



Combustible Dust Explosion Hazard Awareness



Participant Manual

Texas Engineering Extension Service (TEEX)
Professional and Regulatory Training (PRT)

A Member of The Texas A&M University System



OS PRT281 TR 07/09



OSHA TRAINING INSTITUTE

Southwest Education Center

The Texas Engineering Extension Service (TEEX), a member of The Texas A&M University System, is a recognized leader in championing worker safety and health through unparalleled occupational, industrial and construction safety training programs.

The Occupational Safety and Health Administration (OSHA) Training Institute's Southwest Education Center at TEEX serves Texas, Louisiana, New Mexico, Oklahoma and Arkansas. However, TEEX's impact on safety and health extends nationwide. TEEX operated the top OSHA center yet again in 2005, setting a national record for participants trained. Twenty-nine OSHA courses are conducted at the agency's 32,000-square-foot Mesquite, Texas, facility and at locations throughout Region VI.

The TEEX Certified Safety and Health Official (CSHO) professional certificate program is proving beneficial to the hundreds who have completed the required courses and earned CSHO status. This program, originally offered exclusively for safety and health professionals in construction and general industry, has been expanded to include career tracks for oil & gas and petrochemical, aviation and emergency response personnel. This professional certificate program is now recognized by the Council on Certification of Health, Environmental and Safety Technologists (CCHST) and the International Association for Continuing Education and Training (IACET).

Following the disasters of Hurricanes Katrina, Rita and Wilma, TEEX expertise and resources were tapped by OSHA to target health and safety training for reconstruction workers and organizations. TEEX has conducted numerous courses in the disaster-stricken areas, including: Disaster Site Hazard Awareness, the OSHA 10-Hour Construction and Disaster Site Worker Course, plus a Train-the-Trainer Disaster Site Course.

TEEX leads the nation in offering OSHA safety classes in Spanish and training bilingual instructors who reach out to Spanish-speaking workers and small business owners. All training emphasizes safe work practices, personal protective equipment, regulatory compliance and environmental safety.



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PARTICIPANT MANUAL

The Texas A&M University System

Texas Engineering Extension Service (TEEX)

Professional and Regulatory Training (PRT)

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COMBUSTIBLE DUST EXPLOSION HAZARD AWARENESS

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The safety statements, procedures, and guidelines contained in this manual are current as of the publication date. Prior to using the safety statements, procedures, and guidelines contained in this manual, it is advised that you confirm the currency of these statements, procedures, and guidelines with the appropriate controlling authorities.

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Module

0

Introduction and Orientation

Terminal Objective

Upon successful completion of this module, the participant will be able to participate in the course.

Enabling Objectives

1. Complete TEEX course registration forms.
2. Ask questions related to the course.

Introduction

In this module, the participants will complete registration procedures and receive course information, including prerequisites and attendance requirements, as well as evaluation and certification information. The instructor will conduct a brief overview of the course which includes the goals and objectives, required participant equipment, and class schedule.

About this Course

This course provides participants with information about combustible dust that could identify process problems that could cause catastrophic fire or explosion.

Course Goal

Upon successful completion of this course, the participant will be able to assess combustible dust explosion potential and the safety systems in place to minimize dust explosion hazards.

Target Audience

This course is designed for anyone evaluating and managing operations that can generate combustible dust and CSHO leaders.

Delivery Methods

Course delivery consists of lectures and group discussions.

Course Prerequisites

None

Recommended Training

None

Course Length

8 hours

Certification Information

TEEX has been approved as an Authorized Provider by the International Association for Continuing Education and Training (IACET), 8405 Greensboro Drive, Suite 800, McLean, VA 22102. In obtaining this approval, TEEX has demonstrated that it complies with the ANSI/IACET Standards which are widely recognized as standards of good practice internationally. As a result of their Authorized Provider membership status, TEEX is authorized to offer IACET

CEU's for its programs that qualify under ANSI/IACET Standards. TEEX is authorized by IACET to offer 0.4 CEUs for this program.

Registration / Attendance Rosters

TEEX-PRT attendance policy requires all students to fully attend enrolled classes. You must attend the entire class to receive a certificate of completion. We realize that extenuating circumstances may arise that would take you out of class and use the following policy to handle those situations.

If an extenuating circumstance requires you to attend less than 100% of class, you must complete a Student Absentee Request form and submit it to the instructor for approval before leaving. If the extenuating circumstance arises during non-class hours, you must complete the Student Absentee Request form immediately upon return to the classroom and submit it to the instructor for approval. With an approved absence for extenuating circumstances you may have options for make-up work. See your instructor.

Unexcused absences will require you to make up time missed by attending the same course offered at another time. You must enroll through TEEX-PRT Registrars to attend the makeup course. In order to receive a certificate of completion, each participant must:

- Complete a registration form at the beginning of the course;
- Sign the attendance roster for each morning and afternoon of the course; and
- Complete the evaluation at the end of the course.

Class Schedule

Day 1

Morning

Module 0: Introduction and Orientation

Module 1: Combustible Dust Introduction

Module 2: Combustible Dust Control

Module 3: Ignition Control

Afternoon

Module 4: Support Systems

Module 5: Damage Control

Module 6: Facility Dust Assessment

Appendix A: Resources

Course Exam

Participant Evaluation Strategy

The evaluation plan incorporates strategies for evaluating participants' progress in the classroom. The instructor will use oral questioning during the presentation and discussions to assess the participants' mastery of the material. The group activities will also allow the instructor to determine how well participants can apply classroom information to real-life situations. Problem areas identified in the classroom will be reviewed in further detail. Successful completion of the course depends on classroom responses, participation in group discussions, completion of review questions, and successful completion of a course examination with a grade of 70% or higher.

Administrative Instructions

Instructors will use this portion of the course for introductions and to familiarize the participants with the facility's safety and convenience features, the location of the facility's designated smoking area(s), and any additional resources or equipment available.

Resource List

While Appendix A contains a number of resources concerning combustible dust, several online resources worth noting include the following:

- 29 Code of Federal Regulations §1910.119 can be found at www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9760
- *A Guide to Combustible Dusts* by North Carolina Department of Labor can be found at www.nclabor.com/osh/etta/indguide/ig43.pdf
- Combustible Dusts presented by Bruce L. Rottner, CSP at the 2006 American Industrial Hygiene Association (AIHce) can be found at www.aiha.org/aihce06/handouts/cr314rottner.pdf

- *Ethylene Safety Incidents* presented by Kolmetz.com can be found at kolmetz.com/pdf/Ethylene-safety-incidents.pdf
- *Hazardous or Combustible Dusts, Fumes and Fibres* by Government of Western Australia, Department of Commerce's can be found at www.commerce.wa.gov.au/worksafe/PDF/Guides/dust_fume_fibre.pdf
- North Carolina Department of Labor (NCDOL) Industry Alert-Combustible Dust: A Major Hot Work Hazard can be found at www.nclabor.com/osha/etta/hazard_alerts/combust_hotwork.pdf
- *OSHA Fact Sheet: Combustible Dust Explosions* produced by OSHA can be found at www.osha.gov/OshDoc/data_General_Facts/OSHAcombustibledust.pdf
- *Understanding NFPA 654: Protecting Your Plant from Dust Explosions* produced by BS&B Pressure Safety Management, L.L.C can be found at www.bsipd.com/PDF/understandingNFPA654%202006%20Edition.pdf
- U.S. Chemical Safety and Hazard Investigation Board Hearing on Hazard Communication in the 21st Century Workplace (March 2004) can be found at www.osha.gov/dsg/hazcom/finalmsdsreport.html

Summary

Now that the administrative section of the course has been completed, continue to Module 1: Combustible Dust Introduction.

Module

1

Combustible Dust Introduction

Terminal Objective

Upon successful completion of this module, participants will be able to describe the characteristics of combustible dust.

Enabling Objectives

1. Define the key terms relevant to combustible dust.
2. Describe the characteristics of combustible dust.
3. Identify the six classifications of combustible dust flammability.
4. Explain the health hazards associated with combustible dust work environments.
5. Review the event history of combustible dust incidents.

Introduction

To gain a solid foundation in understanding combustible dust, it is important to understand the characteristics and activities that create combustible dust.

Key Terms

There are several terms that are specific to combustible dust. *Combustible Dust* is 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 when dispersed or ignited in air.

