NFPA

91

ANSI / NFPA 91
An American
National
Standard
June 9, 1983

BLOWER AND EXHAUST SYSTEMS 1983

NATIONAL FIRE PROTECTION ASSOCIATION, INC
Batterymarch Park, Quincy, MA 02269

3M-6-83-FP
Printed in U.S.A.

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Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

Continued on inside back cover

Standard for the Installation of

Blower and Exhaust Systems
for Dust, Stock and Vapor Removal or Conveying

NFPA 91-1983

1983 Edition of NFPA 91

This edition of NFPA 91, *Standard for the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying*, was prepared by the Technical Committee on Blower Systems and acted on by the National Fire Protection Association, Inc. on May 18, 1983, at its Annual Meeting in Kansas City, Missouri. It was issued by the Standards Council on June 9, 1983 with an effective date of June 29, 1983, and supersedes all previous editions.

The 1983 edition of this standard has been approved by the American National Standards Institute.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

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. This 1983 edition has been completely updated to conform with the NFPA Manual of Style and incorporates minor revisions in each chapter.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

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.

Contents

Standard for the Installation of
Blower and Exhaust Systems
for Dust, Stock and Vapor Removal or Conveying

NFPA 91-1983

Chapter 1 Introduction

1-1* Scope. This standard is submitted as a guide for the proper installation and safeguarding of these systems, taking into consideration the purpose for which they are intended and the functions that they are designed to perform.

1-2 Purpose. The object of this standard is to eliminate or reduce the known fire and explosion hazards inherent in the operation of these systems and to prevent them from becoming the means of spreading fire.

1-3* Equivalency. Nothing in this standard is intended to prevent the use of new methods or devices, provided that sufficient technical data is submitted to the authority having jurisdiction to demonstrate that the proposed method or device is equivalent in quality, strength, fire endurance, effectiveness, durability, and safety to that prescribed by this standard.

1-4 Retroactivity. This standard is based on product and engineering practices recognized as being acceptable at the date of issue. Therefore, provisions of this standard are not intended to be applied retroactively.

1-5 Definitions.

Blower. A fan used to force air under pressure into a space.

Exhauster. A fan used to withdraw air, gas, or solid materials (dust, refuse and stock) from a space under suction.

Fan. An assembly comprising blades or runners and housings or casings, and being either a blower or exhauster.

Ducts. Pipes, channels, or other enclosures, used for the purpose of conveying air, gas, dust, refuse or other materials.

Fire Wall. A wall having adequate fire resistance and structural stability under fire conditions to accomplish the purpose of completely subdividing a building or completely separating adjoining buildings to restrict the spread of fire.

Noncombustible Material. A material which, 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. Materials reported as noncombustible when tested in accordance with the *Standard Method of Test for Noncombustibility of Elementary Materials*, ASTM E-136 (1973), shall be considered noncombustible materials.

Approved. Acceptable to the "authority having jurisdiction."

NOTE: 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 or 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 concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

Authority Having Jurisdiction. The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

NOTE: 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, 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 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."

Shall. Indicates a mandatory requirement.

Chapter 2 General Requirements.

2-1* General. These general requirements apply to systems for removal of flammable vapors (including paint spraying residue); corrosive fumes; dust, stock and refuse conveying; except as modified or amplified by the specific rules which follow (Chapters 3 and 4) or by the standards applying to specific industries or operations.

2-2 Design.

2-2.1 The design of any air moving equipment (AME) shall include adequate consideration of stock to be handled, its physical and chemical properties and its hazard classification. Two or more materials to be handled by the same AME requires further consideration by the designer to determine if the mixture of two or more materials will be compatible, such as one dust with another dust, flammable vapor with a dust, or a dust with limited amounts of flammable vapors.

2-2.2 The design, construction, workmanship and installation of the duct and system components which conform to the *Industrial Ventilation - A Manual of Recommended Practices*, published by the American Conference of Governmental Industrial Hygienists, is acceptable unless otherwise modified by this standard.

2-2.3 The engineer who designs the blower system shall coordinate his plans with the architect and structural engineer with respect to construction features.

2-3* Maintenance Responsibility.

2-3.1 An adequate maintenance program for all air moving equipment (AME) requires a periodic inspection over its entire length, from entrance to exhaust hood for duct system to point of discharge, including the roof area where air is discharged outdoors.

2-3.2 There shall be an adequate check of the entire AME, including each blower unit, its operating control panel, fume scrubbers, and especially any fire damper for proven tightness when closed, and all flexible connections to determine their tightness.

2-3.3 The responsibility for proper maintenance rests with each plant manager who may assign the daily work to a person trained in this type of work. Such maintenance shall include the determination that a special protection for duct systems is fully operable and that plant automatic sprinkler protection is in service.

2-4 Approvals, Plans and Specifications

2-4.1 Before new equipment is installed or existing equipment remodeled, complete working plans and specifications shall be submitted for approval to the authority having jurisdiction. Plans shall be drawn to an indicated scale, and show all essential details as to location, construction, ventilation duct work, volume of outside air at standard temperature and pressure introduced for safety ventilation and control wiring diagrams. The plans shall include a list of all equipment giving manufacturer and type number, and show the following data:

Name of owner and occupant

Location, including street address

Point of compass

Ceiling construction

Full height cross section

Location of fire walls

Location of partitions

Materials of duct construction

2-4.2 Any deviation from this standard shall require special permission from the authority having jurisdiction.

2-5 Power and Control.

2-5.1 All electrical equipment shall be installed in accordance with NFPA 70, *National Electrical Code®*.

2-5.2 Motors shall be located outside of rooms in which flammable vapors or flammable dust are being generated and removed, unless of the type approved for the particular conditions or hazard. Where necessary to install switches or other electrical apparatus in areas where explosive atmospheres might be created, only such equipment as is approved for the specific conditions obtaining shall be used. (*See Article 500 of the National Electrical Code*).

2-5.3 Remote control of all blower or exhaust fans shall be provided in addition to any control located close to the equipment.

2-6 Fans.

2-6.1* Fans shall be of noncombustible construction and of adequate capacity to properly perform the functions required.

2-6.2 Fans shall be so located and arranged as to afford ready access for repairing, cleaning, inspection and lubricating. They shall be placed on proper foundations or firmly secured to substantial supports.

2-6.3* Where flammable solid materials or vapors are passed through fans, the rotating element and the casing shall be constructed of compatible materials which are unlikely to cause ignition by friction or impact between the rotating elements and the casing. Aluminum and magnesium alloys are not compatible with ferrous alloys which may rust.

