



Member of the FM Global Group



American National Standard for Cleanroom Materials Flammability Test Protocol ANSI/FM Approvals 4910

ANSI/FM Approvals 4910-2013

Revision of ANSI/FM Approvals 4910-2004

Approved October 3, 2013

October 2013

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Foreword

NOTE: This foreword is introductory only and is not part of American National Standard FM 4910.

This standard is intended to verify that the product as described will meet minimum specific stated conditions of performance, safety and quality, useful in determining the potential suitability for end-use conditions of these products. It describes minimum performance requirements for materials that are intended for use in cleanroom facilities by evaluating the ability of the materials and, in turn, the system components, to limit fire spread and smoke damage resulting from a fire in the cleanroom environment.

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ANSI regulations require that this American National Standard shall be revised, reaffirmed or withdrawn within five years of the date of publication.

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1. INTRODUCTION

1.1 PURPOSE

This test standard states test requirements and procedures for the evaluation of materials used in cleanroom occupancies mainly for, but not restricted to, use in the semiconductor industry. The test evaluates the materials' fire propagation behavior, expressed as Fire Propagation Index (FPI), and potential for smoke contamination, expressed as Smoke Damage Index (SDI).

1.2 SCOPE

1.2.1 This test standard describes minimum performance requirements for materials which are intended for use in cleanroom facilities. This standard evaluates the ability of the materials to limit fire spread and smoke damage. All requirements in the standard must be met for materials to be acceptable.

1.2.2 This standard is intended to verify that the materials, as described, will meet minimum specific stated conditions of performance, safety and quality useful in determining the potential suitability for end-use conditions of these materials.

1.3 BASIS FOR REQUIREMENTS

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

1.4 APPLICABLE DOCUMENTS

The following standards, test method descriptions and practices are related to this standard:

1. Tewarson, A., "Generation of Heat and Chemical Compounds in Fires", Chapter 4, Section 3, pp. 3-82 to 3-161. The SFPE Handbook of Fire Protection Engineering, 3rd Edition. The National Fire Protection Association Press, Quincy, MA, June 2002.
2. Tewarson, A., "Flammability", Chapter 42, pp. 577-604. Physical Properties of Polymers Handbook (J.E. Mark, Editor). American Institute of Physics, Woodbury, NY, 1996.
3. ASTM E2058 "Standard Test Methods for Measurement of Synthetic Polymer Material Flammability Using a Fire Propagation Apparatus (FPA)," American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.
4. NFPA 287 "Standard Test Methods for Measurement of Flammability of Materials in Cleanrooms Using a Fire Propagation Apparatus (FPA)", National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269.

1.5 DEFINITIONS

For purposes of this test standard, the following terms apply:

Chemical Heat Release Rate (Q_{ch}): energy actually released by chemical reactions during a test

Critical Heat Flux (CHF): the maximum heat flux at, or below, which there is no ignition.

Fire Propagation Index (FPI): an index representing the propensity of a material to support fire propagation.

Flame Height: elevation of the tip of the contiguous flame region averaged over a 5-second interval

Ignition Zone: the area of the surface of a material heated by an outside source, resulting in ignition.

Smoke Damage Index (SDI): smoke yield multiplied by FPI. It is an indicator of the smoke contamination of the environment during fire propagation.

Smoke yield (y_s): ratio of the total mass of smoke released to the total mass of the material vaporized.

Thermally Thick Behavior: when a material is heated on one side and exhibits a negligible temperature rise above ambient on the unexposed face of the material.

Thermally Thin Behavior: when a material is heated on one side and there is a uniform temperature rise across the thickness of a material.

Thermal Response Parameter (TRP): indicator of the ignition resistance of a material.

2. GENERAL INFORMATION

2.1 CLEANROOMS

Due to the sensitivity of cleanroom environments, the high cost of construction and the high value of 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 useful to evaluate the ability of a material to limit fire propagation and restrict emission of particulates in the form of smoke. The criteria for the selection of materials for use in cleanrooms are based on tests conducted using the Fire Propagation Apparatus (FPA) described in ASTM E2058 (for determining FPI and SDI) or the 8 ft (2.4 m) Parallel Panel Test (when the FPI and SDI results are uncertain or where the thickness is less than 0.25 in (6 mm)). The criteria used to assess cleanroom materials deal with limiting fire propagation beyond the ignition zone and limiting contamination of the cleanroom environment due to smoke.

