Explosions by Heat Generated during Single Impact between Solid Bodies, Rolf K. Eckhoff reported typical spark temperatures for mild steel were ~1500°C - 2700°C. Spark temperature of steel hand tools exceeds the auto-ignition temperature of dusts within the scope of NFPA 654.

· A test conducted by W. Bartknecht, Ignition Capability of Hot Surfaces and Mechanically Generated Sparks in Flammable Gas and Dust/Air Mixtures showed that if steel is rubbed against steel for a longer duration, (0.5-2.0 seconds) then friction sparks are generated. At ignition temperature 400°C, the electrical equivalent energy by steel friction sparks range from 10mJ to 100mJ. At the same ignition temperature, dust will be ignited which have a MIE of less than 100 mJ. Bartknecht concluded that "Hot surfaces generated with steel rubbed against steel will ignite dust/air mixtures easier than flammable gas/air mixtures because the ignition process depends solely on the temperature of the hot surface and the auto-ignition temperature." Therefore, friction sparks from steel wrenches could generate enough power density to ignite dusts found within the scope of NFPA 654.

- In his study, Initiation of Grain Dust Explosions by Heat Generated during Single Impact between Solid Bodies, Eckhoff concluded that "Therefore, it seems unlikely that dust explosions involving dusts of grain, feed or flour can be initiated by heat from accidental single impacts between tramp metal, and anvils of metal, corroded metal, stone or concrete, unless the net impact energies are much higher than 20 J."

- In Ignition of Dust Control and Dust Deposits by Friction Sparks and Hotspots by R L Rogers and others reported a single impact of more than 217 Joules kinetic energy is needed to ignite saw dust.

- Kinetic energy can be calculated as $E_k = \frac{1}{2}MV^2$, m is the mass in kilograms, V is velocity in meter per second (m/s), E_k is the kinetic energy in joules. Rogers' calculation of 217 Joules kinetic energy is based on the assumption of a low velocity of 1 m/s. However, this does not directly relate to hand tools use which is frequently a high velocity application. In the field, hand tool impact can easily generate an impact greater than 1m/s. In Eckhoff's test study, he used a range of 10m/s to 25m/s. Based on assumptions of a 3 pound hammer with an impact velocity of 18m/s, calculated kinetic energy is 220 Joules. Another example, a 5 pound hammer with an impact velocity of 14m/s, calculated kinetic energy is 235 joules. Calculations here show that impact sparks from hand tools can generate power density greater than 20 J reported in Eckhoff's study or 217 J reported in Roger's.

- Rogers also stated that "In assessing the risk of ignition of powder deposits from friction of mechanical equipment it is necessary to consider not only the total power but also the temperatures that are produced." As stated earlier, spark temperature of steel hand tools exceeds the auto-ignition temperature of dusts within the scope of NFPA 654.

A few more documented steel on steel accidents in dust environments:

Friction spark from steel on steel: OSHA inspection# 15050487, a piece of tramp metal was accidentally dumped into the south side hopper along with a load of wood chips and plywood trimmings. The movement of the screens caused a spark to occur. This spark ignited the dust in the confined area of the large and open-spaced dump house.

Spark from a hand tool: listed as accident#82 on dust incident data compiled by the Chemical Safety Board(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.

Impact spark from metal on metal: listed as accident#257 on dust incident data compiled by the CSB, an explosion resulted as spark from a metal on metal strike ignited sawdust and wood shavings when hot embers from a metal strike entered the dust collection system.

Without the proposed specification, steel tools are likely to be used which can be a source of ignition. The proposed text can better mitigate the flammability hazards associated with steel tools for cleanup of fugitive dusts where combustible dusts are present. We respectfully request the committee to reconsider and take action to implement safer work practices. However, if upon further consideration, the Committee still does not see the need for restricting ferrous tools we ask the Committee to at least include the proposed text in Annex text to raise the awareness of ignition hazard associated with ferrous tools in areas where airborne dust or dust accumulations are apt to occur.

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

API SmartBrief, API RP 2214, "Spark Ignition Properties of Hand Tools" Withdrawn, June 3 2011. Available: <http://www.smartbrief.com/news/api/storyDetails.jsp?issueid=D7A54ABE-AE46-4C17-BBDD-7A1B9CE0F8A3©>

id=DB2EC347-F8F7-4C56-9B45-4598329D217A&brief=api&sb_code=rss&&campaign=rss Dust Explosions in the Process Industries, 3rd Edition, by Rolf K. Eckhoff Initiation of Grain Dust Explosions by Heat Generated during Single Impact between Solid Bodies, Geir H. Pedersen and Rolf K. Eckhoff Ignition Capabilities of Hot Surfaces and Mechanically Generated Sparks in Flammable Gas and Dust/Air Mixtures, W. Bartknecht Ignition of Dust Clouds and Dust Deposits by Friction Sparks and Hotspots, R L Rogers, S Hawksworth, M Beyer, C Proust, D Lakic, J Gummer & D Raveau

Committee Meeting Action: Reject

Committee Statement: The submitter has provided new substantiation but is misrepresenting aspects of this new information. For example, with respect to the reference to the API 2214 withdrawal and the NFPA 30 discussions, the conclusion of the Flammable and Combustible Liquids Code Technical Committee established very limited application - hydrogen for example - and limited instances where spark resistant tools might be appropriate. This example provided does not involve combustible dusts. The data showing the MIE values and attempting to equate to mechanical spark energy is not appropriate for comparison. The cited mechanical spark temperatures are not comparable to published MIT data for reasons such as duration of exposure to hot surfaces and area of hot surfaces.

<u>Dust</u>	<u>MIE(mJ)</u>	<u>Equivalent Joules</u>	<u>MIT(°C)</u>
Rubber (dust from grinding):	13	0.013Joules	500
Methylmethacrylate- Butadiene-Styrene:	11	0.011Joules	470
L-Cystin	40	0.04 Joules	400
Methionine	9	0.009Joules	390
Methyl cellulose	12	0.012Joules	400
Dimethyl terephthalate	2	0.002 Joules	460
Emulgator (50% CH, 30% fat)	17	0.017Joules	430
Ferrocene	5	0.005Joules	500
Naphthalic acid anhydride	3	0.003Joules	690
Zinc stearate	5	0.005Joules	520
Stearin/calcium	25	0.025Joules	620
Toner	8	0.008Joules	530

654-33 Log #5 CMD-HAP
(9.1.5)

Final Action: Reject

Submitter: Mindy Wang, Ampco Safety Tools

Comment on Proposal No: 654-69

Recommendation: Add new text to read 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. Spark resistant tools shall be used to make repairs or adjustment on or around any machinery where combustible dust is present.

Substantiation: In response to the original proposal the Committee expressed multiple concerns. The following is intended to discuss each of these concerns:

1. The Committee cites “published literature from API Recommended Practice 2214, Bureau of Mines, and Eckhoff, “Dust Explosions in the Process Industries, 3rd Edition that does not support the need for non-sparking tools in the application recommended.”

- API Recommended Practice 2214 has been withdrawn, effective May 1, 2011. API announced the withdrawal of API RP 2214 on June 3 of API SmartBrief, “The withdrawal of RP 2214 is in recognition of a forthcoming revision in the 2012 edition of NFPA 30, Flammable and Combustible Liquid Code. New explanatory material provided in Annex A of NFPA 30 discusses the need to control sources of ignition, including mechanical sparks from hand tools that might have sufficient energy to ignite flammable vapors. The API Safety and Fire Protection Group determined that the new language in NFPA 30 recognizes that there is a potential for hand tool sparks to ignite flammable vapors for a limited number of chemicals and under certain unique conditions.” API now recognizes the need to control mechanical sparks from hand tools and withdraws API RP 2214.