2-6.4 Where there is a probability of solid foreign material passing through the fan, both the rotating element and the casing shall be constructed of materials which are unlikely to produce a spark upon impact with the foreign material.

2-6.5 Housings or casings shall be of substantial construction to prevent distortion and loss of alignment under operating conditions.

2-6.6 Blades or impellers and shafting shall be sufficiently strong and designed with adequate clearance to prevent contact with casings or prevent distortion under conditions of deposit loading or other factors.

2-6.7 Exposed openings into housings shall be protected with substantial metal screens or gratings to prevent accidents or the entry of foreign material.

2-6.8 Bearings shall be constructed in accordance with the best modern practice and shall be so proportioned, secured and aligned as to prevent overheating. Bearings shall be accessible for lubrication and shall be well designed to prevent leakage of oil and minimize dust infiltration. They shall be located outside of casings and ducts unless proper shielding and dustproofing is provided.

2-7 Ducts.

2-7.1 Except as provided in Chapter 5, ducts shall be constructed entirely of sheet metal or other noncombustible material, and of adequate strength and rigidity to meet the conditions of service and installation requirements, and shall be properly protected where subject to mechanical injury. Minimium thickness for metal ducts are specified in 3-3.3, 4-3.1 and 4-3.2.

2-7.2 The entire duct system shall be self-contained. No rooms or portions of the building shall be used as an integral part of the system unless constructed of noncombustible material, and such design and arrangement shall be subject to the approval of the authority having jurisdiction.

2-7.3 All ducts shall be made reasonably tight throughout and shall have no openings other than those required for the proper operation and maintenance of the system.

2-7.4 All ducts, whether inside or outside of buildings, shall be thoroughly braced where required and substantially supported by metal hangers or brackets.

2-7.5 Where ducts are used for conveying explosive gases or dust, the supports shall be designed to afford strength and rigidity against disruption.

2-7.6 All laps in the piping shall be made in the direction of the air flow.

2-7.7 Changes in size of ducts shall be by means of a taper transformation piece, the included angle of the taper being not more than 30°.

2-7.8 The passing of ducts through fire walls shall be avoided wherever possible (*see definitions of fire wall, Section 1-5*). When ducts or the outlets from or inlets to them pass through fire walls, they shall be provided with automatic closing fire doors on both sides of the wall through which they pass. (*See Figures 2-1 and 2-2.*)

NOTE: Such fire doors shall be provided for the protection of openings in fire walls except that for small openings not exceeding 18 in. (457 mm) in diameter, ⅛-in. (9.5-mm) steel plates may be used in lieu of fire doors, or fire dampers listed by a recognized testing laboratory may be used in accordance with the conditions of their listing.

2-7.9 Actuation of fire doors shall be by fusible links or other approved thermal units, such units to be located on both sides of the fire wall.

2-7.10 Where ducts pass through walls, floors or partitions the space around the duct shall be sealed with rope asbestos, mineral wool or other noncombustible material to prevent the passage of flame and smoke.

2-7.11 Exhaust systems shall be designed with an adequate number of access panels for examining and cleaning of the duct system as well as for manual fire fighting. Hand holes for damper, sprinkler or fusible link inspection or resetting and for residue clean-out purposes shall be equipped with tight fitting sliding or swinging doors provided with substantial latches, except in the case of vertical sliding doors held in place by gravity.

2-8 Duct Clearances.

2-8.1 All duct systems handling noncombustible materials and operating at approximately room temperature shall have a clearance of at least 6 in. (152 mm) from stored combustible materials, and not

less than ½-in. (12.7-mm) clearance from combustible construction even though flameproofed, fire-retardant treated or plastered, except as noted in 2-8.2 and 2-8.3.

2-8.2 Duct systems handling combustible material shall have a clearance of not less than 18 in. (457 mm) from combustible construction or any combustible material. The clearance to combustible construction may be reduced, provided the combustible construction is protected as described in Table 2-8.2. If a duct system is equipped with adequate automatic sprinklers, clearance may be as provided in 2-8.1.

2-8.3 Operation at Elevated Temperatures.

2-8.3.1 Duct systems operating at elevated temperatures [above 100°F (37.7°C)] shall have clearance from combustible building construction or any combustible material not less than shown in Table 2-8.1.

Table 2-8.1

Duct Gas Temperature	Largest Duct Dimension	Clearance
Up to 600°F (315°C) incl.	8 in. (203 mm)	8 in. (203 mm)
	Over 8 in. (203 mm)	12 in. (305 mm)
Over 600°-900°F (315°C-482°C) incl.	8 in. (203 mm)	18 in. (457 mm)
	Over 8 in. (203 mm)	24 in. (610 mm)
Over 900°F (482°C)	All ducts lined with refractories	24 in. (610 mm)

NOTE: Where experience indicates that fires in duct systems are a fairly common occurrence or there is a likelihood that fires will occur, because of the very nature of the occupancy using such duct systems, a greater clearance may be required as is the case of NFPA 33, *Spray Application Using Flammable and Combustible Materials*; and NFPA 96, *Removal of Smoke and Grease Laden Vapors from Commercial Cooking Equipment*, where a clearance of 18 in. (457 mm) between ducts and unprotected combustible material is required.

2-8.3.2 Ducts handling materials at temperatures in excess of 900°F (482°C) shall be lined with refractory material or the equivalent.

2-8.3.3 The clearance to combustible construction for ducts handling materials not in excess of 900°F (482°C) may be reduced provided the combustible construction is protected as described in Table 2-8.2.

