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Combustible dust

How to use this guide

The purpose of this guide is to provide an overview of the dangers of combustible dust explosions along with tools and resources to recognize, evaluate, and control dust explosion hazards. This guide includes dust explosion hazards, the fire and explosion pentagon, secondary dust explosions, serious accident examples, a facility assessment tool, and helpful resources.

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Combustible Dust

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What are the risks?

Combustible dust explosion hazards exist in a variety of industries, including food (e.g., candy, starch, flour, feed), plastics, wood, rubber, furniture, textiles, pesticides, pharmaceuticals, dyes, coal, metals (e.g., aluminum, chromium, iron, magnesium, and zinc), and fossil-fuel power generation. The vast majority of natural and synthetic organic materials, as well as some metals, can form combustible dust.

The National Fire Protection Association (NFPA) Industrial Fire Hazards Handbook states:

> "Any industrial process that reduces a combustible material and some normally noncombustible materials to a finely divided state presents a potential for a serious fire or explosion."

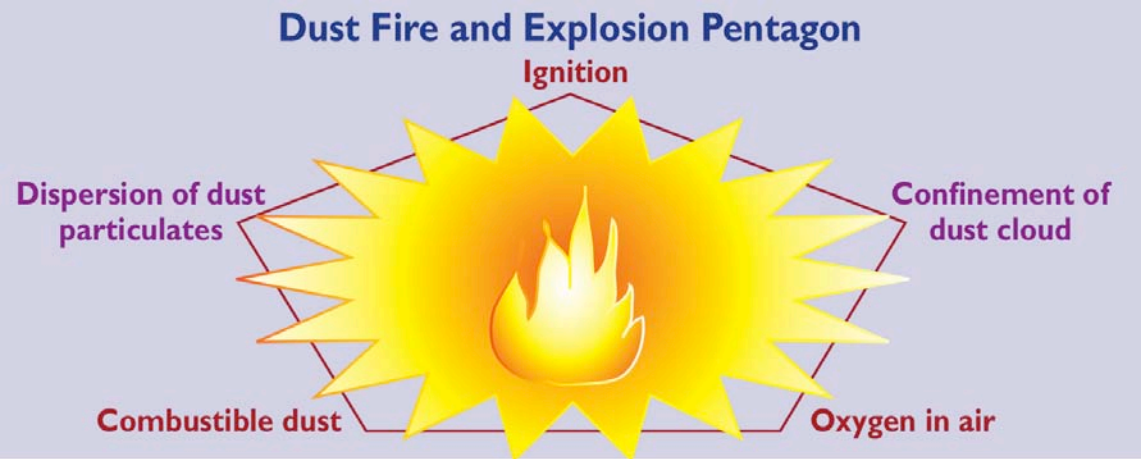
The primary factor in an assessment of these hazards is whether the dust is combustible. Any material that will burn in air in a solid form can be explosive when in a finely divided form. Different dusts of the same chemical material will have different ignitability and explosibility characteristics, depending on many variables such as particle size, shape, and moisture content. One possible source for information on combustibility is the Material Safety Data Sheet (MSDS). However, do not rely on it as a sole source of information. In some cases, additional information such as test results will be available from chemical manufacturers.

Facilities should carefully identify the following to assess their potential for dust explosions:

- Materials that can be combustible when finely divided
- Processes which use, consume, or produce combustible dusts
- Open areas where combustible dusts may build up
- Hidden areas where combustible dusts may accumulate
- Means by which dust may be dispersed in the air
- Potential ignition sources

Know the dust fire and explosion pentagon

The following OSHA fire and explosion pentagon diagram shows combustible dust explosions include the three factors of the familiar fire triangle (fuel, heat, and oxygen) plus the factors of dispersion of dust particulates and the confinement of the dust cloud.

