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Space systems — Safety and compatibility of materials —

Part 2: Determination of flammability of electrical-wire insulation and accessory materials

Systèmes spatiaux — Sécurité et compatibilité des matériaux —

Partie 2: Détermination de l'inflammabilité des systèmes d'isolation des fils électriques, et des matériaux accessoires

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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/TC20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

This second edition cancels and replaces the first edition (ISO 14624-2:2003), which has been technically revised.

The main changes are as follows:

— updated 6.3.5 "Resistance meter";

— 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 2: Determination of flammability of electrical-wire insulation and accessory materials

1 Scope

This document specifies two test methods for determining the flammability of electrical-wire insulation and accessory materials by exposure to an external ignition source in a static environment (test A) and in a gas-flow environment (test B). These tests determine if a wire insulation 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

[SOURCE: ISO 14624-1:2023, 3.1]

3.2
burn length
distance from the ignition location (point directly above the igniter) to the farthest evidence of flame consumption damage or flame attachment point to the test specimen's insulation material 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 2. 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 evidence of damage to the test specimen.

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

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

[SOURCE: ISO 14624-1:2023, 3.3]

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 5.3.3. See Annex A for one method of producing a chemical ignitor.

[SOURCE: ISO 14624-1:2023, 3.4, modified — In note 1 to entry, the cross-reference to 6.3 has been replaced by 5.3.3.]

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.

[SOURCE: ISO 14624-1:2023, 3.5]

3.6
self-extinguish
phenomenon in which the *burn length* (3.2) on a *standard test specimen* (3.7) does not exceed 150 mm

[SOURCE: ISO 14624-1:2023, 3.7]

3.7
standard test specimen
representative part of a wire with insulation materials, taken from a quantity of material or fabricated per required preparation method, with a length of 1,2 m and an active length of 300 mm

Note 1 to entry: See 5.3.2.1 to 5.3.2.3.

Note 2 to entry: Wire configuration and end use application should be considered in determining what constitutes a representative test specimen. Features such as wire conductor size, number of conductors, insulation materials, insulation thickness can impact flammability.

3.8
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 5.3.8.

[SOURCE: ISO 14624-1:2023, 3.10, modified — In note 1 to entry, the cross-reference to 6.8 has been replaced by 5.3.8.]

3.9
worst-case test configuration
test configuration that simulates worst-case anticipated use conditions including wire configuration, test pressure, test temperature, and oxygen concentration

Note 1 to entry: Worst-case represents the cumulative effect of multiple factors that increase the probability that a wire is flammable; wire 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.

4 Test materials

As a minimum, all materials used in testing shall meet or exceed user specifications (see 6.3.2 for minimum material requirements).

Material and configured-system characteristics can be significantly compromised by sources of contamination, such as exposure to solvents, cleaning agents, abnormal temperatures, variations in humidity, environmental pollutants, particulates and handling. It is important that exposure of test specimen(s) to these and other contamination sources be sufficiently controlled to minimize variation in test results.

5 Electrical-wire insulation flammability test in a static environment (test A)

5.1 Principle

The purpose of this test (test A) is to determine if a wire configuration's insulation system, when exposed to an external ignition source, will self-extinguish and will not ignite adjacent materials by the transfer of burning debris (see 5.3.2.1 to 5.3.2.3 for additional guidance). An insulation system is determined to be flammable if the burn length of any one of the five standard test specimen replicate samples is greater than 150 mm at an internal wire temperature of 125 °C or at the maximum operating temperature of the configuration. In addition, the ignited specimens shall not ignite the paper (produce flaming 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 wire test should be conducted without paper to eliminate burning paper interference.

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

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

5.2 Reagents

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

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

5.3 Test system

5.3.1 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. The free space above and below the test fixture shall be at least 200 mm.

5.3.2 Measuring devices, properly calibrated.

5.3.3 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.

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

NOTE This test method and the corresponding ignition source were 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 can not be adequate. In these cases, alternative ignition mechanisms can be utilized but test data is reported as a non ISO 14624-1 standard.

5.3.4 AC power supply, capable of providing 15 A (root mean square), connected to a bare 0,81 mm nickel-chromium wire (5.3.5) to initiate the igniter.

5.3.5 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 and of sufficient length to wrap three equally spaced turns around the chemical igniter.

5.3.6 Suitable specimen holder, capable of supporting the centre third of the wire or wire bundle from one top corner of the fixture to the opposite bottom corner of the fixture at an angle of 15° ± 2° to the vertical (see Figure 1).

