SLOVENSKI STANDARD
SIST EN 3197:2011

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Aeronavtika - Načrtovanje in vgradnja letalskih električnih in optičnih sistemov za medsebojno povezovanje

Aerospace series - Design and installation of aircraft electrical and optical interconnection systems

Luft- und Raumfahrt - Konstruktion und Installation elektrischer und optischer Verkabelung in Luftfahrzeugen

Série aérospatiale - Conception et installation des organes de raccordements électriques et à fibres optiques sur avions

Ta slovenski standard je istoveten z: EN 3197:2010

ICS:

49.090	Oprema in instrumenti v zračnih in vesoljskih plovilih	On-board equipment and instruments

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EUROPEAN STANDARD
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English Version

Aerospace series - Design and installation of aircraft electrical and optical interconnection systems

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This European Standard was approved by CEN on 30 July 2010.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (EN 3197:2010) 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of an identical text or by endorsement, at the latest by June 2011, and conflicting national standards shall be withdrawn at the latest by June 2011.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

ORGANISATION OF THIS STANDARD

(Detailed organisation may be found in Annex A)

NOTE Inside this standard, texts in *italic* come from official texts and cannot be modified without verification.

1 Scope

This European standard provides instructions on the methods to be used when designing, selecting, manufacturing, installing, repairing or modifying the aircraft electrical and optical interconnection networks, now called **E**lectrical **W**iring **I**nterconnection **S**ystem (**EWIS**), and **O**ptical **F**ibre **I**nterconnection **S**ystems **(OFIS),** subjects to the limitations defined in Clause 4 of this standard.

The general content of this standard is described in page 2.

A detailed content of this standard is given in Annex A.

This standard lists all the relevant European standards related to EWIS and OFIS in Annex B.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 60270, *High-voltage test techniques — Partial discharge measurements (IEC 60270:2000)*

ISO 2574, *Aircraft — Electrical cables — Identification marking*

ISO 2685, *Aircraft — Environmental test procedure for airborne equipment — Resistance to fire in designated fire zones*

ISO 4046-1, *Paper, board, pulps and related terms — Vocabulary — Part 1: Alphabetical index*

ISO 7137, *Aircraft — Environmental conditions and test procedures for airborne equipment*

MIL-DTL-22520G, *Revision G General Specification for Crimping Tools, Wire Termination — Entire Set* [1)]

MIL-STD-202, *Test method standard electronic and electrical component parts* [1)]

MIL-T-43435B, *Military specification tape, lacing and tying* [1)]

TR 4684, *Aerospace series — Electrical technology and components definitions* [2)]

TR 9535, *Aerospace series — Substance declaration* [2)]

TR 9536, *Aerospace series — Declarable Substances Recommended Practice* [2)]

AS 81824/1, *Splice, electric, permanent, crimp style copper, insulated, environment resistant, class 1* [3)]

AS 83519, *Shield termination, solder style, insulated, heat-shrinkable, environment resistant with pre installed leads for cables having tin or silver plated shields (class I)* [3)]

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1) Published by: Department of Defense (DoD), http://www.defenselink.mil/.

2) Published as ASD-STAN Technical Report at the date of publication of this standard by Aerospace and Defence Industries Association of Europe-Standardization (ASD-STAN), (www.asd-stan.org).

3) Published by: Society of Automotive Engineers (SAE), (www.sae.org).

ASTM D 1868, *Standard Test Method for Detection and Measurement of Partial Discharge (Corona) Pulses in Evaluation of Insulation Systems* [4)]

NOTE Related to EWIS and OFIS, all today existing ASD Normative references per family of products may be found in Annex B.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in TR 4684 and the following apply.

3.1
Design Authority
in this document, this term covers the Companies, in charge of the original design or to give the design agreement for which Certification will be required from the Regulatory Authorities

3.2
Regulatory Authority
in this document, this term covers the Organisations in charge to write rules to satisfy, to survey the design and to grant Navigability Certificate, like EASA and FAA

4 Limitations

It is recognized that the installation practices contained in this standard do not necessarily represent the full requirements for a safe and satisfactory electrical and optical interconnection system.

In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. However, nothing written in this standard shall override the specific requirements of a Design Authority, the Airworthiness Requirements, applicable laws or any regulation from the regulatory authorities, unless a specific exemption has been obtained.