OSHA identifies 130 products or materials that pose a threat for combustible dust explosions which include the following:

- Agricultural products and dusts
 - Biosolids
 - Carbonaceous dusts
 - Chemical dusts
 - Metal dusts
 - Organic dusts
 - Plastic dusts and additives
 - Wood dusts
- Industries handling combustible dusts
 - Agriculture
 - Chemical
 - Coal
 - Food products
 - Forest and furniture

- Metal processing
- Paper
- Pharmaceutical
- Recycling
- Textile
- Tire and rubber
- Wastewater treatment

Figure 1.1 situates a breakdown of dust explosions, according to industries, occurring in 2008. In 2008, the food industry had 27% of all dust explosions.

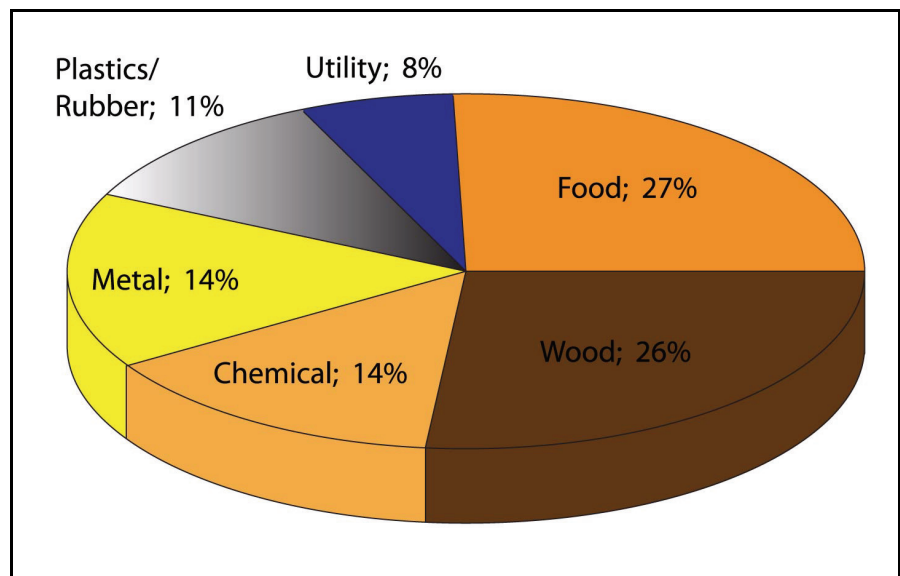


Figure 1.1: Dust Explosions According to Industry

The following are key terms that will be used throughout the remainder of the course:

- Ignition—When the temperature of powder or dust exceeds the temperature of the surrounding air.
- Dispersion—The scattering of dust into the atmosphere.

- Optimum cloud density—Allows sufficient distance between the particles to allow access of oxygen around the particles; but close enough so that the heat of one ignited particle can initiate reactions in nearby particles.
- Fire—A rapid oxidation process with the evolution of light and heat in varying intensities ($2C + O_2 \rightarrow 2CO$).
- Deflagration—Occurs when there is a combustion reaction where the velocity of the reaction front through the unreacted fuel medium is less than the speed of sound. This type of explosion is associated with vapor or dust clouds and can occur when enough dust particles are suspended in an enclosure. Deflagration requires fuel to be in a confined enclosure and easily dispersed within the enclosure.
- Detonation—Combustion where a supersonic shock wave is produced. When related to dust, detonation is often called *layered detonation* and is highly destructive.
- Primary explosion—The initial explosion in processing equipment or in an area where dust has accumulated. This explosion triggers a larger, more destructive explosion.
- Secondary explosion—Triggered by a primary explosion and occurs when accumulated dust is shaken loose or damage occurs to dust containment systems from a primary explosion.

Combustible Dust Characteristics

Characteristics of combustible dust include the following:

- Particle size
- Chemical properties of dust
- Moisture content
- Cloud dispersion

The following are general parameters of combustible dust:

- Average minimum concentration is approximately 0.05 oz/ft³ or 50g/m³
- Materials that ignited above 0.50 joules are not considered sensitive to ignition by electrostatic discharge
- Minimum ignition temperature of the cloud is <400°C
- Minimum ignition temperature of a 5mm layer is <300°C
- Minimum ignition energy of the cloud is <15mJ

Dispersion

Ease of dispersion into the air has several factors including the following:

- Individual density of dust particles
- Diameters
- Shapes
- Cohesive properties with respect to each other
- Adhesive properties with respect to supporting surfaces

There are also external factors that affect dust dispersion. These include the following:

- Structure and intensity of aerodynamic disturbances
- Location of dust loading (roof, floor, walls, shelves) and
- Geometry of those surfaces

Surface Area to Mass Ratio

Dust explosions occur when there is a rapid oxidation of the particle surface. An increasing surface to mass ratio allows less heat to dissipate into the mass. The less heat absorbed by the mass of the particle, the more that heat accelerates the reaction.

Explosion Dynamics

The effect of an explosion depends on the amount of *power* the dust can generate when it explodes. This is often referred to as explosion dynamics and two of its most important attributes are *Thermodynamics* and *Kinetics*.

- Thermodynamics is the amount of heat liberated during combustion. Keep in mind that different types of dust will generate various levels of heat.
- Kinetics is the rate at which heat is liberated during combustion.

When significant heat is released at a rapid rate during the combustion of dust, the explosion is more powerful than when the amount of heat is less or the explosion rate is less rapid.

Classification of Dust Flammability

There are six classifications of dust flammability:

- *Class 1*: there is no self sustained combustion
- *Class 2*: there is local combustion of a short duration
- *Class 3*: a local self-sustained combustion has not propagation
- *Class 4*: there is propagating, smoldering combustion
- *Class 5*: when there is propagation of an open flame
- *Class 6*: there is explosive combustion

Health Hazards

Dusts cause various hazards. The worst health hazard can be death, either by explosion or severe burns or as an airborne contaminant.

Dusts pose other hazards besides explosivity, such as:

- Reduced visibility
- Slippery surface conditions
- Asbestos and silica (While not explosive, present a serious respiratory hazards and can cause long-term health effects, such as silicosis or asbestosis.)

The History of Dust Explosions

Farmer's Export Company–December 28, 1977

A spark near the grain elevators in Galveston, Texas, caused a massive explosion near the Galveston docks. The blast occurred in a tunnel that connected the elevator to a loading dock. Two ships were unloading grain at the time of the blast. Eighteen people died and at least 35 were injured. This was the second explosion at an American grain elevator in five days. The first was in New Orleans where 35 people were killed.

The force of the Galveston blast was tremendous. There were large holes blown out of the side of concrete silos and automobile-sized chunks of concrete were thrown more than 200 feet away. Windows were shattered a mile away and the blast was heard 70 miles away. A nearby railroad switch engine was completely twisted into a tangle of steel.

Amoco Chemical Company–October 21, 1980

A polypropylene unit located near New Castle, Delaware exploded during the night. The initial explosion was triggered by the ignition of a propylene vapor cloud. This explosion shook loose combustible dust that caused a substantial secondary explosion. Six workers died and more than 100 were injured.

The total loss and damage estimate was in excess of \$45 million. There was so much damage to the site that Amoco chose not to rebuild at this site. This decision led to the loss of 300 jobs.

CTA Acoustics–February 20, 2003

The Corbin, Kentucky facility produced fiberglass mats and insulation for the automotive industry. During production, phenolic resin powder (fuel source) dust accumulated in the production area. The dust likely ignited when a fire in a malfunctioning oven ignited a cloud of resin dust generated during the cleaning of a production line.

The Chemical Safety Board (CSB) investigation found use of compressed air, electric fans, and brooms to remove dust formed a cloud near the production line oven. The oven was running hot, due to a malfunctioning temperature controller. Therefore, the oven door was left open to try to control the temperature. The explosion and fire destroyed the manufacturing plant, killed seven workers and injured many others.

Three years before the CTA explosion, there was a similar explosion at the Jahn Foundry plant in Springfield, Massachusetts. This explosion involved the same type of phenolic resin powder and was supplied by the same supplier that CTA used. Three people were killed, nine were injured, and the plant was destroyed in the Jahn Foundry explosion.

The phenolic resin materials sold to CTA by the supplier were not labeled EXPLOSIVE. CTA denied any awareness of the explosive nature of the powder, even though the Jahn Foundry explosion report cited phenolic resin dust as the fuel source. CTA also stated that they relied upon the supplier and their MSDS for information regarding the material.