- Bureau of Mines, “Frictional Ignition of Gas by Mining Machines”, concluded that “...Although the presence of frictional sparks is a warning of potential danger, it should be remembered that hot spots on the contacting surfaces can cause ignitions without visual sparking. To avoid ignitions, gas accumulation and frictional heating or frictional sparks must be prevented.” Although Bureau of Mines did not recommend of spark resistant tools in this report, Bureau of Mines recognized the fact that frictional sparks can ignite flammable gas. Published by OSHA, Occupational Safety and Health Guideline for Coal Dust (< 5% SiO₂) summarizes pertinent information about coal dust for workers and employers as well as for physicians, industrial hygienists, and other occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. One of the steps for undertaking of coal dust spills and leaks is to use non-sparking tools.

- In “Dust Explosions in the Process Industries” 3rd Edition, Rolf K. Eckhoff concluded that “...up to net impact energies of 20J, tangential accidental single impacts between various types of steel and between steel and rusty steel or concrete are unable to ignite clouds of grain and feed dust or flour, even if the dusts are dry....However, for net impact energies > 20J the situation may be different.” Eckhoff’s conclusion on impact sparks ignition is limited to power density of 20J. Eckhoff does not come to clear conclusion that impact sparks greater than 20J will not pose an ignition hazard. In fact, power density from steel impact sparks can generate energy greater than 20J and is illustrated in Section 2 below.

2. The Committee stated that “The submitter has not provided calculations showing that the power density produced by tool impact in probable scenarios is sufficient to ignite the particulates encompassed in the scope of NFPA 654.”

Calculations of power density of mechanical sparks and hot surfaces from steel hand tools can have enough energy to ignite dust/air mixture.

- Dust Explosions in the Process Industries, by Rolf K. Eckhoff, table A.1 Ignitability and Explosibility of Dusts, lists minimum ignition energy (MIE) and minimum ignition temperature(MIT) for various dust layers, a few examples:

INSERT TABLE 654_L5_S HERE

- Mechanical sparks include impact sparks and friction sparks. In his study, Initiation of Grain Dust Explosions by Heat Generated during Single Impact between Solid Bodies, Rolf K. Eckhoff reported typical spark temperatures for mild steel were ~1500°C - 2700°C. Spark temperature of steel hand tools exceeds the auto-ignition temperature of dusts within the scope of NFPA 654.

- A test conducted by W. Bartknecht, Ignition Capability of Hot Surfaces and Mechanically Generated Sparks in

Flammable Gas and Dust/Air Mixtures showed that if steel is rubbed against steel for a longer duration, (0.5-2.0 seconds) then friction sparks are generated. At ignition temperature 400°C, the electrical equivalent energy by steel friction sparks range from 10mJ to 100mJ. At the same ignition temperature, dust will be ignited which have a MIE of less than 100 mJ. Bartknecht concluded that “Hot surfaces generated with steel rubbed against steel will ignite dust/air mixtures easier than flammable gas/air mixtures because the ignition process depends solely on the temperature of the hot surface and the auto-ignition temperature.” Therefore, friction sparks from steel wrenches could generate enough power density to ignite dusts found within the scope of NFPA 654.

- In his study, Initiation of Grain Dust Explosions by Heat Generated during Single Impact between Solid Bodies, Eckhoff concluded that “Therefore, it seems unlikely that dust explosions involving dusts of grain, feed or flour can be initiated by heat from accidental single impacts between tramp metal, and anvils of metal, corroded metal, stone or concrete, unless the net impact energies are much higher than 20 J.”

- In Ignition of Dust Control and Dust Deposits by Friction Sparks and Hotspots by R L Rogers and others reported a single impact of more than 217 Joules kinetic energy is needed to ignite saw dust.

- Kinetic energy can be calculated as $E_k = \frac{1}{2}MV^2$, m is the mass in kilograms, V is velocity in meter per second (m/s), E_k is the kinetic energy in joules. Rogers’ calculation of 217 Joules kinetic energy is based on the assumption of a low velocity of 1 m/s. However, this does not directly relate to hand tools use which is frequently a high velocity application. In the field, hand tool impact can easily generate an impact greater than 1m/s. In Eckhoff’s test study, he used a range of 10m/s to 25m/s. Based on assumptions of a 3 pound hammer with an impact velocity of 18m/s, calculated kinetic energy is 220 Joules. Another example, a 5 pound hammer with an impact velocity of 14m/s, calculated kinetic energy is 235 joules. Calculations here show that impact sparks from hand tools can generate power density greater than 20 J reported in Eckhoff’s study or 217 J reported in Roger’s.

Rogers also stated that “In assessing the risk of ignition of powder deposits from friction of mechanical equipment it is necessary to consider not only the total power but also the temperatures that are produced.” As stated earlier, spark temperature of steel hand tools exceeds the auto-ignition temperature of dusts within the scope of NFPA 654.

A few more documented steel on steel accidents in dust environments:

Friction spark from steel on steel: OSHA inspection# 15050487, a piece of tramp metal was accidentally dumped into the south side hopper along with a load of wood chips and plywood trimmings. The movement of the screens caused a spark to occur. This spark ignited the dust in the confined area of the large and open-spaced dump house.

Spark from a hand tool: listed as accident#82 on dust incident data compiled by the Chemical Safety Board(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.

Impact spark from metal on metal: listed as accident#257 on dust incident data compiled by the CSB, an explosion resulted as spark from a metal on metal strike ignited sawdust and wood shavings when hot embers from a metal strike entered the dust collection system.

Without the proposed specification, steel tools are likely to be used which can be a source of ignition. The proposed text can better mitigate the flammability hazards associated with maintenance in or around machinery and equipment with steel tools where combustible wood dusts are present. We respectfully request the committee to reconsider and take action to implement safer work practices. However, if upon further consideration, the Committee still does not see the need for restricting ferrous tools we ask the Committee to at least include the proposed text in Annex text to raise the awareness of ignition hazard associated with ferrous tools in areas where airborne dust or dust accumulations are apt to occur.

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

API SmartBrief, API RP 2214, "Spark Ignition Properties of Hand Tools" Withdrawn, June 3 2011. Available: http://www.smartbrief.com/news/api/storyDetails.jsp?issueid=D7A54ABE-AE46-4C17-BBDD-7A1B9CE0F8A3©id=DB2EC347-F8F7-4C56-9B45-4598329D217A&brief=api&sb_code=rss&&campaign=rss Dust Explosions in the Process Industries, 3rd Edition, by Rolf K. Eckhoff Initiation of Grain Dust Explosions by Heat Generated during Single Impact between Solid Bodies, Geir H. Pedersen and Rolf K. Eckhoff Ignition Capabilities of Hot Surfaces and Mechanically Generated Sparks in Flammable Gas and Dust/Air Mixtures, W. Bartknecht Ignition of Dust Clouds and Dust Deposits by Friction Sparks and Hotspots, R L Rogers, S Hawksworth, M Beyer, C Proust, D Latic, J Gummer & D Raveau

Committee Meeting Action: Reject

Committee Statement: The submitter has provided new substantiation but is misrepresenting aspects of this new information. For example, with respect to the reference to the API 2214 withdrawal and the NFPA 30 discussions, the conclusion of the Flammable and Combustible Liquids Code Technical Committee established very limited application - hydrogen for example - and limited instances where spark resistant tools might be appropriate. This example provided

does not involve combustible dusts. The data showing the MIE values and attempting to equate to mechanical spark energy is not appropriate for comparison. The cited mechanical spark temperatures are not comparable to published MIT data for reasons such as duration of exposure to hot surfaces and area of hot surfaces.