5 General requirements

5.1 Applicable Rulemaking

The main rulemakings to satisfy for the definition of the various possible electrical installations on large aircrafts are coming from:

— Design technical requirements
From the EASA European Aviation Safety Agency (CS 25) and the FAR Federal Aviation Regulation (14CFR – Part 25).

— Organisation requirements
From the EASA European Aviation Safety Agency (IR 21) and the FAR Federal Aviation Regulation (14CFR – Part 21).

4) Published by: American Society For Testing and Materials (ASTM), http://www.astm.org/.

Important advices:

a) From the P2 issue, this standard includes the EWIS concept and associated consequences which were introduced in the regulation by the FAA in November 2007 and by the EASA in autumn 2008. This was also the opportunity for the authorities to group all the electrical requirements: the rules 25.17xx.

b) CS or FAR 23, 27 and 29 which concern small aircraft, small and large helicopters were not updated in-line.

5.2 EWIS Definition

The definition of the aircraft electrical interconnection network, now called **E**lectrical **W**iring **I**nterconnection **S**ystem (**EWIS**) is now given in the regulation. The retained text, coming from the EASA, is the following:

«CS 25.1701 Electrical Wiring Interconnection System Definition
(a) Electrical wiring interconnection system (EWIS) means any wire, wiring device, or combination of these, including termination devices, installed in any area of the airplane for the purpose of transmitting electrical energy between two or more intended termination points. Except as provided for in Subclause (c) of this Subclause, this includes:

1) *Wires and cables.*
2) *Bus bars.*
3) *The termination point on electrical devices, including those on relays, interrupters, switches, contactors, terminal blocks and circuit breakers, and other circuit protection devices.*
4) *Connectors, including feed-through connectors.*
5) *Connector accessories.*
6) *Electrical grounding and bonding devices and their associated connections.*
7) *Electrical splices.*
8) *Materials used to provide additional protection for wires, including wire insulation, wire sleeving, and conduits that have electrical termination for the purpose of bonding.*
9) *Shields or braids.*
10) *Clamps and other devices used to route and support the wire bundle.*
11) *Cable tie devices.*
12) *Labels or other means of identification.*
13) *Pressure seals.*

(b) The definition in Subclause (a) of this Subclause covers EWIS components inside shelves, panels, racks, junction boxes, distribution panels, and back-planes of equipment racks, including, but not limited to, circuit board back-planes, wire integration units and external wiring of equipment.

(c) Except for the equipment indicated in Subclause (b) of this Subclause, EWIS components inside the following equipment, and the external connectors that are part of that equipment, are excluded from the definition in Subclause (a) of this Subclause:

1) *Electrical equipment or avionics that is qualified to environmental conditions and testing procedures when those conditions and procedures are:*
   i) *Appropriate for the intended function and operating environment, and*
   ii) *Acceptable to the Agency.*
2) *Portable electrical devices that are not part of the type design of the aeroplane. This includes personal entertainment devices and laptop computers.*
3) *Fibre optics».*

5.3 OFIS Definition

The definition of the aircraft optical fibre interconnection network, now called **O**ptical **F**ibre **I**nterconnection **S**ystem (**OFIS**) was created by similarity. The retained text is the following:

"OFIS means any fibre or cable, including termination devices, installed in any area of the aircraft for the purpose of transmitting optical signals between two or more intended termination points. Except as provided for in Subclause (c) of this Subclause, this includes:

1) Fibres and cables.
2) Optical Data buses.
3) The termination point on fibre optic transmitting sources and receiving devices protection devices.
4) Connectors, including feed-through connectors.
5) Connector accessories.
6) Fibre optic splices.
7) Materials used to provide additional protection for fibres and cables, including insulation, and conduit.
8) Clamps and other devices used to route and support the cable bundle.
9) Cable tie devices.
10) Labels or other means of identification.
11) Pressure seals.

a) The definition in Subclause (a) of this Subclause covers OFIS components inside shelves, panels, racks, junction boxes, distribution panels, and back-planes of equipment racks.

b) Except for the equipment indicated in Subclause (b) of this Subclause, OFIS components inside the following equipment, and the external connectors that are part of that equipment, are excluded from the definition in Subclause (a) of this Subclause:

1) Fibre optic equipment or avionics that is qualified to environmental conditions and testing procedures when those conditions and procedures are:
   i) Appropriate for the intended function and operating environment, and
   ii) Acceptable to the Agency"

Particular information on OFIS may be found in EN 4533-001 to EN 4533-004. (See also particular Annex B3).

