NFPA 91

Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids

1999 Edition

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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NFPA 91

Standard for

Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids

1999 Edition

This edition of NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible 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 16–18, 1998, in Atlanta, GA. It was issued by the Standards Council on January 15, 1999, with an effective date of February 4, 1999, and supersedes all previous editions.

This edition of NFPA 91 was approved as an American National Standard on February 4, 1999.

Origin and Development of NFPA 91

The National Fire Protection Association as early as 1899 recognized the hazards of blower and exhaust systems. Since 1900 the NFPA Committees on Blower Systems have given continuing attention to the subject. Following World War II, revisions and additions to the standard were recommended by the NFPA Committee on Blower Systems to cover various new developments in the protection of dust collecting systems and stock and refuse conveying systems, and were adopted by the NFPA at its Annual Meetings in 1946, 1947, 1948, and 1949. Editorially revised editions were published in 1959 and 1961. In 1972 Section 200 (Chapter 2) was expanded, and a new Section 500 (Chapter 5), covering systems involving plastic materials, was added. In the 1973 edition, Section 400 (Chapter 4) was completely revised. The 1983 edition was completely updated to conform with the NFPA *Manual of Style* and incorporated minor revisions in each chapter.

The 1990 edition included minor revisions to Chapter 2 including a new Figure 2-8 and Table 2-8(b). Changes were made to recognize NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals,* and to remove conflicts with that standard. These changes included moving Section 5-2 and Figures 5-2 through 5-5 to Appendix A.

The Technical Committee on Blower Systems completely revised the standard for the 1992 edition, including a new title and new scope. The previous title was *Standard for the Installation of Blower and Exhaust Systems for Dust, Stock, and Vapor Removal or Conveying.* Chapters 3 and 4 from the 1990 edition were deleted with some requirements from those chapters included in the revised and reorganized Chapter 2 and new Chapters 5, 6, and 7.

Minor changes were made to all chapters in the 1995 edition. The Committee clarified their intent that ducts can be round, oval, or rectangular. A new figure was added to show access openings for different shapes of ducts, and a new table was added in the appendix to show duct velocities for types of materials conveyed.

The 1999 edition incorporates a new scope limiting the applicability of this document to noncombustible particulate solids. The Committee on Handling and Conveying of Dusts, Vapors, and Gases is now responsible for NFPA 91 and has made changes consistent with the committee's other documents, NFPA 650, *Standard for Pneumatic Conveying Systems for Handling Combustible Particulate Solids,* and NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids,* that address combustible particulate solids.

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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.

Contents

NFPA 91

Standard for

Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids

1999 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 8 and Appendix B.

Chapter 1 Introduction

1-1* Scope.

1-1.1 This standard provides minimum requirements for the design, construction, installation, operation, testing, and maintenance of exhaust systems for air conveying of vapors, gases, mists, and noncombustible particulate solids except as modified or amplified by other applicable NFPA standards.

1-1.2 This standard does not cover exhaust systems for conveying combustible particulate solids. These materials are covered in other NFPA standards as noted in A-1-1.

1-2 Purpose. The purpose of this standard is to provide technical requirements for exhaust systems that will

(a) Provide safety to life and property from fires and explosions

(b) Minimize the damage in the event that such fires and explosions occur

1-3 Equivalency. Nothing in this standard is 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 that technical documentation is submitted to the authority having jurisdiction to demonstrate equivalency and that the system, method, or device is approved for the intended purpose.

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

Unless otherwise noted, it is not intended that the provisions of this document be applied to facilities, equipment, structures, or installations that were existing or that were 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 adjacent property.

1-5 Definitions.

Air-Moving Device.* A power-driven fan, blower, or other device that establishes an airflow by moving a volume of air per unit time.

Approved.* Acceptable to the authority having jurisdiction.

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

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

Exhaust System.* An air-conveying system for moving materials from a source to a point of discharge.

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.

Limited-Combustible. A building construction material, not complying with the definition of noncombustible material, that, in the form in which it is used, has a potential heat value not exceeding 3500 Btu/lb (8141 kJ/kg) where tested in accordance with NFPA 259, *Standard Test Method for Potential Heat of Building Materials,* and that complies with (a) or (b) below. Materials subject to increase in combustibility or in flame spread index beyond the limits herein established, through the effects of age, moisture, or other atmospheric condition, shall be considered combustible.

(a) Material that has a structural base of noncombustible material, a surfacing not exceeding a thickness of $^1/_8$ in. (3.2 mm), and a flame spread index not greater than 50.

(b) Material, in the form and thickness used, other than as described in (a), having neither a flame spread index greater than 25 nor evidence of continued progressive combustion and of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread index greater than 25 nor evidence of continued progressive combustion.

