

NFPA 650 Standard for Pneumatic Conveying Systems for Handling Combustible Particulate Solids 1998 Edition



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An International Codes and Standards Organization

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NFPA 650
Standard for
Pneumatic Conveying Systems for
Handling Combustible Particulate Solids
1998 Edition

This edition of NFPA 650, *Standard for Pneumatic Conveying Systems for Handling Combustible Particulate Solids*, was prepared by the Technical Committee on Handling and Conveying of Dusts, Vapors, and Gases and acted on by the National Fire Protection Association, Inc., at its Fall Meeting held November 17–19, 1997, in Kansas City, MO. It was issued by the Standards Council on January 16, 1998, with an effective date of February 6, 1998, and supersedes all previous editions.

This document has been submitted to ANSI for approval.

Origin and Development of NFPA 650

NFPA 650 had its origin as NFPA 66, *Standard for Pneumatic Conveying Systems for Handling Feed, Flour, Grain and Other Agricultural Dusts*. NFPA 66 was adopted as a tentative standard in 1963, and as a standard in 1964. Revised standards were adopted in 1970 and 1973.

The 1984 edition of NFPA 650, *Standard for Pneumatic Conveying Systems for Handling Combustible Materials*, differed in many ways from NFPA 66. Besides differing in scope and title, NFPA 650 represented a complete rewrite of NFPA 66. The rewrite made the standard applicable to the pneumatic conveying of combustible materials, both agricultural and non-agricultural.

The 1990 edition of NFPA 650 was a reconfirmation of the 1984 edition.

For the 1998 edition, the Committee completely revised the standard to incorporate new processing and explosion protection technologies. The title of the document now reflects that the standard encompasses the conveying of all combustible particulate solids not otherwise included in previous editions of the standard. The complete revision incorporates new requirements for design basis of systems and design details for management of change.

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on the prevention, control, and extinguishment of fires and explosions in the design, construction, installation, operation and maintenance of facilities and systems processing or conveying flammable or combustible dusts, gases, vapors, and mists.

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Handling Combustible Particulate Solids****1998 Edition**

NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Appendix A.

Information on referenced publications can be found in Chapter 9 and Appendix C.

Chapter 1**1-1 Scope.**

1-1.1* This standard shall apply to all pneumatic conveying systems that transport combustible particulate solids, combustible dusts, or hybrid mixtures containing dusts, regardless of concentration or particle size, including systems that convey nuisance or fugitive combustible dusts.

Exception: This standard shall not apply to pneumatic conveying systems in facilities covered by NFPA 120, Standard for Coal Preparation Plants, and NFPA 8503, Standard for Pulverized Fuel Systems.

1-1.2 Additional requirements relating to specific materials or specific occupancies shall be in accordance with the following standards.

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

NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Products Facilities*

NFPA 65, *Standard for the Processing and Finishing of Aluminum*

NFPA 432, *Code for the Storage of Organic Peroxide Formulations*

NFPA 480, *Standard for the Storage, Handling, and Processing of Magnesium Solids and Powders*

NFPA 481, *Standard for the Production, Processing, Handling, and Storage of Titanium*

NFPA 482, *Standard for the Production, Processing, Handling, and Storage of Zirconium*

NFPA 651, *Standard for the Manufacture of Aluminum Powder*

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

NFPA 655, *Standard for Prevention of Sulfur Fires and Explosions*

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

1-1.3 In the event of a conflict between this standard and a specific occupancy standard, the specific occupancy standard requirements shall apply.

1-2 Purpose.

1-2.1 The purpose of this standard shall be to provide the technical requirements for pneumatic conveying systems that will provide safety to life and property from fires and deflagrations, and minimize the damage in the event that they occur.

1-3 Equivalency. Nothing in this standard shall be intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard, provided technical documentation is made available to the authority having jurisdiction to demonstrate equivalency and the system, method, or device is approved for the intended purpose.