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

5.3.8 Sheet of paper, mounted horizontally approximately 200 mm below the specimen, 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 screen 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;

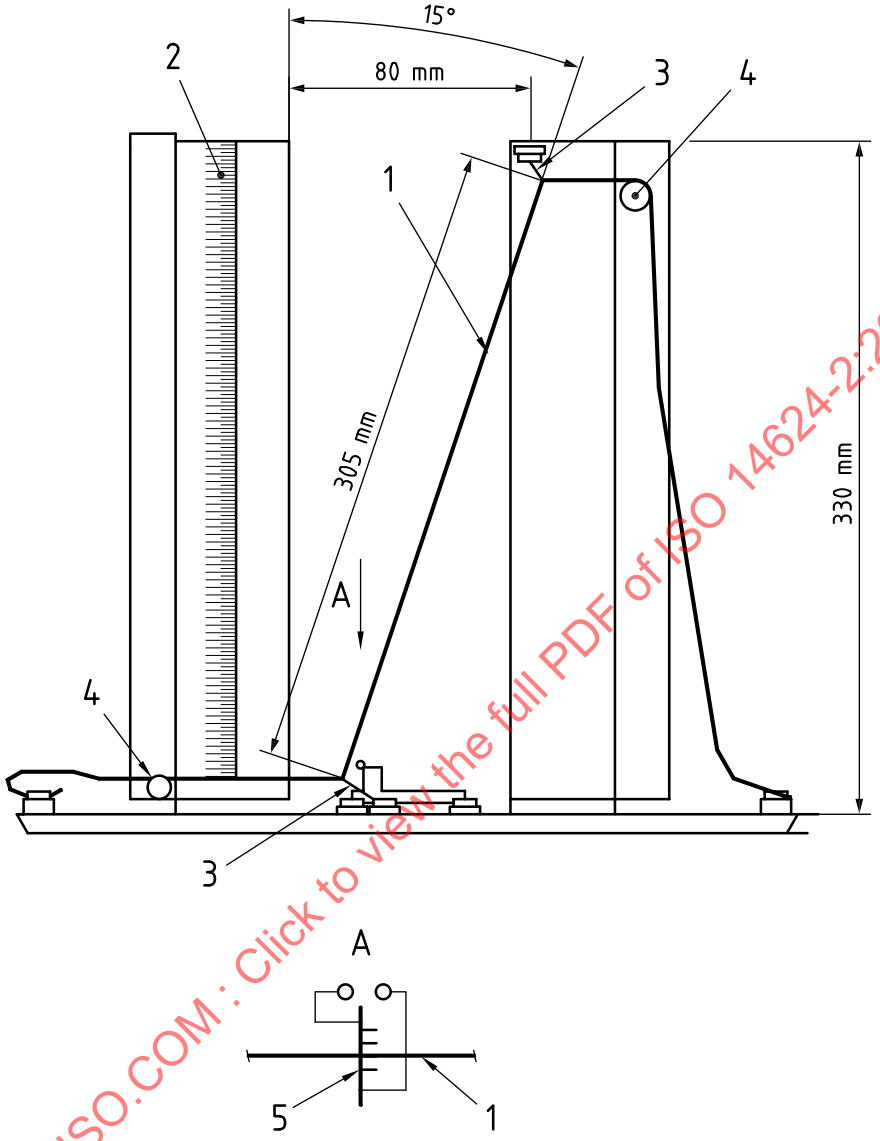
c) type: chemical wood processed;

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 could cause ignition of adjacent materials.

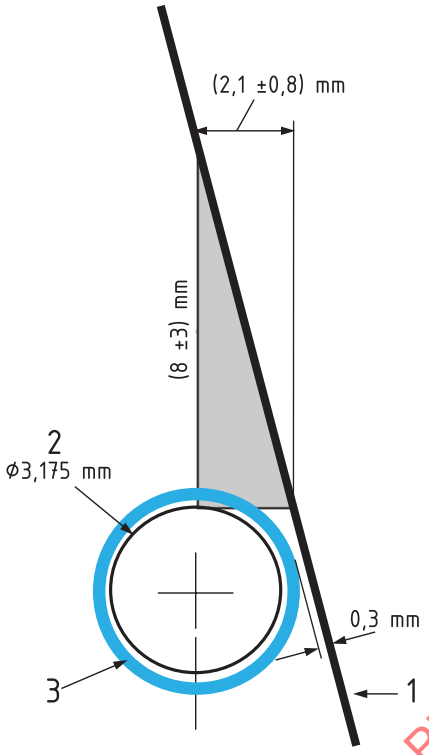
5.3.9 DC power supply, capable of providing a regulated DC current (150 A maximum) to the conductor of the test specimen at the level required to reach the specified internal wire temperature.



Key

1 specimen
2 scale
3 insulating ceramic-fibre thread
4 ceramic insulator
5 ignitor

Figure 1 — Standard test specimen holder and specimen configuration



Key

1 specimen
2 igniter
3 igniter coil

Figure 2 — 15° surface ignition igniter position and ignition point

5.4 Test specimens

5.4.1 Reception and inspection of material

5.4.1.1 Receive and visually inspect the test wires: when received, the wires shall be accompanied by proper identification. Any flaws shall be noted. Wire specimens should have been cleaned and dried to the end-use specifications prior to receipt at the test facility.

