



Member of the FM Global Group

Approval Standard for Fume Exhaust Ducts or Fume and Smoke Exhaust Ducts

Class Number 4922

August 2016

Foreword

The FM Approvals certification mark is intended to verify that the products and services described will meet FM Approvals' stated conditions of performance, safety and quality useful to the ends of property conservation. The purpose of Approval Standards is to present the criteria for FM Approval of various types of products and services, as guidance for FM Approvals personnel, manufacturers, users and authorities having jurisdiction.

Products submitted for certification by FM Approvals shall demonstrate that they meet the intent of the Approval Standard, and that quality control in manufacturing shall ensure a consistently uniform and reliable product. Approval Standards strive to be performance-oriented. They are intended to facilitate technological development.

For examining equipment, materials and services, Approval Standards:

- a) must be useful to the ends of property conservation by preventing, limiting or not causing damage under the conditions stated by the Approval listing; and
- b) must be readily identifiable.

Continuance of Approval and listing depends on compliance with the Approval Agreement, satisfactory performance in the field, on successful re-examinations of equipment, materials, and services as appropriate, and on periodic follow-up audits of the manufacturing facility.

FM Approvals LLC reserves the right in its sole judgment to change or revise its standards, criteria, methods, or procedures.

TABLE OF CONTENTS

1. INTRODUCTION	1
1.1 Purpose.....	1
1.2 Scope.....	1
1.3 Basis for FM Approval.....	1
1.4 Basis for Continued Approval.....	2
1.5 Basis for Requirements.....	2
1.6 Effective Date.....	2
1.7 System of Units.....	2
2. GENERAL INFORMATION	3
2.1 Product Information.....	3
2.2 Requirements.....	3
3. APPLICABLE DOCUMENTS	4
4. GENERAL REQUIREMENTS	5
4.1 Markings.....	5
4.2 Installation Instructions.....	5
4.3 Drawings/Plans/Specifications.....	5
4.4 Other Requirements.....	6
5. PERFORMANCE REQUIREMENTS	6
5.1 Fume Exhaust Ducts.....	6
5.2 Fume and Smoke Exhaust Ducts.....	8
5.3 Small Scale Quality Control Tests.....	10
5.4 Cleanroom Materials.....	11
6 OPERATIONS REQUIREMENTS	12
6.1 Demonstrated Quality Control Program.....	12
6.2 Facilities and Procedures Audit (F&PA).....	12
APPENDIX A: APPROVAL MARKS	13
APPENDIX B: UNITS OF MEASUREMENTS	14
APPENDIX C: Horizontal Fire Test Procedure for Fume or Fume and Smoke Exhaust Ducts	15
C-1 Test Set-Up.....	15
C-2 Test Procedure.....	15
C-3 Performance Requirements.....	16
APPENDIX D: Horizontal/Vertical Combination Fire Test Procedure for Fume or Fume and Smoke Exhaust Ducts	17
D-1 Test Set-Up.....	17
D-2 Test Procedure.....	17
D-3 Performance Requirements.....	18
APPENDIX E: Test Procedure for Evaluating Smoke Removal Ability of Ducts	19
E-1 Purpose.....	19
E-2 Test Set-Up.....	19
E-3 Test Procedure.....	19
E-4 Performance Requirements.....	19
APPENDIX F: Vertical Fire Test Procedure for Fume or Fume and Smoke Exhaust Ducts	20
F-1 Purpose.....	20
F-2 Test Set-Up.....	20
F-3 Test Procedure.....	21
F-4 Performance Requirements.....	21

1. INTRODUCTION

1.1 Purpose

This standard states Approval requirements for ducts used in exhausting noncombustible chemical fumes and corrosive vapors or noncombustible chemical fumes, corrosive vapors and smoke in fire situations.

1.2 Scope

- 1.2.1 This standard sets performance requirements for ducts installed according to limitations and requirements specified for each individually manufactured duct system.
- 1.2.2 The fire performance of a duct depends in part on its ability to limit fire spread and on its ability to exhaust smoke in case of fire, if applicable. It is necessary to evaluate flame spread potential on the interior and exterior of the duct, and its structural integrity after fire exposure when used as a smoke exhaust system.
- 1.2.3 This standard is not intended to determine the suitability for all end use conditions of a product. Conditions under which a duct assembly is used vary widely. For example, ducts may be subjected to environments not represented by standard corrosion tests. This standard, therefore, does not evaluate the corrosion resistance in every environment where duct materials are used for handling corrosive fumes. It is the responsibility of the manufacturer to determine the suitability of the duct system for specific corrosive environments. The manufacturer should be consulted for recommended corrosive fume applications. Further, it is required that the manufacturer comply with all requirements of the “Accepted Industry Practice for Industrial Duct Construction” published by the Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA).
- 1.2.4 This standard evaluates ducts for their performance in regard to fire spread on the inner and outer surface of the duct and the suitability of the duct to be used for smoke removal. However, for ducts not intended for smoke removal in a fire situation (i.e., fume exhaust only) the exhausting capability of the duct is not evaluated.
- 1.2.5 This standard describes the minimum performance requirements for ducts that are intended for use in cleanroom facilities by evaluating the ability of the exterior surface to limit fire spread and smoke damage due to the contamination caused by products of combustion.

1.3 Basis for FM Approval

FM Approval is based upon satisfactory evaluation of the product and the manufacturer in the following major areas:

- 1.3.1 Examination and tests on production samples to evaluate
 - the suitability of the product;
 - the proper operation and performance of the product as specified by the manufacturer and required by FM Approvals; and,
 - the durability and reliability of the product.
- 1.3.2 An examination of the manufacturing facilities and audit of quality control procedures to evaluate the manufacturer’s ability to consistently produce the product as examined and tested, and the marking procedures used to identify the product. These examinations are repeated as part of FM Approvals’ Product follow-up program.

1.4 Basis for Continued Approval

Continued Approval is based upon:

- production or availability of the product as Approved;
- the continued use of acceptable quality control procedures;
- satisfactory field experience;
- compliance with the terms stipulated in the Approval Agreement; and
- re-examination of production samples for continued conformity to requirements.

1.5 Basis for Requirements

1.5.1 The requirements of this standard are based on experience, research and testing and/or the standards of FM Approvals and other organizations. The advice of manufacturers, users, trade associations and loss control specialists was also considered.