5.4 Design precedence

Design of the EWIS and OFIS shall conform to the following precedence:

1st – Safety;
2nd – System requirements;
3rd – The ease of maintenance, removal and replacement of the cabling;
4th – Cost effective aircraft production.

Cabling shall be fabricated and installed so as to achieve the following:

a. Maximum reliability;
b. Minimum interference and coupling between systems;
c. Accessibility for inspection and maintenance including cleaning;
d. Prevention of damage.

5.5 Selection considerations

Parts, materials, directives and procedures covered by existing European Standards shall be given preference by Design Authorities for all new European projects wherever suitable.

This standard lists all the relevant European standards related to EWIS and OFIS in Annex B.

Otherwise the parts, materials, directives and procedures shall meet the levels of performance and safety as required by the regulatory authorities.

5.6 Service life

In normal use conditions, the airframe electrical and fibre optic interconnection systems and its EWIS and OFIS components shall be selected and installed so that their service life is not less than that of the aircraft structure, which for a civil plane is generally 60 000 flying hours or 20 years, unless otherwise specified.

It shall not, however, be assumed that all EWIS and OFIS components will always achieve this life and installations should be designed to permit a satisfactory level of inspection, test and repair according to rule 25.1725.

Similarly, for engines/power plants and undercarriages which normally have a minimum service life of 10 000 hours, but where, due to their modular construction, the interconnection system, or parts thereof, are required to have longer service lives, the system design shall permit satisfactory inspection, test and repair.

For devices and sub-systems which are designed to be disconnected, the number of acceptable mating unmating operations shall be specified in the relevant technical specifications.

5.7 Smoke and Fire Hazards

Components of the interconnection systems defined in this standard have been designed with an awareness of the hazards of smoke and toxic products under failure conditions. General test requirements may be found in EN 2825 and EN 2826 and dedicated test method may be found in the relevant component specifications (for example: for electrical cables see EN 3475-601 and EN 3475-602).

It is the responsibility of the designer to avoid the use of materials which, in any likely conditions of use or abuse, could create a severe failure condition.

When necessary the design of EWIS and OFIS installations shall recognize the need to provide adequate protection or separation of cables and cable harnesses.

Flammability and self-extinguishing requirements shall be specified for all EWIS and OFIS components and it shall be noted that these requirements are intended to minimize, for example, the transmission of fire along cables or the propagation of fire by the release of flaming droplets.

Nevertheless, the installation of EWIS and OFIS shall recognize that severe overheating of electrical cables is a possibility, therefore the maximum number and size of cables with associated loads within the cable harness shall be considered, see EN 2853 for calculation.

Particular care shall be given to the torqueing of terminal lug screws.

When considering the acceptability of wire or fibre optic, reference should be made to EN 3475 or EN 3745 respectively, or alternative standards acceptable to the design authority, defining acceptable test methods, including arc-tracking test methods (see next Subclause).

Damaged wire and insulation can cause electrical arcing, providing the spark that can cause fire. It should be noted that contamination by materials such as dust, dirt, lint, vapours, etc. can provide fuel for fire.

Owing to potential fire hazard, silver-plating shall not be used in areas where they are subject to contamination by ethylene glycol solutions unless suitable protection features are employed.

CASE OF SMALL NON METALLIC PARTS

Small parts are those that would not contribute significantly to the propagation of a fire as knobs, handles, rollers, fasteners, clips, grommets, rub strips, pulleys, and small electrical parts.

When these parts are grouped together in the same zone, virtual volume are equivalent and shall be taken into consideration. Verification of flammability behaviour shall be done, for example on a reference homogenous material specimen of 50 mm wide and 30 cm length.

Shall be taken into account in particular:

- Self extinguishing,
- Smoke density,
- Gas emission toxicity,
- Dripping must not ignite a flammable product (paper as ISO 4046).