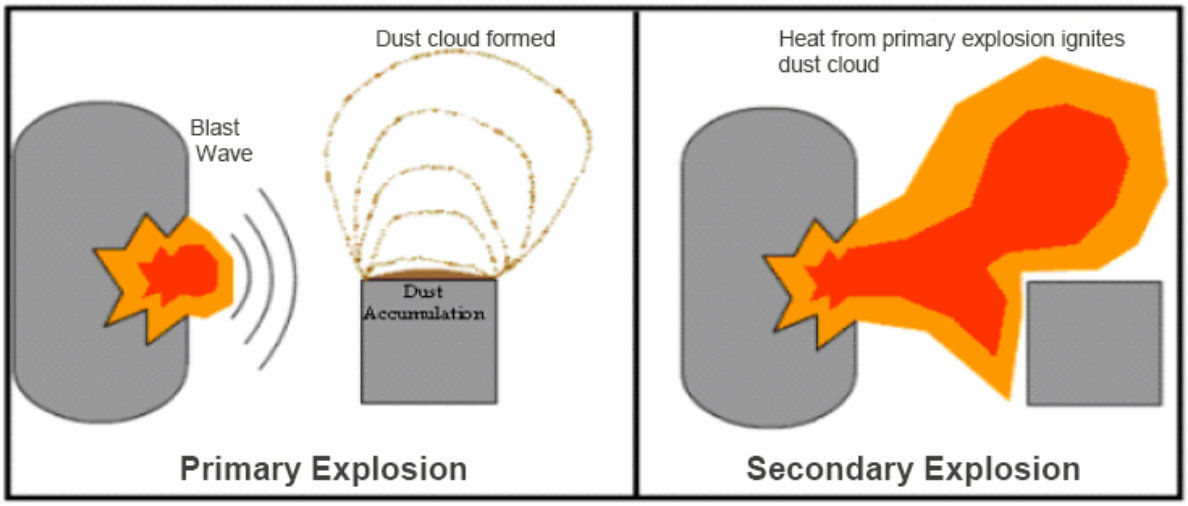


Avoid the secondary dust explosion

A primary dust explosion (deflagration) occurs when dust is suspended within a confined area (e.g., container, room, ventilation system, or piece of equipment) ignites and explodes.

Depending on the amount of settled dust in the area, a small primary explosion may cause powerful secondary dust explosions. A secondary dust explosion may also follow a primary non-dust explosion (e.g., natural gas, pressure, or vessel).

A secondary dust explosion is the result of dust accumulation inside an enclosed area being disturbed and lifted in the air then ignited by the primary explosion. The following OSHA illustration shows the difference between a primary and secondary explosion.



Learn from serious accidents

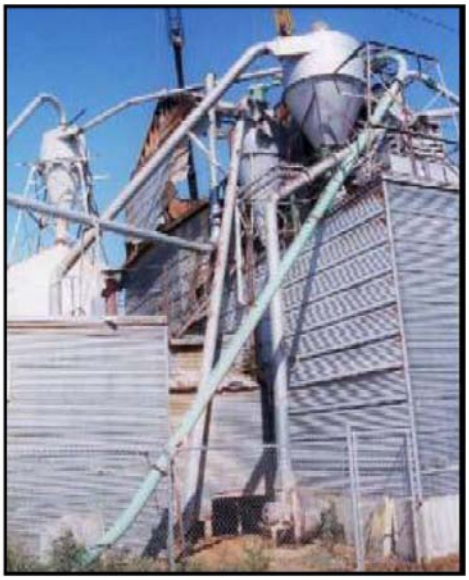
A number of combustible dust accidents have caused deaths and serious injuries. Here are some examples to review and discuss during program reviews and employee training.

Oregon incidents

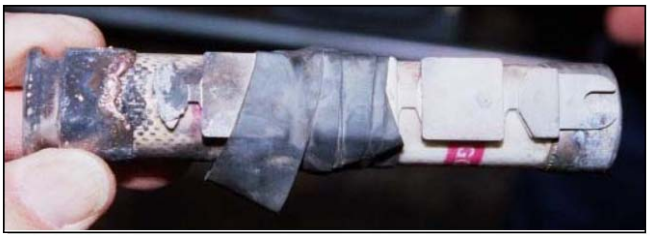
- Commercial Furniture, Roseburg, May 16, 2006: An employee suffered second- and third-degree burns on his hands and arms from a dust fire triggered after two workers changed a bag filter on a powder coating line for office furniture.
- Willamette Industries, Albany, October 25, 2000: An employee died from burns from a combustible dust fire. Investigators found large amounts of wood flour and dust on equipment and lighting fixtures and determined that the fire was ignited from an employee changing a light bulb that was covered in wood dust.
- Mill Rite Farms, Albany, August 8, 2002: Workers were processing feed pellets when the system failed. An employee went upstairs to investigate and was killed when dust in the air exploded and set off a fire. Two other employees suffered serious burns and smoke inhalation.