5.4.1.2 If required, prepare specimens to the proper dimensions.

5.4.1.3 If specimens are received with obvious contamination, clean them. All cleaning methods shall be approved by the test requester prior to use. Surface contamination shall be removed by washing with deionized water and mild detergent, rinsing with deionized water and drying with filtered nitrogen gas.

5.4.1.4 After preparation and/or cleaning at the test facility, inspect the specimens and note any flaws and any residual contamination. If the flaws result from specimen preparation at the test facility, new specimens shall be prepared. Specimens shall be weighed and individually identified.

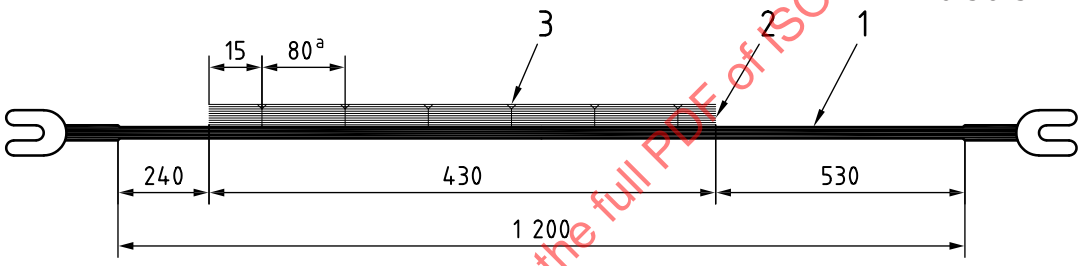
5.4.2 Preparation of test specimens

5.4.2.1 Single wire: To prepare a standard test specimen, cut a single conductor to a length of 1,2 m and remove 10 mm of insulation from each end of the wire using an appropriate wire stripper. Attach appropriate non-insulated crimp spade lugs to the ends of the wire.

5.4.2.2 Multiple wire bundle: To prepare an optional variation of the standard test specimen using a multiwire configuration, cut out six additional wires of length 430 mm. Place the active conductor on the perimeter of the multiwire configuration. Lace the active conductor and the six additional wires tightly together using appropriate non-flammable wire ties placed 80 mm apart (see Figure 3).

5.4.2.3 Other configurations: wire, wire bundles, cables and/or electrical harnesses including other features (i.e. cable clamps, sleeving, splices, end terminations etc.). Duplicates of actual-use electrical harnesses and accessories, with or without connections, may be used in lieu of the specimen described in 5.3.2.2. The active conductor(s) shall be identified by the test requester. Mating connections shall be supplied where applicable.

Dimensions in millimetres



Key

1 active conductor
2 wire bundle
3 wire tie
a Typical distance.

Figure 3 — Optional wire bundle configuration

5.5 Procedure

5.5.1 General

This test method shall be performed per the procedure specified in 5.5.2 and 5.5.3.

WARNING — Burning of materials can produce smoke and toxic gases and residues, which can affect the health of operators. Clear test area of smoke and fumes by suitable means. Ensure appropriate safety precautions are taken at all times.

5.5.2 Before testing

5.5.2.1 Before testing, observe the surfaces of the test specimens and record any pertinent observations, such as imperfections, discolorations. Also, record all pertinent information (including pressure, specimen identification, insulation thickness, pre-test mass, and wire gauge and configuration). Photograph all typical pretest specimens.

5.5.2.2 Determine the amount of current required to obtain the internal wire temperature specified for the test. This is done by mounting the specimen in the test fixture with the power supply attached to the conductor. Maintain the test fixture in a draft-free environment at ambient temperature. Insert

microthermocouple probes (0,18 mm) so that the microthermocouples are in contact with the active conductor. Perform wire temperature measurements in at least three locations: in the middle of the wire and at approximately 30 mm from centre in both directions. Raise electrical current until the test temperature of the wire is attained (as measured at the three locations).

Maintain temperature until stable to within ±3 °C for 5 min. Do not exceed test temperature of the wire. Record the voltage drop and current that produce the required temperature. This determination need only be made once for each wire having the same insulation material and insulation thickness, the same gauge and the same manufacturer.

5.5.2.3 After the wire current has been determined, mount a new 1, 2 m length of wire (3.10) as described in 5.3.6, and arrange the excess lengths of wire to be clear of any flames which could come from the specimen holder area. Place the ignitor 8 mm ± 3 mm below the diagonally mounted test specimen and 3 mm ± 1 mm to the right of the lower attached corner of the test specimen, as shown in Figure 1 and Figure 2. Measurements made from the top point of the igniter surface to the sample surface. Place the ignitor perpendicular to and centred in the plane of the specimen (see Figure 1). Place the test fixture in the test chamber. Connect the ends of the conductor to the power supply and a voltmeter. Finally, mount the paper horizontally 200 mm and centred directly below the specimen. Hold the paper in place by a non-flammable, non-conducting screen material.

5.5.2.4 Video record all specimens during testing.

5.5.3 Test

5.5.3.1 Before ignition of chemical ignitor

Test five replicate test specimens.

Subject the test specimen to vacuum for no less than 1 min, but no more than 3 min before introduction of the proper test atmosphere.

