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Space systems — Safety and compatibility of materials —

Part 1: Determination of upward flammability of materials

Systèmes spatiaux — Sécurité et compatibilité des matériaux —

Partie 1: Détermination de l'inflammabilité verticale des matériaux

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

This second edition cancels and replaces the first edition (ISO 14624-1:2003), which has been technically revised.

The main changes are as follows:

— updated 6.5 "Bare nickel-chromium wire 0,81 mm (0,5 mm^2 diameter)";

— updated annexes;

— updated the Bibliography.

A list of all parts in the ISO 14624 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

In this document, the following verbal forms are used:

— “shall” indicates a requirement;

— “should” indicates a recommendation;

— “may” indicates a permission;

— “can” indicates a possibility or a capability.

Recommended criteria are, while not mandatory, considered to be of primary importance in providing serviceable economical and practical designs. Deviations from the recommended criteria may be made only after careful consideration, extensive testing and thorough service evaluation have shown an alternative method to be satisfactory.

Space systems — Safety and compatibility of materials —

Part 1: Determination of upward flammability of materials

1 Scope

This document specifies a method for the determination of the flammability of aerospace materials by upward flame propagation. This test determines if a material, when exposed to a standard ignition source, will self-extinguish and not transfer burning debris which can ignite adjacent materials.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

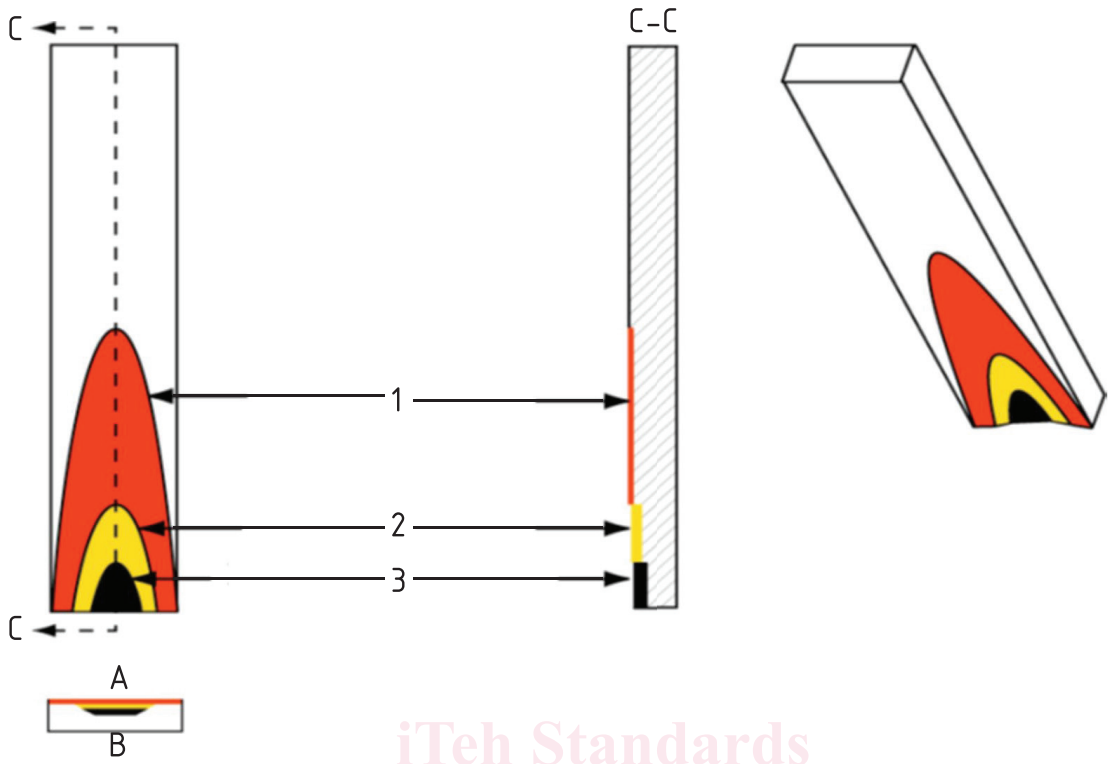
3.1
ambient conditions
test environment with an oxygen concentration of 20,9 % ± 0,2 %, a pressure of 101,4 kPa ± 5 kPa, and a temperature of 23 °C ± 5 °C

3.2
burn length
distance from the bottom of the specimen to the farthest evidence of flame consumption damage or flame attachment point to the test specimen due to flame as determined by visual observation, visual/physical post-test examination, video of burn, and/or other means

Note 1 to entry: See Table 1 and Figure 1. The burn length distance includes areas of partial or complete combustion, charring or embrittlement, but does not include heat affected areas which can have been damaged only by the heat of the flames emanating from sample consumption below. Heat affected areas appear as sooted, stained, warped or discoloured, or areas where the material has shrunk or melted away from the heat. In some cases, the flame can propagate beyond the farthest visual evidence of damage to the test specimen. Typical material burn model depicted in Figure 1, some materials can show multiple flame fronts and/or other variations.