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.

Noncombustible Material.* A material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat.

Noncombustible Particulate Solid.* Any noncombustible solid material composed of distinct particles or pieces, regardless of size, shape, or chemical composition.

Shall. Indicates a mandatory requirement.

Chapter 2 Design and Construction

2-1 General Requirements.

2-1.1 The design and installation of exhaust systems shall be the responsibility of persons having a knowledge of these systems.

2-1.2* Incompatible materials shall not be conveyed in the same system.

2-1.3 In systems conveying flammable vapors, gases, or mists, the concentration shall not exceed 25 percent of the lower flammability limit (LFL).

Exception: Higher concentrations shall be permitted if the exhaust system is designed and protected in accordance with NFPA 69, Standard on Explosion Prevention Systems, using one or more of the following techniques:

(a) Combustible concentration reduction
(b) Oxidant concentration reduction
(c) Deflagration suppression
(d) Deflagration pressure containment

2-1.4 The design of any exhaust system shall require knowledge of the physical and chemical properties and hazardous characteristics of the materials being conveyed.

2-1.5* An air-moving device shall be sized to confine, capture, and remove materials. The velocity shall be adequate to capture materials and convey them through the exhaust system.

2-1.6 Operations generating flames, sparks, or hot materials, such as from grinding wheels and welding, shall not be consolidated in the same exhaust system that air conveys flammable or combustible materials.

2-1.7 Exhaust systems designed to air convey flammable or combustible materials that can contain foreign ferrous materials, shall have magnetic separators installed at those points where the ferrous materials enter the system. Where electromagnetic separators are used, they shall be listed.

2-1.8* Plans and specifications for new systems and systems to be modified shall be submitted to the authority having jurisdiction for approval prior to installation or modification. The submittal shall provide information adequate to describe the hazard and to demonstrate safe performance of the system.

2-1.9 Fire dampers shall be permitted to be installed in exhaust systems in the following situations:

(a) Where ducts pass through fire barriers, fire walls, or floors
(b) Where a collection system installed on the end of the system is protected with an automatic extinguishing system
(c) Where the duct system is protected with an automatic extinguishing system
(d) Where ducts have been listed with interrupters
(e) Where necessary to facilitate the control of smoke pursuant to the applicable NFPA standards

Exception: Fire dampers shall not be installed if the material being exhausted is toxic and if a risk evaluation indicates that the toxic hazard is greater than the fire hazard.

2-1.10 Exhaust ducts shall not pass through fire walls, as defined by NFPA 221, *Standard for Fire Walls and Fire Barrier Walls.*

2-1.11 Ducts that pass through a fire barrier wall having a fire resistance rating of 2 hours or more shall meet the following:

(a) Be constructed and supported so that 10 ft (3 m) of the duct on each side of the fire barrier can resist a 2-hour fire scenario

(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

2-1.12 Ducts that pass through a fire barrier wall having a fire resistance rating of less than 2 hours shall 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.

2-1.13 Fire detection and alarm systems shall not be interlocked to shut down air-moving devices.

Exception No. 1: When shutdown is necessary for the effective operation of an automatic extinguishing system.

Exception No. 2: When a documented risk analysis, acceptable to the authority having jurisdiction, shows that the risk of damage from fire and the products of combustion would be higher with air-moving devices operating.

2-2 Duct Material and Construction.

2-2.1 Duct material shall be noncombustible.

Exception No. 1: Alternative material shall be permitted to be used when the material being conveyed is incompatible with noncombustible construction materials.

Exception No. 2: Listed duct systems that have been evaluated and found to be of low fire hazard not requiring automatic sprinkler protection to prevent fire spread.

Exception No. 3: Plastic duct systems used for handling noncombustible material or flammable corrosive vapors and that have automatic sprinkler protection as required by Chapter 6.

2-2.2 The duct construction shall conform to the following applicable Sheet Metal and Air-Conditioning Contractors' National Association, Inc. (SMACNA) standards:

(a) *Accepted Industry Practice for Industrial Duct Construction*
(b) *Rectangular Industrial Duct Construction Standard*
(c) *Round Industrial Duct Construction Standard*
(d) *Thermoplastic Duct (PVC) Construction Manual*
(e) *Thermoset FRP Duct Construction Manual*

2-2.3 Duct supports shall be designed to carry the weight of the duct system itself plus the anticipated weight of any conveyed materials. If sprinkler protection is provided inside the duct system, then the duct supports shall also be designed to carry the anticipated weight of any accumulation of sprinkler discharge.

2-2.4 Laps in duct construction shall be in the direction of airflow.

2-2.5 Joints in duct construction shall be liquidtight when the conveying system contains condensible vapors or liquids in suspension. Provisions shall be made for drainage of condensate at low points in the duct.