1.5.2 Meeting the requirements qualifies a product as an Approved duct for fume exhaust, fume and smoke exhaust or for use in cleanroom applications, as applicable. Requirements prohibit component substitution without prior authorization by FM Approvals.

1.5.3 The requirements of this standard reflect tests and practices used to examine characteristics of fume or fume and smoke exhaust ducts for the purpose of obtaining FM Approval. These requirements are intended primarily as guides and strict conformity is not always mandatory. Fume and smoke handling ducts having characteristics not anticipated by this standard may be Approved if performance equal or superior to that required by this standard is demonstrated, or if the intent of the standard is met. Alternatively, ducts which meet all the requirements identified in this standard may not be Approved if other conditions which adversely affect performance exist or if the intent of this standard is not met.

1.6 Effective Date

1.6.1 The effective date of an Approval Standard mandates that all products tested for Approval after the effective date shall satisfy the requirements of that standard. Products Approved under a previous edition shall comply with the new version by the effective date or else forfeit Approval. The effective date shall apply to the entire Approval Standard, or, where so indicated, only to specific paragraphs of the standard.

1.6.2 The effective date for this standard is **October 1, 2001** for compliance with all requirements.

1.7 System of Units

Units of measurement are U.S. customary units. These are followed by their arithmetic equivalents in International System (SI) units, enclosed in parentheses. Appendix B lists the selected units for qualities dealt with in testing these products; conversions to SI units are included. Conversion of U.S. customary units is in accordance with the American National Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE)/American Society for Testing Materials (ASTM) SI 10-2010, "American National Standard for Metric Practice."

2. GENERAL INFORMATION

2.1 Product Information

- 2.1.1 Duct materials may be, but are not limited to, metal, coated metal, glass reinforced plastics, and polyvinyl chloride (PVC). Some are preformed, rigid, round, rectangular, or oval ducts.
- 2.1.2 Ducts covered by this standard are used for exhausting noncombustible chemical fumes and corrosive vapors, and/or exhausting smoke in fire situations. Experience has shown that duct materials may transmit fire from one area to another, even when they obtain relatively low flame spread ratings from other test methods. To achieve a representative fire test, the actual end use configuration of the duct materials must be considered under conditions of normal use.
- 2.1.3 Fire spread within a duct system is dependent upon the relative combustibility of the basic duct or lining and its joint material, the diameter or cross section of its main header and branch lines, the air flow and its structural integrity.
- 2.1.4 Fire spread within the duct system may be limited by resistance to ignition or by using some form of interruptor to prevent flame propagation. Interruptors may consist of collapsible sections, firestop dampers or automatic sprinklers. It should be noted that ducts incorporating interruptors in their design are not suitable for smoke exhaust use. However, ducts utilizing automatic sprinklers as a means of limiting fire spread may qualify for smoke exhaust if it can be demonstrated by test performance that sufficient air flow capacity remains to exhaust smoke successfully.
- 2.1.5 Some ducts may have different constructions and/or materials on their interior and exterior surfaces. To determine whether or not the duct will cause a spreading fire on its exterior surface, an additional test will be conducted with a fire exposure impinging on the exterior of the duct to evaluate its potential for flame propagation.
- 2.1.6 Due to the sensitivity of cleanroom environments, the high cost of construction and the high value of the equipment and products produced and stored in them, significant damage can be caused by the presence of small amounts of contamination. As a result, it is necessary to evaluate the ability of the exterior surface of the duct to limit fire propagation and restrict the emission of particulates in the form of smoke.
- 2.1.7 Ducts meeting the requirements of this Standard shall receive a listing in the *Approval Guide* as an Approved Fume and/or Smoke Exhaust Duct, as applicable. Ducts that meet the requirements for use in smoke sensitive areas such as cleanrooms shall be so noted in the *Approval Guide* and on the label denoting FM Approval. Resins used to fabricate Approved ducts are eligible to be listed in the FM Approvals' Specification Tested Products Guide as an Identified Resin System.

2.2 Requirements

- 2.2.1 The requirements of this standard shall be used to measure and describe the fire performance of fume exhaust or fume and smoke exhaust ducts in response to exposure from fire and the subsequent ability of the duct to remove smoke under controlled laboratory conditions. The results of these controlled exposures shall not be used to describe or appraise actual exposure conditions, since such conditions vary widely.

Ducts that are intended to be used in cleanroom facilities shall be evaluated for the ability of their exterior surfaces to limit fire propagation and restrict the emission of particulates in the form of smoke.

- 2.2.2 The Approval examination includes fire tests, smoke removal tests, and other such tests as noted (see Appendices C through E). A complete review of construction and applications specifications shall be conducted to assure, as far as possible, a practical and reliable installation. Inspection of the product manufacturing facility and of at least one field installation, at the discretion of FM Approvals, shall be conducted to assure conformance with the required tests and specifications.
- 2.2.3 In addition to the tests required above, the exterior surface of ducts that are intended to be used in cleanroom facilities shall meet the requirements as described in the latest edition of the FM Approvals' Cleanroom Materials Flammability Test Protocol (Class No. 4910).

3. APPLICABLE DOCUMENTS

The following are standards, test methods and practices referenced in this standard:

- “Horizontal Fire Test Procedure for Fume and/or Smoke Exhaust Ducts” — FM Approvals (Appendix C)
 - “Horizontal/Vertical Combination Fire Test Procedure for Fume and/or Smoke Exhaust Ducts” — FM Approvals (Appendix D)
 - “Test Procedure for Evaluating Smoke Removal Ability of Ducts” — FM Approvals (Appendix E)
 - “Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter” — ASTM D 240-92 (modified)
 - “Test Method for Surface Burning Characteristics of Building Materials” — ASTM E 84-99
 - “Ignition Properties of Plastics” — ASTM E 1929-96
 - “Accepted Industry Practice for Industrial Duct Construction” Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA)
- FM Global Property Loss Prevention Data Sheets 1-56, 7-7, and 7-78 (latest editions)
- FM Approvals Cleanroom Materials Flammability Test Protocol (latest edition)
- “Vertical Fire Test Procedure for Fume and/or Smoke Exhaust Ducts” — FM Approvals (Appendix F)