1-4 Applicability. The provisions of this document shall be considered necessary to provide a reasonable level of protection from loss of life and property from fire and explosion. They reflect situations and the state-of-the-art prevalent at the time the standard was issued.

Unless otherwise noted, it shall not be intended that the provisions of this document be applied to facilities, equipment, structures, or installations that were existing or approved for construction or installation prior to the effective date of the document, except in those cases where it is determined by the authority having jurisdiction that the existing situation involves a distinct hazard to life or property.

1-5 Definitions.

Abort Gate/Abort Damper. A device for the quick diversion of material or air to the exterior of the building or other safe location in the event of a fire.

Air-Material Separator (AMS). Any device designed to separate the conveying air from the material being conveyed. Examples include cyclones, bag filter houses, and electrostatic precipitators. The following are two types of air-material separators:

- (a) *Primary Air-Material Separator.* A collector that removes the bulk of the product or material from the conveying air stream.
- (b) *Secondary Air-Material Separator.* A device for removing the residual dust or product remaining in the air stream after the primary air-material separator.

Air-Moving Device (AMD).* A power-driven fan or blower that moves a volume of air in order to overcome the resistance to flow that is caused by exhaust system components.

Approved.* Acceptable to the authority having jurisdiction.

Authority Having Jurisdiction.* The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

Booster Fan. See Relay Fan.

Combustible Dust.* Any finely divided solid material 420 microns or smaller in diameter (material passing a U.S. No. 40 standard sieve) that presents a fire hazard or a deflagration hazard when dispersed and ignited in air.

Combustible Particulate Solid.* Any combustible solid material comprised of distinct particles or pieces, regardless of size, shape, or chemical composition that generates combustible dusts during handling. Combustible particulate solids include dusts, fibers, fines, chips, chunks, flakes, or mixtures of these.

Deflagration. Propagation of a combustion zone at a velocity that is less than the speed of sound in the unreacted medium.

Detachment Area. Area located in the open air or in a separate building.

Detonation. Propagation of a combustion zone at a velocity that is greater than the speed of sound in the unreacted medium.

Duct. Pipes, tubes, or other enclosures used for the purpose of pneumatically conveying materials.

Dust Collector. See Air-Material Separator.

Explosion. The bursting or rupture of an enclosure or a container due to the development of internal pressure from a deflagration.

Fire Barrier Wall. A wall, other than a fire wall, having a fire resistance rating.

Fire Wall. A wall that has a fire resistance rating and structural stability used to separate buildings or subdivide a building to prevent the spread of fire.

Flammable Limits.* The minimum and maximum concentrations of a combustible material, in homogeneous mixture with a gaseous oxidizer, that will propagate a flame.

Hybrid Mixture.* Any combination of a combustible dust, flammable gas, or combustible mist that produces an ignitable mixture.

K_{St} .* The index of dust explosibility is defined as:

$$K_{St} = \left(\frac{dP}{dt} \right)_{max} V^{1/3}$$

where V is the volume of the test vessel. The value of $(dP/dt)_{max}$ will be a maximum for a particular dust concentration, referred to as the "optimum" concentration, and is characteristic of the particular dust.

Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Listed.* Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets identified standards or has been tested and found suitable for a specified purpose.

Minimum Explosible Concentration (MEC).* The minimum concentration of combustible dust suspended in air, measured in mass per unit volume, that will support a deflagration as defined by the test procedure in ASTM E 1515, *Standard Test Method for Minimum Explosible Concentration of Combustible Dusts*.

Noncombustible Material. A material that, in the form in which it is used and under conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. Materials that are reported as passing ASTM E 136, *Standard Test Method for*

Behavior of Materials in a Vertical Tube Furnace at 750°C, shall be considered noncombustible materials.