2-2.6 The interior of ducts shall be smooth and joints shall be finished neatly.

2-3 Access.

2-3.1 Access doors shall be provided in horizontal ducts adjacent to elbows, junctions, and vertical ducts. Doors shall be located on the tops or sides of the ducts, and door spacing shall not exceed 12 ft (3.6 m).

Exception: Ducts handling materials that do not create a condition requiring access into the duct.

2-3.2 Access doors shall be of the same material and of equal or greater thickness than the duct. Required openings or other penetrations shall be sealed, gasketed, or tightly fitted so that conveyed material will not escape.

2-3.3* Access openings shall be sized to satisfy their intended purpose.

2-4 Design Requirements.

2-4.1 A means shall be provided for balancing the system.

2-4.2 Dampers or shutters shall be permitted only for weather or back-draft protection. Where dampers or louvers are used, they shall be located on the clean-air side of the filtration system.

2-4.3 Balancing devices shall be secured to prevent inadvertent adjustment or loss of transport velocity. Butterfly dampers shall not be permitted for balancing duct systems conveying solid materials.

2-4.4 Ducts shall be self-contained. Building walls, floors, or roofs shall not be used as component parts.

Exception: Use of building walls, floors, or roofs shall be permitted when construction is noncombustible and the building component is designed as an integral part of the duct system.

2-4.5* Ducts shall lead directly to the point of termination. Terminations with discharge to the atmosphere shall be arranged safely.

2-4.6* Materials shall be confined to and removed from the area where they are generated, by hoods or enclosures and an air-moving device.

Exception: When vapors are generated and it is not possible for the process to be enclosed or hoods installed, general ventilation through a system of suction ducts shall be permitted.

2-4.7* Vapors containing residues or noncombustible particulate solids shall be filtered.

2-4.8 Duct liners that are combustible shall meet one of the following requirements.

(a) They shall be tested as part of a listed duct system that has been evaluated and found to be of low fire hazard not requiring automatic sprinkler protection to prevent fire spread.

(b) They shall be used for handling noncombustible material or flammable corrosive vapors and shall have automatic sprinkler protection as required by Chapter 6.

2-4.9 Additional branch ducts shall not be added to an existing system without redesign of the system. Branch ducts shall not be disconnected nor unused portions of the system be blanked off without provision for means to maintain required airflow.

2-4.10 Flexible ducts shall not be used in exhaust systems.

Exception: Flexible ducts shall be permitted to be used at inlets where moveability or portability is required. Where used, they shall have strength equivalent to that of the connecting ducts.

2-5 Hangers and Supports.

2-5.1 Duct supports shall be designed to carry the weight of the duct half filled with material. Where sprinkler protection is provided in the duct, the hanger's design shall include the weight of the duct half filled with water or with the material being conveyed, whichever has the higher density. Loads shall not be placed on connecting equipment.

Exception: Where adequate drainage is provided, the weight of the water shall not require consideration.

2-5.2 Hangers and supports exposed to corrosive atmospheres shall be type 316 SS or equivalent.

2-5.3 To avoid vibration and stress on the duct, hangers and supports shall be securely fastened to the building or structure.

2-5.4 Hangers and supports shall be designed to allow for expansion and contraction.

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: When the combustible material and 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.

2-6.1.2 With all clearance reduction systems using a ventilated airspace, 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/ft^3 (3.6 kg/m^3) 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./ft^2·hr·°F (0.14 W/m^2·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 the 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 airspace between the combustible wall and the wall protector, air circulation shall be provided by one of the following methods.

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.

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

Clearance reduction applied to and covering all combustible surfaces within the distance specified as required clearance with no protection in 2-6.2	Maximum Allowable Reduction in Clearance (%)	
Form of Protection	**As Wall Protector**	**As Ceiling Protector**
(a) $3^1/_2$-in. (90-mm) thick masonry wall without ventilated airspace	33	—
(b) $^1/_2$-in. (13-mm) thick noncombustible insulation board over 1-in. 25.4-mm) glass fiber or mineral wool batts without ventilated airspace	50	33
(c) 0.024-in. (0.61-mm) (24-gauge) sheet metal over 1-in. (25.4-mm) glass fiber or mineral wool batts reinforced with wire, or equivalent, on rear face with at least a 1-in. (25.4-mm) air gap	66	66
(d) $3^1/_2$-in. (90-mm) thick masonry wall with at least a 1-in. (25.4-mm) air gap	66	—
(e) 0.024-in. (0.61-mm) (24-gauge) sheet metal with at least a 1-in. (25.4-mm) air gap	66	50
(f) $^1/_2$-in. (13-mm) thick noncombustible insulation board with at least a 1-in. (25.4-mm) air gap	66	50
(g) 0.024-in. (0.61-mm) (24-gauge) sheet metal with ventilated airspace over 0.024-in. (0.61-mm) (24-gauge) sheet metal with at least a 1-in. (25.4-mm) air gap	66	50
(h) 1-in. (25.4-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. (25.4-mm) air gap	66	50