4. GENERAL REQUIREMENTS

4.1 Markings

- 4.1.1 Each section of duct, elbows and fittings shall bear the manufacturer's name, model number or trade name, and the FM Approval Mark (see Appendix A) with the words "DUCT APPROVED FOR (indicated Approval usage, ie, fume exhaust or fume and smoke exhaust) SUBJECT TO THE CONDITIONS OF APPROVAL AS DESCRIBED IN THE CURRENT EDITION OF THE *APPROVAL GUIDE*".
 - 4.1.1.1 Markings for ducts that meet the requirements for use in cleanrooms shall also contain the wording "FM Approvals Listed Cleanroom Material"
- 4.1.2 When ducts are supplied with interruptors or firestop dampers, the marking shall include a symbol showing the direction of the air flow in addition to the items specified in Paragraph 4.1.1 above.
- 4.1.3 Each container of resin that is listed as an Identified Component shall bear a label indicating the resin manufacturer's name, product designation, and the wording that it is a FM Approvals Identified Component Resin System for use in manufacturing fume and/or smoke exhaust ducts, as applicable.
- 4.1.4 Labels denoting FM Approval or status as an Identified Component Resin System shall be applied by the manufacturer only within and on the premises of manufacturing locations that are under the FM Approvals Facilities and Procedures Audit Program.

4.2 Installation Instructions

- 4.2.1 The manufacturer shall make every reasonable effort to supply all necessary instructions and other assistance to the installer to ensure proper installation. Printed application instructions shall be provided by the manufacturer to demonstrate proper installation procedures. As part of the Approval examination, and at the discretion of FM Approvals, at least one inspection of a field installation during and/or after completion shall be required. In some cases, a continued program of inspections shall be necessary to assess the application procedures or changes within the application techniques.
- 4.2.2 The manufacturer shall inform the installer of specific installation requirements and features of duct manufacture as contained in FM Global Property Loss Prevention Data Sheets 1-56, 7-7, 7-78 and other pertinent FM Global standards.

4.3 Drawings/Plans/Specifications

The manufacturer shall provide FM Approvals with complete typical system drawings and raw material specifications, including proprietary formulation(s). Further, the manufacturer shall notify FM Approvals of any change in the manufacturing procedures or materials of the Approved duct prior to general sale and distribution.

4.4 Other Requirements

- 4.4.1 The manufacturer shall furnish sufficient material to assemble the following duct segments, incorporating at least two field assembled joints in each. For the Horizontal Fire Test the duct segment shall be at least 24 ft (7.3 m) long. For the Horizontal/Vertical Combination Fire Test, a 24 ft (7.3 m) long horizontal segment shall be supplied and connected to a 15 ft (4.6 m) vertical segment by an elbow. In such case the two ducts shall be 12 in. (305 mm) in diameter. Ducts made from the same material in larger diameters up to 60 in. (1524 mm) maximum would be expected to perform as well when tested with the same fire exposure. If the manufacturer wishes to obtain FM Approval for ducts smaller than 12 in. (305 mm) additional tests would be required on the smallest diameter or cross section for which Approval is sought.
- 4.4.2 If the material produces excessive quantities of smoke during the fire tests making it difficult to determine the fire spread performance, additional testing may be required.
- 4.4.3 All submitted products shall be representative of a production run of material. Manufacture of the resin system and duct material tested shall be monitored by a representative of FM Approvals.
- 4.4.4 An Approved duct shall be manufactured with identical resins, raw materials, and reinforcing fibers, as applicable, as tested. The formulation shall be retained on file by FM Approvals.
- 4.4.5 If the process served by this duct system produces combustible vapors or flammable residue which can build up inside the duct, then sprinkler protection in the duct shall be required as recommended in FM Global Property Loss Prevention Data Sheet 7-78.
- 4.4.6 The manufacturer shall determine the suitability of the duct system for specific corrosive environments.
- 4.4.7 Vertical sections of duct shall not exceed 15 ft (4.6 m) unless so tested, nor penetrate to other fire areas; otherwise, internal sprinkler protection shall be required.
- 4.4.7.1 Approval for vertical sections of duct that exceed 15 ft (4.6 m) shall be permitted to be evaluated using the Vertical Duct Fire Test. The Vertical Duct Fire Test shall be permitted to be used only upon successful completion of the Horizontal/Vertical Duct Combination Fire Test noted in Paragraph 4.4.1.

5. PERFORMANCE REQUIREMENTS

5.1 Fume Exhaust Ducts

In order to qualify as an Approved duct for noncombustible fume or corrosive vapor exhaust use, the duct must exhibit its ability to limit fire spread by satisfying the performance criteria listed below for the Horizontal Duct Fire Test and the Horizontal/Vertical Duct Combination Fire Test. In addition, a series of quality control tests (see Paragraph 5.3) is also conducted to aid in monitoring of quality controls exercised in the manufacturing process and/or to characterize materials used in the make-up of the duct assembly. The Vertical Duct Fire Test may be used to assess vertical runs greater than 15 ft (4.6 m) as noted in Paragraph 4.4.7.1.

5.1.1 Horizontal Duct Fire Test

A. Requirement

The ability of a horizontally installed segment of duct material to resist flame propagation shall be investigated.

B. Test/Verification

The test arrangement used to obtain this data shall be the FM Approvals Horizontal Apparatus for the Evaluation of Duct Work (see Appendix C)

Performance shall be considered satisfactory if all the following conditions are met during the 15 minute duration of the test:

- flaming shall not spread on the interior of the duct from the fire exposed end to the 23 ft (7.0 m) point;
- the interior duct temperature recorded at the 23 ft (7.0 m) point shall not exceed 1000°F (538°C)
- when the structural integrity of the duct and/or field joints is not maintained, no portion of the duct or joint material that falls, drips or melts off the test sample shall exhibit any flaming or glowing particles upon contact with the floor;
- there shall be no flaming on the exterior of the duct due to autoignition or temperature transmission from the interior of the duct. In cases where flaming appears on the exterior surface as a result of the external fire exposure, the flaming shall be intermittent in nature and shall not propagate beyond the first field joint located 4 ft (1.2 m) from the fire exposure.

5.1.2 Horizontal/Vertical Duct Combination Fire Test

A. Requirement

The ability of a duct material to resist flame propagation when installed to simulate a duct installation incorporating horizontal and vertical runs shall be investigated.

