SLOVENSKI STANDARD
SIST EN 3475-601:2007

01-november-2007

Aeronavtika - Elektriļ ni kabli za uporabo v zraļ nih plovilih - Preskusne metode - 601. del: Gostota dima

Aerospace series - Cables, electrical, aircraft use - Test methods - Part 601: Smoke density

Luft- und Raumfahrt - Elektrische Leitungen für Luftfahrzeuge - Prüfverfahren - Teil 601: Rauchdichte

Série aérospatiale - Câbles électriques à usage aéronautique - Méthodes d'essais - Partie 601: Densité de fumée

Ta slovenski standard je istoveten z: EN 3475-601:2007

ICS:

49.060	Letalska in vesoljska elektriļ na oprema in sistemi	Aerospace electric equipment and systems

SIST EN 3475-601:2007 en

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 3475-601

August 2007

ICS 49.060

English Version

Aerospace series - Cables, electrical, aircraft use - Test methods - Part 601: Smoke density

Série aérospatiale - Câbles électriques à usage aéronautique - Méthodes d'essais - Partie 601: Densité de fumée

Luft- und Raumfahrt - Elektrische Leitungen für Luftfahrzeuge - Prüfverfahren - Teil 601: Rauchdichte

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EUROPÄISCHES KOMITEE FÜR NORMUNG

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Ref. No. EN 3475-601:2007: E

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Foreword

This document (EN 3475-601:2007) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2008, and conflicting national standards shall be withdrawn at the latest by February 2008.

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1 Scope

This test method is intended for determination of the specific optical density of smoke generated by electrical wire/cable insulation materials due to pyrolitic decomposition under the influence of radiant heat only or with simultaneous flame application.

It is used for evaluation of insulation materials of electrical wire/cable used in the interiors of aerospace vehicles but may be utilized in other applications as specified in applicable procurement documents.

This standard should be used to measure and describe the properties of products in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However results of this test may be used as elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.

2 Terms and definitions

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

2.1
D_s
Specific Optical Density, is a dimensionless measure of the amount of smoke produced per unit area by a material when it is burned

2.2
D_m
maximum value of D_s, that occurs during the specified time of a test

2.3
F-mode
Flaming mode, the pyrolitic decomposition of the specimen under the influence of radiant heat and with simultaneous flame application

2.4
NF-mode
Non Flaming mode, the pyrolitic decomposition of the specimen under the influence of radiant heat only

2.5
T
percent light transmission

2.6
T_t
percent light transmission at the time t

2.7
T_m
minimum percent light transmission

2.8
t_{Dm}
time of the test in seconds at which the maximum optical smoke density occurs

3 Principle of method

The specimens are vertically arranged in a closed test chamber and subjected to decomposition by radiant heat only or with flame application. The smoke density is measured by means of the reduction of light transmission as smoke accumulates and expressed in terms of specific optical density which is derived from a geometric factor and the measured light obscuration.

4 Test apparatus

4.1 Test chamber

The test chamber shall be a square-cornered box with inside dimensions of (914 ± 3) mm width, (610 ± 3) mm depth, and (914 ± 3) mm height. A typical test chamber is shown in Figure 1. The locations of size of items such as the chamber door, chamber controls, flowmeters, etc., is optional except as mandated in the following sections.

The interior surfaces (except for the chamber door, vents, etc.) shall be porcelain-enameled metal, or equivalent coated metal that is resistant to chemical attack and corrosion, and suitable for periodic cleaning.

Commercially available panels of porcelain-enameled steel (interior surface) permanently laminated to a magnesia-insulation core and backed with galvanized steel (exterior surface) have been found acceptable.

The chamber shall be equipped with a door such as indicated in Figure 1 to provide convenient access for changing test specimens, and for cleaning the chamber walls as required. The door shall have a viewing window to observe the chamber interior during a test, especially when any of the flamelets extinguish. The door shall have a seal so that when it is closed during tests, there will be no leakage of chamber contents. A small positive pressure can be developed and maintained inside the test chamber.