- Ace International, Albany, August 11, 2003: A worker died after suffering burns and inhaling toxic, superheated air. A defective piece of electrical equipment created a spark that ignited wood flour and dust.

  Investigation photos:



The top of the factory roof was destroyed in the wood-dust explosion.



A melted fuse was repaired by taping a renewable fuse link on the outside.

  View the entire Oregon Fatality Assessment and Control Evaluation investigation report from this link:

  http://www.ohsu.edu/xd/research/centers-institutes/croet/outreach/or-face/reports/upload/Worker-killed-in-wood-dust-fire-sparked-by-faulty-fuse-PDF.pdf

Incidents from other states

- Rouse Polymerics International, Vicksburg, Mississippi, May 2002: An explosion occurred at this rubber fabricating plant, injuring eleven employees, five of whom later died of severe burns. The explosion occurred when highly combustible rubber dust that had been allowed to accumulate was ignited.

- West Pharmaceutical Services, Kinston, North Carolina, January 2003: An explosion and fire destroyed this pharmaceutical plant in Kinston, North Carolina, causing six deaths, dozens of injuries, and hundreds of

job losses. The facility produced rubber stoppers and other products for medical use. The fuel for the explosion was a fine plastic powder, which accumulated above a suspended ceiling over a manufacturing area at the plant and ignited.

- CTA Acoustics, Inc., Corbin, Kentucky, February 2003: An explosion and fire damaged this manufacturing plant, fatally injuring seven employees. The facility produced fiberglass insulation for the automotive industry. The resin involved contained a phenolic binder used in producing fiberglass mats.

- Hayes Lemmerz, Huntington, Indiana, October 2003: A series of explosions severely burned three employees and caused extensive property damage to this manufacturing plant. One of the severely burned men subsequently died. The plant manufactures cast aluminum automotive wheels, and the explosions were fueled by accumulated aluminum dust, a combustible by-product of the wheel production process.

- Electrical power generation facility, Michigan, 1999: A primary explosion of natural gas in an idle power boiler followed by a secondary explosion of disturbed coal dust in the facility caused six fatalities and fourteen serious injuries.

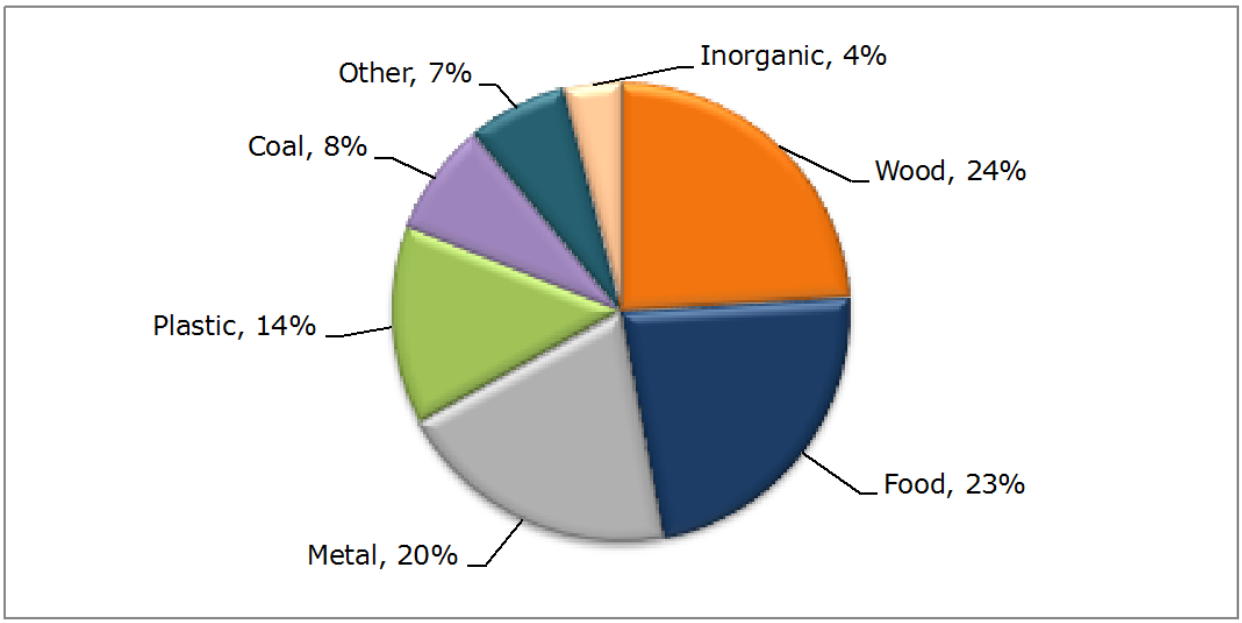
  View the complete incident description in the OSHA Informational Bulletin: “Potential for natural gas and coal dust explosions in electrical power generating facilities.”