CTA had a history of small fires caused by accumulation of combustible materials. It was reported that CTA employees routinely put out these fires using extinguishers and hoses.

Imperial Sugar Company–February 7, 2008

Perhaps the most televised and reported dust explosion occurred at the Imperial Sugar refinery near Savannah, Georgia. Fourteen people died and 38 were injured, including 14 with serious, life-threatening burns.

The explosion damage included tops of silos that were missing completely and brick walls that were totally blown out. The explosion occurred in the section of the refinery where sugar was pulverized into powdered sugar and packaged. The initial explosion was likely caused by a bucket elevator which sent more combustible dust into the atmosphere, providing a fuel source for the larger secondary explosion.

The OSHA investigators found that the Imperial Sugar Senior Management was fully aware of combustible dust hazards and that steps had been taken to find out what the hazards were of combustible dust in the refinery. However, these steps were not followed up with any action to eliminate the hazards.

OSHA indicated 51 serious violations, which included the following:

- Improper installation of a dust collection system
- Lack of sensors on conveyer belts
- Failure to construct a blast-proof exterior wall in the powder room

On March 7, 2008, the head of OSHA sent a letter directly to the CEO of Imperial Sugar because of the blast at the Savannah refinery. This letter urged him to eliminate any potential combustible dust hazards at the plant in Gramercy, Louisiana. On March 14th, OSHA inspected the Gramercy plant. The inspectors found combustible dust ranging from an inch to four feet deep. Due to the inspection findings, OSHA posted an *imminent danger* notice because of the high likelihood of fire and explosion.

The explosion of the Imperial Sugar Company plant in Savannah, has brought significance to the importance of combustible dust regulation in all industries.

Chemical Safety Board (CSB) Study–2003

The CSB conducted a combustible dust explosion study in 2003. They found that over a 25-year period, there were 119 fatalities and 718 injuries contributed to combustible dust explosions and fires.

This study prompted a recommendation to OSHA (Occupational Safety and Health Administration) to get involved with combustible dust incidents and prevention. In addition the CSB recommended to ANSI (American National Standards Institute) to modify the Z400.1. This modification focuses on MSDSs including information on combustible dust hazards.

OSHA Combustible Dust SEP–March 2008

As a result of the CSB study and multiple combustible dust incidents, particularly the Imperial Sugar explosion, OSHA sent out a letter and bulletin entitled, Combustible Dust in Industry: Preventing and Mitigating the Effects of Fire Explosion, to 30,000 workplaces in March 2008. This OSHA-wide directive was issued with instruction, policies and procedures for inspecting workplaces that create or handle combustible dusts. In addition, OSHA reissued the Combustible Dust National Emphasis Program (CPL 03-00-008), which included inspections for combustible dust hazards.

Many unfortunate incidents involving combustible dust occurred before industry and regulators took notice. Just recently regulations and policies are bringing the needed focus on combustible dust safety.

Summary

Until recently, not much was done to regulate safety for combustible dust. Now, regulations and policies are being developed and implemented in many industries to prevent catastrophic occurrences involving combustible dust. In addition to specific history of accidents involving combustible dust, this module provided an overview of properties of combustible dust, health hazards associated with dust, and standards that are specific to the electric industry.

Module 1 Review Questions

Directions: Circle the letter of the best answer.

1. Combustible dust is any finely divided solid material that is _____ microns or smaller in diameter. (1-3)
 - a. 420
 - b. 380
 - c. 240
 - d. 520
2. A primary explosion is often the largest one. (1-5)
 - a. True
 - b. False
3. Which explosion garnered the most attention with respect to the importance of combustible dust regulations? (1-5)
 - a. CTA Acoustics - Corbin, KY
 - b. Imperial Sugar - Savannah, GA
 - c. Amoco Chemical - New Castle, DE
 - d. Farmer's Export Company - Galveston, TX
4. Properties of combustible dust include all of the following EXCEPT: (1-6)
 - a. Particle size
 - b. Chemical Properties of dust
 - c. Cloud dispersion
 - d. Time in Atmosphere
5. The less heat absorbed by the mass of the particle, the _____ that heat accelerates the reaction. (1-8)
 - a. more
 - b. less
6. Reduced visibility is a health hazard associated with combustible dust. (1-9)
 - a. True
 - b. False

Module

2

Dust Control

Terminal Objective

Upon the successful completion of this module, participants will be able to explain combustible dust control techniques.

Enabling Objectives

1. Explain the purpose of the pressure relief valve.
2. Discuss methods used to minimize dust escape.
3. Discuss dust collection methods.
4. Identify procedures necessary to prevent dust accumulation.

Introduction

Now that combustible dust has been defined and characterized, this module will discuss ways that dust can escape and become a hazard. In addition, proper cleanup methods will be discussed.

Pressure Relief Valve

Pressure Relief Valve (PRV)—A safety device that relieves in case of overpressure. When the set pressure is exceeded, the relief valve becomes the *path of least resistance* as the valve is forced open and a portion of the product is diverted through the auxiliary route.

Dust Escape

Dust Escape

Dust escape can occur when raw material escapes through leaks in storage units, conveyors, and processing equipment. The escape of dust can occur during material loading or unloading and during transfer operations.

Facility Design

One way to prevent dust escape is to design the facility for the least amount of dust escape and accumulation. One design measure is to utilize surfaces that minimize dust accumulation and facilitate cleaning. In addition, storage units, containers, elevators and chutes should be sealed. Access should be provided to all hidden areas to permit recurring inspections, especially to elevated surfaces. A very important design measure is to locate relief valves away from dust hazard areas, which could result in dust dispersion.

Equipment Integrity

Many types of equipment can generate dust while in operation. Some of the most common dust-causing equipment include the following:

- Bagging operations
- Conveyor belts
- Driers

- Filters
- Grinders
- Mixers
- Mills
- Ovens

Maintenance of this equipment is critical to minimize the escape of dust. The equipment should be cleaned regularly and maintained to ensure proper working order. Part of equipment maintenance includes regularly checking and maintaining seals on storage units, container, elevators, and chutes.

Dust Collection

In the event of dust escape, cleaning up dust residues needs to occur at regular intervals. It only takes 1/32" of an inch accumulated dust (approximate thickness of a dime) to cause an explosion.

ONLY USE vacuum cleaners approved for dust collection to ensure that dust is not dispersed.

There are several types of dust collectors available including:

- Bag house
- Cartridge
- Cyclone
- Portable
- Wet

Bag House Dust Collector. Provides the effective collection of fine to medium-sized abrasive, sticky or curly particles, or of heavy dust loads.

Cartridge Dust Collector. Provides continuous collection and removal of airborne dust. This type of collector allows for collection of dust without shutting down the area. In addition, this type of collector can be used for a broad spectrum of industrial processes.

Cyclone Dust Collector. Separates and removes medium to large particles of various kinds of dust, such as wood shavings and metal grinding chips.

Portable Dust Collector. Uses an extractor arm to facilitate the extraction of dust, fume, smoke, and mist.

Wet Dust Collector. Provides for the safe collection of potentially hazardous or explosive dusts, such as aluminum, titanium, or mixed metals.

Cleanup Methods

When needed to cleanup dust, USE ONLY cleaning methods that do not generate dust clouds. Types of safe dust removal methods include the wet method or water removal and the use of explosion-proof, industrial vacuums.

If needing to clean a small area, cleaners like Simple Green®, Windex®, or other similar cleaner are acceptable.

Vacuum Cleaner Filter

Filters should be cleaned or replaced according to the manufacturer's instructions. There are also explosion-proof vacuums designed with maintenance-free filters.

Dust Accumulation Prevention

There are several critical steps to prevent dust accumulation. The first is to develop and implement a hazardous dust inspection. Hidden areas and equipment need to be thoroughly checked for dust. Once dust is collected, the dust should be tested to identify if it is considered *combustible*.

The next step is to develop and implement a housekeeping plan to prevent dust accumulation.

The last step is to maintain the control program on a continuous basis. This program needs to be in writing and should establish frequency and methods of dust accumulation prevention.

ALWAYS be vigilant! Inspections are critical when the weather is cold and humidity is low. Low humidity levels make dust particularly easy to disperse and ignite. For examples, of eight catastrophic dust explosions since 1995, all but one occurred during cold weather months, with four occurring in February alone.

When needed to cleanup dust, only use cleaning methods that do *NOT* generate dust clouds. Types of safe dust removal methods include the wet method or water removal and the use of explosion-proof, industrial vacuums.