Table 1 — Burn length assessment characteristics and techniques summary

Burn length / Flame consumption damage	Heat affected damage area	Burn length determination techniques
Complete combustion	Sooted	Visual observation
Partial combustion	Stained	Visual post-test examination
Charring	Warped	Physical post-test examination
Embrittlement	Melted away from heat	Video of burn
Furthest flame attachment point	Shrunk away from heat	Other means



Key

1 heat affected damaged area
2 flame consumption damaged area
3 ignitor influence area
A front
B back
C cross section of sample

Figure 1 — Typical material burn depiction, typical sample consumed area and heat affected damage area

3.3
burn propagation time
time that elapses from ignition of the specimen until vertical flame propagation stops

3.4
chemical ignitor
ignitor validated to strict specifications in order to produce a flame that meets all the requirements for an ignition source

Note 1 to entry: The requirements for the ignition source are specified in 6.3. See Annex A for one method of producing a chemical ignitor.

3.5
good laboratory practice
GLP
practice which involves the testing of standard reference materials to verify data accuracy and repeatability

Note 1 to entry: In addition, the test facility shall successfully demonstrate the ability to obtain repeatable data when testing a selected material. The authority having jurisdiction shall choose appropriate GLP materials and shall determine the frequency of testing these materials for its test facilities.

3.6
maximum allowable oxygen concentration
MOC
highest oxygen concentration (volume fraction), in an oxygen/nitrogen atmosphere, at which at least five specimens pass the acceptance criteria of this test, without a failure, and one or more of the specimens fail the test if the oxygen concentration is increased by an arbitrary increment, typically 1 %

Note 1 to entry: See Annexes B, C, D and ISO/TS 16697 for the threshold approximation procedure.

3.7
self-extinguish
phenomenon in which the *burn length* (3.2) on a *standard test specimen* (3.8) does not exceed 150 mm

3.8
standard test specimen
representative part, taken from a quantity of material or fabricated per required preparation method, meeting the following minimum dimensions:

a) length = 300 mm

b) width = 60 mm [75 mm for *thin-film specimen* (3.9)]

c) thickness – use thickness (minimum thickness of the material in its intended use application, but not to exceed 25 mm, excluding substrate)

Note 1 to entry: The required test specimen exposed width is defined in 6.6.

3.9
thin-film specimen
specimen with a total thickness of less than 0,25 mm

Note 1 to entry: Fabrics or coatings applied to a substrate are not considered thin-film specimens.

3.10
transfer of burning debris
movement of any material from a burning specimen with sufficient energy to ignite adjacent material

Note 1 to entry: The sheet of paper below the test specimen is specified in 6.8.

3.11
upward limiting oxygen index
ULOI
oxygen concentration where approximately 50 % of samples fail the test criteria

3.12
worst-case test configuration
test configuration that simulates worst-case anticipated use conditions including material thickness, test pressure, and oxygen concentration

Note 1 to entry: Worst-case represents the cumulative effect of multiple factors that increase the probability that a material is flammable; can involve smallest thickness for use without a substrate or sufficient thickness to prevent heat loss from a substrate, increased surface area (such as mesh configuration), irregular surface configuration, increased oxygen concentration, increased pressure, increased temperature, etc. Furthermore, oxygen concentration (volume fraction) is typically the primary driver of flammability and should be prioritized over pressure when examining for worst-case conditions.

3.13
worst-case use thickness
material thickness that, for a specific application, makes the material most flammable

Note 1 to entry: Worst-case use thickness can involve the smallest thickness for use without a substrate or sufficient thickness to prevent heat loss from a substrate and increased surface area (such as mesh configuration), irregular surface configuration.

4 Principle

An ignition source with specific characteristics is applied for a defined period of time to the lower end of a standard test specimen of material oriented vertically in a test chamber or fume hood containing a specific test environment. The post-test burn lengths for at least five standard-sized specimens are recorded. Materials are considered flammable in the test conditions if at least one standard test specimen burns more than 150 mm. In addition, the ignited specimens shall not ignite the paper (produce combustion) below the test samples, which indicates that the transfer of burning debris has sufficient energy to ignite adjacent materials. If, during a test, the paper used as an indication of the transfer of burning debris ignites because of burning debris, subsequent burns during the same material test should be conducted without paper to eliminate burning paper interference.