  http://www.osha.gov/dts/tib/tib_data/tib20001106a.pdf

These explosions in Michigan, Mississippi, North Carolina, Kentucky, and Indiana resulted in the loss of 25 lives and caused numerous injuries and substantial property losses.

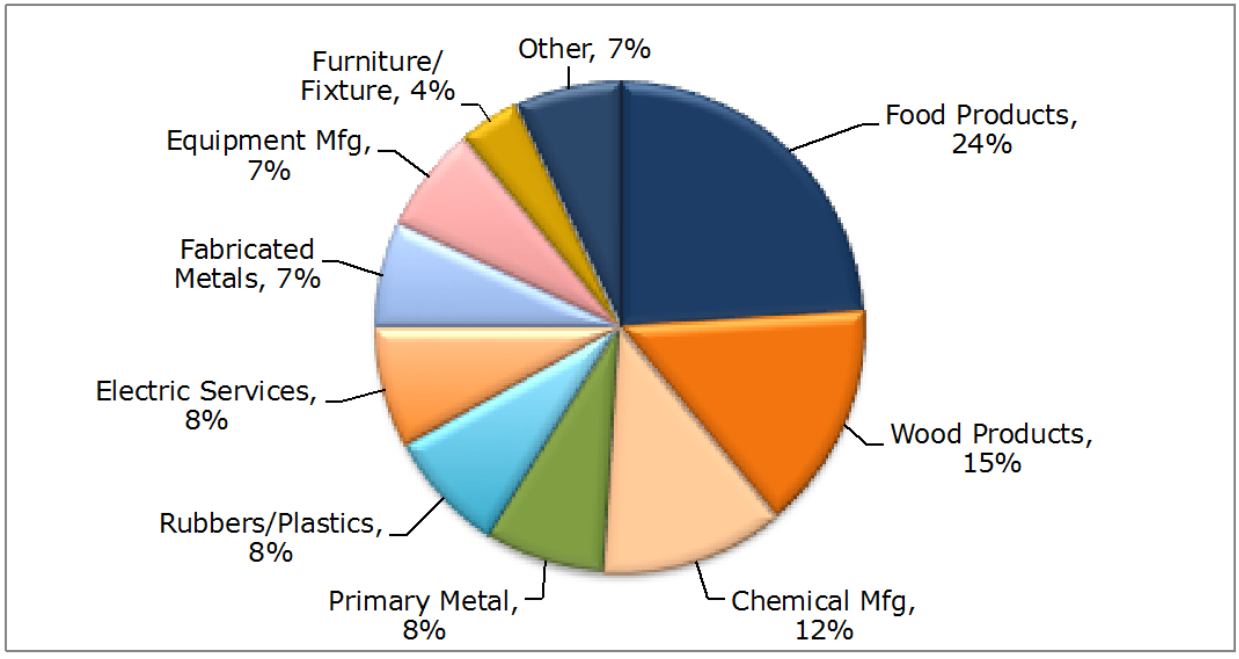
Types of dusts found in incidents

Source: OSHA National Emphasis Program



Industries with dust incidents

Source: OSHA National Emphasis Program



Review your hazards and controls

Use this tool to assess a facility's potential dust explosion hazards and the controls in place. Refer to the Resources section that follows for more detailed information.

Step 1. Find out if the company processes any of these products or materials in powdered form. If so, there's a potential for a combustible dust explosion.