If vacuum exposure damages the test material, purging of the test chamber or gas supplementation can be used to achieve the required test atmosphere.

Expose the test specimen to the proper test atmosphere for a minimum of 3 min before ignition.

Prior to ignition, ensure that a homogenous mixture has been achieved within the chamber.

Measure, verify and record the percentage oxygen concentration and the total pressure for each individual specimen.

Apply the previously determined current to the conductor with the DC power supply to obtain a temperature of 125 °C or the maximum operating temperature specified by the test requester. Maintain this temperature steady for a minimum of 5 min (as indicated by a less than 5 % change in the voltage drop across the specimen).

Activate the recording device prior to activating the chemical ignitor. Activate the chemical ignitor.

5.5.3.2 After ignition of chemical ignitor

Immediately upon ignition of the chemical ignitor, turn off the power to the nickel-chromium wire. Activate the timing device used to measure the burn propagation time once specimen ignition is observed. Retract the ignitor from the test specimen once the ignitor extinguishes.

Observe the surfaces of the specimen and record any pertinent observations. Record any flame jets or sparks emanating from the sample during the test. Observe the paper below the sample for any indications of ignition. Observe and recorded flames emanating from the paper below the wire specimen.

5.5.3.3 After testing

Switch off the current to the wire. Record the final oxygen concentration, the burn length and the post-test mass, and any abnormal occurrences. Take post-test photographs.

5.6 Accuracy

Measurements shall be made within the following tolerance limits:

a) temperature: ±1 °C;

b) absolute pressure: ±1 %;

c) oxygen concentration: ±0,5 %;

d) specimen mass: ±1 %;

e) specimen dimensions: ±5 %;

e) time: ±1 s;

f) current: ±0,5 A;

g) voltage: ±0,05 V;

h) burn length: ±15 mm.

5.7 Test report

5.7.1 Standard tests

The test report shall include details of the specimen identification, the specimen preparation, the wire configuration, the wire diameter, the test conditions, the wire current, the burn length, any ignition of the paper, observations from the test, as well as pre and post-test photographs. Any unusual behaviour, such as wire fusion that can be indicated by loss of current, shall be included. Proper reporting of the test observations, such as the burn length, the transfer of burning debris, and other observations (especially of unusual behaviour) is critical. The test report shall be submitted to the authority having jurisdiction and/or test requester.

5.7.2 Non-standard tests

When there is a deviation from the standard test parameters, such as non-standard test specimen preparation, specimen dimensions, specimen orientation or ignition source, the test shall be identified as non-standard. In addition, all information in 5.7.1 shall be reported.

5.8 Good laboratory practice (GLP)

At least every 2 years, the test facility shall successfully demonstrate the ability to obtain accurate and repeatable data when testing selected insulated wires. The authority having jurisdiction shall choose appropriate GLP materials for its test facilities.

6 Alternative wire-insulation flammability test in a gas-flow environment (test B)

6.1 Principle

6.1.1 This alternative test (test B) is designed to screen wire insulation for flammability characteristics in a gas-flow environment. Failure of any one of five replicate specimens constitutes failure of the material. Failure occurs when any one of the conditions given in 6.1.2 to 6.1.4 is fulfilled. Testing shall be stopped upon failure of one specimen.

6.1.2 At the stabilized temperature prior to flame application there shall be no:

a) spontaneous combustion;

b) splitting of the insulation;

c) baring of the conductor.

6.1.3 During ignition and combustion, there shall be no flaming droplets or particles.

6.1.4 After the burner has been extinguished, the wire shall cease flaming within 10 s and a maximum burn length of 150 mm. The burn length is measured from the downward extent of propagation to the upward extent of propagation and includes damage caused by the burner itself.

6.2 Conditions and limits

The test atmosphere shall be designated by the procuring activity/user programme office. These conditions shall represent the most hazardous atmosphere anticipated in the spacecraft, within the confines of this test.

NOTE Because a Bunsen burner is used in this method, test oxygen concentrations are limited to less than 25 % volume fraction of oxygen.

6.3 Test system

6.3.1 **Test chamber**, with a volume of 250 dm^3. A typical arrangement is shown in Figure 4.

6.3.2 **External electrical supply**, capable of providing a steady DC current.