5.8 Short-Circuit and Arc-Tracking

Experience has shown that people examining fault damages may confuse these two phenomena. So the following Subclauses propose means to differentiate both and give technical information to explain the Arc-tracking phenomenon.

5.8.1 Short-Circuit description

5.8.1.1 Cause

A phenomenon of electrical origin generating an over current (with or without an electric arc), which causes local deterioration of one or more cables (conductor and insulation) by thermal effect.

The origin of this phenomenon is direct contact:

- between at least two conductors (cable core)
- of a conductor with the structure

with different electric voltages.

The over current then appears in the damaged circuit thus causing the protection device located upstream (circuit-breaker, fuse, etc.) to trip.

The duration of the short-circuit is short (a few milliseconds to a few tenths of a second).

5.8.1.2 Effects on electric cable looms

The deterioration depends on the power flowing in the circuit.

With high short circuit current deterioration of collateral cables may occur.

Cable damage generally does not exceed 50 mm length (25 mm on either side of the defect point).

5.8.2 Arc-Tracking description

5.8.2.1 Cause

The origin of this phenomenon is contact between at least two conductors (cable core) with different electric voltages via a wet (liquid) or dry (chafing on structure or between cables) "resistive" circuit.

This results in the appearance of electric arcs limiting the current in the circuit(s) to an integrated value below the tripping threshold of the circuit breaker located upstream.

In returning to the source, the electric arc causes cable deterioration (conductor and insulation) by thermal effect.

As the protection devices do not trip immediately the duration of the arc-tracking phenomenon is relatively longer than that of a short-circuit, and can last for several seconds.

The phenomenon stops when:

— direct contact occurs between adjacent conductors (short-circuit). The over current then appears in the damaged circuit thus causing the protection device located upstream (circuit-breaker, fuse, …) to trip.

— current flows stops due to separation of cores (lack of maintaining, blow effect, …).

The phenomenon cannot propagate if:

— the insulation is arc-tracking resistant, or

— a specific device is used to accelerate tripping from the very beginning of arcs appearance.

5.8.2.2 Effects on electric cable looms

Arc-tracking can be differentiated from a short-circuit mainly through the following indications:

- The cable insulation is partly or fully transformed into blackish carbonized residue,
- The cable damage is always located between the initial defect and the supply source,
- The cable damage is generally longer than 70 mm and can extend to hundreds millimetres.

Deterioration of collateral cables may occur.

5.8.3 Arc-tracking phenomenon

5.8.3.1 General

This phenomenon is basically a thermal effect resulting in the conversion of some particular insulating polymer into an electrically conducting material.

There are various ways to initiate this degradation of the insulation, nevertheless once a power arc is produced the resultant reaction is the same.

In any case the generator shall have a 1-minute rating of not less than 20 kVA. Similar results are obtained with higher ratings. Location and tightness of cable-ties are of particular importance to obtain repeatable results.

Present test methodologies are carried out with 115 Va.c. in order to cover all present existing voltage sources used on aircraft, three main ways exist, classified as wet test, dry test or wet short circuit test.

Current test methods do not cover new voltages such as 230 Va.c. and ± 270 Vd.c. For these new voltages, appropriate fault protection is essential particularly where d.c., with its absence of zero voltage crossing points, is involved.

Combinations of materials may be employed to optimise the performance of an insulating system.

Use of Arc Fault protection, such as AFCB (Arc Fault Circuit-Breaker) is another solution. It can be used to accelerate tripping from the very beginning of arcs appearance, thus limiting collateral damages.

5.8.3.2 Wet tracking

This is a surface phenomenon that can act over a significant distance.

When failure occurs the conversion proceeds through the bulk of the insulation and results in more extensive damage (see note below). A continuing supply of electrolyte is required over the polymer surface, bridging points at different electrical potential typically exposed by some form of damage. When the supply of electrolyte is at a suitable rate multiple random dry spots on the surface, due to heating in the electrolyte, lead to very small low current, short duration arcs (scintillation). These arcs have a temperature of 1 000+ degrees acting over a very tiny area and in a tracking material gradually produce a characteristic “treeing” pattern on the surface of the insulation. When a branch (or branches) of the “tree” eventually forms a complete path between the electrodes a sustained high temperature power arc is established. This can lead to an avalanche effect where the resultant high energy and temperature convert adjacent insulating material, that was not initially involved, into a thermally and mechanically stable, electrically conducting graphitic material.