B. Test/Verification

The test arrangement used to obtain this data shall be the FM Approvals Horizontal/Vertical Combination Apparatus for the Evaluation of Duct Work (see Appendix D)

Performance shall be considered satisfactory if all the following conditions are met during the 15 minute duration of the test:

- flaming on the interior of the duct shall not spread from the fire exposed end to the 23 ft (7.0 m) point in the horizontal duct section;
- flaming on the exterior of the duct shall be limited to the vertical duct section and shall not spread to the exterior portion of the horizontal duct section;
- the interior duct temperature recorded at the 23 ft (7.0 m) point shall not exceed 1000°F (538°C)
- when the structural integrity of the duct and/or field joints is not maintained, no portion of the duct or joint material that falls, drips or melts off the test sample shall exhibit any flaming or glowing particles upon contact with the floor.

5.1.3 Vertical Duct Fire Test

A. Requirement

The ability of a duct material to resist flame propagation when vertical runs of duct exceed 15 ft (4.6 m) shall be permitted to be investigated.

B. Test/Verification

The FM Approvals Vertical Duct Test (see Appendix F) may be used to obtain this data as noted in Paragraph 4.4.7.1.

Performance shall be considered satisfactory if all the following conditions are met during the 15 minute duration of the test:

- flaming on the interior of the duct shall not spread to within 10 ft (3.1 m) of the top of the duct
- flaming on the exterior of the duct shall not spread to within 5 ft (1.6 m) of the top of the duct
- the interior duct temperature recorded 1 ft (0.3 m) from the top of the duct shall not exceed 1000°F (538°C)
- when the structural integrity of the duct and/or field joints is not maintained, no portion of the duct or joint material that falls, drips or melts off the test sample shall exhibit any flaming or glowing particles upon contact with the floor.

5.2 Fume and Smoke Exhaust Ducts

In order to qualify as an Approved duct for both noncombustible fume or corrosive vapor and smoke exhaust use, the duct must exhibit its ability to retain its structural integrity and continue to exhaust smoke as well as limiting fire spread by satisfying the performance criteria listed below for the Test for Smoke Removal Ability, in addition to the Horizontal Duct Fire Test and the Horizontal/Vertical Duct Combination Fire Test. A series of Quality Control Tests (see Paragraph 5.3) is also required for Approval in this category. The Vertical Duct Fire Test may be used to assess vertical runs greater than 15 ft (4.6 m) as noted in Paragraph 4.4.7.1.

5.2.1 Horizontal Duct Fire Test

A. Requirement

The ability of the horizontally installed segment of duct material to resist flame propagation and maintain its ability to exhaust smoke effectively shall be investigated.

B. Test/Verification

The test arrangement used to obtain this data shall be the FM Approvals Horizontal Apparatus for the Evaluation of Duct Work (see Appendix C)

Performance shall be considered satisfactory if all the following conditions are met during the 15 minute duration of the test:

- flaming shall not spread on the interior of the duct from the fire exposed end to the 23 ft (7.0 m) point;
- the interior duct temperature recorded at the 23 ft (7.0 m) point shall not exceed 1000°F (538°C);
- the duct and all field applied joints shall maintain their structural integrity without developing any through openings;
- there shall be no flaming on the exterior of the duct due to autoignition or temperature transmission from the interior of the duct. In cases where flaming appears on the exterior surface as a result of the external fire exposure, the flaming shall be intermittent in nature and shall not propagate beyond the first field joint located 4 ft (1.2 m) from the fire exposure;
- no portion of the duct or joint material shall fall, drip or melt off the test sample;
- no smoke or other particulates shall be emitted from the inlet end or the exterior surface of the duct (Exception: smoke or other particulates shall be allowed to be emitted from the exterior surface of the duct provided that the exterior surface is tested in accordance with, and meets the requirements of, the FM Approvals Cleanroom Materials Flammability Apparatus Test Protocol).

5.2.2 Horizontal/Vertical Duct Combination Fire Test

A. Requirement

The ability of a duct material to resist flame propagation and maintain its ability to exhaust smoke effectively when installed to simulate a duct installation incorporating horizontal and vertical runs shall be investigated.

B. Test/Verification

The test arrangement used to obtain this data shall be the FM Approvals Horizontal/Vertical Combination Apparatus for the Evaluation of Duct Work (see Appendix D).

Performance shall be considered satisfactory if all the following conditions are met during the 15 minute duration of the test:

- flaming on the interior of the duct shall not spread from the fire exposed end to the 23 ft (7.0 m) point on the horizontal duct section;
- flaming on the exterior of the duct shall be limited to the vertical duct section and shall not spread to the exterior portion of the horizontal duct section;
- the interior duct temperature recorded at the 23 ft (7.0 m) point shall not exceed 1000°F (538°C)
- the duct and all field applied joints shall maintain their structural integrity without developing any through openings;
- no portion of the duct or joint material shall fall, drip or melt off the test sample;
- no smoke or other particulates shall be emitted from the inlet end or the exterior surface of the duct (Exception: smoke or other particulates shall be allowed to be emitted from the exterior surface of the duct provided that the exterior surface is tested in accordance with, and meets the requirements of, the FM Approvals Cleanroom Materials Flammability Apparatus Test Protocol).

5.2.3 Test for Smoke Removal Ability

A. Requirement

After subjecting the duct to the horizontal fire exposure test as noted in Paragraph 5.2.1, the ability of the duct to exhaust smoke effectively shall be evaluated.

B. Test/Verification

The test apparatus used to obtain this data shall be the FM Approvals Horizontal Apparatus for the Evaluation of Duct Work (see Appendix C).

Upon completion of the horizontal fire test, the exposure source shall be removed and the fan speed increased to induce an air velocity of 2000 ft/min (10 m/sec), and maintained for 10 minutes. Performance shall be considered satisfactory if the following conditions are met:

- there shall be no reduction in the cross-sectional area of the duct
- there shall be no interruption or reduction of air movement through the duct
- no smoke shall be emitted from the inlet end or from the exterior surface of the duct (Exception: smoke or other particulates shall be allowed to be emitted from the exterior surface of the duct provided that the exterior surface is tested in accordance with, and meets the requirements of, the FM Approvals Cleanroom Materials Flammability Apparatus Test Protocol).
- conformance to all performance criteria as specified in Paragraph 5.2.1 above

5.2.4 Vertical Duct Fire Test

A. Requirement

The ability of a duct material to resist flame propagation and maintain its ability to exhaust smoke effectively when vertical runs of duct exceed 15 ft (4.6 m) shall be permitted to be investigated.