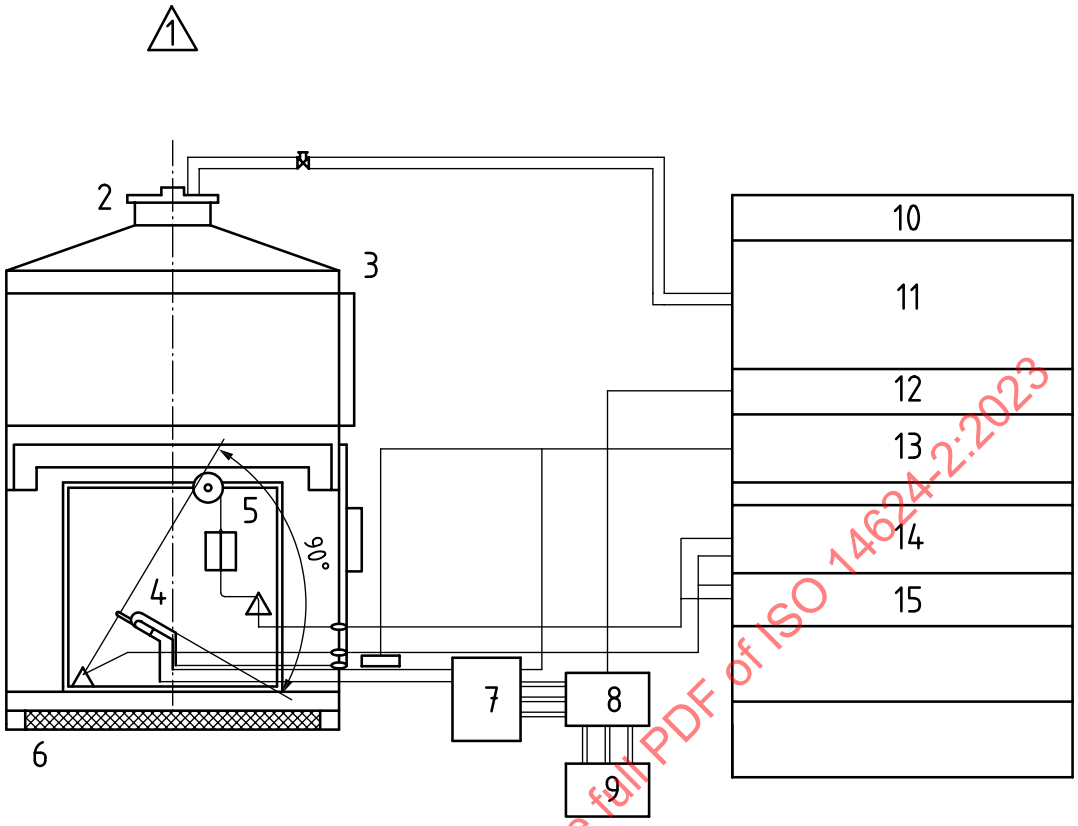
6.3.3 **Voltmeter**, capable of measuring the voltage drop in the wire in volts to two decimal places.

6.3.4 **Ammeter**, capable of measuring the current in the wire in amps to two decimal places.

6.3.5 **Resistance meter**, capable of measuring resistance in milliohms to two decimal places.

6.3.6 **Burner**, of the Bunsen type, mounted perpendicular to the specimen and at 30° to the vertical (see Figure 5), with a 9,5 mm bore modified to allow an external supply of air to be fed to the burner collar (see Figure 6), and with a spacer cone to give the correct stand-off distance between the burner and specimen.

The flame temperature shall be 1 100 °C ± 100 °C, measured at a point 35 mm from the end of the burner barrel. The burner is fuelled with commercial-grade propane gas (minimum 85 % purity) and forced air to produce a flame 75 mm high with an inner blue cone of height 25 mm.



Key

1	fume extractor, 1 400 m^3/h	9	gas supply
2	upper adapter	10	switch panel
3	test chamber	11	oxygen analyser
4	burner, Bunsen type	12	power supply and display (see also item 8)
5	specimen and burner assembly	13	timer
6	distribution unit	14	power supply
7	magneto-electric valves	15	current and voltage measurement
8	mass flow controller (see also item 12)		

Figure 4 — General arrangement of test equipment

6.3.7 **Weights**, for keeping the specimen taut (see Figure 5).

6.3.8 **Video camera**, for recording all the flammability tests.

6.3.9 **Timer**, positioned such that it is visible to the video camera (6.3.8).

6.4 Test specimens

6.4.1 Preparation of specimens for testing shall be in accordance with 5.3.2, but carrying out the additional tasks described in 6.3.2 and 6.3.3.

6.4.2 The minimum quantity of material required for a single wire test configuration using either Test A or Test B is 10 m length. Material quantities required for testing of multiple wire bundle or other configurations shall be established and approved by the authority having jurisdiction or the test requester (see 5.3.2.1 to 5.3.2.3 for additional guidance).

6.4.3 Five specimens, each 1,2 m in length, shall be cut consecutively from the same coil of wire. The specimens shall be weighed and individually identified. The specimens shall be cleaned and dried to the end-use specifications. Visible contamination shall be removed with distilled water and a lint-free cloth. Subsequently, the specimens shall be dried using filtered nitrogen gas. All cleaning procedures shall be verified to have no influence on the test results.

6.4.4 After cleaning, the specimens shall be handled wearing gloves. Prior to testing, the specimens shall be conditioned at (55 ± 10) % relative humidity and at a temperature of 20 °C ± 3 °C for a period of at least 16 h. Remove approximately 6 mm of the insulation from both ends of the test specimens and crimp a ring tongue with a typical single-ring tool onto each wire. Measure and record the conductor resistance at ambient temperature. Position the wire in the test chamber as shown in Figure 4.