<u>Dust</u>	<u>MIE(mJ)</u>	<u>Equivalent Joules</u>	<u>MIT(°C)</u>
Rubber (dust from grinding):	13	0.013Joules	500
Methylmethacrylate- Butadiene-Styrene:	11	0.011Joules	470
L-Cystin	40	0.04 Joules	400
Methionine	9	0.009Joules	390
Methyl cellulose	12	0.012Joules	400
Dimethyl terephthalate	2	0.002 Joules	460
Emulgator (50% CH, 30% fat)	17	0.017Joules	430
Ferrocene	5	0.005Joules	500
Naphthalic acid anhydride	3	0.003Joules	690
Zinc stearate	5	0.005Joules	520
Stearin/calcium	25	0.025Joules	620
Toner	8	0.008Joules	530

654-34 Log #32 CMD-HAP
(9.3)

Final Action: Accept in Principle

Submitter: Bill Stevenson, CV Technology, Inc.

Comment on Proposal No: 654-14

Recommendation: Revise text to read as follows:

~~9.3.3 Intermediate Bulk Containers (IBCs).~~

~~9.3.3.1* Dispensing material from intermediate bulk containers into combustible atmospheres shall be performed only under the following conditions:~~

~~(1) A conductive (i.e., metallic) rigid intermediate bulk container (RIBC) shall be permitted to be used for dispensing into any flammable vapor, gas, dust, or hybrid atmospheres provided the RIBC is electrically grounded.~~

~~(2) A Type B flexible intermediate bulk container (FIBC) shall be permitted to be used for dispensing into dust atmospheres where the minimum ignition energy (MIE) is greater than 3 mJ, but no flammable vapor or gas is present.~~

~~(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 less than 1 megohm to ground.~~

~~(4) A Type D FIBC shall be permitted to be used for dispensing into flammable vapor, gas, dust, or hybrid atmospheres for which the FIBC has been tested and found suitable.~~

~~(5) A Type A FIBC or insulating RIBCs shall not be permitted to be used for combustible powder applications, processes, or operations unless a documented risk evaluation assessing the electrostatic hazards is acceptable to the authority having jurisdiction.~~

~~9.3.3.2* FIBCs that are listed or tested by a recognized testing organization and are shown not to ignite flammable atmospheres during transfer shall be permitted to be used.~~

~~9.3.3.3 Documentation of test results shall be made available to the authority having jurisdiction.~~

~~IGNITION SOURCES 654-17~~

~~2006 Edition~~

9.3.3 Flexible Intermediate Bulk Containers (FIBCs).

9.xxx Description. Flexible intermediate bulk containers (FIBCs) are basically very large fabric bags supported in a frame. They are more convenient than rigid IBCs, because they can be fully collapsed after use, taking up little storage space.

9.xxx The fabric is usually polypropylene, and the fabric is sewn to form a three-dimensional cube or rectangle with lifting straps. An FIBC can be filled with a powder or granular material and moved about with conventional materials-handling equipment.

9.xxx An advantage of FIBCs is that they can be unloaded quickly, typically 300 kg to 500 kg in 30 sec or less. Therefore, rates at which static electric charges are generated can often exceed the rates at which the charges can relax under common conditions of use, and accumulation of a static electric charge can be expected.

9.xxx Charge Generation. Static electric charges can be generated during the filling and emptying of FIBCs and can accumulate on both the contents and the fabric of the FIBC. If the accumulated charge is strong enough and is released in the presence of an ignitable atmosphere, ignition can occur.

9.xxx Types of FIBCs and Inner Liners. The International Standard IEC 61340-4-4 describes four types of FIBCs, Type A, Type B, Type C, and Type D, defined by the construction of the FIBCs, the nature of their intended operation and associated performance requirements. FIBCs should be tested in accordance with the requirements and test procedures specified in IEC 61340-4-4 and in accordance with their intended use before being used in hazardous environments. See Table 10.1.6.3 for a summary of FIBC use, as described in Sections 10.1.6.4 through 10.1.6.7. The subject of inner liners is not addressed in this *Recommended Practice*. Guidance on the safe use of inner liners is given in IEC 61340-4-4.

9.xxx Type A FIBCs.

9.xxx Type A FIBCs are constructed of nonconductive materials (e.g. polypropylene fabric with polyester stitching) and have no special features incorporated in their design to control static electric discharge hazards. Type A FIBCs can be used for materials that do not form ignitable atmospheres in normal handling operations.

9.xxx Experience has shown that Propagating brush discharges can occur in Type A FIBCs. The energy released in propagating brush discharges can reach 1000 mJ. The following criteria apply:

(1) Type A FIBCs should not be used for powder or granular materials that have an MIE of less than 1000 mJ.

(2) Type A FIBCs should never be used in areas where a flammable (gas, vapor, hybrid) atmosphere is present.

(3) Type A FIBCs should not be used for conductive powders ($P_v < 1$ megohm-m).

9.xxx Type B FIBCs.

9.xxx Type B FIBCs, like Type A FIBCs, are constructed of nonconductive materials (e.g., polypropylene fabric with polyester stitching) . However, the material of construction of Type B FIBCs is designed to have a breakdown voltage less than 6KV and hence control static electric discharge hazards.

9.xxx Type B FIBCs are designed to avoid the occurrence of propagating brush discharges. Propagating brush discharges can only occur in FIBCs if the materials from which FIBCs are constructed have sufficient electrical strength to sustain high surface charge densities. Research has shown that propagating brush discharges cannot occur if the breakdown voltage of the materials used to construct FIBCs is less than 6 kV.

9.xxx Filling charged, high resistivity powder into FIBCs may generate a region of very high space charge density within the heap of bulked powder. This leads to high electrical fields at the top of the heap. Under these circumstances, cone discharges running along the surface have been observed. Although cone discharge can occur in all forms of containers, including grounded conductive containers, cone discharges may have a much higher energy in Type B FIBCs than in grounded conductive containers, where the walls of the containers will be at close to zero potential. Energy calculations predict that in Type B FIBC, cone discharges may be incendiary to powders with MIE of up to 3 mJ.

9.xxx Since Type B FIBCs have no mechanism for dissipating electrostatic charge, brush discharges might occur that can ignite flammable gases and vapors. The following criteria apply:

(1) Type B FIBCs should be made from materials with breakdown voltage less than 6 kV.

(2) Type B FIBCs should not be used for powder or granular materials that have an MIE of 3 mJ or less.

(3) Type B FIBCs should never be used in areas where a flammable (gas, vapor, hybrid) atmosphere is present.

(4) Type B FIBCs should not be used for conductive powders ($P_v < 1$ megohm-m).

9.xxx Type C FIBCs.

9.xxx Type C FIBCs are constructed entirely from conductive material or insulating material that contain fully inter-connected conductive threads or tapes with specific spacing and can be treated the same way as conductive IBCs, as specified in Section 10.1.4. It is essential that Type C FIBCs be grounded during filling and emptying operations.

9.xxx FIBCs constructed of nonconductive fabric and containing woven, grounded, conductive filaments can be considered to be conductive. One type of FIBC has conductive filaments spaced less than 20 mm apart, each of which is connected at least once to its neighbor, preferably at both ends. They are intended to be grounded. Another type has conductive filaments or threads that form an interconnecting grid of not more than 50 mm mesh size. They also are intended to be grounded.

9.xxx The recommendations for conductive IBCs given in Section 10.1.4 also apply to conductive FIBCs. A grounding tab that is electrically connected to the conductive material or threads is provided and is intended to be connected to a ground point when the FIBC is filled or emptied. The resistance between the conductive elements in the FIBC and the grounding tabs should be less than $1.0 \times 10^2 \Omega$.