Summary

In order to be able to control dust in a facility, it is important to understand how dust accumulates and how to plan and implement a dust control program. This module discussed how dust escapes from equipment and accumulates on surfaces. It also described the steps to take to prepare a dust control program. The next module will discuss how to keep ignition of dust under control.

Module 2 Review Questions

Directions: Circle the letter of the best answer.

1. A _____ is a safety device that relieves in case of overpressure.(2-3)
 - a. pressure relief valve
 - b. bag house dust collector
 - c. cartridge dust collector
 - d. portable dust collector
 - e. wet dust collector
2. Dust escape can occur when _____. (2-3)
 - a. raw material leaks through leaks or cracks
 - b. loading, unloading, or transferring of material is taking place
 - c. storage units are not properly sealed
 - d. All of the above
3. Which of the following is crucial in the design of a facility to prevent combustible dust incidents? (2-3)
 - a. Utilizing surfaces that maximize dust accumulation
 - b. Storage units, containers, elevators, and chutes need to remain open
 - c. Providing access to all hidden areas
 - d. Locate relief valves near dust hazard areas
4. ONLY USE vacuum cleaners approved for dust collection to ensure that dust is not dispersed. (2-4)
 - a. True
 - b. False
5. If dust escapes, use cleanup methods that do not generate dust clouds, such as _____. (2-6)
 - a. Airing out the facility
 - b. Water removal/Wet method
 - c. Blower fans
 - d. None of the above

Module

3

Ignition Control

Terminal Objective

Upon the successful completion of this module, participants will be able to explain the work procedures for controlling ignition.

Enabling Objectives

1. Identify the five elements present in a dust explosion.
2. Identify ignition sources.
3. Discuss hot work permits and Lockout/Tagout (LOTO).
4. Discuss use of separator devices.
5. Identify classifications applicable to combustible dust contained in the National Electric Code (NEC).

Introduction

Similar to any fire, there are certain elements that must exist for a dust explosion to occur. These elements, with a focus on ignition sources, will be discussed in this module.

Five Elements for Dust Explosions

In addition to the three basic elements of the Fire Triangle (oxygen, fuel and ignition) that must be present for a fire or explosion to occur, dust explosions require a total of five elements, turning the fire triangle into a fire pentagon. These five elements include the following:

- Combustible dust in fine particles
- Oxygen
- Dust dispersed into air
- Energy source to ignite mixture
- Confinement (walls, ceilings, floors, roofs, process equipment, ducting)

The standard *fire triangle* contains three components: fuel, ignition, and oxygen. The combustible dust components also include fuel, ignition, and oxygen but add confinement and dispersion. So instead of a triangle, combustible dust explosions are best represented by a pentagon, Figure 3.1.

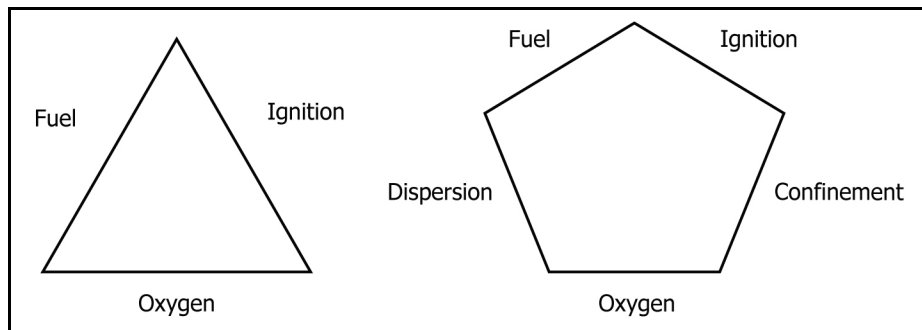


Figure 3.1: Fire Triangle vs. Fire Pentagon

Ignition Sources

Definition of an Ignition Source

An *ignition source* is anything that can deliver enough energy in the form of heat to ignite a substance. Examples include the following:

- Static electricity
- Hot surfaces
- Open flame or embers
- Electric arcs and sparks
- Industrial trucks
- Powder actuated tools
- Smoldering nests
- Heat from accidental mechanical impact

Static Electricity

Static electricity is defined as an electrical charging of materials through physical contact and separation, and the positive and negative electrical charges formed by this process.

When dealing with static electricity, if the process is not or cannot be properly grounded then the charge may build up to the point where it will discharge with a static arc. This discharge may provide an ignition source to any nearby mixture of dust and air.

Hot Surfaces

Any surface that exceeds the minimum auto-ignition temperature is considered a *hot surface*. When a hot surface has a layer of combustible dust, then the combination of the two may cause ignition. Combustible liquids can often mix with dust layers that are on a hot surface, providing another source of ignition. Combustible liquids include lubricants and oils often necessary for equipment to operate.

Open Flame or Glowing Ember

It is critical to eliminate ALL open flames or embers. These sources may not be evident and include the following:

- Candles
- Smoking
- Sterno Heaters
- Flares
- Strike anywhere matches
- Single-action lighter
- Furnaces

Electric Arcs and Sparks

An *electric arc* is a continuous discharge of a current formed when a strong current jumps a gap in a circuit or between two electrodes. In comparison, a *spark* is a random, momentary discharge.

Industrial Trucks

A motor vehicle, such as an industrial truck, can create a spark when the engine is engaged. There are several ways for this spark to occur:

- Starter
- Combustion
- Backfire

There is an additional hazard with diesel engines. Gases can be sucked into a diesel engine, which makes shutting off the engine impossible.

Powder Actuated Tools

These types of tools provide a spark when a bullet is fired. In addition, the concussion caused from the firing of the tool can shake dust loose.

Smoldering Nests

A *smoldering nest* is a collection of material that is in a dust environment and can smolder from a chemical or biological reaction. An example is sewage sludge that has a reaction that produces heat and smolders. This smoldering material is located near combustible dust. The dust is disturbed and the area and ignites.

Accidental Mechanical Impact

Accident mechanical impact can occur in rotating equipment when repeated impact gives rise to a hot spot. If this equipment contains materials that can produce a spark, like titanium and some aluminums, then a spark can occur.

Hot Work Permits and Lockout/Tagout

A permit MUST BE obtained prior to any hot work such as:

- Welding
- Brazing
- Cutting
- Grinding
- Soldering

When combustible material within a 35-foot radius of hot work cannot be removed, flame retardant tarps are used to cover materials.

Floors and surfaces within the 35-foot radius of a hot work area must be completely free of any combustibles including dust. And all openings or cracks in walls, floors, or ducts must be covered.

Lockout and Tagout (LOTO) is used on equipment to prevent sparks from activating switches or breakers. Using these procedures eliminates any change of an accidental ignition source from occurring.

LOTO procedures are designed to prevent unintentional or accidental operation of equipment or electrical circuits that may provide an ignition source. Locking out requires a lock that physically prevents the switch, breaker or other device from being activated. The tagout of the system is important and includes the person locking the equipment and other important conditions of the LOTO.

Separator Devices

These devices remove foreign materials capable of igniting combustible dusts. When using an air separation device, an explosion isolation device must be installed on return air lines to prevent an explosion.

Intrinsically Safe Devices

An Intrinsically Safe (IS) device contains equipment and wiring that is incapable of releasing sufficient electrical or thermal energy under normal or abnormal conditions to cause the ignition of a specific hazardous atmospheric mixture in its most easily ignited concentrated.

For example, mining operations use intrinsically safe air-conditioning devices to supply air, but do not create enough energy to be considered an ignition source.

Other examples include the following:

- Infrared temperature sensors
- LED indicating lights
- Magnetic pickup flowmeters
- Pressure, flow, and level switches
- Potentiometers
- Proximity switches
- Solenoid valves
- Strain gauges
- Telephones and radios
- Thermocouples

Explosion Proof Devices

These devices should be used on the following:

- Light fixtures
- Engine switches

- Pumps
- Motors
- Other equipment that may be placed in hazardous areas

This explosion-proof technology should be the sole option only when an IS-rated device is unavailable. An IS device may not be an option on a pump with a large motor that is of a size that it cannot be made intrinsically safe.

National Electric Code

The National Electric Code (NEC) is a U.S. standard for safe installation of electrical wiring and equipment. These standards are part of the National Fire Codes series published by the National Fire Protection Association (NFPA) and are commonly mandated by state or local law. These standards were first published in 1897 and are updated every three years. The most recent issue was published in 2008.