6.5 Procedure

6.5.1 General

This test method shall be performed per the procedure specified in 6.5.2 and 6.5.3.

WARNING — Burning of materials can produce smoke and toxic gases, which can affect the health of operators. The test area shall be cleared of smoke and fumes by suitable means. Appropriate safety precautions shall be taken at all times.

6.5.2 Before testing

6.5.2.1 Record all pertinent information (including specimen identification, insulation thickness, pre-test mass, wire diameter and wire configuration) and photograph all the specimens.

6.5.2.2 With the propane flow adjusted to 0,35 l/min and the air flow to 6 l/min, check the flame height and temperature for conformance to 6.3.5. Adjust the gas flows as necessary to ensure compliance with 6.3.5. Ensure that the burner can be switched on and off repeatedly, and that it automatically switches off after 15 s of burning time.

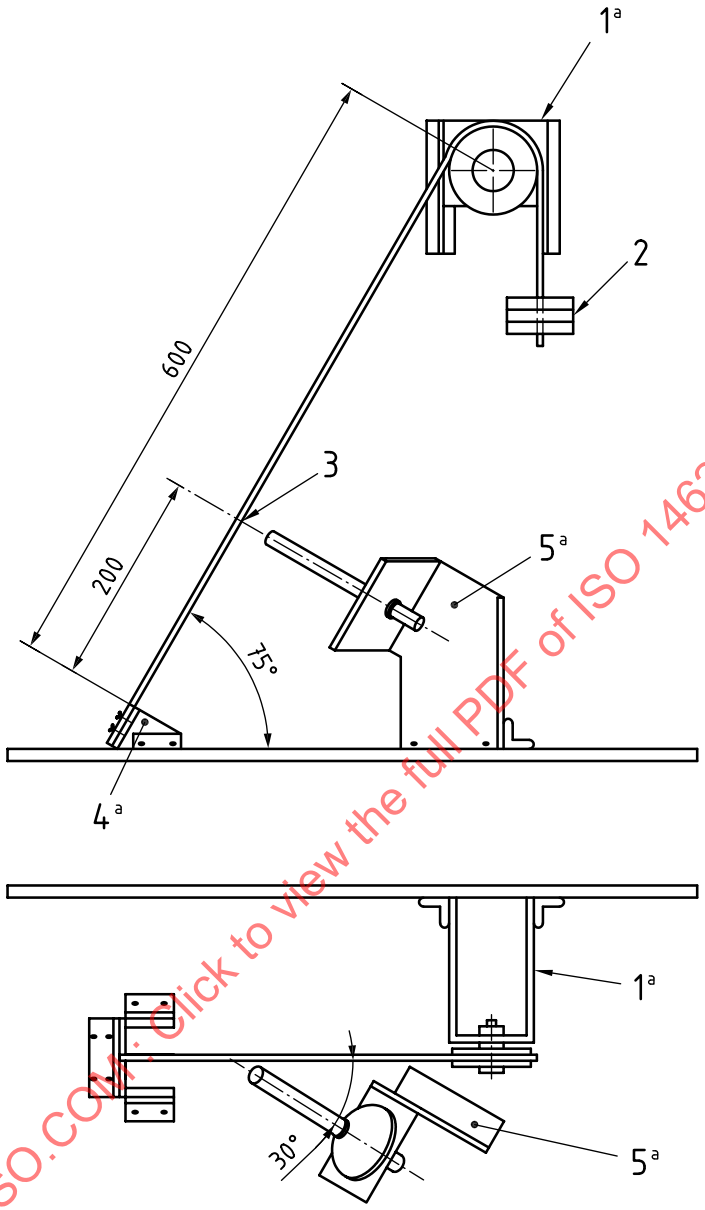
6.5.2.3 The oxygen and nitrogen supplies shall be adjusted to provide a flow of 25 l/min, and the proper test atmosphere concentration, and then turned off.

6.5.2.4 Position a prepared specimen in the test chamber as shown in Figure 4. Clamp the conductor at the lower bottom left-hand side of the apparatus by means of the electrical connector block and pass the wire under the lower left-hand guide and over the upper right-hand guide pulley where a weight is attached to keep the specimen taut. Then connect up the other end electrically to complete the circuit.

6.5.2.5 Position the burner below the specimen. Place the spacer cone in the barrel of the burner so that it exceeds the length of the burner by 35 mm. Adjust the burner by its assembly screws. The burner is at the correct stand-off distance when the cone contacts the wire. Remove the cone.

6.5.2.6 Open the vent and switch on the extractor fan. Open the oxygen and nitrogen supply valves and allow the chamber to fill by purging the chamber at a constant flow rate. After 15 min, check the test atmosphere. If the specified concentration of oxygen has been reached, reduce the flow to a constant rate, and maintain this flow for the duration of the test phase.