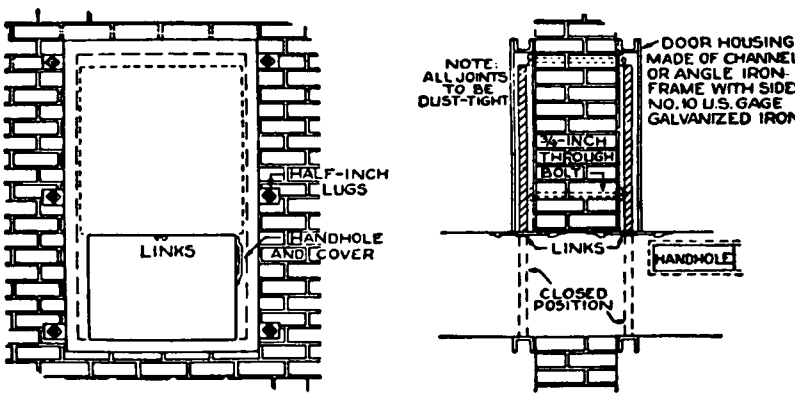


Figure 2-1 Suggested type of vertical fire door for duct passing through opening in fire wall

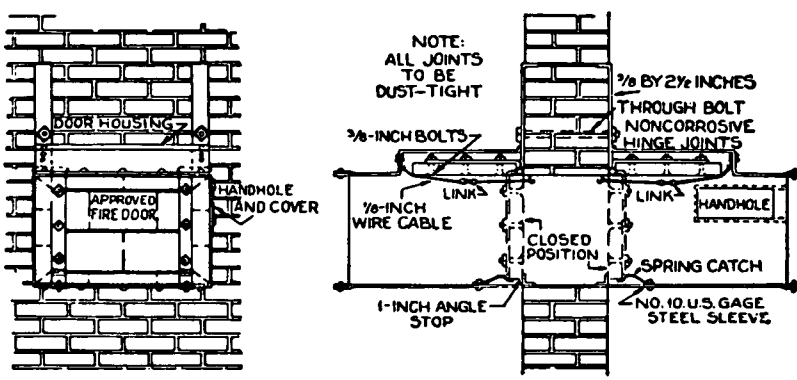


Figure 2-2 Suggested type of automatic hinged fire door for duct passing through opening in fire wall

Table 2-8.2

Clearances, Inches, with Specified Forms of Protection*

Type of Protection Applied to the Combustible Material. Thicknesses are Minimum	Where the Required Clearance with No Protection is [in. (mm)]: 8 in. (203 mm)	12 in. (305 mm)	18 in. (457 mm)	24 in. (610 mm)
a) ¼-in. (6.5 mm) asbestos millboard spaced out 1 in.†	3 (76)	6 (152)	12 (305)	18 (457)
b) 28-gauge sheet metal on ¼-in. (6.5 mm) asbestos millboard	3 (76)	6 (152)	12 (305)	16 (406)
c) 28-gauge sheet metal spaced out 1 in. (25.4 mm)†	2 (51)	4 (102)	9 (229)	12 (305)
d) 28-gauge sheet metal on ⅛-in. (3.2 mm) asbestos millboard spaced out 1 in. (25.4 mm)†	2 (51)	4 (102)	9 (229)	12 (305)

*All clearances shall be measured from the surface of the duct to combustible material disregarding any intervening protection applied to the combustible material.

†Spacers shall be of noncombustible material.

2-9 Protection Against Static Electricity.

2-9.1 All metal parts of apparatus, used in systems for the removal of flammable gases or vapors, or systems used for conveying combustible or flammable dust, stock or refuse, considered in these requirements, including fans, ducts, etc., as well as shafting in connection therewith, shall be electrically bonded and grounded in an effective and approved manner. (*See NFPA 77.*)

2-9.2 When metallic contact is broken at duct joints or at other points on the installation assembly, metallic straps, preferably of copper, shall be installed where necessary to afford effective bonding connections.

2-9.3 When systems are used for the handling of flammable gases or vapors or combustible or flammable dust, stock or refuse, static electricity shall be removed from belts by grounded metal combs or other effective means. (*See recommendations of NFPA 77.*)

2-10 Fire Extinguishing Apparatus, Manual or Automatic.

2-10.1* The provision of automatic or special extinguishing equipment for systems handling flammable vapors or combustible materials shall be subject to the authority having jurisdiction.

2-10.2 For specific recommendations, see Chapters 3, 4 and 5 covering the particular type of materials being handled, as well as the applicable NFPA standards for the specific materials. (*See Section 2-1.*)

2-10.3* For installation of a particular type of fire protection system, see the applicable NFPA standard for that system. For other protection systems, the installation shall be subject to the authority having jurisdiction.

2-10.4 When a sprinkler system is installed, adequate means shall be provided to prevent water accumulation in the duct or flow of water back to a process subject to damage by water.

Chapter 3 Systems for Removal of Flammable Vapors

3-1 General.

3-1.1 Where systems of this class are installed, the following rules and the preceding general rules except as modified herein shall apply. See Section 2-1.

3-1.2* Due to the hazardous nature of the vapors to be removed, it is important that they be withdrawn from the rooms or equipment in which they are generated and taken to the outside of the building in the most direct manner possible.

3-1.3 Exhaust outlets to atmosphere shall extend above or away from surrounding structures to prevent accumulation of combustible residues on such structures.

3-2 System Design.

3-2.1 In the design of any vapor removal system, control at the point of generation shall be provided wherever possible. Such systems shall consist of hoods or enclosures connected to suction ducts. They are more positive and require lower exhaust volumes than general ventilation through remote suction openings.

Exception: When flammable vapors are so generated that they cannot be readily picked up at the source, general ventilation through a system of suction ducts with inlets to the room or area may be employed. As suction inlets have but little directional effect beyond a few inches from the face of the inlet, such inlets should be located to best produce a sweeping or purging effect that will tend to avoid pockets in which vapors may accumulate. An air supply system properly located with reference to point of vapor generation and exhaust openings will be beneficial in vapor dilution and removal.

3-2.2 In addition to the requirements of 3-2.1, where heavier than air vapors or mixtures are handled, exhaust openings located near the floor line shall be required. Conversely for vapors or mixtures lighter than air, exhaust system inlets shall be located near the top of the room, hood, or enclosure.

3-2.3 Outlets to atmosphere shall be kept clear of and away from any combustible material.

3-3 Ducts.

3-3.1 Ducts installed under this classification shall be independent structures, and not built in the walls. Exhaust ducts shall lead to the outside of the building as directly as possible, and never through intermediate rooms.

3-3.2 The installation of dampers, valves and shutters in this type of system is not advisable. However, these devices may be necessary at outlets to afford weather protection when the system is shut down or where such devices are used for the final balancing of the exhaust system. In such cases the dampers shall be securely locked to prevent further manipulation, or complete shutoff.

3-3.3 Ducts shall be so constructed as to provide structural strength and stability at least equivalent to sheet steel of not less than the following thicknesses:

In Greatest Dimension	
Up to 8 in. (203 mm) incl.	No. 24 U.S. gauge
Over 8 in. (203 mm) to 18 in. (457 mm) incl.	No. 22 U.S. gauge
Over 18 in. (457 mm) to 30 in. (762 mm) incl.	No. 20 U.S. gauge
Over 30 in. (762 mm)	No. 18 U.S. gauge

3-3.4 Material for duct lining shall be noncombustible.