Agricultural Products	Cottonseed	Soybean dust	**Chemical Dusts**	Epoxy resin
Egg white	Garlic powder	Spice dust	Adipic acid	Melamine resin
Milk, powdered	Gluten	Spice powder	Anthraquinone	Melamine, molded (phenol-cellulose)
Milk, nonfat, dry	Grass dust	Sugar (10x)	Ascorbic acid	Melamine, molded (wood flour and mineral filled phenol-formaldehyde)
Soy flour	Green coffee	Sunflower	Calcium acetate	(poly) Methyl acrylate
Starch, corn	Hops (malted)	Sunflower seed dust	Calcium stearate	(poly) Methyl acrylate, emulsion polymer
Starch, rice	Lemon peel dust	Tea	Carboxy-methylcellulose	Phenolic resin
Starch, wheat	Lemon pulp	Tobacco blend	Dextrin	(poly) Propylene
Sugar	Linseed	Tomato	Lactose	Terpene-phenol resin
Sugar, milk	Locust bean gum	Walnut dust	Lead stearate	Urea-formaldehyde/ cellulose, molded
Sugar, beet	Malt	Wheat flour	Methyl-cellulose	(poly) Vinyl acetate/ ethylene copolymer
Tapioca	Oat flour	Wheat grain dust	Paraformaldehyde	(poly) Vinyl alcohol
Whey	Oat grain dust	Wheat starch	Sodium ascorbate	(poly) Vinyl butyral
Wood flour	Olive pellets	Xanthan gum	Sodium stearate	(poly) Vinyl chloride/ ethylene/vinyl acetylene suspension copolymer
Agricultural Dusts	Onion powder	**Carbonaceous Dusts**	Sulfur	(poly) Vinyl chloride/ vinyl acetylene emulsion copolymer
Alfalfa	Parsley (dehydrated)	Charcoal, activated	**Metal Dusts**	
Apple	Peach	Charcoal, wood	Aluminum	
Beet root	Peanut meal and skins	Coal, bituminous	Bronze	
Carrageen	Peat	Coke, petroleum	Iron carbonyl	
Carrot	Potato	Lampblack	Magnesium	
Cocoa bean dust	Potato flour	Lignite	Zinc	
Cocoa powder	Potato starch	Peat, 22% H_20	**Plastic Dusts**	
Coconut shell dust	Raw yucca seed dust	Soot, pine	(poly) Acrylamide	
Coffee dust	Rice dust	Cellulose	(poly) Acrylonitrile	
Corn meal	Rice flour	Cellulose pulp	(poly) Ethylene (low-pressure process)	
Cornstarch	Rice starch	Cork		
Cotton	Rye flour	Corn		
	Semolina			

Source: Federal OSHA Combustible Dust Poster
www.osha.gov/Publications/combustibledustposter.pdf

Step 2. Assemble a review team.

Work with knowledgeable employees from within the facility, including the Facility Safety Manager, Production Superintendent or Supervisor, Equipment Operators, Electrician or Electrical Engineer, and Maintenance Employees or Mechanical Engineer.

Each employee should provide knowledge into the processes and equipment throughout the facility. The production superintendent and supervisors should provide a detailed knowledge of the process from beginning to end. They should be able to identify raw materials, intermediate materials, and the final product. Equipment operators will be able to provide insight on how the equipment operates, its operating parameters, and sources of fugitive dust emissions. An

electrician or electrical engineer should be able to provide information on Class II and Class III locations and if equipment and wiring meet the requirements for hazardous locations. Maintenance employees or a mechanical engineer should provide maintenance records and service logs for equipment. More importantly, these are the individuals that may be assigned to remedy fugitive dust emissions, implement preventative maintenance programs, or make modifications to material transfer points.

Step 3. Confirm combustible dust hazard controls are in place.

Materials used and past incidents

- ☐ Review Material Safety Data Sheets (MSDSs) and related information for the chemicals and materials used or processed to determine the potential to create combustible dusts.

- ☐ If the facility as a history of fires and explosions involving combustible dusts, review the potential causes of these incidents and the preventive measures put in place following the incidents.

Dust control measures

- ☐ Make sure settled dust layers on horizontal surfaces, including exposed rafters, do not exceed a depth of 1/32-inch, either on:
  - o More than 5 percent of all horizontal surfaces for a building up to 20,000 square feet), or
  - o Up to 1,000 square feet for buildings greater than 20,000 square feet.
- ☐ Confirm the dust-containing systems (ducts and dust collectors) are designed in a way that do not expose employees to hazards nor allow fugitive dusts to accumulate in the work area. Examples include:
  - o No leaking of dust into work area.
  - o Collected air exhausted to the outside.
  - o Dust collectors not located inside buildings (some exceptions).
  - o Dust collector cleaning locations are away from the work area.
  - o Isolation devices to prevent deflagration propagation (spreading) between pieces of equipment connected by ductwork.