Dimensions in millimetres

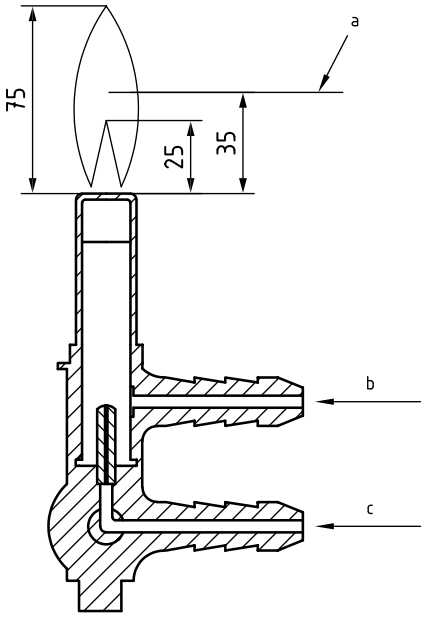


Key

1 pulley mounting bracket
2 weights as required
3 flame application point
4 bottom-clamp mounting
5 Bunsen burner mounting
[a] Low thermal conductivity.

Figure 5 — Test specimen and burner set-up

Dimensions in millimetres



a Flame temperature measurement point.

b Air inlet.

c Propane gas inlet.

Figure 6 — Modified burner showing flame dimensions

6.5.2.7 Apply a DC electric current, I, to the conductor and measure the voltage drop, U. From the current and voltage values, calculate the resistance of the conductor at elevated temperature, R_1, from the following formula:

$$R_1 = \frac{U}{I}$$

6.5.2.8 Determine the temperature, T, in degrees Celsius, of the conductor from the change in resistance, using the following formula based on the variation of the specific resistivity of the copper with the temperature:

$$R_1 = \left[\left(\frac{T-20}{250}\right)+1\right]\cdot R$$

where R is the resistance measured earlier at ambient temperature.

6.5.2.9 Adjust the current so that the conductor temperature stabilizes at the maximum operating temperature for the wire, taken from the manufacturer's specification. Maintain this temperature ±3 % for 5 min before igniting the flame. No further alteration shall be made to the current until the test is completed.

6.5.3 Test

6.5.3.1 At least five replicate specimens shall be tested. Switch on the exhauster fan. The distance between the exhauster inlet and the top of the test chamber shall be at least 0,7 m. Start the video recorder and timer. Apply the flame to the specimen for a period of 15 s. After all flaming has ceased,

note the time, continue to apply the current for an additional 60 s, and observe. If no further flaming occurs, switch off the current, close the oxygen supply valve and vent the chamber.

6.5.3.2 Record any observations, the post-test mass and the burn length.

6.6 Accuracy

Measurements shall be made to the same accuracy as in 5.6, with the exception of the current which shall be measured to within a tolerance of ±0,05 A.

6.7 Test report

6.7.1 Standard tests

The test report shall include details of the specimen identification, the wire configuration, the test conditions, the wire diameter, the wire temperature and the burn length. The test report shall be submitted, in an acceptable format, to the authority having jurisdiction and/or test requester.

6.7.2 Non-standard tests

When there is a deviation from the standard test parameters, such as non-standard test specimen preparation, specimen dimensions, specimen orientation or ignition source, the test shall be identified as non-standard. In addition, all information in 6.7.1 shall be reported.

6.8 Good laboratory practice

At least every 2 years, the test facility shall successfully demonstrate the ability to obtain accurate and repeatable data when testing selected insulated wires. The authority having jurisdiction shall choose appropriate GLP materials for its test facilities. The materials selected shall include both flammable and flame-resistant materials.

Annex A
(informative)

Preparation and qualification of chemical ignitors

A.1 General

This annex provides one method of manufacturing chemical ignitors which produce a flame that meets the requirements for testing in atmospheres in which the oxygen concentrations are between 15 % and 50 %. Any ignition source meeting the criteria outlined in this document can be utilized.

A.2 Safety requirements

All personnel associated with the manufacturing of these ignitors should be familiar with the safety requirements associated with the materials and equipment used.

A.3 Materials

A.3.1 Hexamethylenetetramine (HMT), 98 %, or higher, pure reagent grade, in powder form, properly packaged and stored to prevent contamination by moisture.

A.3.2 Anhydrous sodium metasilicate, 98 %, or higher, pure reagent grade, in granule form, properly packaged and stored to prevent contamination by moisture.

A.3.3 Gum arabic (acacia), in powder form.

A.3.4 Deionized water, for mixing with the dry ingredients to form the ignitor dough.

A.3.5 Certified breathing air, used in the certification of the ignitors.

A.4 Equipment

A.4.1 Hammer mill, for grinding the dry components of the ignitor mixture.

A.4.2 Glove box with a temperature/humidity meter, used when grinding some of the dry ingredients.

NOTE Alternatively, ignitors can be manufactured in a fume hood if the relative humidity is lower than 20 %.

A.4.3 Bags, for storing the ground dry ingredients.

A.4.4 40-mesh (40 µm) screen, for sieving the ground dry ingredients.