3-3.5 No dissimilar matter shall be handled through one exhaust system when the intermingling or contact of one type of material with another would create a fire or explosion hazard in the duct system, collection unit or air flow producing equipment. Operations generating sparks, such as from hot materials or grinding wheels, shall not be consolidated in the same exhaust system that handles flammable or explosive matter.

Chapter 4 Duct Systems for Moving, Conveying or Transporting Stock, Vapor or Dust

4-1 General.

4-1.1* The proper design and installation of ducts and system components are necessary for the moving, conveying or transporting of stock, vapors or dust. (*Also see Section 2-10.*)

4-1.2 Except as provided in Chapter 5, ducts shall be constructed entirely of metal or other noncombustible material and of adequate strength and rigidity to meet the conditions of service and installation requirements. The sheet metal duct system shall be properly protected where subject to mechanical damage.

4-1.3 All duct systems shall be installed in a permanent and workmanlike manner.

4-2 System Design.

4-2.1 In systems handling combustible materials or flammable vapors, the Air Moving Equipment (A.M.E.) shall comply with Section 3-3 and be located on the clean air side of the collector.

4-2.2 Conveying systems for cotton and similar textile materials which are readily ignitable shall be designed so as not to create suction in machines producing the material.

4-2.3 Rooms or bins into which readily ignitable material is discharged by a collecting or conveying system shall be of noncombustible or fire-resistive construction. Such rooms or bins shall be provided with explosion vents in accordance with NFPA 68, *Guide for Explosion Venting*.

4-2.4 The use of a trap at the junction of a hood or a branch duct shall be subject to the authority having jurisdiction, and shall be so arranged that it cannot be filled completely with dust or stock.

4-2.5 Approved magnetic separators of the permanent magnetic or electromagnetic types shall be installed at those points where combustible materials which contain foreign ferrous particles enter the system. The separators shall be of sufficient size to insure the removal of all ferrous materials passing over them.

4-3 Construction.

4-3.1 The materials, thickness, construction, and installation of ducts shall provide structural strength and durability in conformance with recognized good practice. Ducts shall be deemed as meeting the intent of this section if constructed and installed in accordance with:

(a) Industrial Ventilation - A Manual of Recommended Practices. (*See Section 2-2.2.*)

(b) The ASHRAE Handbook and Products Directory, 1979 Equipment.

(c) Round Industrial Duct Construction Standards (1977) and Rectangular Industrial Duct Construction Standards (1980) (Sheet Metal and Air Conditioning Contractors National Association).

4-3.2 Metal ducts shall be constructed of sheet steel of not less than the following gauges (*see references in 4-3.1*):

Table 4-3.2

Diameter of Straight Ducts	U.S. Standard Gauge for Steel Duct		
	Class I	Class II	Class III
Up to 8 in. (203 mm)	24	22	20
Over 8 in. (203 mm) to 18 in. (457 mm)	22	20	18
Over 18 in. (457 mm) to 30 in. (762 mm)	20	18	16
Over 30 in. (762 mm)	18	16	14

Class I: Includes nonabrasive applications such as paint spray, woodworking, pharmaceutical and food products, discharge ducts from dust collectors.

Class II: Includes nonabrasive materials in high concentrations. (Low pressure pneumatic conveying) moderately abrasive materials; and highly abrasive materials in light concentrations. Typical examples are conveying of chemicals and wood dusts; exhaust of foundry shakeouts and sand-handling systems, grain dusts; coal crushing and screening and grinding; buffing and polishing.

Class III: Includes all highly abrasive materials in moderate to heavy concentration and moderately abrasive materials in heavy concentrations such as low pressure conveying of tobacco; exhaust systems from sand and grit blasting, abrasive cleaning operation, rock and ore screening, crushing dryers and kilns; fly ash from boiler stacks.

4-3.3 The main suction and discharge ducts shall be made as short as practicable.

4-3.4 Every duct shall be kept open and unobstructed throughout its length and no screen shall be placed in it.

4-3.5 Additional branch ducts shall not be added to an existing system without redesigning the system. Branch ducts may not be disconnected nor unused portions of the system be blanked off without providing orifice plates to maintain required airflow.

4-3.6 When flexible duct section is necessary, it shall be a type which will not restrict the airflow, will be as short as possible, and number of flexible sections shall be kept to a minimum.

4-4 System Details.

4-4.1 Acceptable longitudinal seams of ducts are continuous welded, lapped and riveted, or spot welded on 3 in. (76 mm) centers maximum.

Exception: Double-lock seams may be used on Class I ducts.

4-4.2 Lapped girth joints of ducts shall be made with the inner lap in direction of airflow, with 1 in. (25.4 mm) lap for diameters 19 in. (483 mm) or less and with 1¼ in. (32 mm) laps for diameters over 19 in. (483 mm).

4-4.3 Hoods shall be free of sharp edges or burrs and reinforced to provide necessary stiffness.

4-4.4 The duct connection to a fan inlet shall be made with a split sleeve drawband at least one pipe diameter long, but not less than 12 in. (305 mm) or be an approved flexible connector.

4-4.5 Transitions in mains and sub-mains are to be tapered; the taper shall be 5 in. (127 mm) long for 1 in. (25.4 mm) change in diameter.

4-4.6 Access openings or cleanouts shall be provided as necessary for proper maintenance of equipment near each elbow, change of direction of more than 15 degrees or duct junction in horizontal sections, except for systems with noncorrosive gases and vapors containing no particulate matter.

4-4.7 Where blast gates are used for adjustment of the system, they shall be located near the connection of the branch to the main. A means of locking the blast gates after adjustments have been made shall be provided. Butterfly dampers shall not be permitted.

4-4.8 When transporting stock or dust, rectangular ducts may be used only when clearance prevents the use of round ducts. Rectangular ducts shall be made as nearly square as possible. Construction details are to be equal to round duct construction whose diameter equals the longest side.

Chapter 5 Plastic Systems for Removal of Nonflammable Corrosive Fumes and Vapors

5-1 General.

5-1.1 Duct systems of plastic material may be used to handle only nonflammable corrosive fumes and vapors when conventional metal duct systems will not be adequate. The choice of the type material is the responsibility of the design engineer, but contained herein are minimum standards of materials, construction, and workmanship deemed necessary to insure minimum fire hazard in the operation of these systems. All chemical resistant plastics have heat limitations which must be considered when designing a system.