NEC Classification—Article 500

Article 500 of the National Electric Code (NEC) defines area classification based on Classes, Groups, and Divisions.

The Class designates the type of flammable substance that may be present in an area, such as gas vs. dust.

The Group further defines the Class by designating the specific substance that may be present such as, acetylene vs. hydrocarbon.

The Division designates the likelihood of the flammable substance being present.

NEC Classification—Groups E, F, and G

Within Class II Dusts, there are three groups: E, F, and G.

Group E. Atmospheres containing combustible metal dusts such as: Aluminum, Chromium Ferromanganese, Iron, Manganese, and Magnesium.

Group F. Atmospheres containing combustible carbonaceous dusts. These dusts have more than 8% total entrapped volatiles or have been sensitized by other materials so that they present an explosion hazard. These include Coal, Carbon Black, Charcoal, Pitch, and Coke Dust.

Group G . Atmospheres containing other combustible dusts such as Flour, Grain, Wood Flour, Plastic, and Chemicals.

Summary

Eliminating ignition sources from a combustible dust area is key to preventing an explosion. An often-overlooked source is an ignition source outside of the immediate area that still has access to the area through a venting system, ductwork, or other route. All ignition sources, where in the immediate area or connected to the combustible dust area, must be eliminated.

Module 3 Review Questions

Directions: Circle the letter of the best answer.

1. The shape that best represents the elements of combustible dust explosions is a _____. (3-4)
 - a. square
 - b. triangle
 - c. pentagon
 - d. hexagon
2. Possible ignition sources include all of the following EXCEPT: (3-5)
 - a. Static electricity
 - b. Dented surface
 - c. Open flame or embers
 - d. Electric arcs and sparks
3. Which of the following is an example of open flame or flowing ember ignition source? (3-6)
 - a. Smoking
 - b. Flares
 - c. Furnaces
 - d. All of the above
4. Combustible materials must be moved far away from hot work zone. How far away from the hot zone should materials be moved? (3-7)
 - a. 15-foot
 - b. 35-foot
 - c. 55-foot
 - d. 75-foot

5. Lockout/Tagout is used to perform what function? (3-8)
 - a. Inform workers what circuits to operate
 - b. Prevent activation of equipment or electrical circuits that can cause injury or provide an ignition source.
 - c. Keep personal items secure
 - d. Protect high security areas
6. In the case where a pump with a large motor is of a size that cannot be made intrinsically safe, explosion-proof equipment and practices would be mandatory. (3-9)
 - a. True
 - b. False
7. The _____ is a U.S. standard for safe installation of electrical wiring and equipment. (3-9)
 - a. CSB
 - b. SEP
 - c. NEC
 - d. CTA

Module

4

Support Systems

Terminal Objective

Upon the successful completion of this module, participants will be able to explain methods organizations may use to reinforce combustible dust safety.

Enabling Objectives

1. Discuss four organizational support systems.
2. Explain how a documentation system may be used to support safety efforts.

Introduction

Just as important as a combustible dust program is having the support for one. Support comes in different forms, and these forms will be discussed in this module.

Organizational Support

Plant Personnel Support

A critical aspect of any program is to ensure that everyone is trained properly prior to working in a hazardous environment. Initial training needs to include specific topics directly related to combustible dust hazards. Training should also include how to use Material Safety Data Sheets (MSDS) once it is verified that the MSDS are current and thorough.

In addition, training needs to include how to respond to combustible dust incidents. This training not only needs to be specific to combustible dust, but this training should be refreshed and redelivered on a periodic basis and should be up-to-date on any new regulations and policies.

Management Support System

Management plays a key role in any successful combustible dust program. Any substantial efforts of training and safety begin at this level. Management can begin by ensuring that the proper and approved cleaning equipment is available for use. Management should also initiate and monitor a regular cleaning program and openly support combustible dust training initiatives.

Engineering Support System

Engineering has a huge impact on the prevention and mitigation of combustible dust explosions.

In the design phase, engineering should allow access to hidden areas around equipment, design combustible dust-producing areas that are separated, blast-proof, and resistant. In addition, the use of intrinsically safe and explosion-proof devices needs to be incorporated into the design.

During damage control construction efforts, engineering should evaluate the level of pressure resistance, relieving, and venting in the combustible dust areas. A thorough review of relief valve placement, detection systems, and extinguishing systems may reveal that improvements are needed.

Operations Support System

Operations also plays an important part in any combustible dust program. Good housekeeping is very important wherever any combustible materials are used. These areas should be clear of burnable materials, and liquid spills need to be cleaned up immediately.

Another way that operations plays an important role is to report any malfunctioning equipment to maintenance immediately.

In the day-to-day operations, the elimination of ignition sources reduces the probability of a combustible dust incident.

Maintenance Support Systems

Regular equipment inspection and maintenance are important for controlling hazards of flammable and combustible materials.

Maintenance personnel must carry out repairs to equipment promptly and properly, making note of special equipment, like explosion-proof fittings.

Past incidents show that fires and explosions have resulted from the addition of non-approved parts or equipment to approved systems when maintenance was being performed.

Documentation Systems

A documentation system is critical to the success of a combustible dust program. All of the support systems of a facility contribute data to the documentation system. Any time data is being collected and recorded, it is necessary, and may be required to maintain all documentation related to that data.

A documentation systems allows for the following:

- Program review (for internal or OSHA audits): by entering checklists and items into a documentation system, audits for internal review can be performed, and results documented.
- Employee participation efforts: One of the fourteen PSM elements is employee participation. Using a documentation system is one way of keeping employees involved in the combustible dust program, as well as fulfilling the PSM requirement.
- Data backup (back up electronic information)
- Easy retrieval of information

Summary

Everyone in the organization plays a role in preventing combustible dust explosions. This commitment to safety needs to be unified and visible throughout the organization. A zero-tolerance approach should always be the standard when dealing with safety issues, especially those related to combustible dust.

Module 4 Review Questions

Directions: Circle the letter of the best answer.

1. All plant personnel must _____. (4-4)
 - a. be aware of combustible materials used in plant
 - b. be aware of necessary response to combustible dust incidents
 - c. attend combustible dust training
 - d. all of the above
2. Engineering has a huge impact on combustible dust prevention by all of the following EXCEPT: (4-4)
 - a. Allowing hidden areas
 - b. Designing combustible dust producing areas to be blast-proof and resistant
 - c. Using intrinsically safe and explosion-proof devices in design
 - d. Placing relief valves away from combustible dust areas
3. A documentation system is critical to the success of a combustible dust program. (4-5)
 - a. True
 - b. False

Module

5

Damage Control

Terminal Objective

Upon the successful completion of this module, participants will be able to describe methods used to prevent or control damage from a combustible dust explosion.

Enabling Objectives

1. Discuss types of damage control systems.
2. Discuss emergency response planning.

Introduction

The saying "plan for the worst, but hope for the best" definitely should be applied when it comes to preparing for a safety incident such as a dust explosion. This module will discuss systems that need to be in place to guard against a catastrophic event due to combustible dust.

Damage Control Systems

A damage control system is any system used for monitoring, suppressing, and eliminating dust.

There are various types of systems that can be used in a combustible dust area. These include:

- Spark ember detection
- Extinguishing
- Hazards separation
- Hazard segregation
- Deflagration venting
- Pressure relief venting
- Specialized fire suppression

Spark Ember Detection

This type of system can eliminate early causes of fires or dust explosions by detecting spark or ember IR radiation.

Spark ember detection systems are primarily used as a fire prevention method in dust collectors and where pneumatic conveying systems are used. When a spark or ember is detected, the system automatically activates programmable countermeasures such as the following:

- Deluge valves
- Abort gates
- Alarm systems

- Automatic machinery shutdown
- Extinguishing devices

Extinguishing System

When an extinguishing system is triggered, it immediately releases a fine mist of water downstream. Sparks and embers are extinguished without interrupting production. This type of system greatly reduces the risk of personnel injury, equipment damage, and downtime.

Hazard Separation

This system is one that is best considered during the design of the facility or during a remodel. The hazard separation system isolates the combustible dust hazard by putting distance between combustible dust areas. By separating volatile areas, the risk of turning a bad situation into a catastrophic one is minimized.

Hazard Segregation

If putting distance between areas is not an option, a hazard segregation system may be an option. This system isolates the hazard by placing a barrier between combustible dust areas. By doing this, special protection measures can be implemented without burdening the entire plant or building.