9.xxx For FIBCs constructed of multi-layer materials, the resistance between the inside or outside surface of the FIBC and the grounding tabs should be less than $1.0 \times 10^2 \Omega$. If the inside layer does not have a resistance to grounding tabs of less than $1.0 \times 10^2 \Omega$, then the material should have a breakdown voltage of less than 6 kV. All layers of multi-layer materials should remain in firm contact during filling and emptying operations.

9.xxx Materials used to construct inner baffles, other than mesh or net baffles, should meet the requirements stated in Sections 10.1.6.6.3 and 10.1.6.6.4.

9.xxx Type D FIBCs.

9.xxx Type D FIBCs are constructed from fabrics and/or threads with special electrostatic properties to control discharge incendivity and are intended for use without grounding in the presence of flammable vapors or gases with MIE of 0.14 mJ or greater, and with combustible powders, including those with ignition energies of 3 mJ or less.

9.xxx Before being used in hazardous environments, Type D FIBCs should be qualified as safe, i.e. by demonstrating that no incendiary discharge can occur under normal operating conditions. IEC 61340-4-4 describes test procedures for ignition testing that can be used for this purpose.

9.xxx If Type D FIBCs are made from materials that have an insulating layer (e.g. coating film or lamination) on the inside of the container, the materials should have a breakdown voltage of less than 6 kV. All layers of multi-layer materials shall remain in firm contact during filling and emptying operations.

*****Insert Table 9.xxx Here*****

Table 9.xxx Use of different types of FIBCs

<u>Bulk product in FIBC</u>	<u>Surroundings</u>		
<u>MIE of dust^a</u>	<u>Non-flammable atmosphere</u>	<u>Class II, Divisions 1 & 2 (1,000 mJ ≥ MIE > 3 mJ)^a</u>	<u>Class I, Divisions 1 & 2 (Gas Group C & D) or Class II, Divisions 1 & 2 (MIE ≤ 3 mJ)^a</u>
<u>MIE > 1,000 mJ</u>	<u>A, B, C, D</u>	<u>B, C, D</u>	<u>C, D^b</u>
<u>1,000 mJ ≥ MIE > 3 mJ</u>	<u>B, C, D</u>	<u>B, C, D</u>	<u>C, D^b</u>
<u>MIE ≤ 3 mJ</u>	<u>C, D</u>	<u>C, D</u>	<u>C, D^b</u>

NOTE 1 Additional precautions are usually necessary when a flammable gas or vapour atmosphere is present inside the FIBC, e.g. in the case of solvent wet powders.

NOTE 2 Non-flammable atmosphere includes dusts having a MIE > 1,000 mJ.

^aMeasured in accordance with IEC 61241-2-3, capacitive discharge circuit (no added inductance).

^bUse of Type D shall be limited to Gas Groups C & D with MIE ≥ 0.14 mJ.

Substantiation: The recommended changed text reflects the latest changes to the EN document. This new text is identical to that agreed to at the ROP meeting for NFPA 77. Adoption of this text would align 654 with 77 and be consistent with the EN document.

Committee Meeting Action: Accept in Principle

See Committee Action on Committee Comment 654-8 (Log# CC2).

Committee Statement: See Committee Action and Substantiation on Committee Comment 654-8 (Log# CC2).

654-35 Log #8 CMD-HAP
(9.3.1.2)

Final Action: Accept

Submitter: Thomas C. Scherpa, The DuPont Company, Inc.

Comment on Proposal No: 654-70

Recommendation: Revise text to read as follows:

9.3.1.2 Nonconductive system components shall be permitted where all of the following conditions are met:

(a) Hybrid mixtures are not present

(b) Conductive dusts are not handled

(c) The MIE of the material being handled is greater than 3 mJ

(d) The nonconductive components do not result in isolation of conductive components from ground

(e)* The breakdown strength across nonconductive sheets, coatings, or membranes does not exceed ~~6~~ 4 kV when used in high surface charging processes

A.9.3.1.2(e) The potential for propagating brush discharges exists where nonconductive materials with breakdown voltages exceeding ~~6~~ 4 kV are exposed to processes that generate strong surface charges such as pneumatic conveying. Such discharges do not occur where the breakdown voltage is less than ~~6~~ 4 kV.

Substantiation: The correct threshold for propagating brush discharge in sheets, coatings, or membranes is 4 kV. The 6 kV limit is for woven materials, i.e., FIBCs.

Committee Meeting Action: Accept

654-36 Log #31 CMD-HAP
(9.3.3.1)

Final Action: Reject

Submitter: George Petino, Jr., Hazards Research Corporation, Inc.

Comment on Proposal No: 654-75

Recommendation: This provision should be revised as follows:

9.3.3.1* Dispensing material from intermediate bulk containers into combustible atmospheres shall be performed only under the following conditions:

(1) A conductive (i.e., metallic) rigid intermediate bulk container (RIBC) shall be permitted to be used for dispensing into any flammable vapor, gas, dust, or hybrid atmospheres provided the RIBC is electrically grounded.

(2)* A Type B flexible intermediate bulk container (FIBC) shall be permitted to be used for dispensing into dust atmospheres where the minimum ignition energy (MIE) is greater than 10 ~~3~~ mJ, but no flammable vapor or gas is present.

(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 less than 1 megohm to ground as measured at the ground tab on the FIBC.

(4)* A Type D FIBC shall be permitted to be used for dispensing into flammable vapor, gas, dust, or hybrid atmospheres for which the FIBC has been tested and found suitable.

(5)* A Type A FIBC or insulating RIBCs shall ~~not~~ be permitted to be used for combustible powder applications, processes, or operations where the minimum ignition energy (MIE) is greater than 10 mJ, but no flammable vapor or gas is present. ~~unless a documented risk evaluation assessing the electrostatic hazards is acceptable to the authority having jurisdiction.~~

Throughout the document, the phrase "acceptable to the authority having jurisdiction" should be deleted.

Substantiation: The maximum potential brush discharge from these materials is 3 mJ, but MIE test results are subject to some variability. Therefore, we recommend using 10 mJ to provide an appropriate safety factor. The repeated use of the phrase "acceptable to the authority having jurisdiction" should be eliminated because it implies that there is an obligation to apply for and obtain AHJ approval when that is not the case. The obligation to comply with the building codes is stated in other standards and legislation and there is no reason to include it in this document.

Committee Meeting Action: Reject

Committee Statement: Best practice that has been substantiated by test data and expert opinion for Type B is 3 mJ per IEC Standard 61340-4-4 and not 10 mJ as proposed. The use of Type A or insulating RIBC poses an ignition hazard due to the potential for formation of propagating brush discharges, which can produce energies in excess of 10 mJ. The Committee also notes that the general recommendation in this comment to "delete all use of 'acceptable to the authority having jurisdiction'" is not actionable at this stage in the process as that language has not been modified in all sections of the standard so is not suitable at this stage in the process. The suggestion for Type C FIBC to have the resistance measured at the ground tab already exists per the ROP approved text in 654-14.