5-1.2 Environments containing oxidizers classed by NFPA 43A as 2, 3, 4, or Class 1 oxidizers that can deposit residue in the duct shall not be handled in plastic ducts.

5-1.3 The plastic shall have a flame spread rating of 25 or less as measured in accordance with NFPA 255, *Standard Method of Test for Surface Burning Characteristics of Building Materials*.

5-1.4 Plastic duct material used in multistory buildings or which run through concealed spaces other than fire-rated vertical shafts shall have a smoke developed rating of 50 or less, unless the duct system is protected externally by an approved automatic sprinkler system.

5-2 System Components. In order to avoid misunderstandings caused by different terminology in various parts of the country and within the air handling industry, the following components of a typical industrial exhaust system and a typical laboratory fume hood exhaust system are described by diagrammatical reference to the numbered and lettered components listed below, shown in Figures 5-2, 5-3, 5-4, and 5-5.

I. Equipment
   A. Cabinet type laboratory fume hood
   B. Bench type laboratory fume hood
   C. Filter box for special or high efficiency filters
   D. Shaft
   E. Horizontal type fume scrubber

F. Vertical type fume scrubber

G. Service pit or trench

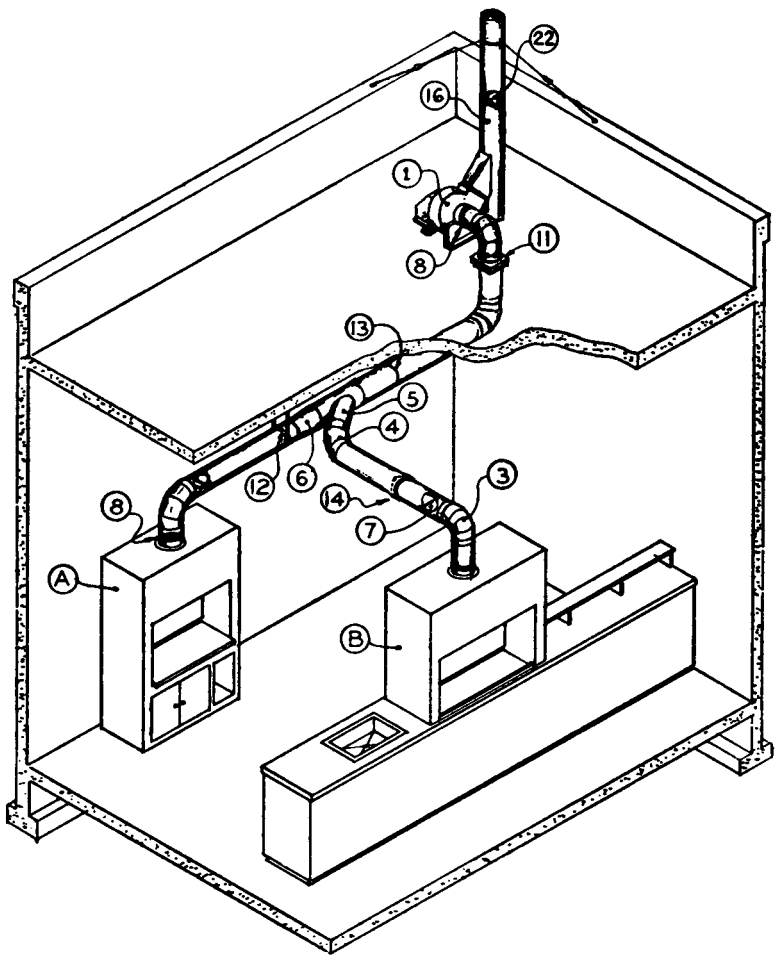
II. System Components

1. Air moving equipment (centrifugal type exhaust fan)
2. Horizontal duct section
3. 90° Elbow
4. Elbow (less than 90°)
5. Lateral entry
6. Transition
7. Manual balancing damper
8. Flexible connection
9. Fire damper
10. Access door
11. Counterflashing
12. Duct hanger
13. Circumferential girth joint (butt welded)
14. Bell end duct seam
15. Weather cap
16. Fan discharge stack
17. Flanged duct connection
18. Open face tank exhaust hood (updraft)
19. Slotted face tank exhaust hood (updraft)
20. Open face tank exhaust hood (downdraft)
21. Round to rectangular (or square) transitional fitting
22. Gravity operated back draft damper

5-3 Installation.

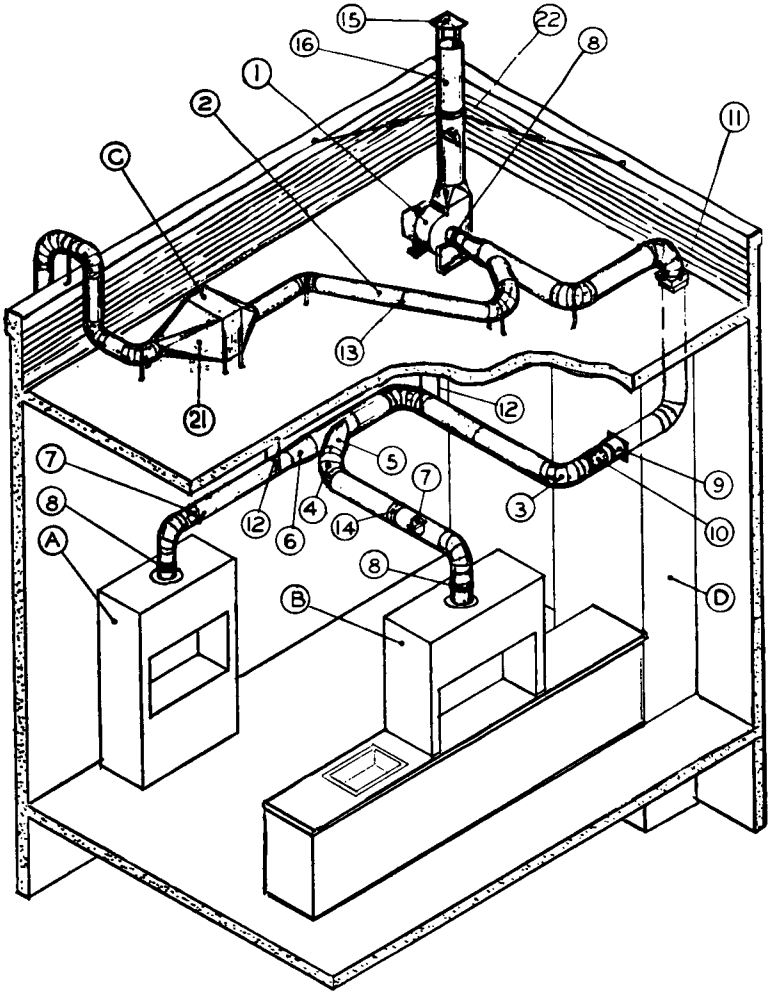
5-3.1 The ducts shall lead to the outside as directly as practicable. They shall not penetrate fire walls or fire rated floors. When penetrating a fire rated shaft wall or fire partition, the opening shall be protected by a fire damper, protected against corrosion from the agent being conveyed.