B. Test/Verification

The FM Approvals Vertical Duct Test (see Appendix F) may be used to obtain this data as noted in Paragraph 4.4.7.1.

Performance shall be considered satisfactory if all the following conditions are met during the 15 minute duration of the test:

- flaming on the interior of the duct shall not spread to within 10 ft (3.1 m) of the top of the duct
- flaming on the exterior of the duct shall not spread to within 5 ft (1.6 m) of the top of the duct
- the interior duct temperature recorded 1 ft (0.3 m) from the top of the duct shall not exceed 1000°F (538°C)
- the duct and all field applied joints shall maintain their structural integrity without developing any through openings;
- no portion of the duct or joint material shall fall, drip or melt off the test sample;
- no smoke or other particulates shall be emitted from the inlet end or the exterior surface of the duct (Exception: smoke or other particulates shall be allowed to be emitted from the exterior surface of the duct provided that the exterior surface is tested in accordance with, and meets the requirements of, the FM Approvals Cleanroom Materials Flammability Apparatus Test Protocol).

5.3 Small Scale Quality Control Tests

The following series of tests is designed to allow monitoring of quality controls exercised in the manufacturing process and/or to characterize individual materials used in the make-up of the duct assembly.

5.3.1 Requirement

Additional small scale burn tests shall be conducted on the materials used in the make-up of the duct assembly as follows.

5.3.2 Verification

- A. Heat of Combustion — oxygen bomb calorimetry conducted in accordance with ASTM D 240-92 (modified).
- B. Autoignition — conducted in accordance with ASTM D 1929-96
- C. Total Ash — conducted in accordance with the following procedure:

Approximately 10 grams of material are placed in a crucible and dried at 212°F (100°C) until a constant weight is obtained. The crucible is then placed in a muffle furnace with a temperature set at 1500°-2200°F (816°-1204°C) and maintained until a constant weight is obtained. The weight is subtracted from the constant weight obtained and a residue weight is calculated. The residue weight is taken as the weight of total ash. A percent of total ash is then calculated.

D. Surface Burning and Smoke Developed — conducted in accordance with ASTM E 84 (99).

Flame Spread and Smoke Developed values shall be determined for the interior and exterior (if different material from the interior) surfaces. The apparatus used to obtain this data shall be the FM Approvals E-84 Tunnel. The Flame Spread and Smoke Developed values determined shall be reported as specified in ASTM E-84.

E. Ignition Characteristics and Fire properties — conducted using the FM Approvals Laboratory Scale Flammability apparatus (50 kW) in accordance with the following procedure:

- 1) Ignition Characteristics — Piloted ignition tests are conducted in normal air and natural air flow conditions. The sample consists of two sheets of duct material, 4 in. × 4 in. (102 × 102 mm) × minimum wall thickness, which are placed horizontally one on top of the other. The sample surface is blackened with wood charcoal powder so that the surface absorptivity to radiant heat flux remains approximately at unity. The samples are exposed to various external heat flux values (up to 60 kW/m²) and time to ignition is recorded. From a plot between times to ignition and external heat flux values, a minimum heat flux below which ignition is not expected to occur, and a thermal resistance parameter (or ignition resistivity) are determined for the sample.
- 2) Fire Properties — A sample as described above is exposed to a 50 kW/m² radiant heat flux value in normal air. Fire properties, such as chemical heat release rate, mass loss rate, generation of CO and optical density of smoke are measured as a function of time. The peak values are reported.

5.4 Cleanroom Materials

A. Requirement

The ability of the duct's exterior surface to limit fire propagation and restrict the emission of particulates in the form of smoke shall be investigated.

B. Test/Verification

The test apparatus and procedure used to obtain this data shall be the FM Approvals 50 kW Flammability Apparatus as described in the FM Approvals Cleanroom Materials Flammability Apparatus Test Protocol (Class No. 4910).

Performance is considered satisfactory if the results of the Fire Propagation Index (FPI) and the Smoke Damage Index (SDI) are less than or equal than the limitations shown in the FM Approvals Cleanroom Materials Flammability Apparatus Test Protocol (Class No. 4910).

6 OPERATIONS REQUIREMENTS

6.1 Demonstrated Quality Control Program

6.1.1 A Quality Control Program is required to assure that subsequent batch of resin or duct and fittings produced by the manufacturer shall present the same quality and reliability as the specific duct and resin sample(s) examined. Design quality, conformance to design and performance are the areas of primary concern.

Design quality is determined during the examination and tests.

Conformance to design is verified by control of quality in the following areas:

- existence of corporate quality control guidelines
- incoming assurance, including testing
- in-process assurance, including testing
- final inspection and tests
- equipment calibration
- drawing and change control
- packaging and shipping
- handling and disposition of discrepant materials

Quality of performance is determined by field performance and by periodic re-examination and test.

6.1.2 The manufacturer shall establish a system of product configuration control to prevent unauthorized changes, including as appropriate:

- engineering drawings
- engineering change requests
- engineering orders
- change notices

These shall be executed in conformance with a written policy and detailed procedures. Records of all revisions to all Approved products shall be kept.

6.1.3 The manufacturer shall assign an appropriate person or group to be responsible for obtaining FM Approvals authorization of all changes anticipated to Approved or Listed products. FM Approvals Form 797, Approved Product Revision Report or Address/Contact Change Notice is provided to notify FM Approvals of pending changes. Any such changes shall be submitted prior to fabrication and/or distribution, and shall be agreed to in writing by FM Approvals.

6.2 Facilities and Procedures Audit (F&PA)

6.2.1 Inspection of the product manufacturing facility (resin producing and duct fabricating) shall be part of the Identified Component Listing and Approval investigation. Its purpose shall be to determine that resin blending of chemicals and duct fabrication equipment, procedures, and the manufacturer's quality controls are properly maintained to produce a product of the same quality, construction and resin formulation as initially tested.

6.2.2 Unannounced follow-up inspections are conducted to assure continued quality control and product uniformity.

APPENDIX A

APPROVAL MARKS

REPRODUCTION ART: FM Approval Marks

**For use on nameplates, in literature, advertisements,
packaging and other graphics.**



- 1) The FM Approvals diamond mark is acceptable to FM Approvals as an Approval mark when used with the word "Approved."
- 2) The FM Approval logomark has no minimum size requirement, but should always be large enough to be readily identifiable.
- 3) Color should be black on a light background or a reverse may be used on a dark background.