Deflagration Venting

The deflagration venting system controls damage caused by explosions. When an explosion occurs, the vents release expanding gases through openings thereby reducing pressure below the level that would cause damage.

Pressure Relief Venting

Pressure relief venting follows the same premise as deflagration venting. It provides pressure relief for equipment, such as storage tanks and low pressure vessels, to prevent an explosion from occurring.

Specialized Fire Suppression Systems

Sprinklers

One of the most standard forms of fire suppression systems is the sprinkler system. A series of water pipes are supplied by a reliable water supply. Each sprinkler head is independent, heat-activated, and responsible for water distribution during a fire.

Carbon Dioxide

Water can be damaging to electronic equipment. The Carbon Dioxide CO₂ system should be used in areas where there is sensitive electronic equipment since the CO₂ will not normally cause damage to this type of equipment.

This system extinguishes fire by reducing the oxygen content below the point where it can support combustion. The system is supplied by CO₂ stored in high pressure cylinders or low pressure CO₂ tanks.

Dry Powder Extinguishers

Standard or multi-purpose dry powder fire extinguishers are safe to use on most kinds of fires (Class A, B, and C). Some examples of these types of fires are those caused by oil, fat, paint, solvents, grease, propane, butane, natural gas, or electrical equipment. The effect of the powder is to *knock down* the flames. These extinguishers are best for fires involving flammable liquids or gases. Standard powders work well only on burning liquids, however the multi-purpose type is more effective on other types of fire, especially on burning solids.

Deluge Foam

The deluge foam system is connected to a water supply through a deluge valve. This valve is opened by the operation of a smoke or heat detection system.

This type of system should be used in high hazard areas, such as chemical storage or processing facilities needing high velocity suppression.

Emergency Response Planning

Detailed planning must be done for the following dust explosion events:

- Pre-explosion
- Dust explosion
- Post-explosion

A fire, in its beginning or incipient stage, can be controlled with portable fire extinguishers, Class II standpipe systems, and small hose systems.

Pre-explosion

Prior to an explosion ever occurring, develop an Emergency Action Plan (EAP) with special consideration for combustible dust.

Dust Explosion

If a dust explosion occurs, evacuate the area immediately and initiate the Emergency Action Plan.

An incipient fire can initiate dust explosion even if the fire is of some distance from the combustible dust area. Ignited materials can travel through process equipment far from the ignition source until it reaches the combustible cloud.

Even though an incipient fire can initiate dust explosions, these types of explosion are not incipient. Incipient fire brigades are not trained to fight dust explosion fires and cannot use hose streams to fight these types of fires. In addition, these brigades typically have little or no personal protective equipment (PPE).

Dust explosions are categorized as a fully involved fire that prompts a fire department response. These departments have the necessary specialized training required to fight involved fires.

Post Explosion

After the explosion hazard has passed and the fires are extinguished, initiate an investigation as soon as the area is safe.

Unfortunately, combustible dust fires and explosion destroy much of the evidence necessary for the investigation.

It is difficult to determine what causes a combustible dust explosion. It is estimated that a cause for the explosion is determined in only 50% of the dust explosion cases. However, any dust samples that can be collected should be gathered for analysis.

After an incident, the working environment at the plant will change. The community and regulatory industries will have a renewed interest in the facility.

Having the proper person or people chosen to speak to the public is a necessity. Internally, facility personnel will have a perceived risk of elevated hazard. There may even be displayed fear from personnel who are apprehensive about returning to their work areas.

Communications from the organization is strongly recommended. There may also be a strong push to rebuild and resume operations. Getting personnel back to work and manufacturing back online is important not only monetarily, but also psychologically. However, EHS personnel, along with the facility management, are the ones to decide when to resume normal operations.

A different focus needs to be placed on rebuilding equipment and facilities once thought to be safe but still led to a dust explosion. Theories and solution may be numerous and varied, so strong leadership and direction will be needed to recover.

Summary

Planning for the worst beforehand could save lives and reduce injuries to employees, neighbors to the facility, and the facility itself. No one wants to think about the worst actually occurring, but doing so allows the organization to be ready in the event of a combustible dust explosion.

Module 5 Review Questions

Directions: Circle the letter of the best answer.

1. The following is an example of a damage control system: (5-4)
 - a. Spark ember detection
 - b. Hazard segregation
 - c. Deflagration venting
 - d. All of the above
2. A deluge fire suppression system is used in places considered to be a high hazard area, such as chemical storage. (5-6)
 - a. True
 - b. False
3. Which is a key emergency response activity that must be performed prior to an explosion occurring? (5-7)
 - a. Being familiar with response measures and where response tools are located
 - b. Developing an EAP
 - c. Being familiar with emergency rescue procedures
 - d. All of the above
4. Determining the cause of a combustible dust explosion is only achieved in about _____ of cases. (5-8)
 - a. 10%
 - b. 25%
 - c. 50
 - d. 75%

Module

6

Facility Dust Assessment

Terminal Objective

Upon the successful completion of this module, participants will be able to describe the benefits of a facility dust assessment.

Enabling Objectives

1. Explain the importance of a facility dust assessment.
2. Identify the components of a facility dust assessment.
3. Discuss the value of self-audit checklists.

Introduction

In the previous module, types of prevention and response systems were discussed, as well as emergency response actions. This module covers the importance of also conducting a detailed assessment that identifies the type of dust hazard at your facility, and how to create a checklist that can be used for auditing.

Facility Dust Assessment

Conducting an assessment is an important step toward implementing a combustible dust program. A facility analysis needs to be conducted by a qualified team and each facility needs to have a specific hazard analysis.

The dust assessment should consider the following:

- All locations where combustible dust is concentrated during normal equipment operations as well as in the event of equipment failure
- Areas where dust can settle, both in normally occupied areas and in hidden concealed areas

When conducting a facility dust assessment, carefully identify the following:

- Materials that can be combustible, including particle size of materials
- Processes that use, consume, or produce combustible dusts
- Open areas where combustible dusts may build up
- Hidden areas where combustible dusts may accumulate
- Ways that dust may be dispersed in the air
- Potential ignition sources
- Electrical equipment classification
- Ventilation systems
- Physical barriers present or needed to hinder explosion effects

Dust Assessment Characteristics

Dust Combustibility

Dust combustibility is the primary factor in an assessment. Identify all materials that can be combustible when finely divided. In addition, identify the processes which use, consume, or produce combustible dusts.

It is a requirement to declare all hazards of a product on the Material Safety Data Sheet (MSDS). Unfortunately, the dust explosion hazard is under-recognized and often not declared on the MSDS. Do not rely solely on the MSDS for all dust explosion hazards. Laboratory testing of your specific dust will determine if there is a hazard.

Laboratory Testing

Testing is necessary to determine if a facility's specific dust is a hazard. The facility needs to be checked for the concentration levels for combustion.

There are several tests that are typically conducted and are:

Minimum Ignition Temperature (MIT) Cloud

Using a Godbert-Greenwald furnace to conduct this test the following should be performed:

1. Disperse air into the furnace.
2. Watch for positive results if flame is at bottom of furnace.
3. Test continues in increments of 5°C.
4. The standard quality of dust should remain at 0.1g (limits of 0.05 and 1.0).
5. Combustibility is verified if positive results occur in one or more trials in a group of four.

Minimum Ignition Temperature Layer

Using the US Bureau of Mines test perform the following:

1. This test involves a metal-mesh basket filled with dust to be tested.
2. Air of a known temperature is flowed across the dust powder.
3. When the temperature of dust powder exceeds the surrounding air, then the ignition temperature of the dust layer is determined.

Hot Plate Test

Using the Hot Plate Test perform the following:

1. A metal ring is placed on a the hot plate.
2. The ring is filled with the dust to be tested.
3. Thermocouples record the temperature of the hot plate and dust.
4. If the dust temperature exceeds the hot plate by 20°C, the ignition is recorded.

Conduct Maximum Explosion Pressure (P_{max})/Rate of Pressure Rise (R_{max})

Using a Hartmann apparatus and a 20-liter sphere.

Dust Characteristics

Different dusts of the same materials will have various ignitability and explosibility characteristics, depending on the following:

- Particle size
- Particle shape
- Moisture content

Note: Characteristics of a material can change while passing through process equipment, so testing of the material under like conditions is critical.

Area Volume

When determining the area volume, include all open areas where dusts may accumulate.