654-37 Log #CC1 CMD-HAP
(A.3.3.4)

Final Action: Accept

Submitter: Technical Committee on Handling and Conveying of Dusts, Vapors, and Gases,

Comment on Proposal No: 654-8

Recommendation: Revise the first paragraph of A.3.3.4 as follows:

A.3.3.4 Combustible Dust. Dusts traditionally have been defined as a material 420 μm or smaller (capable of passing through a U.S. No. 40 standard sieve). For consistency with other standards, 500 microns (capable of passing through a U.S. No. 35 standard sieve) is now considered an appropriate size criterion. Particle surface area to volume ratio is a key factor in determining the rate of combustion. Combustible particulate solids with a minimum dimension more than 500 microns generally have a surface to volume ratio that is too small to pose a deflagration hazard. Flat platelet-shaped particles, flakes, or fibers with lengths that are large compared to their diameter usually do not pass through a 500 μm sieve yet could still pose a deflagration hazard. Many particulates accumulate electrostatic charge in handling, causing them to attract each other, forming agglomerates. Often agglomerates behave as if they were larger particles, yet when they are dispersed they present a significant hazard. Consequently, it can be inferred that any ~~particle~~ particulate that has a minimum dimension of less than or equal to 500 microns could behave as a combustible dust if suspended in air or the process specific oxidizer. If the minimum dimension of the particulate is greater than 500 microns, it is unlikely that the material would be a combustible dust, as determined by test. The determination of whether a sample of combustible material presents a flash fire or explosion hazard is a combustible, explosible dust should could be based on a screening test methodology such as provided in the ASTM E 1226, *Test Method for Pressure and Rate of Pressure Rise for Combustible Dusts*. Alternatively, a standardized test method such as ASTM E 1515, *Standard Test Method for Minimum Explosible Concentration of Combustible Dusts* could ~~can~~ be used to determine dust explosibility.

Remainder of A.3.3.4 is unchanged from the ROP revisions.

Substantiation: The revision to the annex material includes changes to be consistent with the defined term in 3.3.4, such as adding the words, "or the process specific oxidizer." The annex was also clarified to indicate that the threshold particulate size was 500 microns or smaller and that particulates greater than 500 microns are unlikely to be combustible based on test. The annex is further amended to indicate that the determination of flash fire or explosion hazard could be by one of two ASTM test methods.

Committee Meeting Action: Accept

654-38 Log #CC7 CMD-HAP
(A.4.2.1)

Final Action: Accept

Submitter: Technical Committee on Handling and Conveying of Dusts, Vapors, and Gases,
Comment on Proposal No: 654-89

Recommendation: Revise text to read as follows:

A.4.2.1 One method by which this requirement can be satisfied is with a process hazard analysis conducted in accordance with the methods outlined by the AIChE Center for Chemical Process Safety in *Guidelines for Hazard Evaluation Procedures*. To determine if a dust deflagration hazard exists, consider the following:

- (1) Is the dust explosible? Determine using either ASTM E 1226 or equivalent.
- (2) Determine where in the process a dust cloud sufficient to support a deflagration could occur. Use loss records and knowledge of process conditions to make this assessment.
- (3) Identify likely ignition sources. Recognize that ignition sources are complex and not always predictable. ~~It is best to assume ignition is possible in all cases.~~
- (4) ~~Assess the likelihood of an event. For example, a material with a low MIE has a greater likelihood of ignition, all else being equal. Determine MIE, if appropriate, using ASTM E 2019.~~
- (5) In terms of a worst case scenario, consider what are the predictable consequences might be, using conservative assumptions to yield a credible worst case. Start with predictable primary events and then consider secondary events.
- (5) Assess the likelihood of the event. For example, a material with a low MIE has a greater likelihood of ignition, all else being equal. Determine MIE, if appropriate, using ASTM E 2019.
- (6) Assess the risk of the event considering both the consequence and the likelihood. If the risk is intolerable to either the owner/operator or the AHJ, identify mitigation techniques that would reduce the risk by reducing the likelihood and/or the consequences.
 - (a) Can the risk be eliminated?
 - (b) Can controls be applied to minimize the likelihood?
 - (c) Can the risk be tolerated utilizing mitigation techniques to reduce or control the consequences?
- (7) Assign responsibility and due dates for implementing the additional mitigation techniques and follow up to ensure their implementation.

Substantiation: The Committee modified the annex to be consistent with conventional Process Hazard Analysis best practices as outlined in the referenced publications. The sequence of some of the existing steps were reordered to match these best practices.

Committee Meeting Action: Accept

654-39 Log #CC6 CMD-HAP
(A.8.2.3.1)

Final Action: Accept

Submitter: Technical Committee on Handling and Conveying of Dusts, Vapors, and Gases,
Comment on Proposal No: 654-66

Recommendation: Revise A.8.2.3.1 as shown:

A.8.2.3.1 If a large quantity of material is spilled in an unclassified area, the bulk material should be collected by sweeping, shoveling, or with a portable vacuum cleaner listed as suitable for Class II locations. Vacuum cleaners meeting the requirements in 8.2.3.2 can be used to clean up residual material after the bulk of the spill has been collected.

These requirements for portable vacuum cleaners should be applied to the use of vacuum trucks for combustible dust as well. However, there can be other safety issues concerning vacuum truck applications that are not covered within this section. Given that this application might represent a change from normal procedures, operators should also consider the guidance found in conducting a management of change evaluation.

Substantiation: The Committee added vacuum trucks to the existing annex item to highlight that it is common practice in some industrial applications for vacuum trucks to be used for cleaning purposes and dust collection. This note suggests that the requirements for portable vacuum cleaners could also be applied for use with vacuum trucks, but cautions that other hazards might be associated with such operations. If the use of vacuum trucks is not part of the existing facility plans for dust collection, then the annex also recommends reviewing the safety practices in place for such operations in the context of a change in procedure before going forward.

Committee Meeting Action: Accept

654-40 Log #CC4 CMD-HAP
(Annex D)

Final Action: Accept

Submitter: Technical Committee on Handling and Conveying of Dusts, Vapors, and Gases,
Comment on Proposal No: 654-96

Recommendation: Revise Annex D as shown:

Include 654_LCC4_Annex D_R here

Substantiation: An updated Annex D has been developed based upon the new equations and example solutions are shown. The revision of Chapter 6 that includes the four alternative methods for determining where a flash fire hazard or dust explosion hazard area exists, is supported with the examples shown in the proposed revised Annex D. The examples worked out show comparisons with the 2006 methodology and are also consistent with the changes reflected in the approved TIA.

Committee Meeting Action: Accept

Annex D Dust Layer Characterization and Precautions

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

D.1:

The threshold mass equations of section 6.1 provide a means to determine whether the normal accumulation of combustible dust in the building/room requires the addition of a safeguard for workers in the immediate area or a safeguard for workers remote from the immediate area. This is similar to the concept of maximum allowable quantity in control areas in building codes. Above the maximum quantity, the area is considered hazardous and additional safeguards are required. NFPA 5000, *Building Construction and Safety Code*, 2009 edition, indicates in Chapter 6 that, when combustible dusts are stored, used, or generated in a manner creating a severe fire or explosion hazard the building/room would be considered to contain High Hazard Level 2 contents.

This document acknowledges that accumulation of combustible dust outside of equipment can present a severe hazard when the quantity exceeds certain thresholds. When the threshold is exceeded, this document imposes physical barriers and explosion venting to limit and control the explosion hazard as well as personal protective equipment and fire separations to address the flash fire hazard.

In addition to the many process design constraints intended to limit ignition potential, use of proper electrical equipment is separately addressed. It is important to recognize that the criteria for requiring electrically classified equipment are different than the thresholds for flash fire or explosion hazard. As an example, in a single room the total dust accumulation could be large enough that the entire room is deemed an Explosion Hazard Area yet, if the dust accumulation is evenly distributed it is possible that electrically classified equipment is not needed. Conversely, there could be an isolated area with thick layers of dust that would require the installation of electrically classified equipment and yet the room, in total, does not contain sufficient dust accumulation to exceed the threshold mass.

D.3 Mass Methods A and B:

The user can apply both of the Mass Method A equations in paragraphs 6.1.43.1 and 6.1.43.2 to separately determine if an explosion hazard or a flash fire hazard exists from total accumulated dust mass in the building/room. If so, then safeguards are required for workers remote from or in the immediate area, respectively. Alternately, the user can apply both of the Mass Method B equations in paragraphs 6.1.5.14 and 6.1.5.2 to separately determine if an explosion hazard or a flash fire hazard exists from total accumulated dust mass in the building/room.