5-3.2 Manifold systems shall be limited to 50,000 cfm (23.6 cubic meters per second) capacity, except when special process engineering considerations necessitate larger manifolded systems. Such systems shall be designed by a registered professional engineer.



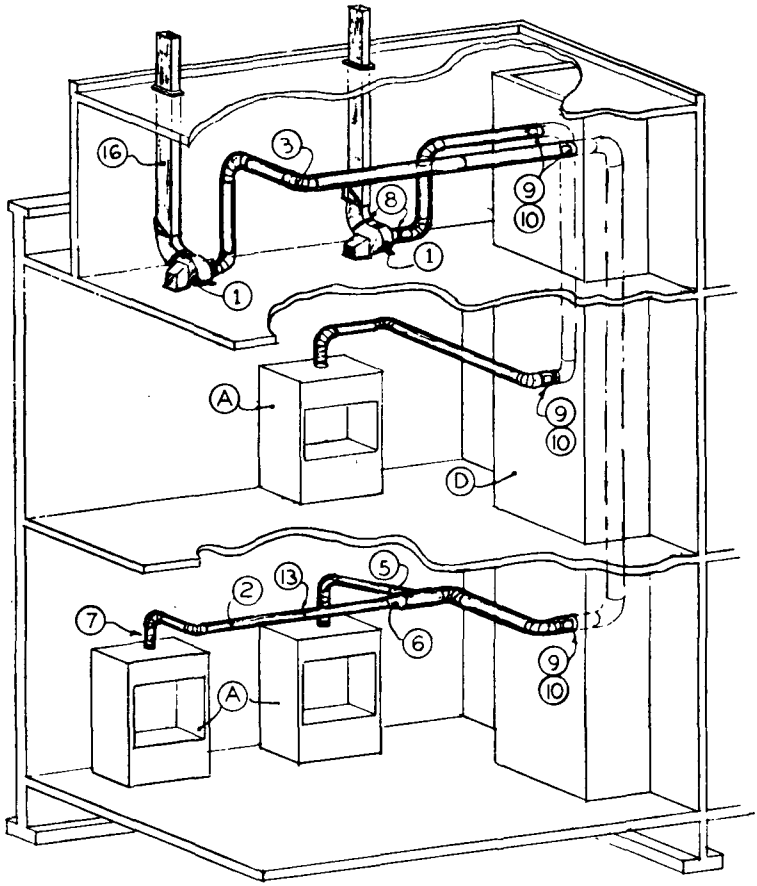
See Legend in Section 5-2.

Figure 5-2 Rooftop exhaust system for one-story building occupied by a cabinet-type laboratory fume hood and bench-type laboratory fume hood.



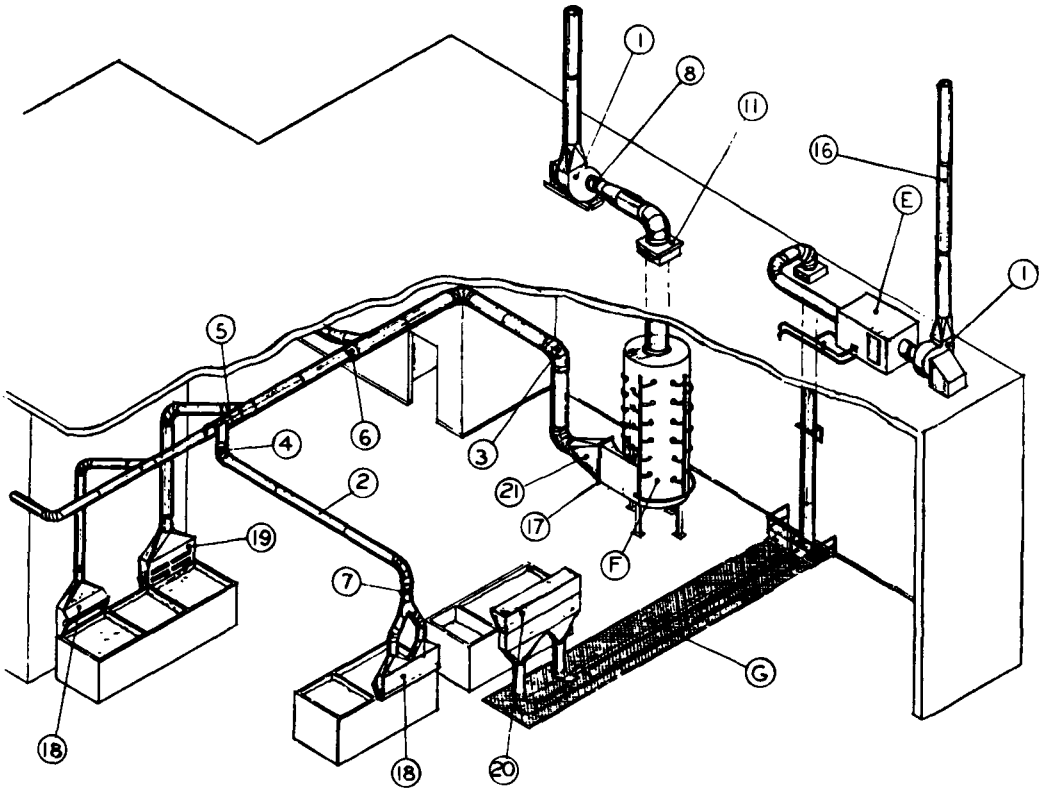
See Legend in Section 5-2.

Figure 5-3 Exhaust system with filter box for multistory building occupied by a cabinet-type laboratory fume hood and bench-type laboratory fume hood.



See Legend in Section 5-2.