Hidden Area Inspection

Identify any hidden areas where dusts may accumulate, such as the following:

- Behind equipment
- On top of beams
- Above suspended ceilings
- On top of light fixtures
- On platforms

Dispersion Method

Identify means by which dust may be dispersed in the air. Make note of the quantity and concentration that is likely dispersed.

Ignition Sources

Identify potential ignition sources and be sure to consider ignition sources that are connected to the area by process equipment.

Electrical Classification

Identify areas requiring special electrical equipment classification due to the presence (or potential presence) of combustible dust.

29 CFR §1910.307 covers the requirements for electric equipment and wiring in locations that are considered *classified*. Classifications depend on the following:

- Properties of flammable vapors, liquids or gases, or combustible dusts or fibers that may be present
- The likelihood that a flammable or combustible concentration or quantity is present

Class II locations are areas where there is a hazard of combustible dust.

Ventilation Systems

Ventilation systems are a key issue when these systems connect to a possible stray ignition source.

When assessing a ventilation system and the connected areas, consider the following:

- Fans and blowers
- Air separation devices
- Ducts
- Exhaust air

Physical Barriers

There are three types of physical barriers that can be used to contain the effects of a combustible dust explosion, as follows:

- Physical: Walls, partitions
- Mechanical: Fast-acting shutoff valves and rotary valves
- Chemical: Suppressant injected to extinguish flame when pressure wave or flame detected

These physical barriers should be created in the path of a possible explosion.

Checklist "Self-Audit"

Creating a checklist is recommended to ensure all topics of a dust assessment are covered. This checklist may also be used to conduct regular self-audits. The following sample questions may be included on the checklist:

- "No Smoking" signs posted in the area?
- Fire extinguishers selected and provided for the types of materials in areas where they are to be used?
- Equipment is free of dust?
- Storage tanks are equipped with emergency venting?
- Rooms where combustible dust is present have explosion-proof lights? Switches?

Online system can be used create electronic checklists, audits, and record findings and recommendations. Figure 6.1 from MESHsystems™ is an example of an online Audit system.

The screenshot shows the MESHsystems™ Online Audit System interface. The top navigation bar includes links for Home, Environmental, Health, Learning, Safety, and Security, along with a 'Welcome Administrator' message. The left sidebar shows a tree view of facilities and audit categories, with 'Combustible Dust' selected. The main area displays a list of audit questions with a 'Response' dropdown for each. Below the questions are sections for Observations, Recommendations, Attachments, and Validations.

Category	Question	Response
Training	All operations personnel been trained on combustible dust?	Select a Response
Housekeeping	Area kept clean to extent that nature of work allows so as to avoid creation of hazards?	Select a Response
Hazard Communication	List of hazardous substances used in the work area?	Select a Response
Hazard Communication	MSDS readily available for each hazardous substance used?	Select a Response
Hazard Communication	Are NFPA signs posted where appropriate?	Select a Response
Hazard Communication	Containers of hazardous chemical labeled, tagged or marked?	Select a Response
Lockout/Tagout	Program in place to control hazardous energy during equipment maintenance (LO/TO)?	Select a Response
Lockout/Tagout	Lockout points for equipment identified and lockout devices available?	Select a Response
Engineering Controls	Operational ventilation equipment provided for removal of airborne contaminants generated by ...	Select a Response
Engineering Controls	Work area ventilation system appropriate for work performed?	Select a Response

Observations

Recommendations

Attachments

Validations

Figure 6.1: MESHsystems™ Online Audit System

Summary

Conducting a dust assessment is the first step in launching a combustible dust program at your facility. If you already have a dust program in place, an assessment is a valuable tool to evaluate what you have in place and make improvements to ensure the safety of your employees. Formulating assessment questions and creating a dust assessment audit is a way to continuously improve safety and avoid organizational complacency. An online system, like MESHsystems™ allows for up-to-date, real-time access to checklists and audit information that can be tracked and monitored.

Module 6 Review Questions

Directions: Circle the letter of the best answer.

1. When conducting a facility dust assessment, one should carefully identify which of the following? (6-4)
 - a. Combustible materials
 - b. Open areas
 - c. Hidden areas
 - d. All of the above
1. Different dusts of the same materials will have various ignitability and explosibility characteristics, depending on all EXCEPT: (6-6)
 - a. Particle size
 - b. Density
 - c. Particle shape
 - d. Moisture content
2. The following is an area where dust may accumulate: (6-6)
 - a. Behind equipment
 - b. On top of beams
 - c. On top of light fixtures
 - d. All of the above
3. A fast-acting shutoff valve is an example of what type of barrier? (6-8)
 - a. Mechanical
 - b. Physical
 - c. Chemical
 - d. Particle
4. Creating a checklist is recommended to ensure all topics of a dust assessment are covered.
 - a. True
 - b. False

Appendix

A

Resources

Resources

As combustible dust incidents have drawn more attention, more and more resources are available to assist in research and prevention of explosions due to combustible dust.

Organizations

There are three leading organizations in the forefront of combustible dust policies. The following three organizations offer incident histories, regulations, and policies on combustible dust:

- Occupational Safety and Health Administration (OSHA) (www.osha.gov)
- U.S. Chemical Safety and Hazard Investigation Board (CSB): (www.chemsafety.org)
- Combustible Dust Policy Institute (www.combustibledust.com)

Web Sites

Regulatory Compliance Portal

A valuable resource is the Regulatory Compliance Portal (www.compliancehome.com). This site has the latest white papers, training information, conferences, webcast information, news, regulations, jobs, and information about vendors' products and services. Although there are many other topics besides combustible dust, there is also a good amount of information on combustible dust.

EHS Today

The Web site ehstoday.com contains article from the EHS Today magazine.

OHS Online

At www.ohsonline.com you will find a vast amount of information on various topics in Health and Safety.

The Pump Handle

This site, <http://thepumphandle.wordpress.com>, calls itself as the "Water cooler for the public health crowd." There are a lot of non-industry topics, but the industry-related topics are very informative.

Books

More and more books are becoming available regarding combustible dust. The books that serve as good resources include the following:

- Development and Control of Dust Explosions by John Nagy
- Industrial Dust Explosion by Cashdollar/Hertzberg
- Dust Explosions in Process Industries by Rolf K. Eckhoff
- Classifying Explosion-Prone Areas for Petroleum, Chemical, and Related Industries by W.O.F. Korver
- Dust Explosion Prevention and Protection by John Barton

Regulations and Standards

The National Fire Protection Association (NFPA) has created codes dealing with combustible dust hazards and prevention. The NFPA codes include the following:

- **NFPA 61:** Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Product Facilities
- **NFPA 70:** National Electric Code (2008)
- **NFPA 484:** Standards for Combustible Metals
- **NFPA 499:** Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas (2004)
- **NFPA 654:** Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids (2006)
- **NFPA 664:** Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities

Directives

Occupational Safety and Health Administration (OSHA) released a program entitled CPL 03-00-008 OSHA Combustible Dust National Emphasis Program. This program contains policies and procedures for inspecting workplaces that create or handle combustible dusts.

A poster was created by OSHA and can be downloaded and posted on your job site. The poster can be found at www.osha.gov/Publications/combustibledustposter.pdf.