The concerned test method is EN 3475-603.

The test was designed to simulate the effect of moisture creating an electrical path between insulation damage on adjacent cables. This damage may come from insulation ageing or from possible mechanical aggression for example from bad hot stamp markings.

5.8.3.3 Electrical erosion

Where a material does not produce conductive surface spots the scintillation may lead to the loss, by evaporation or de-polymerisation, of tiny amounts of insulation whilst leaving the surface chemically unaltered. In tests for wet tracking it is important that the pass/fail criteria be set to discriminate between violent tracking failure and the longer term, relatively benign effects resulting from extreme erosion in materials prone to this effect.

It is important to quote that all insulating systems subjected to a permanent electrical erosion will fail, even collateral cables. It is just a question of time.

So visual examination of test samples is an important way of discriminating between the arc-tracking and electro erosion phenomena (see 5.8.2.2).

5.8.3.4 Dry tracking

This is a bulk rather than a surface effect. No electrolyte or moisture is required.

Very localised heating occurs over the cross section of the insulation at the “fault” point. The heating results from tiny intermittent, short duration, sparks from the bridging of exposed conductors that do not trip a conventional circuit breaker. Such faults are known as “splashing” or “ticking” faults and may be caused in service by vibrating conductor to structure contact or flexing of wire with broken conductor strands. Such sparks act in a similar manner to scintillation and gradually pyrolyse the whole bulk of the insulation producing, in the case of a tracking polymer, a conducting graphitic structure with the potential for avalanche failure within a bundle in the same manner as for the wet case above.

Typically in tests for dry tracking the initiation is via a vibrating metal edge which bridges power carrying conductors at points having different electrical potential.

The concerned test method is EN 3475-604.

The test was designed to simulate the effect of chaffing against structure creating an electrical path between insulation damage on adjacent cables.

5.8.3.5 Wet short circuit test

This involves the simultaneous shorting, by drops of electrolyte that run down the insulation and across the exposed flush cut ends of conductors in a wire bundle. The conductors are energised at different potentials and because of the small inter-conductor distances vigorous arcing is quickly established on all wires. There is a combination of some surface scintillation between the electrolyte drip point and the conductors but primarily vigorous arcing over the short distance of the insulation cross section. In a tracking insulation there is rapid conversion into a graphitic structure and rapid “burn back” towards the electrical source. In a non-tracking system the conductor itself is gradually eroded within the insulation. The insulation remains as a tube and the path length between conductors slowly increases to the point where activity ceases.

The concerned test method is EN 3475-605.

The test was designed to simulate the effect of moisture ingress into a connector back shell which, where bung sealing is faulty, can lead to shorting between rear parts of pins via wire insulation and/or across the surface of the sealing bung.

5.8.3.6 Notes on arc characteristics

Metal to metal arcs are of high current density and relatively unstable; as such they tend to “cut” conductors rapidly and thus limit damage to the faulted wire. Graphite to metal and particularly graphite to graphite arcs are low current density, stable and spread over a large area so that circuit interruption is delayed; this delay gives time, in tracking materials (only a few milliseconds are required), for the conversion of adjacent insulation to conducting material and the potential avalanche effects.

5.9 Installation Groups

The design, modification and repair of EWIS and OFIS need to be considered for each of the following groups according to their specific requirements:

- engine cable harnesses;
- electrical power generation - heavy duty;
- airframe non-pressurized SWAMP (Severe Wind And Moisture Problems) areas;
- general airframe;
- equipment cabling (line replaceable unit boxes, panels and racks, etc.);
- radio- and/or video frequency;
- data bus and/or video digital links;
- optical fibre link.

5.10 Maintenance considerations

The maintainability of EWIS and OFIS including cleaning and inspection shall be a prime consideration in the selection, design, installation and identification of harnesses, electrical/optical cable assemblies and wiring system components. All cabling should be accessible, repairable and/or replaceable at the maintenance level specified by the design authority. Other specific requirements concerning maintenance, such as cleaning methods, are specified in the appropriate Subclause on the subject.

It shall be noted that EWIS and OFIS of some particular systems or parts may require particular maintenance considerations, examples: engines, landing gears, fly-by-wire, shielded bundles.