Pneumatic Conveying System. A pneumatic conveying system consists of a material feeder, an air-material separator, an enclosed ductwork system, and an air-moving device in which a combustible particulate solid is conveyed from one point to another with a stream of air or other gases. Such systems are of the following two principal types:

(a) *Positive-Pressure Conveying.* Positive pressure-type systems transport material by utilizing gas at greater than atmospheric pressure. These systems consist of a sequence of an air-moving device, a feeder for introducing materials into the system, an air-material separator, and interconnecting ducts.

(b) *Negative-Pressure Conveying.* Negative-pressure-type systems transport material by utilizing gas at less than atmospheric pressure. These systems consist of a sequence of an air intake, a material feeder, an air-material separator, an air-moving device, and interconnecting ducts.

Relay Fan. A fan or a blower installed in-line to overcome the pressure drop due to frictional losses in the conveying stream.

Separation. The interposing of distance between the combustible particulate solid process and other operations that are in the same room.

Shall. Indicates a mandatory requirement.

Should. Indicates a recommendation or that which is advised but not required.

Spark. A moving particle of solid material that emits radiant energy due either to its temperature or the process of combustion on its surface.

Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

Wall Protector (Shield). Noncombustible surfacing applied to a wall area for the purpose of reducing the clearance between the wall and a heat-producing appliance.

Water-Compatible.* A material that is neither reactive with water nor incompatible with water and consequently can be extinguished with a water-based extinguishing system.

Water-Incompatible.* A material that does not chemically react with water but undergoes a change of phase or state upon mixture with water that renders it permanently changed or incompatible with the remainder of the process.

Water-Reactive.* A material that chemically reacts with water producing some other compound that can represent a different set of fire protection concerns.

Chapter 2 Fundamentals of Pneumatic Conveying System Design

2-1 General. The provisions of this section shall address the overall design of all pneumatic conveying systems for combustible particulate solids.

2-1.1* Plans and specifications for new and modified systems shall be prepared by qualified engineers who are knowledgeable in the design, installation, and safe operation of pneumatic conveying systems and their associated hazards.

2-1.2 Additions of branch lines shall not be made to an existing system without redesigning the entire system. Branch lines shall not be disconnected nor shall unused portions of the system be blanked off without providing a means to maintain required and balanced airflow.

2-1.3 The rate of airflow at each hood or other pick-up point shall be designed to convey and control the material.

2-1.4 All ductwork shall be sized to provide the air volume and air velocity to keep the duct interior clean and free of residual material.

2-1.5 The design of systems handling combustible particulate solids shall be consistent with the following:

- (a) The physical and chemical properties of the process materials, materials of construction, and any extinguishing agents
- (b) The hazards represented, including incompatibilities

2-1.6* The design basis and design shall be documented and shall include the properties defining the hazards of the material being processed.

2-1.7 Pneumatic conveying systems removing material from operations generating flames, sparks, or hot material shall not be interconnected with pneumatic conveying systems that transport combustible particulate solids or hybrid mixtures.

2-1.8 Air-Moving Devices (Fans and Blowers).

2-1.8.1 Systems shall be designed in such a manner that combustible material does not pass through an air-moving device.

*Exception No. 1:** Those systems designed to operate at a combustible particulate solids or hybrid mixture concentration of less than 0.0003 oz/ft³ (0.3 gm/m³).

*Exception No. 2:** Those systems operating at combustible particulate solids or hybrid mixture concentration equal to or greater than 0.0003 oz/ft³ (0.3 gm/m³) and protected in the following ways:

(a) The use of an approved explosion prevention or isolation system to prevent the propagation of the flame front from the fan to other equipment in accordance with any of the following: 3-9.1(a), (d), or (e) and 3-9.2(c), (d), or (e).

(b) AMDs shall be designed, constructed, and installed using the following materials and methods.