A.4.5 Fume hood, used when grinding some of the dry ingredients, and for mixing the ignitor dough. The air flow rate in the fume hood should be at least 30 m/s.

A.4.6 Respirator with organic canisters, used when grinding the HMT.

A.4.7 250 ml burette, for holding the deionized water and gradually adding it to the mixture.

A.4.8 Heavy-duty electric mixer, for mixing the ignitor dough.

A.4.9 Spatula, for scraping the sides of the mixing bowl during preparation of the ignitor dough.

A.4.10 Plastic trays, non-stick, measuring approximately 76 mm × 380 mm × 1,5 mm, to catch the extruded ignitor dough and hold it while it dries.

A.4.11 Conveyor belt, to move the plastic trays at a constant rate so that the string of ignitor dough is not stretched or allowed to become too thick.

A.4.12 Extruder, for extruding the ignitor dough on to the plastic trays.

A.4.13 Cutting tools, for cutting the ignitor dough string to the proper lengths.

A.4.14 Drying racks, for holding the plastic trays containing the ignitor dough string.

A.4.15 Desiccator with desiccant, to ensure that the proper humidity is maintained during drying and storage of the ignitors.

A.4.16 Balance, for weighing the dried ignitors.

A.4.17 Corrugated plastic holder, used when cutting overweight dried ignitors to a length that ensures the correct mass.

A.4.18 Power supply, capable of providing 15 A (RMS), used in the certification of the ignitors.

A.4.19 Bare 20 AWG nickel-chromium wire, with a nominal resistivity of 2,3 Ω·m, used in the certification of the ignitors.

A.4.20 Graduated ruler, for measuring the length of the ignitors and the ignitor flame height during certification.

A.4.21 Test chamber (or fume hood), used during certification of the ignitors.

A.4.22 Calibrated stopwatch, for determining the burn time during certification of the ignitors.

A.4.23 Soft-bristled brush, for cleaning the ignitor coil between certification of individual ignitors.

A.4.24 Plastic container (box), for storing the ignitors.

A.4.25 Corrugated-foam wrap, for wrapping the stored ignitors.

A.5 Grinding the ignitor-mix ingredients

A.5.1 To ensure a homogeneous mixture, grind the raw materials using a hammer mill. Grinding is not necessary for the gum arabic.

A.5.2 Grind the sodium metasilicate in a glove box, as follows. Place the hammer mill, the material to be ground and any other necessary tools inside the glove box. Attach a bag to the output end of the

hammer mill with tape to capture the ground material. In addition, place a 40-mesh screen inside the hammer mill. Seal the glove box and, before grinding the material, purge the glove box with dry air for approximately 4 h or until the humidity inside the glove box is below 20 %.

A.5.3 Grind the material. Detach the bag from the hammer mill, seal the bag, place it inside another bag and seal the second bag.

A.5.4 Clean the hammer mill between the grinding of different materials.

A.5.5 Grind the HMT in a fume hood. The air flow rate in the fume hood should be at least 30 m/s, and a respirator with organic canisters should be worn by the operator. Follow the same procedures as when grinding the sodium metasilicate described in A.5.2 to A.5.4.

A.5.6 After grinding, store each material separately, suitably identified.

A.6 Weighing and mixing the ignitor-mix ingredients

A.6.1 To make a 400 g mixture, the following amounts of each solid ingredient are necessary:

— (280,8 ± 0,2) g of HMT;

— (105,2 ± 0,2) g of anhydrous sodium metasilicate;

— (14,0 ± 0,2) g of gum arabic.

A.6.2 For other size batches, the mixture should be comprised of 70,2 % ± 0,1 % HMT, 26,3 % ± 0,1 % sodium metasilicate and 3,5 % ± 0,1 % gum arabic.

A.6.3 Carry out the weighing and mixing on the day of extrusion (do not mix the dry ingredients prior to the day of extrusion).

A.7 Adding water

A.7.1 Adding water and the subsequent works should be performed under the environment with humidity below 20 %. Pour 200 ml of deionized water at room temperature into a 250 ml burette.

A.7.2 Open the tap of the burette and allow approximately 10 ml of deionized water to flow into the mixing bowl of a heavy-duty electric mixer. Cool the mixing bowl using an iced water bath to absorb the heat generated by the mixture.

A.7.3 Place the dry ignitor mix in the mixing bowl. Ensure the ignitor mix is evenly distributed in the bowl.

A.7.4 Operating the electric mixer at low speed, slowly add deionized water to the mixture. Initially, the mixture is very wet. As the sodium metasilicate absorbs the water, the mixture starts to thicken and eventually achieves a dough-like consistency. This can take 20 min to 30 min, depending on the environmental conditions. During mixing, scrape the sides of the mixing bowl with a spatula.

A.7.5 As the proper dough-like consistency is achieved, the mixture starts to pull away from the sides of the bowl. When this occurs, stop adding water. Too much water causes the mixture to be too wet to extrude. Generally, 190 ml to 200 ml of deionized water is added from the burette to the mixture.