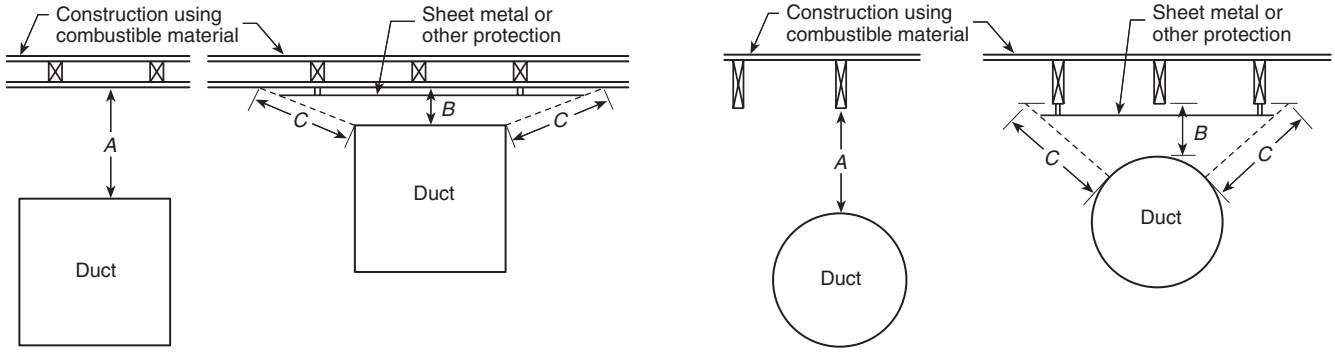
2-6.4 All clearances shall be measured from the outer surface of the combustible material to the nearest point on the outer surface of the duct, disregarding any intervening protection applied to the combustible material. Clearances shall be measured as shown in Figure 2-6.4. Clearances with protection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

The minimum allowable clearance with protection shall be determined using the following equation:

$$C_{pr} = C_{un}\left(\frac{1 - R}{100}\right)$$

where:

C_{pr} = minimum allowable clearance with protection
C_{un} = required clearance with no protection
R = maximum allowed reduction in clearance



Notes:
1. *A* = required clearance with no protection
2. *B* = reduced clearance permitted
3. The protection applied to the construction using combustible material shall extend far enough in each direction to make *C* = *A*.

Figure 2-6.4 Extent of protection required to reduce clearances from ducts.

Chapter 3 Corrosive Materials

3-1 General. Exhaust systems utilizing plastic material shall be permitted to be used to convey corrosives. The choice of the material type shall be the responsibility of the design engineer. All chemical-resistant plastics have heat limitations that shall be considered in the design of a system. The following minimum standards of materials, construction, and workmanship shall be deemed necessary to ensure minimum fire hazard in the operation of these systems.

3-1.1 Plastic ducts shall be in accordance with 2-2.1 and 2-4.8. All hoods and air-moving device surfaces that are part of the system shall have flame spread ratings at least equivalent to the flame spread rating of the material of the duct system.

3-1.2 When located in a multistory building or a concealed space, plastic duct materials shall be listed with an external smoke development rating of 50 or less.

Exception No. 1: Duct systems that are located in an area protected by an automatic sprinkler system.

Exception No. 2: Duct systems that are located in a 1-hour fire-rated enclosure.

Chapter 4 Air-Moving Devices

4-1 General. Air-moving devices shall be constructed of noncombustible materials and shall be designed and installed to convey materials through the exhaust system safely.

Exception: Where the materials conveyed are not compatible with metals, alternate materials of construction shall be permitted.

4-2 Flammable or Combustible Materials. Where the materials conveyed are flammable or combustible, the rotating element of the air-moving device shall be nonferrous, or the air-moving device shall be constructed so that a shift of the rotating element or shaft does not permit two ferrous parts to rub or strike.

4-3 Clearance. Clearance between the rotating element and the fan casing shall be provided to avoid friction that might lead to fire. Allowances shall be made for expansion and loading to prevent contact between moving parts and the duct or fan housing.

4-4 Fans. Fan-rotating elements shall be mounted on a shaft designed to maintain proper alignment even when the blades or impeller are loaded.

4-5 Motors and Other Electrical Equipment. Motors, bearings, drive components, and electrical equipment shall not be placed inside ducts unless they are protected or enclosed to prevent ignition of flammable vapors, mists, residues, dusts, or other combustible materials that are conveyed in the exhaust system.