1. Spark-resistant materials
2. Components compatible with the material being conveyed
3. Bearings external to the casing
4. Proper clearance between the fan and casing
5. Belt drives external to the casing
6. Impellers, bearings, and shafts restrained to prevent axial or lateral shift
7. Detection of material build-up or overheating in the AMD housing, and interlocking to shut off the AMD
8. Foundations and supports for AMDs designed to withstand the vibration that can result from operation of the AMD

2-1.9 Where a system or any part of a system operates as a positive-pressure-type system and the air-moving device discharge pressure is a gauge pressure of 15 psi (103 kPa) or greater, the

system shall be designed in accordance with ASME *Boiler and Pressure Vessel Code*, Section VIII or ASME B 31.3, *Process Piping*.

2-2 Sequence of Operation. All pneumatic conveying systems shall be designed with the operating logic, sequencing, and timing outlined in 2-2.1 and 2-2.2.

2-2.1 Start-Up. Pneumatic conveying systems shall be designed so that upon start-up, the system achieves and maintains design air velocity prior to the admission of material to the system.

2-2.2 Shutdown. Pneumatic conveying systems shall be designed so that upon shutdown of the process, the system shall maintain design air velocity until material is purged from the system.

2-3 Recycled Air.

2-3.1 Systems that recycle air back into the building shall be designed to prevent both return of dust with an efficiency of 99.9 percent at 10 microns, and the transmission of energy or products of combustion from a fire or explosion to the building.

Exception: Recycling of air to the building shall not be permitted under any circumstances involving hybrid mixtures or reduced oxygen (inerted) atmospheres.

2-3.2 Protection measures for the transmission of energy shall be provided in accordance with 3-9.2 of this standard.

2-4 Inerting for the Control of Ignitability.

2-4.1 Where inerting is used to maintain the material/air mixture in a nonignitable state, the system shall be designed and operated in accordance with Chapter 2 of NFPA 69, *Standard on Explosion Prevention Systems*.

2-4.2 Where oxygen monitoring is used, it shall be installed in accordance with ISA S84.01, *Application of Safety Instrumented Systems for the Process Industries*.

2-4.3* When the chemical properties of the material being conveyed require a minimum concentration of oxygen to control pyrophoricity, that level shall be maintained.

2-5 Penetration of Fire Barriers.

2-5.1 Ducts shall not pass through a fire wall, as defined by NFPA 221, *Standard for Fire Walls and Fire Barrier Walls*.

2-5.2 If ducts pass through a fire barrier wall having a fire resistance rating of 2 hours or more, they shall meet the following criteria:

- (a) Be constructed and supported so that 10 ft (3 m) of the ductwork on each side of the fire barrier can resist a 2-hour fire scenario, or be provided with an approved fire damper equivalent to the wall rating
- (b) Be protected by sealing the opening around the duct with a listed or approved material of a fire resistance rating equivalent to that of the fire barrier wall

2-5.3 If ducts pass through a fire barrier wall having a fire resistance rating of less than 2 hours, they shall meet the following criteria:

- (a) Be protected by sealing the opening around the duct with a listed or approved material of a fire resistance rating equivalent to that of the fire barrier wall
- (b) Be permitted to pass through the wall without installation of fire dampers

2-5.4* Where ducts pass through a physical barrier erected to segregate dust deflagration hazards, physical isolation protection shall be provided to prevent propagation of deflagrations between segregated spaces.

2-6 Duct Clearances.

2-6.1* All ductwork and system components handling combustible material and operating at less than 140°F (60°C) shall have a clearance of not less than 18 in. (46 cm) from combustible construction or any combustible material.

Exception No. 1: When the ductwork system is equipped with an approved automatic extinguishing system designed for the specific hazard, the clearance shall be permitted to be reduced to 6 in. (15 cm) from combustible materials and 1/2 in. (13 mm) from combustible construction.

Exception No. 2: The combustible material and any combustible construction is protected by the use of materials or products listed for protection purposes or in accordance with Table 2-6.1.

2-6.1.1 Spacers and ties for protection materials shall be of noncombustible material and shall not be used directly behind the duct.