For Cast-On Marks



- 4) Where reproduction of the mark described above is impossible because of production restrictions, a modified version of the diamond is suggested. Minimum size specifications are the same as for printed marks. Use of the word "Approved" with this mark is optional.

NOTE: These Approval marks are to be used only in conjunction with products or services that have been FM Approved. The FM Approval marks should never be used in any manner (including advertising, sales or promotional purposes) that could suggest or imply FM Approval or endorsement of a specific manufacturer or distributor. Nor should it be implied that Approval extends to a product or service not covered by written agreement with FM Approvals. The Approval marks signify that products or services have met certain requirements as reported by FM Approvals.

Additional reproduction art is available through

FM Approvals
P.O. Box 9102,
Norwood, Massachusetts 02062
U.S.A.

APPENDIX B:
UNITS OF MEASUREMENTS

LENGTH:	in. – “inches” (mm – “millimeters”) mm = in. × 25.4 ft – “feet” (m – “meters”) m = ft × 0.3048
HEAT:	BTU – “British thermal units” (J – “joules”) $J = \text{Btu} \times 1.0551 \times 10^3$
TEMPERATURE:	°F – “degrees Fahrenheit” (°C – “degrees Celsius”) $^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times \frac{5}{9}$

APPENDIX C:

Horizontal Fire Test Procedure for Fume or Fume and Smoke Exhaust Ducts

C-1 Test Set-Up

- C-1.1 The standard apparatus for the FM Approvals Horizontal Duct Test is designed to test a representative section of the duct for which FM Approval is desired. The fire test conditions are intended to simulate building fire conditions. A standard fire exposure is placed directly below the inlet of a duct. During the test the fire is then drawn into the duct where it may or may not ignite the duct and propagate the full length of the duct.
- C-1.2 This apparatus (see Figure C-1) consists of a 24 ft (7.3 m) length of horizontal duct 12 in. (305 mm) in diameter, incorporating at least two field-assembled joints, a centrifugal exhaust blower with an adjustable damper, a draft-free enclosure or draft shield containing the fire exposure, and supporting framework with supports spaced in accordance with the manufacturer's installation instructions. The first joint shall be located 4 ft (1.2 m) from the exposure source. If the manufacturer wishes to obtain FM Approval for ducts smaller than 12 in. (305 mm) in diameter an additional test would be required on the smallest diameter or cross section for which the Approval is desired, in addition to the 12 in. (305 mm) diameter. The duct is suspended 32 in. (0.8 m) above the floor by steel hangers to simulate an actual field installation. The duct intake end was inserted into a 4 ft × 4 ft × 7 ft (1.2 × 1.2 × 2.35 m) high draft shield (3 walls and a roof), flush with the inside surface of the enclosure wall. The exhaust end is connected through a transition piece to the blower which pulls air through the duct at the required air velocities.
- C-1.3 The fire exposure consists of a square steel pan 1 ft × 1 ft × 8 in. (0.3 m × 0.3 m × 0.2 m) deep, containing 4 in. (100 mm) of heptane on 3 in. (75 mm) of water. At the start of the test the liquid surface is 24 in. (0.6 m) below the inside bottom surface of the duct. The pan itself is positioned so that it is centered directly below the central axis of the duct, and its closest vertical surface is 1½ in. (38 mm) ahead of the duct opening. Heat output from the 1 sq ft (0.1 m²) pan of heptane is approximately 10,000 Btu/min (17.59 × 10⁴ J/sec).
- C-1.4 Four thermocouples positioned 1 in. (25 mm) below the top inside surface of the duct, directly above the central axis, monitor temperatures during the test. The four points of measurements are 6 in. (152 mm), 6 ft (1.8 m), 12 ft (3.7 m), and 23 ft (7.0 m) from the fire exposed end of the duct.

C-2 Test Procedure

- C-2.1 After the required draft velocity has been verified and set, the fire exposure source is ignited to start the test.

C-2.3 Observations of the performance of the duct and the temperatures achieved within the duct are made continuously for the full 15 minutes of the test.

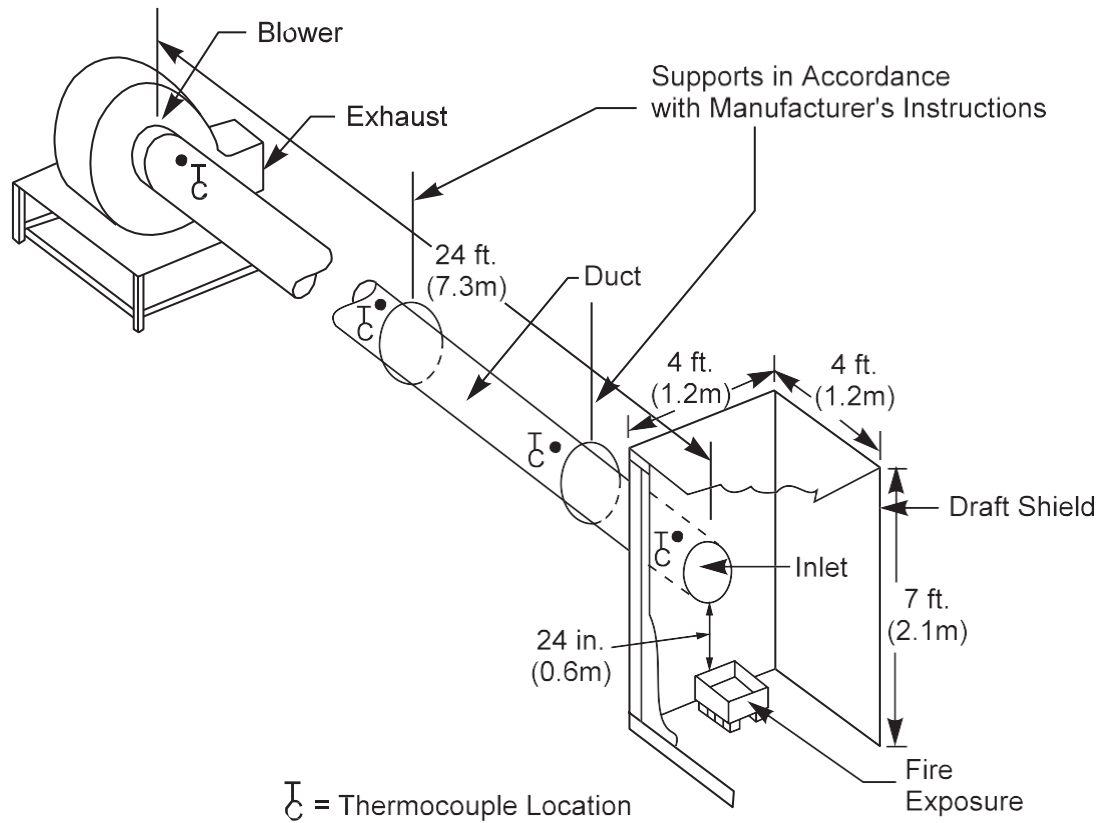


Figure C-1. FM Approvals' Apparatus for the Horizontal Evaluation of Duct Work.