Figure 5-4 Internal exhaust system for multistory building occupied by cabinet-type laboratory fume hoods.



See Legend in Section 5-2

Figure 5-5 Exhaust system for one-story building occupied by various-type fume hoods with vertical-type fume scrubber and service trench.

5-3.3 Flexible Connections. Vibration isolation between ductwork and air moving equipment can be accomplished by flexible connections at the inlet and discharge of the equipment. Corrosion resistance, smoke developed rating, and flame spread rating of these connections shall be at least equal to that of the material of the duct system.

5-3.4 All hoods and air moving equipment surfaces which are part of the system shall have flame spread rating at least equal to the material of the duct system. Design and workmanship shall meet all physical requirements and shall conform to the general sections of this standard.

5-3.5 Hangers and Supports. Ductwork shall be supported in accordance with the engineer's specifications and recommendations. In locations where hangers are exposed to corrosive atmosphere adjacent to hoods, tanks, or other process equipment, hanger material and hardware shall be Type 316 stainless steel or equal. In locations where hangers are not subject to corrosive fumes, other steel with rust protection shall be provided. Hangers and supports shall be securely fastened to the building or structure to avoid vibration. Care shall be taken in supporting the ductwork to avoid creating conditions of stress on the material in the finished installation.

5-4* Fire Protection.

5-4.1 Automatic protection shall be provided at the duct intake, hood, canopy and the immediate areas thereof to quickly extinguish source fires. (*See NFPA Standards 11, 11A, 12, 12A, 12B, 13, 15, and 17.*)

5-4.2 Sensing elements provided at these aforementioned sources shall be arranged to shut down the blower system. This automatic shutdown may be waived if fire control can be improved through continued operation.

5-5 Identification. Plastic duct components shall be identified as to the manufacturer, type of material, flame spread rating, and smoke-developed rating.

5-6 Maintenance Responsibility. After a system is installed and turned over to the owner or operator, it is important that the system is maintained in good operating condition. This responsibility entails periodic inspection of all components at least twice each year. Inspections shall include at least the following parts of the system:

Hood face velocity for all types of hoods

Clean filters in filter boxes

Proper function of fume scrubbers

Proper operation of air moving equipment, including greasing of bearings and replacement of worn belts on drives
Fan discharge stack
Gravity operated back draft dampers
Motor operated close off dampers
Manual balancing dampers
Flexible connections at inlet and discharge of air moving equipment
Fire dampers
Access doors
Duct and equipment hangers and supports.

5-7 Reinforced Thermosetting Plastic Duct

5-7.1* The generic term "reinforced thermosetting plastic duct" can refer to many plastic materials. In commercial practice, reinforced thermosetting plastic duct construction is largely confined to glass-fiber reinforced thermosetting polyester, fabricated to the Department of Commerce voluntary standard PS-15-69.

5-7.2 System Design.

5-7.2.1 The construction, workmanship and assembly of the duct and hoods shall conform to the Department of Commerce Standard PS-15-69. Other related methods, such as filament winding, may be considered acceptable provided they are shown to afford the same overall strength and chemical resistance that would be obtained with a contact molded laminate meeting the specified thickness of PS-15-69.

5-7.2.2 The mechanical properties of all laminates shall conform to Table 5-7.2.2 taken from PS-15-69.

Table 5-7.2.2
Requirements for Properties of Reinforced-Polyester Laminates

Property at 73.4°F (23°C)	Thickness [in. (mm)] ⅛ to 3/16 (3.2 mm to 4.8 mm) psi	¼ (6.5 mm) psi	5/16 (8 mm) psi	⅜ and up (9.6 mm) psi
Ultimate tensile strength-minimum	9,000	12,000	13,500	15,000
Flexural strength-minimum	16,000	19,000	20,000	22,000
Flexural modulus of elasticity (tangent)-minimum	700,000	800,000	900,000	1,000,000

For SI Units: 1 psi = 6.89 kPa.

5-7.2.3 The size of round duct shall be determined by the inside diameter in inches (mm). Unless otherwise specified, the tolerance shall be ± 1/16 in. (1.6 mm) for ducting up to and including 6 in. (152 mm) diameter, and ± 1/8 in. (3.2 mm) or ± 1 per cent, whichever is greater, for ducting exceeding 6 in. (152 mm).

5-7.2.4 The size of rectangular ducting shall be determined by the inside dimensions. The tolerances shall be ± 3/16 in. (4.8 mm) for dimensions up to 18 in. (457 mm) and under; ± 1 percent for dimensions over 18 in. (457 mm).

5-7.2.5 The minimum thickness of round, contact molded duct shall be in accordance with Table 5-7.2.5 taken from PS-15-69. For rectangular ducting, the minimum thickness shall be specified as in Table 5-7.2.5, substituting the longer side for the diameter.

5-7.2.6 The maximum deflection of a side on a rectangular duct shall not exceed 1 percent of the width of the side under operating conditions. Ribs or other special construction shall be used to meet the deflection requirement.

5-7.2.7 Other design details, such as fittings, flanges, methods of joining, etc. are to conform to PS-15-69.

5-7.2.8 For cleanouts and other general requirements see Chapter 2.

5-8 Thermoplastics.

5-8.1 Thermoplastic materials are a separate group of plastics from the thermosets outlined in Section 5-7. Thermoplastics have in common a number of chemical, physical and mechanical properties which make them suitable to application on exhaust systems conveying corrosive agents.

5-8.2 Materials used in the fabrication of the system components shall conform to ASTM-D-1784-69 under cell classifications 12454-B (for Type I Grade I), 12454-C (for Type I Grade II) and 23447-B (for Type IV). Base product standards are as follows:

Laminated Sheet	ASTM D-1927-67
Pressure Rated	ASTM D-2241-67
Extruded Pipe and Duct	ASTM D-1785-67A

Table 5-7.2.5

Reinforced-Polyester Round Duct Dimensions[1]

(For SI Units: 1 ft = .3048 m; 1 in. = 25.4 mm)