4-6 Maintenance and Inspection. Air-moving devices shall be located to permit ready access for inspection, lubrication, maintenance, cleaning, and repair. They shall be placed on foundations or firmly secured to supports.

4-7 Location of Air-Moving Devices. Air-moving devices used in systems that air convey dust or vapors containing residue shall be located on the clean-air side of the filtration system.

4-8 Flexible Connections. Flexible connections shall be permitted in order to minimize the transmission of vibration.

Chapter 5 Ignition Sources

5-1 Electrical Equipment. All electrical equipment and installations shall comply with the requirements of NFPA 70, *National Electrical Code®*.

5-2* Static Electricity.

5-2.1* All system components shall be conductive. Bonding and grounding with a resistance of less than 1.0×10^6 ohms to ground shall be provided.

Exception: Nonconductive equipment shall be permitted to be used as covered in this document by Chapter 3, Corrosive Materials, where it is shown that the material conveyed does not create an atmosphere that is above 25 percent of the lower flammable limit (LFL).

5-2.2 Where belt drives are used, the belts shall be electrically conductive at 1 megohm or less.

5-3 Manifolds. Operations generating flames, sparks, or hot material such as from grinding wheels and welding shall not be manifolded into any exhaust system that handles flammable or combustible materials.

5-4 Open Flames and Sparks. The requirements of 5-4.1 through 5-4.3 shall be applied retroactively.

5-4.1 Cutting and welding shall comply with the applicable requirements of NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work.*

5-4.2 Grinding, chipping, and other operations that produce either sparks or open flame ignition sources shall be controlled by a hot work permit system in accordance with NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work.*

5-4.3 Smoking shall be permitted only in designated areas.

5-5 Removal of Ferrous Materials. Ferrous materials capable of igniting combustible material being conveyed shall be removed from the exhaust stream by magnetic separators of the permanent or electromagnetic type. Where electromagnetic separators are used, provisions shall be made to indicate the loss of power to the electromagnetic separators.

5-6* Belt Drives. Belt drives shall be designed to stall without the belt slipping, or a safety device shall be provided to shut down the equipment if slippage occurs.

5-7* Bearings. Roller or ball bearings shall be used on all processing and transfer equipment. Lubrication shall be performed in accordance with the manufacturer's recommendations.

Exception: Bushings shall be permitted to be used when an engineering evaluation shows that mechanical loads and speeds preclude ignition due to frictional heating.

5-8 Equipment. Equipment with moving parts shall be installed and maintained so that true alignment is maintained and clearance is provided to minimize friction.

Chapter 6 Fire Protection

6-1* General. Exhaust systems utilizing combustible components or having the potential for combustible residue buildup on the inside shall be provided with an automatic extinguish-

ing system within the duct and at the duct intake, hood, enclosure, or canopy.

Exception No. 1: Ducts with cross-sectional areas less than 75 in.^{2} (0.0484 m^2).

Exception No. 2: Systems constructed of material listed for use without sprinkler protection.

6-2 Drainage. When a sprinkler system is installed, means shall be provided to prevent water accumulation in the duct or flow of water back to a process subject to damage by water.

6-3 Testing and Inspection. Fire protection shall be tested and inspected in accordance with the applicable NFPA standards.

Chapter 7 Testing and Maintenance

7-1 General. Exhaust systems shall be tested, inspected, and maintained to ensure safe operating conditions.

7-1.1 The responsibility for proper maintenance shall be assigned to trained personnel who are capable of recognizing potential hazards.

7-1.2 Such maintenance shall include the determination that special protection for duct systems is fully operable and that plant automatic sprinkler protection is in service.

7-2* System Test. When installation of new systems is complete, the system shall be fully tested to demonstrate performance before acceptance by the owner. Modified systems shall be retested.

7-3* Existing Systems. Existing systems shall be tested periodically by the owner to demonstrate continued performance.

7-4* System Inspection. All system components shall be inspected monthly.

Exception No. 1: Where manufacturer's requirements are more stringent.

Exception No. 2: Where conditions of service dictate more frequent inspection.

7-4.1 Adequate maintenance of air-conveying systems requires monthly inspection of the duct, fittings, hardware, filtration system, and air-moving devices.

7-4.2 This inspection shall include the hoods, enclosures, air inlets, ducts, and access doors through the termination of the system. It shall include the termination, adjacent surfaces, and any adjacent air intakes.

7-4.3 The user's operational and maintenance program shall include all of the manufacturer's listed procedures that are applicable to the equipment.

7-4.4 An operational and maintenance checklist shall be maintained and is essential to safe operation of the equipment.