C-3 Performance Requirements

C-3.1 The performance requirements for fume exhaust ducts are shown in Paragraph 5.1.1 of this standard.

C-3.2 The performance requirements for fume and smoke exhaust ducts are shown in Paragraph 5.2.1 of this standard.

C-3.3 The performance requirements for fume or fume and/or smoke exhaust ducts that are used in cleanroom applications shall also meet the requirements shown in Paragraph 5.4 of this standard.

APPENDIX D:

Horizontal/Vertical Combination Fire Test Procedure for Fume or Fume and Smoke Exhaust Ducts

D-1 Test Set-Up

- D-1.1 The standard apparatus for the FM Approvals' Horizontal/Vertical Combination Duct Test is designed to test a representative section of the duct for which FM Approval is desired. The fire test conditions are intended to simulate building fire conditions. A standard fire exposure is placed directly below the inlet of a duct. During the test the fire is then drawn into the duct where it may or may not ignite the duct and propagate the full length of the duct.
- D-1.2 This apparatus (see Figure D-1) consists of a 24 ft (7.3 m) length of horizontal duct connected to a standard radius elbow and a 15 ft (4.6 m) length of vertical duct, a centrifugal exhaust blower with an adjustable damper, a fire exposure source and suspending hangers. The manufacturer may select a longer or shorter length of vertical duct for testing. If a shorter vertical length is tested, Approval would be limited to that height for vertical risers. The ducts are 12 in. (305 mm) in diameter and both the horizontal and vertical segments shall incorporate at least two field-assembled joints. The joints in the vertical segment shall be located at the 5 ft (1.5 m) and 10 ft (3.0 m) levels above the inlet. The joints in the horizontal segment shall be located at 4 ft (1.2 m) and 14 ft (4.3 m) from the outlet edge of the elbow. If the manufacturer wishes to obtain FM Approval for ducts smaller than 12 in. (305 mm) in diameter an additional test would be required on the smallest diameter or cross section for which the Approval is desired, in addition to the 12 in. (305 mm) diameter. The horizontal duct is suspended 32 in. (0.8 m) above the floor by hangers in accordance with the manufacturer's installation instructions. The vertical section of duct extends down to within 1 ft (0.3 m) of the fire exposure source, and is supported in accordance with the manufacturer's installation instructions.
- D-1.3 The fire exposure consists of a square steel pan 1 ft × 1 ft × 8 in. (0.3 m × 0.3 m × 0.2 m) deep, containing 4 in. (100 mm) of heptane on 3 in. (75 mm) of water. At the start of the test the liquid surface is 12 in. (0.3 m) below the bottom surface of the duct. The pan itself is positioned so that it is centered directly below the central axis of the duct. Heat output from the 1 sq ft (0.1 m²) pan of heptane is approximately 10,000 Btu/min (17.59 × 10⁴ J/sec).
- D-1.4 Four thermocouples in the horizontal section of duct positioned 1 in. (25 mm) below the top inside surface of the duct, directly above the central axis, monitor temperatures during the test. The four points of measurements are 6 in. (152 mm), 6 ft (1.8 m), 12 ft (3.7 m), and 23 ft (7.0 m) from the outlet edge of the duct. Thermocouples are also located in the vertical section of duct at 4 ft 6 in. (1.4 m), 9 ft 6 in. (2.9 m) and 14 ft 6 in. (4.4 m) above the bottom edge.

D-2 Test Procedure

- D-2.1 The induced draft velocity through the duct is measured at the center of the horizontal duct 6 ft (1.8 m) from the exhaust end. Velocity measurements are taken at ambient temperature before each test. The induced draft velocity for this test is adjusted to 600 ft/min (3 m/sec) ± 30 ft/min (± 0.15 m/sec) for testing chemical or corrosive fume exhaust ducts. The fire exposure source shall be kept covered while the draft velocity is obtained and until the test is started.
- D-2.2 After the required draft velocity has been verified and set, the fire exposure source is ignited to start the test.

D-2.3 Observations of the performance of the duct and the temperatures achieved within the duct are made continuously for the full 15 minutes of the test.