When the dust accumulations are non-separated, the accumulations are combined and compared to the permissible dust accumulation. When accumulations are segregated, detached, or separated in accordance with Section 6.2, the accumulations are individually compared to the permissible dust accumulation.

The basic equations of Mass Method A, paragraphs 6.1.43.1 and 6.1.43.2, do not require measurement of any physical or combustibility properties for application. They are independent

of these properties and offer a generally conservative approach. The only variables are the total building/room floor area and the general height of the building/room, which provides a volume correction. In practice, the user can weigh the amount of accumulated dust in various areas outside of equipment to estimate the total dust mass in the building/room. If the dust mass exceeds the threshold determined according to 6.1.43.1, then the area is a Dust Explosion Hazard Area. If the dust mass exceeds the threshold determined according to section 6.1.43.2, then the area is a Dust Flash Fire Hazard Area. Depending on building height, the area of dust accumulation could be either, a Dust Explosion Hazard Area, a Dust Flash Fire Hazard Area, or both.

The equations of Mass Method B, paragraphs 6.1.5.14 and 6.1.5.2, require additionally not only combustibility properties of the dust, but also, for equation 6.1.5.14, information about the building/room strength against explosions. With this information, it is then possible to be more accurate when evaluating the potential hazards created by the dust accumulation.

An example application is a 1000 sq meter building, having a peaked roof with eave height of 9 meters and peak height of 10 meters. The owner/user expects only minor dust accumulation near certain activities and has provided electrically classified equipment in these limited areas. When operations began, a routine housekeeping schedule was documented and instituted to minimize dust accumulation. After 2 months of operation the owner/user weighed dust samples from 6 different areas in the plant as below in Table D.34.

Table D.34					
Section Name	Floor Area, m²	Above Floor Area, m²	Sampled Area, m²	Sampled Wt, kg	Estimated Wt, Kg
Bag unloading	20		2	0.5	5
Processing	600		4	0.05	7.5
Packaging	180		3	0.65	39
Shipping	200		4	0.05	2.5
Bar Joist		50	2	0.1	2.5
Mezzanine		105	3	0.1	3.5
Total	1000				60

Based on the weighed samples, the user multiplied the mass per unit area by the estimated floor area for the samples, and estimated the weight of dust in each section of the plant. As a result, the user determined that practicable housekeeping allowed the dust to accumulate to about 60 kg

over the building. According to Equations 6.1.43.1 and 6.1.43.2, the threshold masses are 38 kg for an Explosion Hazard Area and 20 kg for a Flash Fire Hazard Area.

$$M_{basic-exp} = 0.004 \cdot A_{floor} \cdot H = 0.004 \cdot 1000m^2 \cdot 9.5m = 38kg$$

~~$$M_{basic-exp} = 0.004 \cdot 1000m^2 \cdot 9.5m = 38kg$$~~

$$M_{basic-fire} = 0.02 \cdot A_{floor} = 0.02 \cdot 1000m^2 = 20kg$$

~~$$M_{basic-fire} = 0.02 \cdot 1000m^2 = 20kg$$~~

Practicable housekeeping has resulted in too much dust without additional safeguards and the owner/user would have to modify equipment to better contain the dust or provide the additional prescribed safeguards. The user could decide to proceed with the results of the basic equations without further evaluation. However, since the building is new, the design information is readily available and the user decides to evaluate the current dust accumulation using the equations of paragraphs 6.1.5.14 and 6.1.5.2.

The building is constructed of pre-engineered columns with metal siding on steel girts. The girts stabilize the columns, and fail at 0.036 bar (75 lb/ft²) internal pressure. The metal siding is designed for 0.017 bar (35 lb/ft²) internal pressure; however the user determines there is nothing of importance mounted to the metal siding. It is the user's choice to accept potential siding damage during an explosion. A sample of the accumulated dust was tested according to ASTM-E1226 and has a K_{St} of 150 bar-m/sec, P_{max} of 7 bar and C_w of 0.60 kg/m³.

In order to evaluate the threshold mass for the explosion hazard, the user must establish the enclosure strength, P_{es}, based on the weakest structural element not intended to vent or fail. According to the description, this would be the girts at 0.036 bar. The second building construction parameter is the Dynamic Load Factor, DLF. More details about Dynamic Load Factor are presented in NFPA-68. In this case, the user can assume the value of 1.5. The user must also choose the tolerable probability of flash fire injury, p, limited to a maximum of 0.05 (5%). In this case, 5% is chosen.

~~The other parameter needed is the entrainment factor, representing the fraction of accumulated dust that is anticipated to become airborne and participate in a secondary deflagration. The user can assume a value of 0.25.~~

$$M_{exp} = \left[\frac{P_{es}}{DLF} \right] \cdot \left[\frac{C_w}{P_{max}} \right] \cdot \frac{A_{floor} \cdot H}{\eta_D} = \left[\frac{0.036bar}{1.5} \right] \cdot \left[\frac{0.60 \frac{kg}{m^3}}{7b \text{ arg}} \right] \cdot \frac{1000m^2 \cdot 9.5m}{0.25} = 76kg$$

$$M_{fire} = 0.05 \cdot C_w \cdot \left[\frac{P_{initial}}{P_{initial} + P_{max}} \right] \cdot \frac{A_{floor} \cdot D}{\eta_D} = 0.05 \cdot 0.60 \frac{kg}{m^3} \cdot \left[\frac{1 \text{ bar}}{1 + 7 \text{ barg}} \right] \cdot \frac{1000 m^2 \cdot 2 m}{0.25} = 30 kg$$

Using Mass Method B ~~the alternate method~~, the user determines that the practicable housekeeping result of 60 kg dust accumulation exceeds the threshold for a Flash Fire Hazard Area, but not for a Dust Explosion Hazard Area. Since it is an open building without internal fire-rated separation walls, this means that all of the workers will have to be protected from a Flash Fire Hazard as prescribed in Chapter 11. Current housekeeping is maintaining total dust mass below 76 kg, meaning that the structure of the building not intended to vent or fail is safe from the explosion hazard.

Since the original design of the building presumed which areas would experience dust accumulation outside equipment, the owner/user should review the electrical area classification against the actual locations of accumulations, based on NFPA 499.

[Editorial Note – Retitle Figure D.1 to Figure D.3]

****Insert Figure D.1 Here****

D.2 Layer Depth Criterion Method:

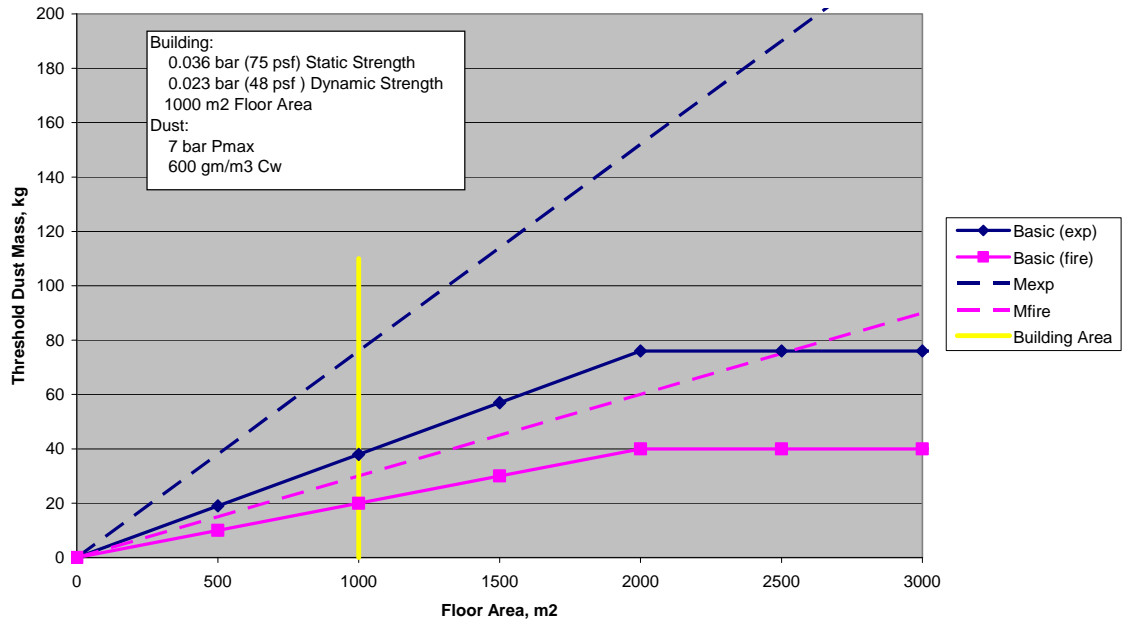
The dust accumulation is a product of the actual layer depth and the total area of accumulation. The limitations in ~~6.1.1.3~~ **6.1.3.2(1) and (3)** are is expressed as a product of the Layer Depth Criterion and a percentage of the footprint area of the room or building. Within a single room or building, areas of significant dust accumulation could be ~~contiguous-non-separated~~ or separated. When they are non-separated, the ~~separate~~ accumulations are combined and compared to the permissible dust accumulation. When accumulations are segregated, detached, or separated in accordance with Section 6.2, the accumulations are individually compared to the permissible dust accumulation. The Layer Depth Criterion can be increased for a specific dust when the bulk density is known.

For rooms or buildings where dust accumulations are limited to a small area, one way to determine if the actual dust accumulation is sufficient to result in a dust deflagration hazard is to ratio the actual dust accumulation to the permissible dust accumulation. If the ratio exceeds 1, then a dust deflagration hazard exists in the subject building or room.

Surfaces where dust could settle include floors, beam flanges, piping, ductwork, equipment, suspended ceilings, light fixtures and walls. Particular attention should be given to dust adhering to walls and vertical surfaces as it can be easily dislodged.

When determining the total volume of dust accumulations, accumulation areas where the ~~actual thickness is less than 1/64~~ surface color is discernible can be excluded.

Figure D.1
Threshold Mass for a Dust



Example 1: A single floor accumulation area in a small portion of a 25 ft. by 40 ft. room. The dust has a bulk density of 75 lb/ft³.

Layer Depth Criterion = 1/32 inch

Room footprint area = 1000 ft²

Actual accumulation area = 20 ft²

Average layer depth in accumulation area = 1/16 inch

$$\text{Ratio} = \frac{20 \text{ ft}^2 \cdot \left(\frac{1}{16}\right) \text{ inch}}{0.05 \cdot 1000 \text{ ft}^2 \cdot \left(\frac{1}{32}\right) \text{ inch}} = \frac{1.3 \text{ ft}^2 \cdot \text{inch}}{1.6 \text{ ft}^2 \cdot \text{inch}} \leq 1$$

Since the ratio is less than or equal to 1, a dust deflagration hazard does not exist in the room. When the actual accumulation area is less than 5% of the room footprint, the layer thickness can be greater without resulting in a dust deflagration hazard.

Example 2: A single floor accumulation area in a portion of a 25 ft. by 40 ft. room. The dust has a bulk density of 30 lb/ft³. First adjust the Layer Depth Criterion for the reduced bulk density.

$$\text{LayerDepthCriterion} = \frac{\left(\frac{1}{32}\right) \text{ inch} \cdot 75 \text{ lb} / \text{ft}^3}{30 \text{ lb} / \text{ft}^3} = 0.078 \text{ inch} \cong \left(\frac{1}{16}\right) \text{ inch}$$

Room footprint area = 1000 ft²

Actual accumulation area = 100 ft²

Average layer depth in accumulation area = 1/32 inch

$$\text{Ratio} = \frac{100 \text{ ft}^2 \cdot \left(\frac{1}{32}\right) \text{ inch}}{0.05 \cdot 1000 \text{ ft}^2 \cdot 0.078 \text{ inch}} = \frac{3.1 \text{ ft}^2 \cdot \text{inch}}{3.9 \text{ ft}^2 \cdot \text{inch}} \leq 1$$

Since the ratio is less than or equal to 1, a dust deflagration hazard does not exist in the room.

A dust with a bulk density less than the basis 75 lb/ft³ can accumulate to 1/32 inch layer depth in more than 5% of the room footprint area and still not present a dust deflagration hazard.

Example 3: Multiple floor level and elevated accumulation areas with different layer depths for each area. The room is 100 ft by 100 ft. ~~For rooms less than 20,000 ft², the limitation is based on a maximum of 5% of the footprint area.~~ The dust has a bulk density of 30 lb/ft³. First adjust the Layer Depth Criterion for the reduced bulk density.

$$\text{LayerDepthCriterion} = \frac{\left(\frac{1}{32}\right)\text{inch} \cdot 75\text{lb}/\text{ft}^3}{30\text{lb}/\text{ft}^3} = 0.078\text{inch} \cong \left(\frac{1}{16}\right)\text{inch}$$

Room footprint area = 10000 ft²

Table D.2.1 Multiple Accumulation Areas for Example 34

Accumulation Location	Accumulation Area	Average Layer Depth	Accumulation
Floor	50 ft ²	1/16 inch	3.1 ft ² -inch
Beam Surfaces	500 ft ²	1/32 inch	15.6 ft ² -inch
Equipment Surfaces	100 ft ²	1/8 inch	12.5 ft ² -inch

$$\text{Ratio} = \frac{50\text{ft}^2 \cdot \left(\frac{1}{16}\right)\text{inch} + 500\text{ft}^2 \cdot \left(\frac{1}{32}\right)\text{inch} + 100\text{ft}^2 \cdot \left(\frac{1}{8}\right)\text{inch}}{0.05 \cdot 10000\text{ft}^2 \cdot 0.078\text{inch}} = \frac{31\text{ft}^2 \cdot \text{inch}}{39\text{ft}^2 \cdot \text{inch}} \leq 1$$

Since the ratio is less than or equal to 1, a dust deflagration hazard does not exist in the room. There could be many more separated accumulation areas than listed in Table D.2.1 and all significant areas should be included. Note that areas where the surface color is discernible beneath the dust layers ~~are less than 1/64 inch~~ would not be included.

When there is a single accumulation area or the actual layer depth is the same over all accumulation areas, Figure D.2 indicates the actual layer depth which results in a dust deflagration hazard.

[Editorial Note – Retitle Figure A.6.1.1.1 to Figure D.2]

*****Insert Figure A.6.1.1.1 Here*****

The limitations in **6.1.3.2(2) and (4)** are expressed as a product of the Layer Depth Criterion and a maximum 1000 ft² area. For a building or room with a footprint larger than 20,000 ft², the 1000 ft² dust accumulation area and equivalent volume become limiting in determining whether a deflagration hazard area exists. The following table provides guidance for evaluating isolated accumulations of dust in a building larger than 20,000 ft². These types of accumulations commonly occur due to leaks in equipment and machining operations. Table D.2.2 The table lists various areas of non-separated accumulation and the corresponding layer depth criterion. It assumes a bulk density of 75 lb/ft³ and a rectangular shaped accumulation. The layer depth can be adjusted for bulk density.