7-4.5 Accumulations of conveyed materials and residues shall be removed from hoods and enclosures, ducts and fittings, and air-moving devices. The ducts shall be checked for obstructions such as improperly adjusted dampers or shutters. Filtration systems shall be inspected and filters cleaned or replaced as required.

7-4.6 Air-moving devices shall be inspected for belt tension and wear and lubrication.

7-4.7 Hoods and enclosures shall be inspected for proper confinement and removal of materials.

7-5 Cleanliness. Ductwork shall be examined periodically to determine adequacy of cleaning frequency.

7-6 Maintenance Program. All system components shall be maintained in good operating condition. A written maintenance program shall be established. The program shall include any and all recommendations provided by the manufacturer.

All deficiencies found during testing and inspection shall be corrected. Serious deficiencies shall require immediate attention.

7-7 Maintenance Log. An operational maintenance log shall be kept to document maintenance actions.

Chapter 8 Referenced Publications

8-1 The following documents or portions thereof are referenced within this standard as mandatory requirements and shall be considered part of the requirements of this standard. The edition indicated for each referenced mandatory document is the current edition as of the date of the NFPA issuance of this standard. Some of these mandatory documents might also be referenced in this standard for specific informational purposes and, therefore, are also listed in Appendix B.

8-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work,* 1999 edition.

NFPA 69, *Standard on Explosion Prevention Systems,* 1997 edition.

NFPA 70, *National Electrical Code®,* 1999 edition.

NFPA 221, *Standard for Fire Walls and Fire Barrier Walls,* 1997 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials,* 1998 edition.

8-1.2 SMACNA Publications. Sheet Metal and Air-Conditioning Contractors' National Association, Inc., 4201 Lafayette Center Drive, Chantilly, VA 22021.

Accepted Industry Practice for Industrial Duct Construction, 1975.

Rectangular Industrial Duct Construction Standard, 1980.

Round Industrial Duct Construction Standard, 1977.

Thermoplastic Duct (PVC) Construction Manual, 2nd edition, 1995.

Thermoset FRP Duct Construction Manual, 1997.

Appendix A Explanatory Material

Appendix A is not a part of the requirements of this NFPA document but is included for informational purposes only. This appendix contains explanatory material, numbered to correspond with the applicable text paragraphs.

A-1-1 The following NFPA standards contain information on the application of exhaust systems to specific industries or operations.

NFPA 30, *Flammable and Combustible Liquids Code*

NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products*

NFPA 32, *Standard for Drycleaning Plants*

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

NFPA 34, *Standard for Dipping and Coating Processes Using Flammable or Combustible Liquids*

NFPA 35, *Standard for the Manufacture of Organic Coatings*

NFPA 36, *Standard for Solvent Extraction Plants*

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*

NFPA 46, *Recommended Safe Practice for Storage of Forest Products*

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

NFPA 68, *Guide for Venting of Deflagrations*

NFPA 86, *Standard for Ovens and Furnaces*

NFPA 86C, *Standard for Industrial Furnaces Using a Special Processing Atmosphere*

NFPA 86D, *Standard for Industrial Furnaces Using Vacuum as an Atmosphere*

NFPA 88B, *Standard for Repair Garages*

NFPA 92A, *Recommended Practice for Smoke-Control Systems*

NFPA 92B, *Guide for Smoke Management Systems in Malls, Atria, and Large Areas*

NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations*

NFPA 120, *Standard for Coal Preparation Plants*

NFPA 204, *Guide for Smoke and Heat Venting*

NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*

NFPA 303, *Fire Protection Standard for Marinas and Boatyards*

NFPA 318, *Standard for the Protection of Cleanrooms*

NFPA 409, *Standard on Aircraft Hangars*

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 650, *Standard for Pneumatic Conveying Systems for Handling Combustible Particulate Solids*

NFPA 651, *Standard for the Machining and Finishing of Aluminum and the Production and Handling of Aluminum Powders*

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*

NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*

NFPA 8501, *Standard for Single Burner Boiler Operation*

A-1-5 Air-Moving Device. An air-moving device is a fan, centrifugal fan, or mixed-flow fan. These devices have previously been called blowers or exhausters.

A-1-5 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A-1-5 Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A-1-5 Exhaust System. A system can consist of an air-moving device with ducting, connected either to the inlet or discharge or to both. More complicated systems can include ductwork, an air-moving device, control dampers, a filtration system, noise attenuation, and pollution control equipment.

A-1-5 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A-1-5 Noncombustible Material. Materials reported as passing ASTM E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C,* are considered noncombustible materials.

A-1-5 Noncombustible Particulate Solid. Noncombustible particulate solids include dusts, fibers, fines, chips, chunks, flakes, and mixtures of these.

A-2-1.2 Materials, when mixed, should not create a fire, explosion, or health hazard.