Table 2-6.1 Reduction of Duct Clearance with Specified Forms of Protection

Form of Protection	Maximum Allowable Reduction in Clearance %	
	As Wall Protector	As Ceiling Protector
3 1/2-in. (90-mm) thick masonry wall without ventilated air space	33	—
1/2-in. (13-mm) thick noncombustible insulation board over 1-in. (25-mm) glass fiber or mineral wool batts without ventilated air space	50	33
0.024 in./0.61 mm (24 gauge) sheet metal over 1-in. (25-mm) glass fiber or mineral wool batts reinforced with wire, or equivalent, on rear face with at least a 1-in. (25-mm) air gap	66	66
3 1/2-in. (90-mm) thick masonry wall with at least a 1-in. (25-mm) air gap	66	—
0.024 in./0.61 mm (24 gauge) sheet metal with at least a 1-in. (25-mm) air gap	66	50
1/2-in. (13-mm) thick noncombustible insulation board with at least a 1-in. (25-mm) air gap	66	50
0.024 in./0.61 mm (24 gauge) sheet metal with ventilated air space over 0.024 in./0.61 mm (24 gauge) sheet metal with at least a 1-in. (25-mm) air gap	66	50
1-in. (25-mm) glass fiber or mineral wool batts sandwiched between two sheets 0.024 in./0.61 mm (24 gauge) sheet metal with at least a 1-in. (25-mm) air gap	66	50

Note: Clearance reduction applied to all combustible surfaces within the distance specified as required clearance with no protection in 2-6.2 and 2-6.3.

2-6.1.2 With all clearance reduction systems using a ventilated air space, air circulation shall be provided as described in 2-6.4. There shall be at least 1 in. (2.5 cm) between the wall protector and combustible walls and ceilings for clearance reduction systems using a ventilated space.

2-6.1.3 Mineral wool batts (blanket or board) shall have a minimum density of 8 lb/ft³ (3.6 kg/m³) and have a minimum melting point of 1500°F (816°C).

2-6.1.4 Insulation board used as a part of a clearance reduction system shall have a thermal conductivity of 1 Btu/in.·ft²·hr.°F (0.14 W/m²·hr.°C) or less. Insulation board shall be formed of noncombustible material.

2-6.1.5 There shall be at least 1 in. (2.5 cm) between the duct and the wall protector. In no case shall the clearance between the duct and the wall surface be reduced below that shown in Table 2-6.1.

2-6.2 Duct systems operating at elevated temperatures above 140°F (60°C) shall have clearances from combustible building construction or any combustible material of not less than 18 in. (46 cm).

2-6.3 Where clearance is reduced by using an air space between the combustible wall and the wall protector, air circulation shall be provided by one of the methods described in 2-6.3.1, 2-6.3.2 and 2-6.3.3.

2-6.3.1 Air circulation shall be permitted to be provided by leaving all edges of the wall protector open with at least a 1-in. (2.5-cm) air gap.

2-6.3.2 If the wall protector is mounted on a single flat wall away from corners, air circulation shall be permitted to be provided by one of the following:

- (a) Leaving top and bottom edges open to circulation by maintaining the 1-in. (2.5-cm) air gap
- (b) Leaving top and both side edges open to circulation by maintaining the 1-in. (2.5-cm) air gap

2-6.3.3 Wall protectors that cover two walls in a corner shall be permitted to be open at the top and bottom edges with at least a 1-in. (2.5-cm) air gap.

2-6.4 All clearances shall be measured from the outer surface of the combustible material to the nearest point on the outer surface of the duct, disregarding any intervening protection applied to the combustible material. Clearances shall be measured as shown in Figure 2-6.4. Clearances with protection provided shall be calculated by using the following equation.

$$B = A \left(\frac{1-R}{100} \right)$$

where:

B = minimum allowable clearance with protection

A = required clearance with no protection

R = maximum allowed percent reduction per Table 2-6.1

A and B are in the same units of length.