An inlet-outlet vent for pressure equalization shall be provided. The vent shall have a seal so that when it is closed during tests, there will be no leakage of chamber contents and a small positive pressure can be developed and maintained inside the test chamber.

To avoid an excessive increase of pressure in the chamber during testing an airtight safety disc is required, e.g. a sheet of aluminium foil of thickness not greater then 0,04 mm and a minimum area of 800 cm^2 shall be provided in an opening of the chamber floor.

4.2 Manometer

A device such as a manometer or pressure transducer shall be provided to monitor chamber pressure and leakage. The device shall have a range up to 15 hPa, and be connected to a suitable port in the test chamber wall.

4.3 Pressure regulator

A pressure regulator shall be provided that consists of an open water-filled bottle and a piece of tubing, not to exceed 3 050 mm in length, that has an inside diameter of at least 25 mm. One end of the tubing shall be connected to a port on the top or within 152 mm from the ceiling of the chamber; the other end of the tubing shall be held in position 102 mm below the water surface.

4.4 Chamber wall thermocouple

The temperature of the test chamber wall shall be monitored by a thermocouple suitable for measuring a temperature of 35 °C. The thermocouple shall be mounted with its junction secured to the geometric centre of the inner rear wall panel of the chamber using an electrically insulating disk cover.

4.5 Electric power supply

At least 650 W, single phase electric power shall be provided for the radiant heat furnace and accessories. Where line voltage fluctuations exceed 2,5 %, a constant voltage transformer shall be provided.

4.6 Radiant heat furnace

4.6.1 General

An electric furnace and associated controlling devices shall be provided that is capable of providing a constant thermal flux density of (25 ± 0,5) kW/m^2 on the specimen surface.

4.6.2 Furnace construction

The dimensions of the electric furnace are shown in Figure 2. The furnace shall be located centrally along the long axis of the chamber with the opening facing toward and approximately 305 mm form the right wall. The centerline of the furnace shall be approximately 197 mm above the chamber floor.

4.6.3 Heating element

The heating element shall consist of a coiled wire capable of dissipating about 525 W. With the furnace installed, the heating element shall be positioned as shown in Figure 3.

4.6.4 Furnace control system

The furnace control system shall be capable to hold the settings of voltage and current which is measured by the radiant heat output at the required level of (25 ± 0,5) kW/m^2 under steady-state conditions with the chamber door closed for at least 20 min.

The control system shall consist of an AC solid state voltage or power controller and a voltmeter or other means for monitoring the electrical input.

It is recommended to use a digital voltmeter to monitor the furnace voltage output and a digital ampere-meter to monitor the furnace current.

4.6.5 Heat flux density gauge

An air-cooled heat flux density gauge shall be provided for calibrating the output of the radiant heat furnace. The heat flux density gauge shall be a circular foil type.

Compressed air at a pressure of 0,10 MPa to 0,21 MPa shall be provided to cool the heat flux density gauge. The body temperature of the heat flux density gauge shall be monitored with a thermometer having an accuracy of 1 °C at 93 °C in a 12,5 mm by 12,5 mm by 38 mm long brass or copper well drilled to accept the thermometer with a close fit. Silicone grease shall be used to provide good thermal contact. The circular receiving surface of the heat flux density gauge shall be spray-coated with an infrared-absorbing black paint.

A voltmeter or other device which has a resolution of 0,01 mV and an accuracy of 0,3 % is required to monitor the heat flux density gauge output.

4.7 Pilot burner system

4.7.1 Pilot burner

The pilot burner shall be a straight tip burner with six tubes, as shown in Figure 4. The six tubes shall be fabricated from stainless steel tubing having an outer diameter of 3,2 mm and a inner diameter of (1,4 ± 0,025) mm. The six tubes shall be attached to a common manifold, as shown in Figure 4 fabricated from stainless steel tubing having an outer diameter of 6,4 mm and a wall thickness of 0,9 mm. One end of the manifold shall be closed, and the other end of the manifold be attached to a gas supply fitting in the chamber floor.