2.2 FPI AND SDI

Materials examined using the Fire Propagation Apparatus are evaluated based on the following two criteria:

2.2.1 The Fire Propagation Index (FPI) is used as a criterion for fire propagation beyond the ignition zone. The criterion is based on the maximum value of FPI for a 15 second running average of the data during the entire test duration. A value of $FPI \leq 6 \text{ (m/s}^{1/2}\text{)/(kW/m)}^{2/3}$ has been assigned for materials intended for use in cleanrooms.

2.2.2 The Smoke Development Index (SDI) is used as a criterion for significantly limiting smoke concentration for non propagating fires beyond the ignition zone. A value of $SDI \leq 0.40 \text{ [(m/s}^{1/2}\text{)/(kW/m)}^{2/3}\text{)][g/g]}$ has been assigned for materials intended for use in cleanrooms.

2.3 REQUIRED TESTS

2.3.1 The FPI and SDI indices shall be quantified in the Fire Propagation Apparatus. In order to do so, three types of tests shall be performed: 1) ignition; 2) fire propagation; and 3) combustion.

2.3.2 The purpose of the ignition test is to determine the Thermal Response Parameter (TRP). The fire propagation test is conducted to quantify the chemical heat release rate during fire propagation. The chemical heat release rate

and the TRP value are utilized to calculate the FPI value. The combustion test is conducted in order to quantify the yield of smoke. The yield of smoke shall be multiplied by the FPI value to calculate the SDI value.

2.3.3 The reported test data shall be rounded such that the FPI is rounded to the nearest integer whole number (1, 2, etc.). The SDI shall be rounded to the nearest tenth (0.1, 0.2, etc.).

2.4 UNCERTAINTY RANGES OF FPI AND SDI

2.4.1 Experience has shown that an uncertainty range of FPI and SDI exists. These ranges encompass FPI values between 6 and 7 $(\text{m/s}^{1/2})/(\text{kW/m})^{2/3}$ and SDI values between 0.4 and 0.5 $[(\text{m/s}^{1/2})/(\text{kW/m})^{2/3}][\text{g/g}]$. When the FPI and/or SDI value falls within these ranges, the material can exhibit fire propagation and smoke development characteristics undesirable of materials utilized in cleanroom environments. In these cases, the 8 ft (2.4 m) Parallel Panel Test shall be conducted in order to determine the material's suitability.

2.4.2 The Parallel Panel Test shall be permitted to be used as an alternate to the Fire Propagation Apparatus regardless of a material's FPI or SDI. In cases where the FPI and SDI have been determined and a Parallel Panel Test has been conducted, the results of the Parallel Panel Test shall govern.

2.5 MATERIALS THINNER THAN 0.25 IN. (6 MM)

Materials whose thickness is less than 0.25 in. (6 mm) cannot be tested in accordance with ASTM E2058 on the FPA. These thin materials must be tested utilizing the Parallel Panel Test.

3. FIRE PROPAGATION APPARATUS TESTS

3.1 TEST SAMPLES

3.1.1 Ignition and combustion tests samples of planar materials shall be 4 by 4 in. (± 0.125 in.) [100 by 100 mm (± 3 mm)] square with a minimum thickness of 0.25 in. (6 mm) and a maximum thickness of 1 in. (25 mm).¹ 3.1.2 Fire propagation tests samples of planar materials shall be 12 in. ± 0.125 in. long by 4 in. ± 0.125 in. wide [305 mm (± 3 mm) long by 102 mm wide (± 3 mm)] with a minimum thickness of 0.25 in. (6 mm) and a maximum thickness of 1 in. (25 mm).

3.2 SAMPLE PREPARATION AND PLACEMENT IN THE APPARATUS

3.2.1 Ignition and combustion tests - the samples shall be wrapped in heavy duty aluminum foil, 0.002 in. (0.05 mm) thick, to tightly cover the edges and back of the sample. For the ignition test, the sample surface shall be coated with a thin layer of fine graphite powder or Thermo-lux Solar Collective black paint to compensate for surface absorptivity differences. The wrapped sample shall be placed horizontally, exposed surface up, in the Fire Propagation Apparatus at the locations shown in Figure 3 and Figure 5. For the ignition test, the quartz tube shall not be used. For the combustion test, the sample shall be located inside the quartz tube.

¹ A maximum thickness of 1 in. (25mm) is the limit that can readily be tested on the FPA apparatus.