Table D.2.2 Corresponding Layer Depths for Non-Separated Accumulations

Dust Accumulation Area	Layer Depth Criterion
1000 ft ²	1/32 inches
100 ft ²	0.3 inches
50 ft ²	0.6 inches
25 ft ²	1.3 inches
16 ft ²	2.0 inches
9 ft ²	3.5 inches
4 ft ²	7.8 inches
2 ft ²	15.7 inches

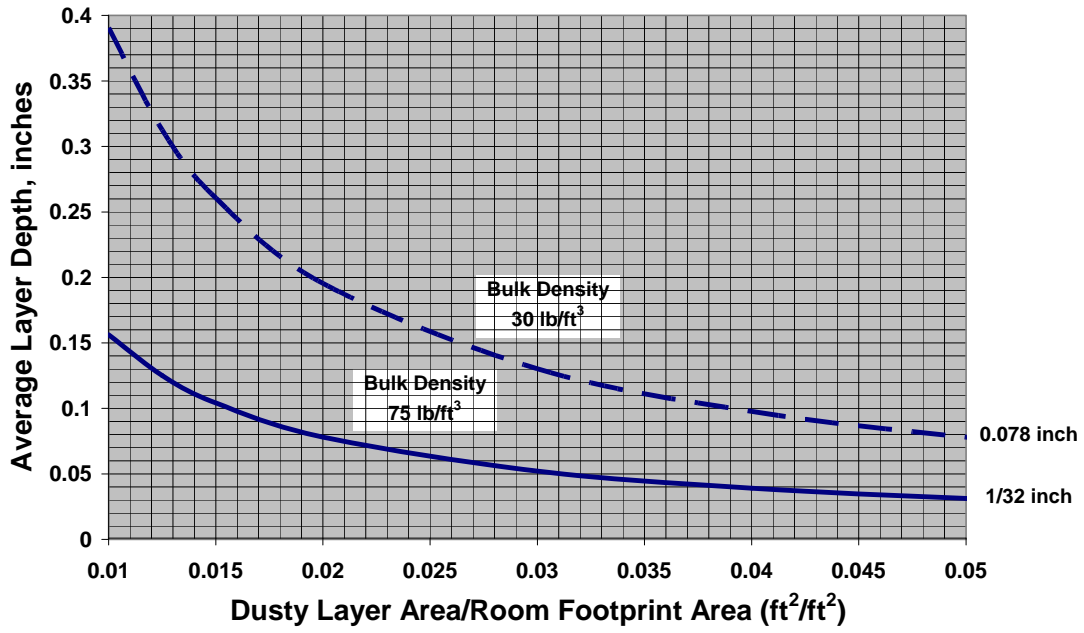
[Editorial Note – Example 4 to be moved prior to discussion of Areas larger than 20,000 ft²]

Example 4: Machining operation resulting in piles of dust accumulations. The machining operation is located in a 10 ft by 10 ft area in a 100 ft x 100 ft room. Between periodic housekeeping, the machining operation results in three 12 inch x 12 inch x 16 inch high piles of dust with a bulk density of 40 lb/ft³ and a uniform dust layer thickness throughout the room of less than 1/64 inch.

Room footprint area = 10,000 ft²

Actual accumulation area = 100 ft²

**Figure A.6.1.1.1 Dust Deflagration Hazard Limitation -
Average Layer Depth with Reduced Accumulation Area for
Buildings or Rooms less than 20,000 ft²**



1. Determine adjusted layer depth criterion

$$\text{Layer depth criterion} = ((1/32) \text{ inch} * 75 \text{ lb/ft}^3) / 40 \text{ lb/ft}^3 = 0.059 \text{ in}$$

2. Determine the allowable volume of dust

$$\text{Allowable volume of dust} = 0.05 * 10,000 \text{ ft}^2 * (0.059 \text{ in}) * 1 \text{ ft}/12 \text{ in} = 2.46 \text{ ft}^3$$

3. Determine the actual volume of dust

The layer of dust less than $1/64$ inch does not need to be factored into the calculation.

$$\text{Volume of dust per pile} = (12 \text{ inch} * 12 \text{ inch} * 16 \text{ inch}) * 1 \text{ ft}^3 / 1728 \text{ in}^3 = 1.33 \text{ ft}^3$$

$$\text{Total volume of dust} = 3 * 1.33 \text{ ft}^3 = 4 \text{ ft}^3$$

The total volume of dust exceeds the allowable volume of dust; therefore a dust deflagration hazard exists.

Example 5: Processing operation with several areas of accumulation. The building area is 350 ft x 150 ft. There are 3 accumulation areas:

1. 15 ft x 100 ft mezzanine with $1/2$ inch dust accumulation
2. 50 ft x 150 ft area with $1/8$ inch dust accumulation at east end
3. 15 ft x 10 ft area with $1-1/2$ inch average depth at west end

The dust has bulk density of 2 lbs/ ft².

Room footprint area = 350 ft x 150 ft = 52,500 ft² (Note: the mezzanine area does not increase the room footprint area)

1. Determine adjusted layer depth criterion

$$\text{Layer depth criterion} = ((1/32) \text{ inch} * 75 \text{ lb/ft}^3) / 2 \text{ lb/ft}^3 = 1.17 \text{ in}$$

2. Determine the allowable volume of dust. This is limited to 1000 ft² because the total room footprint exceeds 20,000 ft².

$$\text{Allowable volume of dust} = 1000 \text{ ft}^2 * (1.17 \text{ in}) * 1 \text{ ft}/12 \text{ in} = 97.5 \text{ ft}^3$$

3. Determine the actual volume of dust

$$\text{Volume of mezzanine dust} = 1500 \text{ ft}^2 * \frac{1}{2} \text{ inch} * 1 \text{ ft}/12 \text{ in}^2 = 62.5 \text{ ft}^3$$

$$\text{Volume of east end dust} = 7500 \text{ ft}^2 * \frac{1}{8} \text{ inch} * 1 \text{ ft}/12 \text{ in}^2 = 78.13 \text{ ft}^3$$

$$\text{Volume of east west dust} = 150 \text{ ft}^2 * 1.5 \text{ inch} * 1 \text{ ft}/12 \text{ in}^2 = 18.75 \text{ ft}^3$$

4. Total volume of dust = $62.5 + 78.13 + 18.75 = 159.4 \text{ ft}^3$

The total volume of dust exceeds the allowable volume of dust; therefore a dust deflagration hazard exists.

D.43

While the threshold mass equations consider all of the dust mass throughout the building, it is not anticipated that the dust will be evenly distributed. Rather there will be localized areas of accumulation where fugitive dust is not completely captured. If the threshold mass of dust were actually evenly distributed, it would typically be an extremely thin layer. This layer would be too thin to create a hazard because the entrainment fraction would be much smaller and only a small portion of the dust mass would actually be involved in the event. The inclusion of all accumulated dust mass is conservative in this respect.

Where processing areas are separated by walls and the entries are self-closing, this can be used to limit the area where the user has to apply safeguards against a flash fire hazard. Similarly, where separation walls and entries are also pressure resistant, this can be used to limit the area where the user has to apply safeguards against an explosion hazard. Where a multi-floor building is effectively separated at the floor levels, explosion and flash fire hazards can be evaluated on a floor-by-floor basis.

Where there are open mezzanines above a floor level, the accumulated dust on these levels is added to that on the main level without increasing the floor area.

When determining the total dust mass in a building or room, due consideration should be given to dust that adheres to walls, since it is easily dislodged. Attention and consideration should also be given to other projections such as light fixtures, which can provide surfaces for dust accumulation.

Dust collection equipment should be monitored to ensure it is operating effectively. For example, dust collectors using bags operate most effectively between limited pressure drops of 3 in. to 5 in. of water (0.74 kPa to 1.24 kPa). An excessive decrease or low drop in pressure indicates insufficient coating to trap dust.