All tubes of the pilot burner shall be directed perpendicular to the exposed surface of the specimen.

4.7.2 Pilot burner position

The pilot burner shall be centred in front of and parallel to the specimen holder. The tips of the tubes shall be placed (6,4 ± 1) mm above the lower opening of the specimen holder and (6,4 ± 0,5) mm away from the face of the specimen surface, see Figure 4.

A fixture to accurately position the pilot burner is recommended to establish a precise pilot burner position for testing, and to facilitate accurate repositioning of pilot burner after removal and replacement.

4.7.3 Burner fuel

The gas fuel for the pilot burner shall be prepared by mixing filtered oil-free air with 95 % minimum purity propane, and feeding the mixture to the pilot burner. Each gas shall be metered through separate, calibrated flowmeters and needle valves. The air-propane mixture shall consist of an air flow rate equivalent to (500 ± 20) cm^3/min (referred to 23 °C and 1 013 hPa), and a propane flow rate equivalent to (50 ± 3) cm^3/min (referred to 23 °C and 1 013 hPa). The compressed air supply shall be fed to its flowmeter at (0,14 ± 0,03) MPa, and the propane at (0,10 ± 0,02) MPa.

A backflow valve or a flame arrester should be provided in the lines where air and propane are mixed.

4.7.4 Igniter System

An igniter system is recommended to relight the pilot burner flamlets to ensure that none of them extinguishes for more than 3 s during the test.

If an electric sparking device is used, an appropriate method of suppression and an equipment shielding must be applied to have no interference with ability of data acquisition equipment to accurately record data.

4.8 Specimen holder

4.8.1 General

The specimen holder shall consist of a stainless steel frame, a wire holder frame, a backing made of insulation millboard and a spring and retaining rod to secure the specimen in place.

4.8.2 Specimen holder frame

The specimen holder frame shall be fabricated of stainless steel sheet by bending and brazing (or spot welding) stainless steel sheet of (0,60 ± 0,05) mm nominal thickness to conform in shape and dimension to Figure 6. The frame shall be at least 51 mm deep, and shall provide an exposed specimen surface that is nominally (65 ± 1,5) mm by (65 ± 1,5) mm.

A trough to catch and retain dripping material shall be attached to the bottom front of the holder

Guides to permit accurate centering of the exposed specimen area in front of the furnace opening shall be attached to the top and bottom of the holder frame.

4.8.3 Wire holder frame

Holder frame is used to support the specimens. Construction details of the frame are shown in Figures 7A and 7B. The frame is applicable for wires with an outer diameter up to 3,3 mm.

4.8.4 Specimen backing

A piece of insulation millboard shall be used as a backing for the specimen and as a simulated blank specimen. The millboard shall be (13 ± 1) mm thick with a density of (800 ± 160) kg/m^3, or equivalent. Pieces shall be cut (74 ± 1) mm by (74 ± 1) mm to fit inside the specimen holder.

4.8.5 Retaining spring

A spring from 76 mm by 75 mm by 0,25 mm thick stainless steel sheet, shown in Figure 6, shall be used with a stainless steel retaining rod to securely hold the specimen and millboard backing in position during testing.

4.9 Support for radiant heat furnace and specimen holder

A typical support frame to support the radiant heat furnace and specimen holder is shown in Figure 9. This support frame shall have provision to establish accurate alignment for the furnace opening so that it is (38 ± 1) mm away from, parallel to, and centered with the exposed specimen surface. Adjustment screws shall be provided to align the furnace with reference to the specimen.