I.D. inches	Wall Thickness (Min.) inches	Allowable Vacuum[2] inches of water	Allowable Pressure[2] inches of water	Flange Diameter (O.D.) inches	Flange Thickness inches	Bolt Circle Diameter inches	Bolt Hole Diameter inches	No. of Bolt Holes
2	0.125	405	750	6-3/8	1/4	5	7/16	4
3	0.125	405	500	7-3/8	1/4	6	7/16	4
4	0.125	210	410	8-3/8	1/4	7	7/16	4
6	0.125	64	350	10-3/8	1/4	9	7/16	8
8	0.125	30	180	12-3/8	1/4	11	7/16	8
10	0.125	16	340	14-3/8	3/8	13	7/16	12
12	0.125	9	280	16-3/8	3/8	15	7/16	12
14	0.125	7	220	18-3/8	3/8	17	7/16	12
16	0.125	6	290	20-3/8	1/2	19	7/16	16
18	0.125	5	240	22-3/8	1/2	21	7/16	16
20	0.125	5	190	24-3/8	1/2	23	7/16	20
24	0.187	9	140	28-3/8	1/2	27	7/16	20
30	0.187	7	100	34-3/8	1/2	33	7/16	28
36	0.187	5	70	40-3/8	1/2	39	7/16	32
42	0.250	10	120	46-3/8	5/8	45	7/16	36
48	0.250	9	100	54 3/8	5/8	52	9/16	44
54	0.250	7	80	60-3/8	5/8	58	9/16	44
60	0.250	6	60	66-3/8	5/8	64	9/16	52

[1] 5 to 1 design factor of safety based on data in Table 1. Also based on 10 ft (3.04 mm) lengths between stiffener rings for vacuum service.

[2] These ratings are suitable for use up to 180° F (82.2° C) in pressure service and ambient atmospheric temperatures on vacuum service. For ratings at higher temperatures consult the manufacturer.

5-8.3 System Design.

5-8.3.1 Round Ductwork.

5-8.3.1.1 Round ductwork can be fabricated from sheet material by heating the material to a pliable state and forming it over cylindrical mandrels. After forming the duct section, the longitudinal seam must be welded. Round duct is also available as an extruded, seamless tube starting at 6-in. (152 mm) diameter in 1-in. (25.4 mm) increments through 12-in. (305 mm) diameter, as well as 14-in. (356 mm) diameter and 16-in. (406 mm) diameter. Minimum wall thickness for round duct shall be in accordance with the following table:

Inside Duct Diameter	Minimum Wall Thickness
Up to 18 in. (457 mm)	1/8 in. (3.2 mm)
19 to 30 in. (483 mm to 762 mm)	5/16 in. (4.8 mm)
31 to 54 in. (787 mm to 1372 mm)	1/4 in. (6.5 mm)
55 to 72 in. (1397 mm to 1829 mm)	1/4 in. (6.5 mm) with 2 in. (51 mm) wide girth straps on 4 ft. (1.22 m) centers.

5-8.3.1.2 Elbows and bevels shall have a minimum centerline radius of 1½ times the duct diameter whenever possible. Elbows shall have at least five sections, and bevels shall be pieced accordingly. Molded, vacuum-formed or die-formed elbows and bevels with a centerline radius of 1½ times the duct diameter are also acceptable. Transition fittings in mains and submains are to have a taper of 5 in. (127 mm) in length for each 1-in. (25.4 mm) change in diameter, wherever possible. Branch ducts shall tee into the main at the large end of the transition at an angle not exceeding 45°. Branch tees shall not be placed directly opposite each other.

5-8.3.2 Rectangular Ductwork.

5-8.3.2.1 Rectangular duct sections shall be uniform throughout their length with formed corner construction for maximum strength. Welded corner seams are to be avoided unless some special condition necessitates welded corner construction. Rectangular ducts shall have minimum wall thickness in accordance with the following table:

Longer Side	Minimum Wall Thickness
Up to 18 in. (457 mm)	1/8 in. (3.2 mm)
19 to 30 in. (483 mm to 762 mm)	5/16 in. (4.8 mm)
31 to 48 in. (787 mm to 1219 mm)	1/4 in. (6.5 mm)
49 to 60 in. (1244 mm to 1524 mm)	1/4 in. (6.5 mm) with angle or T-bar reinforcing on 4 ft (1.22 m) centers.
61 in. (1549 mm) and up	1/4 in. (6.5 mm) with angle or T-bar reinforcing on 2 ft (0.61 m) centers.

5-8.3.2.2 Elbows and bevels can be either formed corner construction or welded corner seams. Whenever possible, elbows are to have a centerline radius equal to 1½ times the depth of the duct. Where space limitation or other conditions necessitate the use of square backed and square throated elbows, turning vanes shall be installed to minimize the system static pressure. Transitions shall be formed corner construction wherever possible. Branch ducts shall tie into mains close to the large end of transitions at an angle not exceeding 45°. Branch tees shall not be positioned directly opposite one another on a main or submain.

5-8.3.3 Welding. Welding shall be done by the hot gas fusion method utilizing filler rod of the same base materials being joined. Welding shall be performed by workmen adequately trained in the art of thermoplastic welding based on ASTM D-1789-65, and by the American Welding Society, 2501 N.W. 7th Street, Miami, FL 33125, in their Welding Handbook, Section 38, Sixth Edition, Chapter 56.

5-8.3.4 System Components Connections. Component parts of the system shall be connected together in such a manner that the system will be approximately equal in strength and rigidity to each individual section, or as recommended by the engineer.

Appendix A

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

The following notes, bearing the same number as the text of this standard to which they apply, contain useful explanatory material and references to standards.

A-1-1 The design and installation of systems coming within the scope of this standard should be in the hands of competent engineers and their maintenance and operation should be in charge of reliable and experienced persons.

A-1-3 In the standards for specific industries or operations there will be found special requirements not embodied in this standard or modifications of certain of these requirements.

A-2-1 The following NFPA standards contain information on the application of blower and exhaust systems to specific industries or operations.

NFPA 30, *Flammable and Combustible Liquids Code*

NFPA 32, *Dry Cleaning Plants*

NFPA 33, *Spray Application Using Flammable and Combustible Liquids*

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

NFPA 35, *Manufacture of Organic Coatings*

NFPA 36, *Solvent Extraction Plants*

NFPA 40E, *Storage of Pyroxlyin Plastic*

NFPA 45, *Fire Protection for Laboratories Using Chemicals*

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

NFPA 48, *Storage, Handling and Processing of Magnesium*

NFPA 61A, *Manufacturing and Handling Starch*

NFPA 61B, *Prevention of Fires and Explosions in Grain Elevators and Facilities Handling Bulk Raw Agricultural Commodities*

NFPA 61C, *Prevention of Fire and Dust Explosion in Feed Mills*

NFPA 65, *Processing and Finishing of Aluminum*