A-2-1.5 Capture, control, and conveying of materials is achieved by inward airflow generated by the exhaust pickup or intake, the intake velocity, and the duct velocity.

Capture velocities should be high enough to maintain control of the material

(a) To convey the material to the intake opening

(b) To overcome thermal air currents from hot processes or heat-generating operations

(c) To overcome air currents caused by grinding wheels and belt conveyors

(d) To overcome air currents caused by dumping and filling operations

Exhaust systems designed for gases, vapors, fumes, and fine dust particles (20 microns or less) require intake velocities high enough to offset air currents caused by room cross-drafts.

Duct velocities are determined by the type of material conveyed *(see Table A-2-1.5).*

The designer also must consider sticky or wet residues or particles, electrostatic effects, and so forth.

Table A-2-1.5 Range of Minimum Duct Design Velocities

Nature of Contaminant	Examples	Design Velocity
Vapors, gases, smoke	All vapors, gases, and smoke	Any desired velocity (economic optimum velocity usually 1000–2000 ft/min) (305–610 m/min)
Fumes	Welding	2000–2500 ft/min (610–763 m/min)
Very fine light dust	Cotton lint, wood flour, litho powder	2500–3000 ft/min (763–915 m/min)
Dry dusts and powders	Fine rubber dust, Bakelite® molding powder dust, jute lint, cotton dust, shavings (light), soap dust, leather shavings	3000–4000 ft/min (915–1220 m/min)
Average industrial dust	Grinding dust, buffing lint (dry), wool jute dust (shaker waste), coffee beans, shoe dust, granite dust, silica flour, general material handling, brick cutting, clay dust, foundry (general), limestone dust, packaging and weighing asbestos dust in textile industries	3500–4000 ft/min (1068–1220 m/min)
Heavy dusts	Sawdust (heavy and wet), metal turnings, foundry tumbling barrels and shake-out, sand blast dust, wood blocks, hog waste, brass turnings, cast iron boring dust, lead dust	4000–4500 ft/min (1220–1373 m/min)
Heavy or moist	Lead dusts with small chips, moist cement dust, asbestos chunks from transite pipe cutting machines, buffing lint (sticky), quick-lime dust	4500 ft/min and up (1373 and up m/min)

Source: *Industrial Ventilation — a Manual of Recommended Practice,* ACGIH.

For further information, refer to *Industrial Ventilation — a Manual of Recommended Practice,* published by the American Conference of Governmental Industrial Hygienists (ACGIH).

A-2-1.8 The design of the exhaust system should be coordinated with the architectural and structural designs. The plans and specifications should include a list of all equipment, giving manufacturer and type number, and should show the data listed below. Plans should be drawn to an indicated scale and show all essential details as to location, construction, ventilation ductwork, volume of outside air at standard temperature and pressure introduced for safety ventilation, and control wiring diagrams. The details of the plan should include the following:

(a) Name of owner and occupant
(b) Location, including street address
(c) Point of compass
(d) Ceiling construction
(e) Full height cross-section
(f) Location of fire walls
(g) Location of partitions
(h) Materials of duct construction

A-2-3.3 Access into ducts is required to perform intended inspection, to clean interior surfaces, and to service or replace devices located inside the duct.

A-2-4.5 Discharge should terminate away from outside air intakes to prevent material from entering the air intakes. For duct systems containing flammable or combustible materials, an evaluation is necessary to determine adequate exhaust stack termination design. Information on stack height can be found in the *ASHRAE 1997 Handbook Fundamentals,* the "Airflow Around Buildings" chapter, or the ACGIH publication, *Industrial Ventilation — a Manual of Recommended Practice.*

A-2-4.6 In any vapor-conveying system, control should be provided at the point of generation. Control is provided by hoods or enclosures connected to suction ducts. These can confine vapors and, in most cases, will do this with lower air volume.

When the vapors cannot be readily picked up at the source, general ventilation through a system of suction ducts can be used. The suction inlets have little directional effect beyond a few inches from the inlet; they should be located to sweep the air and minimize pockets that have no air movement. The location of the air makeup system ductwork and discharge points will provide more uniform air movement.

When vapors are heavier than air or vapors and residues are mixed, inlets located near the floor should be considered. When the vapors are lighter than air, the inlets should be located near the ceiling of the room or enclosure.

A-2-4.7 Methods of filtering include other means besides cloth or paper-type filters. Examples of filtration devices include, but are not limited to, disposable or cleanable filters, scrubbers, cyclones, dust collectors, or reduction of transport velocity.

A-5-2 See NFPA 77, *Recommended Practice on Static Electricity,* for information on this subject.

A-5-2.1 Bonding minimizes the potential difference between conductive objects. Grounding minimizes the potential difference between objects and ground.