The framework shall have two 10 mm diameter transverse rods of stainless steel to accept the guides of the specimen holder. The rods shall support the holder so that the exposed specimen surface is parallel to the furnace opening. Spacing stops shall be mounted at both ends of each rod to permit rapid and accurate lateral positioning of the specimen holder. An externally operated control rod shall be provided to replace the test specimen with the blank specimen holder in front of the furnace.

4.10 Photometric system

4.10.1 General

A photometric system capable of detecting light transmittance values of 1,0 % minimum to an accuracy of 0,03 % shall be provided. The system shall consist of a light source and photomultiplier tube that are oriented vertically to reduce measurement variations due to stratification of the smoke in the chamber during the test, a photomultiplier microphotometer that converts the photomultiplier tube output either to relative intensity and/or to optical density, and a strip chart recorder of other suitable means is necessary to record light transmission versus time. A typical system is shown in Figure 8.

4.10.2 Light source

The light source shall be an incandescent lamp mounted in a sealed, light-tight box below the chamber floor. An adjustable constant-voltage transformer shall be set at a level that the operating light brightness temperature is (2 200 ± 100) K. The box shall contain the necessary optics to produce a collimated light beam (38 ± 3) mm in diameter, passing vertically up through the chamber. The light source and its optics shall be isolated from the chamber atmosphere by a glass window that is mounted flush with the chamber bottom panel, and sealed to prevent leakage of chamber contents. To minimize smoke condensation, the window shall be provided with a ring-type electric heater mounted in the light-tight box, out of the light path, that maintains a minimum window temperature of 52 °C on the surface of the window inside the chamber.

4.10.3 Photomultiplier tube

The photo multiplier tube shall have an S-4 linear spectral response and a dark current less than 10^{-9} A.

The photo multiplier tube and associated optics shall be mounted in a second light-tight box that is located above the chamber ceiling directly opposite the light source. The photo multiplier tube and its optics shall be isolated from the chamber atmosphere by a glass window that is mounted flush with the chamber ceiling panel, and permits a viewing cross section of (38 ± 3) mm. The window shall be sealed to prevent leakage of chamber contents.

4.10.4 Microphotometer

The photometer used with its instrument shall have an accuracy of ± 3 % of the maximum reading on any range. It involves a spectral band quite similar to that corresponding to the human vision. The micro photometer shall be capable to converting the signal from the photo multiplier tube to a linearized relative intensity and/or to optical density. The micro photometer/-photo multiplier tube combination shall be sensitive enough that the micro photometer can be adjusted to produce a full-scale reading (100 % relative light intensity, or optical density = 1) using the photo multiplier tube's response (output) to the light source when a neutral colour optical filter of 0,5 or greater optical density is placed in the light path.

4.10.5 Alignment fixture

The two optical windows and their housings shall be kept in alignment and spaced (914 ± 3) mm apart with an alignment fixture consisting of three metal rods, 13-19 mm in diameter fastened securely to 8 mm thick externally mounted top and bottom plates and symmetrically arranged about the collimated light beam (see Figure 10).

4.10.6 Optical filters

A set of nine neutral colour optical filters – 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9 optical density – shall also be provided. The optical filters, one or more as required, may be mounted in the light path in the optical measuring system to compensate for the sensitivity of the photomultiplier tube. These filters may also be used to adjust the photometric system as the light source and/or photomultiplier tube change sensitivity through aging, and/or as discoloration of the optical windows occurs.

4.10.7 Recorder

A recording device shall be furnished that provides a record of the percent light transmission and/or optical density versus time during the test. The record shall consist either of a continuous curve on a chart recorder or discrete values taken at least every 5 s when a computerized data acquisition system or a point by point chart recorder is used.

4.11 Exhaust hood

An exhauster system for removing the chamber contents after each test may be connected to a suitable exhaust hood. Locating an exhaust hood directly above the smoke chamber door is recommended as an additional safety device.

5 Test specimens

5.1 General

The specimens must be taken from the electrical wire or cable to be tested.