Failure of any one specimen constitutes failure of the material in that test environment.

Materials shall be tested in the worst-case test configuration. If the worst-case oxygen concentration is uncertain, determination of the maximum allowable oxygen concentration is recommended.

5 Reagents

5.1 Test gases. The test atmosphere shall consist of a mixture of oxygen and nitrogen, mixed thoroughly before testing a specimen. These gases can be premixed before introduction of the mixture into the test chamber, or the oxygen and nitrogen can be introduced separately into the test chamber, and then mixed inside the test chamber with a test specimen.

Oxygen gases used in test gas mixtures shall be verified to have a minimum purity of 99,5 % and moisture < 7 µl/l[1)]. Nitrogen gases used in test gas mixtures shall be verified to have a minimum purity of 99,9 % and moisture <11,5 µl/l.

Also, the gas mixture shall be verified for conformity with the specification (including accuracy) for oxygen concentration to within +1 % −0 %. Pre and post-test gases are analysed for CO and CO_2 and post test results reported.

6 Test system

6.1 Test chamber, large enough so that complete combustion of the specimen can occur with no more than a 5 % relative depletion of oxygen concentration. In addition, the test chamber shall not interfere chemically or physically with the test.

6.2 Measuring devices, properly calibrated.

6.3 Chemical ignition source, meeting the following specifications in ambient conditions:

a) temperature: 1 100 °C ± 90 °C measured using a 0,81 mm (0,5 mm^2 diameter) exposed tip type K thermocouple;

b) burning duration: 25 s ± 5 s;

c) maximum visible flame height: 65 mm ± 6,5 mm.

1) 1 µl/l = 1 part per million (ppm). The use of "ppm" is deprecated.

Annex A provides a procedure for preparing, certifying and storing chemical ignitors.

NOTE This test method and the corresponding ignition source are designed to evaluate materials for use in spacecraft habitable environments with typical oxygen concentration ranges (19 % to 50 % volume fraction of oxygen). When evaluating environments outside of these typical ranges the standard ignition source cannot be adequate. In these cases, alternative ignition mechanisms can be utilized but test data is reported as a non ISO 14624-1 standard.

6.4 Power supply, capable of providing 15 A (root mean square), connected to a bare 0,81 mm diameter nickel-chromium wire (6.5) to initiate the igniter.

6.5 Bare nickel-chromium wire 0,81 mm (0,5 mm^2 diameter), with a nominal resistivity of 2 Ω·m to 2,5 Ω·m,3 m and of sufficient length to wrap three equally spaced turns around the chemical igniter.

6.6 Suitable specimen holder, capable of supporting the specimen in the vertical position

6.6.1 Standard test specimen holder (see Figure 2), allowing a minimum of 50 mm of the width of the specimen to be exposed and extending over the full length of the specimen. The test specimen exposed width for materials other than thin-film specimens shall be 50 mm to 60 mm.

The bottom of the specimen holder shall be located at least 250 mm from the bottom of the test chamber.

6.6.2 Specimen holder for thin-film specimens, allowing at least 50 mm of the width of the specimen to be exposed and minimizing shrinkage of the test material away from the flame. The test specimen exposed width for thin films shall be between 75 mm to 85 mm.

NOTE When mounting thin films for testing, minimized tension across the material reduces test stand influence. When the influence of the test stand on the results is of concern, large thin films measuring (300 mm x 200 mm × the use thickness) can optionally be used, subject to the approval of the authority having jurisdiction.

Two types of specimen holder can be used:

a) a holder for a standard test specimen (see 6.6.1 and Figure 2), which employs three wing-nut clamps or one long clamp;

b) a holder employing needle rakes to hold thin film specimens (see Figure 3).

6.7 Scale, attached to one side of the specimen holder, for measurement of the burn length.

6.8 Sheet of paper, mounted horizontally approximately 200 mm below the specimen holder, but 50 mm above the bottom of the test chamber, centred directly below the specimen. The paper shall be supported by a non-flammable, non-conducting material. The paper shall have the following characteristics:

a) dimensions: (200 mm ± 50 mm) × (300 mm ± 50 mm);

b) surface density: between 200 g/m^2 and 300 g/m^2;

c) type: chemical wood processed;

d) colour: uniformly white;

e) condition: clean, free from dirt spots, oil spots and foreign matter (lint, fuzz, etc.), free from holes, tears, cuts, folds and scuff marks, and containing no splices.

The sheet of paper is used to assess if burning debris from the specimen can cause ignition of adjacent materials.