Appendix

B

List of Products/Materials in Powdered Form

Products/Materials in Powdered Form

The following list provides a number of product/materials in powdered form that have the potential to cause a catastrophic event:

- **Agricultural Products**
 - Egg white
 - Milk, powdered
 - Milk, nonfat, dry
 - Soy flour
 - Starch, corn
 - Starch, rice
 - Starch, wheat
 - Sugar
 - Sugar, milk
 - Sugar, beet
 - Tapioca
 - Whey
 - Wood flour
 - Agricultural dusts
 - Alfalfa
 - Apple
 - Beet root
 - Carrageen
 - Carrot

PM **List of Products/Materials in Powdered Form**
B - 4 *Products/Materials in Powdered Form*

- Cocoa bean dust
- Cocoa powder
- Coconut shell dust
- Coffee dust
- Corn meal
- Cornstarch
- Cotton
- Cottonseed
- Garlic powder
- Gluten
- Grass dust
- Green coffee
- Hops (malted)
- Lemon peel dust
- Lemon pulp
- Linseed
- Locust
- Bean gum
- Malt
- Oat flour
- Oat grain dust
- Olive pellets
- Onion powder

- Parsley (dehydrated)
- Peach
- Peanut meal and skins
- Peat
- Potato
- Potato flour
- Potato starch
- Raw yucca seed dust
- Rice dust
- Rice flour
- Rice starch
- Rye flour
- Semolina
- Soybean dust
- Spice dust
- Spice powder
- Sugar (10x)
- Sunflower
- Sunflower seed dust
- Tea
- Tobacco blend
- Tomato
- Walnut dust

- Wheat flour
- Wheat grain dust
- Wheat starch
- Xanthan gum
- **Carbonaceous Dust**
 - Charcoal, activated
 - Charcoal, wood
 - Coal, bituminous
 - Coke, petroleum
 - Lampblack
 - Lignite
 - Peat, 22% H₂O
 - Soot, pine
 - Cellulose
 - Cellulose pulp
 - Cork
 - Corn
- **Chemical Dusts**
 - Adipic acid
 - Anthraquinone
 - Ascorbic acid
 - Calcium acetate
 - Calcium stearate

- Carboxy-methylcellulose
- Dextrin
- Lactose
- Lead stearate
- Methyl-cellulose
- Paraformaldehyde
- Sodium ascorbate
- Sodium stearate
- Sulfur
- **Metal Dusts**
 - Aluminum
 - Bronze
 - Iron carbonyl
 - Magnesium
 - Zinc
- **Plastic dusts**
 - (poly) Acrylamide
 - (poly) Acrylonitrile
 - (poly) Ethylene (low-pressure process)
 - Epoxy resin
 - Melamine resin
 - Melamine, molded (phenol-cellulose)
 - Melamine, molded (wood flour and mineral filled phenol-formaldehyde)

PM **List of Products/Materials in Powdered Form**
B - 8 *Products/Materials in Powdered Form*

- (poly) Methyl acrylate
- (poly) Methyl acrylate, emulsion polymer
- Phenolic resin
- (poly) Propylene
- Terpene-phenol resin
- Urea-formaldehyde/cellulose, molded
- (poly) Vinyl acetate/ethylene copolymer
- (poly) Vinyl alcohol
- (poly) Vinyl butyral
- (poly) Vinyl chloride/ethylene/vinyl acetylene suspension copolymer
- (poly) Vinyl chloride/vinyl acetylene emulsion copolymer

Appendix

C

Relevant Acronyms

Acronyms

ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
CCPS	Center for Chemical Process Safety
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DCS	Distributed Control System
EMR	Experience Modification Rate
EPA	Environmental Protection Agency
ERPG	Emergency Response Planning Guideline
EHS	Environment, Health, and Safety
EVC	Equilibrium Vapor Concentration
FMEA	Failure Mode and Effects Analysis
FTA	Fault Tree Analysis
GOCO	Government Owned Contractor Operated
HAZCOM	Hazard Communication (Standard)
HAZOP	Hazard and Operability Analysis

<i>HDBK</i>	Handbook
<i>HHC</i>	Highly Hazardous Chemical
<i>IDLH</i>	Immediately Dangerous to Life or Health
<i>IEEE</i>	Institute of Electrical and Electronic Engineers
<i>ISA</i>	Instrument Society of America
<i>JHA</i>	Job Hazard Analysis
<i>JSA</i>	Job Safety Analysis
<i>LPG</i>	Liquid Petroleum Gas
<i>M&O</i>	Management and Operations
<i>MOC</i>	Management of Change
<i>MSDS</i>	Materials Safety Data Sheet
<i>NDT</i>	Nondestructive Testing
<i>NFPA</i>	National Fire Protection Association
<i>ORC</i>	Organization Resources Counselors
<i>OSHA</i>	Occupational Safety and Health Administration
<i>P&ID</i>	Piping and Instrumentation Diagram
<i>PEL</i>	Permissible Exposure Limit
<i>PHA</i>	Process Hazard Analysis
<i>PrHA</i>	Process Hazard Analysis
<i>PSI</i>	Process Safety Information
<i>PSM</i>	Process Safety Management
<i>PSR</i>	Pre-startup Review

<i>PSI</i>	Process Safety Information
<i>QA</i>	Quality Assurance
<i>RCRA</i>	Resource Conservation and Recovery Act
<i>RMP</i>	Risk Management Program
<i>SAR</i>	Safety Analysis Report
<i>SASS</i>	Safety Assurance System Summary
<i>SCBA</i>	Self-Contained Breathing Apparatus
<i>SHI</i>	Substance Hazard Index
<i>SOP</i>	Standard Operating Procedure
<i>TLV</i>	Threshold Limit Value
<i>TQ</i>	Threshold Quantity
<i>TSD</i>	Treatment, Storage, and Disposal

Appendix

D

Course Exam

Course Exam

1. A primary explosion is often the largest one.
 - a. True
 - b. False
2. The less heat absorbed by the mass of the particle, the _____ that heat accelerates the reaction.
 - a. more
 - b. less
3. Characteristics of combustible dust include all of the following EXCEPT:
 - a. Particle size
 - b. Chemical properties of dust
 - c. Cloud dispersion
 - d. Time in atmosphere
4. Which explosion brought about the most amount of attention to the importance of regulations for combustible dust?
 - a. CTA Acoustics-Corbin, KY
 - b. Imperial Sugar-Savannah, GA
 - c. Amoco Chemical-New Castle, DE
 - d. Farmer's Export Company-Galveston, TX
5. Dust escape can occur when _____.
 - a. raw material leaks through leaks or cracks
 - b. loading, unloading or transferring of material is taking place
 - c. storage units are not properly sealed
 - d. All of the above

6. The design of a facility is crucial to prevent combustible dust incidents and include _____.
 - a. utilizing surfaces that maximize dust accumulation
 - b. storage units, containers, elevators, and chutes need to remain open
 - c. providing access to all hidden areas
 - d. locate relief valves near dust hazard areas
7. If dust escapes, use cleanup methods that do not generate dust clouds, such as _____.
 - a. airing out the facility
 - b. water removal/Wet method
 - c. blower fans
 - d. none of the above
8. When it comes to the fire triangle for combustible dusts, the shape that best represents the elements of combustible dust explosions is a _____.
 - a. square
 - b. triangle
 - c. pentagon
 - d. hexagon
9. Possible ignition sources include all of the following EXCEPT
 - a. Static electricity
 - b. Dented surface
 - c. Open flame or ember
 - d. Electric arcs and sparks
10. Which of the following is an example of open flame or glowing ember ignition source?
 - a. Smoking
 - b. Flares
 - c. Furnaces
 - d. All of the above

11. Combustible materials must be moved far away from hot work zone. What radius away from the hot work zone should the materials be moved to?
 - a. 15-foot
 - b. 35 foot
 - c. 55-foot
 - d. 75-foot
12. A pump with a large motor is of a size that cannot be made intrinsically safe, so explosion proof equipment and practices would be mandatory.
 - a. True
 - b. False
13. All plant personnel must _____.
 - a. be aware of combustible materials used in plant
 - b. be aware of necessary response to combustible dust incidents
 - c. attend combustible dust training
 - d. All of the above
14. Engineering has a huge impact on combustible dust prevention by all EXCEPT:
 - a. Allowing hidden areas
 - b. Designing combustible dust producing areas to be blast proof and resistant
 - c. Using intrinsically safe and explosion-proof devices in design
 - d. Placing relief valve away from combustible dust areas
15. An example of a damage control system is a _____.
 - a. spark ember detection
 - b. hazard segregation
 - c. deflagration venting
 - d. All of the above
16. A deluge fire suppression system is used in places considered to be a high hazard area, such as chemical storage.
 - a. True
 - b. False

17. Which is a key emergency response activity that must be performed prior to an explosion occurring?
- a. Being familiar with response measures and where response tools are located
 - b. Developing EAP
 - c. Being familiar with emergency rescue procedures
 - d. All of the above
18. Determining the cause of a combustible dust explosion is only achieved in about _____ of cases.
- a. 10%
 - b. 25%
 - c. 50%
 - d. 75%
19. Different dusts of the same materials will have various ignitability and explosibility characteristics, depending on the following, EXCEPT:
- a. Particle Size
 - b. Density
 - c. Particle Shape
 - d. Moisture Content
20. _____ is an area where dust may accumulate.
- a. Behind equipment
 - b. On top of beams
 - c. On top of light fixtures
 - d. All of the above
21. A fast acting shutoff valve is an example of a _____.
- a. mechanical
 - b. physical
 - c. chemical
 - d. particle

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