Using metal ducts with nonconductive plastic liners to convey mists and particulate solids can create a propagating brush discharge ignition or shock or both.

A-5-6 Transmission of power by direct drive should be used where possible in preference to belt or chain drives.

A-5-7 Consideration should be given to the potential for overheating caused by dust entry into bearings. Bearings should be located outside the exhaust stream where they are less exposed and more accessible for inspection and service. Where bearings are in contact with particulate solid streams, sealed or purged bearings are preferred.

A-6-1 For additional information on these topics, please see the following:

NFPA 11, *Standard for Low-Expansion Foam*
NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*
NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*
NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*
NFPA 13, *Standard for the Installation of Sprinkler Systems*
NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*
NFPA 17, *Standard for Dry Chemical Extinguishing Systems*
NFPA 17A, *Standard for Wet Chemical Extinguishing Systems*
NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems.*

A-7-2 *Initial Test.* The following outlines the required procedure and the minimum data necessary for a thorough initial ventilation test:

(a) Review the system specifications and drawings to determine the relative location and sizes of ducts, fittings, and associated system components.

(b) Inspect the system to determine that its installation is in accordance with the specifications and drawings. Check such items as fan rotation, belt slippage, damper settings, and thermal overload sizes of starters.

(c) Make a single-line drawing of the installed system and select and identify test locations.

(d) Measure the air volume, fan static pressure, motor rpm and amperes, and the temperature of the air in the system. Also, determine pressure drops across all components (such as air-cleaning equipment).

(e) Record the test data and design specifications.

(f) Compare the test data with design specifications and determine if alterations or adjustments of the system are necessary to meet specifications.

(g) If alterations or adjustments are made, retest the system and record the final test data, noting any physical changes that were made on the sketch.

(h) Provide a permanent label indicating fan data — static pressures, rpm, and motor current.

(i) Lock all dampers and mark positions with permanent marker.

(j) Retain test data sheets for the life of the system.

Field Test. The field tests described above pertain to air-handling characteristics only. At times it is necessary or desirable to conduct tests of the environment to determine if the system is providing the desired environmental control. In these cases, the services of a trained industrial hygienist would be required.

For some tests, moisture content of the air in the system or the ambient barometric pressure should be obtained.

All periodic measurements can also be made continuously by means of an operating console or other remote readout system.

The value of obtaining ventilation test data is noted in the following applications:

(a) To record the initial performance of the system and determine if it is functioning in accordance with specifications
(b) To determine the degree of compliance with applicable codes or trade association standards
(c) To provide data upon which to base any necessary changes in the system
(d) To obtain data to assist in the design of future systems
(e) To determine whether the system has sufficient capacity for additional ductwork or other alterations
(f) To obtain data through periodic checks to determine when maintenance or repairs are necessary

A-7-3 The following procedure should be followed for measurements needed to perform the periodic tests:

(a) Refer to the initial test data sheet for test locations.

(b) Inspect the system for physical damage (broken, corroded, collapsed duct, and so forth) and proper operation of components (fan rotation, damper positions, air cleaner condition, and so forth).

(c) Measure static pressure at the same locations used in the initial test.

(d) Compare measured static pressure recorded at the same locations used in the initial test to the initial pressure values.

(e) Make and record any corrections required.

(f) Recheck the system to verify performance if corrections have been made.

A-7-4 Inspection should include hoods; enclosures; ducts; duct connections; filtration system; blast gates locked in marked positions; access openings closed and secured; air-moving device inlets and outlets; air-moving device for belt tension, vibration, and lubrication; and termination and adjacent surfaces.

Appendix B Referenced Publications

B-1 The following documents or portions thereof are referenced within this standard for informational purposes only and are thus not considered part of the requirements of this standard unless also listed in Chapter 8. The edition indicated here for each reference is the current edition as of the date of the NFPA issuance of this standard.

B-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 11, *Standard for Low-Expansion Foam,* 1998 edition.
NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems,* 1999 edition.
NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems,* 1998 edition.
NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems,* 1997 edition.
NFPA 13, *Standard for the Installation of Sprinkler Systems,* 1996 edition.
NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 1996 edition.
NFPA 17, *Standard for Dry Chemical Extinguishing Systems,* 1998 edition.
NFPA 17A, *Standard for Wet Chemical Extinguishing Systems,* 1998 edition.
NFPA 30, *Flammable and Combustible Liquids Code,* 1996 edition.
NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products,* 1998 edition.
NFPA 32, *Standard for Drycleaning Plants,* 1996 edition.
NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials,* 1995 edition.
NFPA 34, *Standard for Dipping and Coating Processes Using Flammable or Combustible Liquids,* 1995 edition.