- ☐ The working surfaces are designed to minimize dust accumulation and facilitate cleaning.

- ☐ The facility has a housekeeping program with regular cleaning frequencies established for floors and horizontal surfaces (e.g., ducts, pipes, hoods, ledges, beams, cable trays, and on and around equipment) to minimize dust accumulations within operating areas of the facility.

- ☐ The cleaning methods used prevent combustible dusts from being suspended in the air. High-efficiency (HEPA) vacuum cleaning equipment or wet methods is recommended. Blowing off the settled dust with compressed air is discouraged.

Ignition control measures

Consider potential ignition sources including open sparks or flames from welding or abrasive cutting or grinding; embers; electrical equipment; static sparks; and hot surfaces (e.g., dryers, extruders, and heaters).

- ☐ Electric cleaning devices such as sweepers or vacuum cleaners, and electrical equipment are approved for the combustible dust locations.

- ☐ Spark detection and fire and explosion suppression systems are well designed and maintained.

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

- ☐ The facility has separator devices to remove foreign materials capable of igniting combustible dusts (i.e., iron filings).

- ☐ The facility has a Hot Work Program including performing hot work in approved locations; written permitting procedures for hot work outside of designated areas; fire watcher training; and fire extinguisher user training.

- ☐ Combustible dust locations and other areas where smoking is prohibited are posted with “No Smoking” signs.

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

- ☐ The facility selects and uses powered industrial trucks (e.g., forklifts and loaders) that are approved for the combustible dust locations.

Prevention measures

- ☐ Material Safety Data Sheets (MSDSs) or other information for the chemicals and materials that could become combustible dusts are available to employees.
- ☐ Employees have had hazard awareness training on the fire and explosion hazards of combustible dusts and the control methods.

Protection measures

- ☐ The facility has an emergency action plan.
- ☐ Rooms, buildings, or other enclosures (dust collectors) have explosion relief venting distributed over the exterior wall of buildings and enclosures and directed away from work areas.
- ☐ Emergency exit routes are maintained properly to allow clear and visible exit routes.
- ☐ The personal protective equipment (PPE) has been selected for the job tasks involving combustible dusts, including:
  - o The need for flash-resistant clothing has been determined for employees required to work in environments where combustible dust hazards exist.
  - o Airborne concentrations of respirable dust have been evaluated to determine the need for respirators.
  - o A written respiratory protection program that includes respirator selection, training, medical screening, and fit testing is in place where respirators are needed.

Resources

Oregon OSHA

Combustible dust hazard alert http://orosha.org/pdf/hazards/2993-17.pdf

Combustible dust national emphasis program inspection guidelines http://orosha.org/pdf/pds/pd-268.pdf

Federal OSHA

Combustible dust topic page http://www.osha.gov/dsg/combustibledust/index.html

Combustible dust poster www.osha.gov/Publications/combustibledustposter.pdf

Combustible dust in industry: Preventing and mitigating the effects of fire and explosions http://www.osha.gov/dts/shib/shib073105.html

National Fire Protection Association (NFPA)

Related codes and standards http://www.nfpa.org/catalog

NFPA 61, Standard for the prevention of fires and dust explosions in agricultural and food processing facilities

NFPA 68, Guide for venting of deflagrations

NFPA 69, Standard on explosion prevention systems

NFPA 70, National electric code

NFPA 77, Recommended practice on static electricity

NFPA 86, Standard for ovens and furnaces

NFPA 91, Standard for exhaust systems for air conveying of vapors, gases, mists, and noncombustible particulate solids

NFPA 484, Standard 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

NFPA 654, Standard for the prevention of fires and dust explosions from the manufacturing, processing, and handling of combustible particulate solids

NFPA 664, Standard for the prevention of fires and explosions in the wood processing and woodworking facilities

NFPA 2113, Standard on selection, care, use and maintenance of flame-resistant garments for protection of industrial personnel against flash fire

NFPA 85, Boiler and combustion systems hazard code

Oregon Occupational Fatality Assessment and Control Evaluation (OR-FACE) Program

Fatality reports http://www.ohsu.edu/xd/research/centers-institutes/croet/outreach/or-face/reports/index.cfm