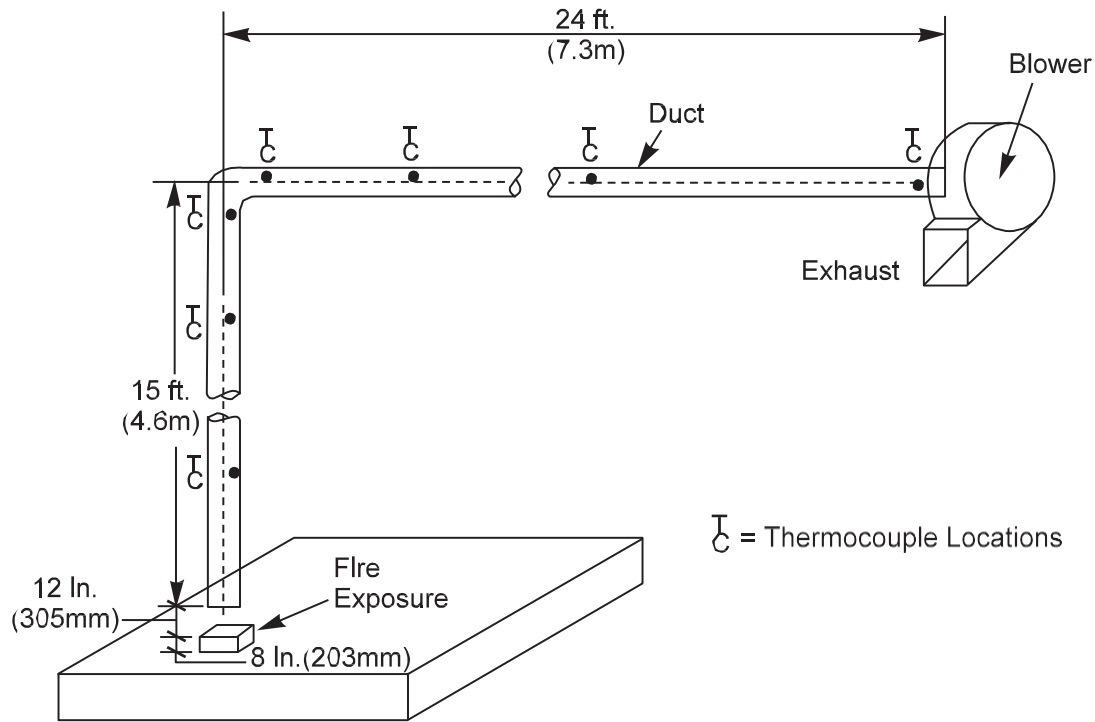


Figure D-1. FM Approvals' Apparatus for the Horizontal/Vertical Combination Evaluation of Duct Work.

D-3 Performance Requirements

- D-3.1 The performance requirements for fume exhaust ducts are shown in Paragraph 5.1.2 of this standard.
- D-3.2 The performance requirements for fume and smoke exhaust ducts are shown in Paragraph 5.2. of this standard.
- D-3.3 The performance requirements for fume or fume and/or smoke exhaust ducts that are used in cleanroom applications shall also meet the requirements shown in Paragraph 5.4 of this standard.

APPENDIX E:

Test Procedure for Evaluating Smoke Removal Ability of Ducts

E-1 Purpose

In circumstances such as a fire situation, certain sensitive equipment or special purpose rooms must not be contaminated by smoke. The exhaust system and duct work used for corrosive fume handling may also serve to exhaust smoke when tested for that purpose. The intent of this procedure is to evaluate the smoke removal ability of a duct system while also preventing fire spread within the duct.

E-2 Test Set-Up

The duct system and associated exhaust fan are assembled as noted in Appendix C for the horizontal fire spread test. The 12 in. (305 mm) duct is erected horizontally 24 ft (7.3 m) and the fan must be capable of inducing a minimum air velocity of 2000 ft/min (10 m/sec). If the manufacturer wishes to obtain FM Approval for ducts smaller than 12 in. (305 mm) in diameter an additional test would be required on the smallest diameter or cross section for which the Approval is desired, in addition to the 12 in. (305 mm) diameter.

E-3 Test Procedure

Immediately following the Horizontal Fire Test (Appendix C), the fire exposure source is removed and the fan speed is increased to achieve the desired air velocity of 2000 ft/min $910 \text{ m/sec} \pm 100 \text{ ft/min}$ (0.5 m/sec), and maintained for a period of 10 minutes. The induced draft velocity through the duct shall be measured at the center of the duct 18 ft (5.5 m) from the intake. Velocity measurements may be taken at ambient temperature readings preceding the Horizontal Fire Test.

E-4 Performance Requirements

Performance requirements for fume and smoke exhaust ducts are shown in Paragraph 5.2.3 of this standard.

APPENDIX F:

Vertical Fire Test Procedure for Fume or Fume and Smoke Exhaust Ducts

F-1 Purpose

F-1.1 The purpose of the Vertical Fire Test is to provide an alternate method to the Horizontal/Vertical Combination Fire Test when assessing the ability of a duct material to resist flame propagation and maintain its ability to exhaust smoke effectively when vertical segments of ducts exceed 15 ft (4.6 m).

F-2 Test Set-Up

F-2.1 The FM Approvals' Vertical Fire Test is designed to test a representative section of the duct for which FM Approval is desired. The fire test conditions are intended to simulate building fire conditions using a natural draft or chimney effect in the duct. A standard fire exposure is placed directly below the inlet of a duct. During the test the fire is then drawn into the duct where it may or may not ignite the duct and propagate the full length of the duct.

F-2.2 The test set-up consists of a length of vertical duct 12 in. (305 mm) in diameter, incorporating field- assembled joints every 5 ft (1.5 m) and supporting framework with supports spaced in accordance with the manufacturer's installation instructions. The length of the vertical duct shall be greater than 15 ft (4.6 m) and shall extend down to within 1 ft (0.3 m) of the exposure. The first joint shall be located 5 ft (1.5 m) from the bottom edge of the duct with additional field joints spaced every 5 ft (1.5 m) thereafter. If the manufacturer wishes to obtain FM Approval for ducts smaller than 12 in. (305 mm) in diameter an additional test would be required on the smallest diameter or cross section for which the Approval is desired, in addition to the 12 in. (305 mm) diameter.

F-2.3 The fire exposure shall consist of a square steel pan 1 ft × 1 ft × 8 in. (0.3 m × 0.3 m × 0.2 m) deep, containing 4 in. (100 mm) of heptane on 3 in. (75 mm) of water. At the start of the test the liquid surface shall be 12 in. (305 mm) below the inside bottom surface of the duct. The pan itself shall be positioned directly below the central axis of the duct. Heat output from the 1 sq ft (0.1 m) pan of heptane is approximately 10,000 Btu/min (17.59×10^4 J/sec).

F-2.4 Thermocouples shall be positioned 1 in. (25 mm) from the inside surface of the duct to monitor temperatures during the test. The first thermocouple shall be located approximately 5 ft (1.5 m) above the bottom of the duct with subsequent thermocouples placed on approximately 5 ft (1.5 m) centers with the exception of the uppermost thermocouple which shall be placed 1 ft (0.3 m) from the top edge of the duct.

F-3 Test Procedure

F-3.1 The fire exposure source is ignited to start the test. Observations of the performance of the duct and the temperatures achieved within the duct are made continuously for the full 15 minutes of the test.

F-4 Performance Requirements

F-4.1 The performance requirements for fume exhaust ducts shall be as shown in Paragraph 5.1.3.

F-4.2 The performance requirements for fume and smoke exhaust ducts shall be as shown in Paragraph 5.2.4.

F-4.3 The performance requirements for fume or fume and/or smoke exhaust ducts that are used in cleanroom applications shall also meet the requirements shown in Paragraph 5.4 of this standard.